ʹAbd al-Raḥmān al-Ṣūfī and His Book of the Fixed Stars: A Journey of Re-discovery

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Abstract

Al-Ṣūfī's *Book of the Fixed Stars*, dating from around AD 964, is one of the most important medieval Arabic treatises on astronomy. This major work contains an extensive star catalog, which lists star co-ordinates and magnitude estimates, as well as detailed star charts. Other topics include descriptions of nebulae, colors of stars and Arabic folk astronomy. Al-Ṣūfī's book was based on Ptolemy's classical work called the *Almagest* which was written around A.D. 137. Al-Ṣūfī updated Ptolemy's stellar longitudes from A.D. 137 to 964 by adding 12 degrees and 42 minutes on Ptolemy's longitude values to allow for precession. However, it is surprising that at present no English translation of al-Ṣūfī's treatise exists. Therefore this is a Doctorate thesis which includes for the first time a complete English translation of the main parts of al-Ṣūfī's work as well as a detailed study of this important book.

The main topics which have been discussed in this study include a brief biography on al-Ṣūfī, the extant manuscripts of al-Ṣūfī's treatise, the structure of the book and star catalogue, and the star maps and charts. One of al-Ṣūfī's innovations in charting the stars was the production of dual illustrations for each of Ptolemy's constellations. One illustration was as portrayed on a celestial globe. The other illustration was as viewed directly in the night sky. Al-Ṣūfī's contribution to astronomy was not only limited to writing this book but he was also instrumental in developing the science of astronomy for a very long time. He also contributed to the building of an important observatory in the city of Shiraz as well as constructing many astronomical instruments such as astrolabes and celestial globes. His influence reverberated throughout history reaching as far as the end of the 19th century. This study also includes a major finding which is al-Ṣūfī's magnitude unique 3-step intermediate magnitude system. Al-Ṣūfī identified more than one hundred new stars which he mentioned in his commentaries on the constellation but they were not included in the tables nor were they mentioned in the *Almagest* or any other ancient star catalogs.

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1. INTRODUCTION

> "A really correct and reliable edition, with reproductions of the drawings in the original shape, using some of the oldest extant manuscripts remains a desideratum," (Kunitzsch, 1989).

This was what Professor Paul Kunitzsch wrote when he was describing one of the most important books in the history of Arabic and Islamic astronomy. This book was called *Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een*, later known by its short name *The Book of the Fixed Stars*. It was written in Arabic by the famous Persian author and astronomer ʹAbd al-Raḥmān al-Ṣūfī around A.D. 964.

Ever since I read this comment by Professor Kunitzsch I wondered what prompted one of the foremost experts in the history of Arabic astronomy to write such a comment about a book, which had always been the one main reference in the history of Arabic observational astronomy? It is the one book that is almost always mentioned by anyone who wants to describe the level of development of Arabic astronomy in the Middle Ages (Evans, 1998). This impelled me to look for copies of this book and to search for any references, which mentioned either the book or the author. However, to my surprise, from the literature review that I made I found little detailed published information on this subject. I found out that until now al-Ṣūfī's work has not been translated into English, and has not even been commented on in recent times. The last translation of this significant work was done in French by Hans Karl Frederik Schjellerup back in A.D. 1874 (Schjellerup, 1874). However, Latin, Persian and Spanish translations are known to exist (Kunitzsch, 1989). Most of the scholarly works I found which mentioned this book have had something to do with the comparison of al-Ṣūfī's star coordinates with those provided by Ptolemy in his famous work *Almagest* (Knobel and Peters, 1915) or with other similar star catalogs (Fujiwara; Yamaoka; and Miyoshi, 2004). I have not seen many references which describe al-Ṣūfī's work for its own merits except as a general reference to the importance of his star catalog from a historical perspective (Hoskin, 1997) or the influence of his charts on Western or European astronomy (Harley; Woodward; and Lewis, 1987). The other main references I found on al-Ṣūfī described the nebulae which he wrote about in his book (Abinda, 1999).

Therefore I took upon myself to write a thesis on al-Ṣūfī's work *Ṣuwar al-Kawākib al-Thamāniyah wa-al-Ārba'een.* My main objective for this thesis was first directed at translating the main sections of this book. The other objective was to try and point out the importance of this author and this book in the history of astronomy. I found that al-Ṣūfī's work also includes other topics, such as stellar magnitude values, Arabic folk astronomy and so on, which should be highlighted for their own. My justification in writing this thesis is that very few people have access to al-Ṣūfī's work and many researchers believe that an English translation and a study of such works by Arab astronomers are very important at this time. This turned out to be a journey of re-discovery of a man who helped influence the science of astronomy and courageously tried to correct our views of the celestial sphere.

Before I embarked on this endeavor I needed to set up a method or framework by which I would go about conducting this research. Such a study requires the expertise of astronomy, history of science, Arabic and Islamic history as well as linguistics. However I do not claim to be an expert in all these fields and I was always grateful to receive constructive comments and corrections on the various topics, which are relevant to this study. Therefore to conduct this study I first had to understand the history of ancient classical astronomy and the main events that shaped the development of Arabic and Islamic astronomy throughout history. I also had to be aware of the old Arabic astronomical tradition and why it was important to many Arab and Islamic astronomers, including al-Ṣūfī. And in order to understand al-Ṣūfī's work I had to fully understand the general characteristics of Arabic and Islamic astronomy. I also needed to study Ptolemy's star catalog, which is to be found in the *Almagest.* I had to study its history, from Ptolemy's time until it passed down to al-Ṣūfī, and finally down to the present day. Therefore, in the second part of this study I tried to summarize the above-mentioned topics in order to give a better understanding of the history of Arabic astronomy before I could start to understand and analyze al-Ṣūfī's work.

ʹAbd al-Raḥmān, Abū al-Ḥusaīn, Ibn ʹUmar, Ibn Muḥammad, al-Rāzī, al-Ṣūfī, the author of this most important book in the history of medieval astronomy, was born in A.D. 903 in Rayy, south east of what is now called Tehran (Iran), and he died in A.D. 986. In the third part of this effort to re-discover this author I tried to construct a short biography on this 10th century astronomer. This included the background on al-Ṣūfī's time period as well as all those people, heads of states and scholars who influenced our author or have been influenced by him. I also tried to summarize the other works which were ascribed to our author, and discussed their importance in the history of Arabic astronomy. It is well known that al-Ṣūfī built an observatory in Shiraz (Sayili, 1960). Therefore, it was also important to describe the significance of this observatory, its location, the astronomers who worked in it, and the contributions they made to the progress of astronomy. The importance of al-Ṣūfī in the history of astronomy is a known fact; however it was good to see how al-Ṣūfī's work influenced the development of astronomy in the Islamic world as well as in the Western world later on. Al-Ṣūfī has been mentioned by many astronomers but his name has often been miss-spelled and miss-written. He has been referred to by various names such as: Abolfazen, Ebenasophy and Azophi (Kunitzsch, 1989). It had been a fascinating exercise to search for these names which were given to al-Ṣūfī in history and the reason they were transformed in this way. Finally, to commemorate the name of this important astronomer, it should be noted that in 1935 the International Astronomical Union named a crater on the Moon by the name of Azophi. It was interesting at that point in this study, to identify this crater, and include a picture of it in the final effort to construct this biography.

Al-Ṣūfī's star catalog was based on Ptolemy's star catalogue in the *Almagest* with the addition of 12 degrees 42 minutes to allow for precession. However, al-Ṣūfī also commented in detail on every constellation before every section of those star charts. Al-Ṣūfī also used ecliptical coordinates, as did Ptolemy before him. Al-Ṣūfī's original Arabic text contained 55 astronomical tables as well as duel charts to 48 constellations, one as seen in the heavens and another as depicted on a celestial globe. These tables and charts were divided into three main sections. The first contained 21 northern constellations which are: Ursa Minor, Ursa Major, Draco, Cepheus, Bootes, Corona Borealis, Hercules, Lyra, Cygnus, Cassiopeia, Perseus, Auriga, Ophiuchus, Serpens, Sagitta, Aquila, Delphinus, Equuleus, Pegasus, Andromeda and Triangulum. The second section contained the 12 constellation of the zodiac: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpios, Sagittarius, Capricorns, Aquarius and Pisces. And finally, the third section contained the following 15 southern constellations: Cetus, Orion, Eridanus, Lepus, Canis Major, Canis Minor, Argo Navis, Hydra, Crater, Corvus, Centaurus, Lupus, Ara, Corona Australis and Piscis Austrinus.

The main objective of this thesis and my attempt to revive the treasures hidden in al-Ṣūfī's book was in translating this major work. Therefore, in the fourth section of this thesis I tried to translate the main introductory chapter as well as six complete chapters of al-Ṣūfī's work. This is because the text is immense and its full translation would not be within the scope of this thesis. I have included some explanations and commentaries in the discussions section of this study to help understand some of the concepts and ideas which were found in those chapters. The first part in the translation effort was to translate the introductory chapter where al-Ṣūfī explains the reasons why he wrote *The Book of the Fixed Stars*. He mentioned that his book was dedicated to the Buwayhid ruler, 'Aḍud al-Dawla, who was a great patron of astronomy and himself an accomplished scholars and astronomer. Al-Ṣūfī also described the methods he used in constructing his catalogue, especially in calculating precession. In his introductory chapter al-Ṣūfī also commented upon several other works, such as al-Battānī's star catalog, al-Daīnawari's book on old Arabic astronomical tradition and Ptolemy's *Almagest*. The second part in the translation effort was to translate the entire star catalogue which was found at the end of each constellation chapter. For all these translations I have used the oldest extant copy of al-Ṣūfī's book, as well as the copy written by the famous Muslim astronomer Ulugh Bēg in the 15th century, which is a well-written manuscript.

Al-Ṣūfī's work was written in old Arabic style with no comas or stops, therefore it was sometimes a little difficult to understand the meaning of every thought. As I described earlier, it was necessary at first to study the old Arabic astronomical traditions and the idea of the star mansions, as well as Ptolemy's account in the *Almagest*, in order to fully understand the translation of al-Ṣūfī's book. Therefore, in the translation efforts I tried to follow the ideas and sentence structure of al-Ṣūfī exactly as he wrote them, and at the same time attempt to make them comprehensible given our present style of writing and sentence structure, so I had to translate exactly as al-Ṣūfī wrote, and leave the analysis, comparison and error measurement for the next section of this study.

It was a normal rainy day when I walked into the British Library in London. I was looking for a copy of al-Ṣūfī work *The Book of the Fixed Stars*. After the tedious bureaucratic effort to register my request and obtain a visitor's library card, I was ushered into the main floor where the Arabic manuscripts were usually kept. I was well prepared: I had all the relevant information about the author and the book, as well as the manuscript number. "It is strange. We seem to have it but I could not find the manuscript number. We need several days to locate this book. Do you want me to hold it for you? You should come back in a few days if you want." This was the reply I got from the librarian at that time. I wondered then why an important book such as this one was not easy to locate. Was it buried under loads of other books? When was the last time anyone had requested it? Anyway, this was almost the same reply I got in many other libraries which were known to have copies of this manuscript. It proved to be a tedious effort to locate all the main sources and available copies or manuscripts of this book. I had to travel to Paris, London, Oxford and many other libraries worldwide in order to collect some of the major copies which I used in this study. It was only once all these extant manuscript were located that I began my translation and investigation of al-Ṣūfī's work.

The study and analysis of this book begins with a description of the structure and layout. What are the main ideas that are presented in the book? How was it written? And what are the main factors that distinguished this book from other similar works that predated it? I have tried to answer all these research questions and many more, in this attempt to study and analyze the most important work of observational astronomy to come out of the Middle Ages.

Another aspect of the study was the maps, which are considered a unique feature of this work. Al-Ṣūfī drew two distinct sets of maps of the constellations. One set depicted the constellation as seen in the sky, and the other as seen on a celestial globe. Such a concept was considered a ‘first’ in observational astronomy, in an effort to identify every constellation in the sky, determine it size and locate all of the major stars in each constellation.

The next step of the analysis was to compare al-Ṣūfī’s stellar data with those found in the *Almagest*. This analysis eventually led to the examination of the accuracy of al-Ṣūfī’s values compared to today’s figures. In this study I tried to identify all those stars which show a difference in magnitude so I could analyze the reasons for these discrepancies and the level of accuracy of al-Ṣūfī’s data. I also found that al-Ṣūfī identified many other stars which had not been mentioned by Ptolemy or any other astronomer before him. Al-Ṣūfī also mentioned the colors of some stars as well as stars which were normally used on the astrolabes. He also mentioned the location of some stars which he considered to be double stars. As mentioned earlier, many references are found in history of astronomy books to those few nebulae which al-Ṣūfī identified. Therefore, in this part of the study I tried to locate all the above mentioned stars as well as these nebulous objects and summarize what al-Ṣūfī wrote about them. I am hoping that all this information might hopefully be used in future studies and research of applied astronomical research. The final part of this re-discovery effort was to examine the old Arabic astronomical traditions mentioned in al-Ṣūfī’s work. How significant were they? and why did he include them in his work?

As we will see, al-Ṣūfī and *The Book of the Fixed Stars* have a very important place in Arabic and Islamic astronomy. Al-Ṣūfī managed to combine the old Arabic *Anwā’* tradition with the ancient classical Greek astronomy to join two separate astronomies into one (Brown, 2009). Professor Kunitzsch wrote that a more detailed study of this subject is required; therefore I hope that I have managed to satisfy some of these endeavors. Finally, to recap what Schjellerup wrote in his introduction: “al-Ṣūfī’s ... work deserves the highest confidence as in its perfection it surpasses Ptolemy’s tables which had remained without a rival for the previous nine centuries.”

2 KEY ELEMENTS OF ARABIC AND ISLAMIC ASTRONOMY

2.1 A Short History of Arabic and Islamic Astronomy

The study of astronomy and the degree which it has reached in our time, is a result of the huge efforts of ancient astronomers, philosophers and thinkers of the past. Astronomy, like any other science, is like a tree with it roots in the ground and its branches growing and flourishing. No branch could have evolved without these roots. Therefore, it is always essential to study and understand these roots before we attempt to proceed with our own study of our author ʹAbd al-Raḥmān al-Ṣūfī and his *Book of the Fixed Stars*.

Before we start our brief study on the history of Arabic and Islamic astronomy we have to set our terminologies straight. The terms Arabic and Islamic astronomy are sometimes confusing. Sometimes the term 'Arabic' is used and sometimes it is 'Islamic'. So what is the difference between the two and why do we have two different classifications for what seems to be one topic? Islamic science and astronomy usually refers to the work of those scientists and astronomers who lived in the Islamic empires in the Middle Ages. As a result Islam had an influence on them- even though some of them were not Muslims in their beliefs. These scholars mainly wrote their work in the Arabic language, which was the official language of the Islamic states. Therefore, the terms Arabic and Islamic are sometimes used interchangeably and sometimes as distinctive terms that describe these scholars. However, I believe that the best way to describe these scientists is by combining the terms: Arabic and Islamic scientists and Astronomers. If we only use the term Arabic then we will exclude many distinguished non-Arabs (Persians, Turks, Indians….) who contributed greatly to the history of Arabic and Islamic science. And vice versa: if we only use the term Islamic then we will also be excluding many non-Muslims (Christians, Jewish, Sabian…) who also made immense contributions to the advancement of Arabic and Islamic science and astronomy. This reasoning applies to our author ʹAbd al-Raḥmān al-Ṣūfī. He was a Muslim and a Persian astronomer who wrote all his works in Arabic.

Prior to beginning this study we also have to understand the historical background and the astronomical knowledge that was present in the geographical area where this astronomy evolved. Therefore, in the next part of this study I will attempt to give a brief picture of the historical development and significance of ancient astronomy leading to the study of the history of Arabic and Islamic astronomy.

2.1.1 Background on the History of Ancient Astronomy

Astronomy grew out of problems originating with the first civilizations, that is, the need to establish with precision the proper times for planting and harvesting crops and for religious celebrations and to find bearings and latitudes on long trading journeys or voyages. The curiosity of ancient people concerning day and night, the Sun, the Moon, and the stars eventually led to the observation that the heavenly bodies appear to move in a regular manner that is useful in defining time and direction on Earth. To ancient people the sky exhibited many regularities of behavior. The bright Sun, which divided day from night, rose every morning from one direction, from the east, moved steadily across the sky during the day, and set in a nearly opposite direction, in the west. At night more than 2000 visible stars followed a similar course, appearing to rotate in permanent groupings, around a fixed point in the sky. In the North Temperate Zone, people noticed that days and nights were unequal in length. On long days the Sun rose north of east and climbed high in the sky at noon; on days with long nights the Sun rose south of east and did not climb so high at noon. Observation of the stars showed that the relative position of the Sun among the stars changed gradually. Further study showed that the sky also holds the Moon and five bright planets. These bodies, together with the Sun, move around the star sphere within a narrow belt called the ecliptic. The Moon traverses the ecliptic quickly, overtaking the Sun about once every 29.5 days. This period is now known as the synodic month. Star watchers in ancient times attempted to arrange the days, the months and the years into a consistent time system, or calendar. The Sun and Moon always traverse the ecliptic from west to east. However, some of these planets -Mars, Jupiter and Saturn- also have a generally eastward motion against the background of the stars, move westward, or retrograde, for varying durations during each synodic period. Thus, the planets appear to pursue an eastward course erratically, with periodic loops in their paths. In ancient times, people also imagined that celestial events, especially the planetary motions, were connected with their own fortunes. This belief, called astrology, encouraged the development of mathematical schemes for predicting the planetary motions and thus furthered the progress of astronomy during ancient times.

Several ancient people, notably the Egyptians, the Mayans, and the Chinese, developed interesting constellation maps and useful calendars (Walker, 1996). Among those ancient cultures were the Babylonians who accomplished even greater achievements (Hunger et al., 1999). The Babylonians distinguished stars according to groups or constellations and introduced the sexagesimal system of calculation. To perfect their calendar, they studied the motions of the Sun and Moon. It was their custom to designate the first day of the month when the lunar crescent first appears after sunset. Originally this day was determined by observations, but later the Babylonians wanted to calculate it in advance. They also realized that the apparent motions of the Sun and Moon from west to east around the ecliptic do not have a constant speed. These bodies appear to move with increasing speed for half of each revolution to a definite maximum and then to decrease in speed to the former minimum. The Babylonians attempted to represent this cycle arithmetically by giving the Moon, for example, a fixed speed for its motion during half its cycle and a different fixed speed for the other half. Later they refined the mathematical method by representing the speed of the Moon as a factor that increases linearly from the minimum to maximum during half of its revolution and then decreases to the minimum at the end of the cycle. With these calculations of the lunar and solar motions, Babylonian stargazers could predict the time of the new Moon and the day on which the new month would begin. As a by-product, they knew the daily positions of the Moon and Sun for every day during the month. In a similar manner the planetary positions were calculated, with both their eastward and retrograde motions represented. Archaeologists have unearthed hundreds of cuneiform tablets that show these calculations. A few of these tablets, which originated in the cities of Babylon and Uruk, on the Euphrates River, bear the name of Naburiannu, who flourished about B.C. 491, and Kidinnu, who flourished about B.C. 379 (Neugebauer, 1969: 137).

However the Greeks were later to make one of the most important theoretical contributions to the science of astronomy. It all started with the *Odyssey* of Homer who referred to such constellations as the Great Bear, Orion, and the Pleiades and described how the stars may serve as a guide in navigation. Other poems informed the farmer which constellations rose before dawn at different seasons of the year to indicate the proper times for plowing, sowing, and harvesting (Evans, 1998: 3). In about 370 B.C. the astronomer Eudoxus of Cnidus explained that a huge sphere bearing the stars on its inner surface moved around the Earth in a daily rotation. In addition, to account for solar, lunar, and planetary motions, he assumed that inside the star sphere there existed other interconnected transparent spheres that revolved in various ways (Heath, 1932: 65). This cosmological system of nested celestial spheres was depicted by Peter Apian in his Cosmographicus in A.D. 1524 as shown in Figure 1 below.

Figure 1 The Universe According to the Greeks with Nested Celestial Spheres was Depicted by Peter Apian in his Cosmographicus in A.D. 1524

Probably the most original ancient Greek observer of the heavens was Aristarchus of Samos. He believed that the motions of the sky could be explained by the hypothesis that the Earth turns around on its axis once every 24 hours. He also explained that the Earth along with the other planets revolve around the Sun; however most Greek philosophers rejected this explanation. The theory of the Earth-centered Universe, known as the geocentric system, remained virtually unaccepted for about 2000 years. From the 2nd century B.C. until the 2nd century A.D. Greek astronomers combined their celestial theories with carefully planned observations. The astronomers Hipparchus and later on Ptolemy determined the positions of about 1000 bright stars and used this star chart as a background for measuring the planetary motions (Grasshoff, 1990). Abandoning the spheres of Eudoxus for a more flexible system of circles, they postulated a series of eccentric circles with the Earth near a common center to represent the general eastward motions at varying speeds of the Sun, Moon, and planets around the ecliptic. To explain the periodic variations in the speed of the Sun and Moon and the retrogressions of the planets, they postulated that each of these bodies revolved uniformly around a second circle, called an epicycle, the center of which was situated on the first as shown in Figure 2. By proper choice of the diameters and speeds for the two circular motions ascribed to each body, its observed motion usually could be mathematically represented. In some cases a third circle was required. Ptolemy described this technique in his great work the *Almagest*.

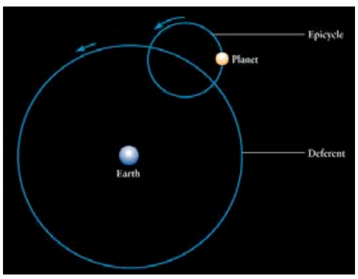


Figure 2 The Ptolemaic System with Deferents and Epicycles

With the conquests of Alexander the Great in the Mediterranean region around B.C. 330, Greek civilization dominated the area for centuries. As a result of this cultural interaction, Greek astronomy was exchanged between the Syrians, the Hindus, and the Arabs (Sarton, 1959). Arab and Islamic astronomers compiled star catalogs in the 9th and 10th centuries and subsequently developed tables of planetary motion, which were mainly based on Greek astronomy. Many scholars of history believe that although the Arabs were good observers, however they made very few useful contributions to astronomical theories (Lindberg, 1992: 175). However this shallow reasoning has long been revamped as a result of continuous discoveries and research on the history of Arab and Islamic astronomy (Saliba, 1994). In the 13th century, Arabic translations of Ptolemy's *Almagest* filtered into Western Europe. It is this act which has re-stimulated the interest in astronomy leading to the Copernicus and the Newtonian revolutions.

2.1.2 A Brief History of the Arab and Islamic Empire

At the beginning of the seventh century A.D. the Arabian Peninsula was rocked with the birth of a new religion: Īslām. This religion first engulfed the Arab world and changed the whole social and political structure of the area. It also transformed the whole perceptions and interest of the Arabs who populated this region. On the 29th of September in A.D. 571 the Prophet Muḥammad was born. In A.D. 611 he received the first revelation from God and in A.D. 622 he migrated to Madīnah which marks the start, of the known Islamic *Hijrī* calendar and the birth of the first Islamic state under the leadership of the Prophet himself, then later by his successors or Caliphs. This early era of Islamic history is marked by the struggle to spread the message of faith and to strengthen the newly-born state. Therefore as a result of this, war was inevitable in order to spread and fulfill the message and defend the gains that were achieved.

Upon the death of the Prophet Muḥammad in A.D. 632, Abū-Bakr, the friend of the Prophet and the first adult male to embrace Islam, became caliph. Abū-Bakr ruled for two years to be succeeded by 'Umar who was the caliph for a decade. During 'Umar's rule Islam spread extensively east and west conquering the Persian Empire, Syria and Egypt. 'Umar also established the first public treasury and a sophisticated financial administration. He established many of the basic practices of Islamic government. 'Umar was succeeded by 'Uthmān who ruled for some twelve years during which time the Islamic expansion continued. He is also known as the caliph who had the definitive text of the Qur'an copied and sent to the four corners of the Islamic world. He was in turn succeeded by 'Alī, the Prophet's cousin and son-in-law who is known to this day for his eloquent sermons and also for his bravery. With his death the rule of the 'rightly-guided' caliphs, who hold a special place of respect in the hearts of Muslims, came to an end.

The Islamic community had expanded rapidly after the Prophet's death, and within a few decades the territory under Islamic rule extended onto three continents: Asia, Africa and Europe. Over the next few centuries this Empire continued to expand and Islam gradually became the chosen faith for the majority of its inhabitants. As Islamic civilization developed, it absorbed the heritage of ancient civilizations like Egypt, Persia and Greece, whose learning was preserved in the libraries and with the scholars of its cities. Some Arab and Islamic scholars turned their attention to these centers of learning and sought to acquaint themselves with the knowledge taught and cultivated in them. They, therefore, set about with a concerted effort to translate the philosophical and scientific works available to them, not only from the Greek and Syriac languages (the languages of eastern Christian scholars), but also from the scholarly language of pre-Islamic Persia, and even from Sanskrit, an ancient Indian language.

In A.D. 661 the rule of the Umayyad dynasty began which was to last for about a century. During this time Damascus became the capital of an Islamic world, which stretched from the western borders of China to southern France. Not only did the Islamic conquests continue during this period through North Africa to Spain and France in the West and to Central Asia and India in the East, but the basic social and legal institutions of the newly-founded Islamic world were established. All this started with the first Umayyad Caliph Mu'aweyah Ibn Abū Sufyān whose rule lasted until A.D. 680. Mu'aweyah's conflict with 'Alī the last of the rightly-guided caliphs and his sons brought about the first internal power struggle of the Islamic world. Those who supported 'Alī and his son's right to succession were to be called Shiite (Shī'ah) Muslims. Those who supported Mu'aweyah and the idea of majority rule were to be called Sunnī Muslims. Therefore the Umayyad rule from the beginning was characterized by continuous struggle to expand while keeping this Dynasty alive.

The Abbasids (al-'Abbāsīyeen), who succeeded the Umayyad in A.D. 750, shifted the capital to Baghdād, which soon developed into an incomparable center of learning and culture as well as the administrative and political heart of a vast world. They ruled for over 500 years but gradually their power waned and they remained only symbolic rulers bestowing legitimacy upon various sultans and princes such as the Buwayhid and the Seljūks who wielded actual military power. The Map below in Figure 3 shows the extent of Abbasids Islamic Empire during the 9th century.

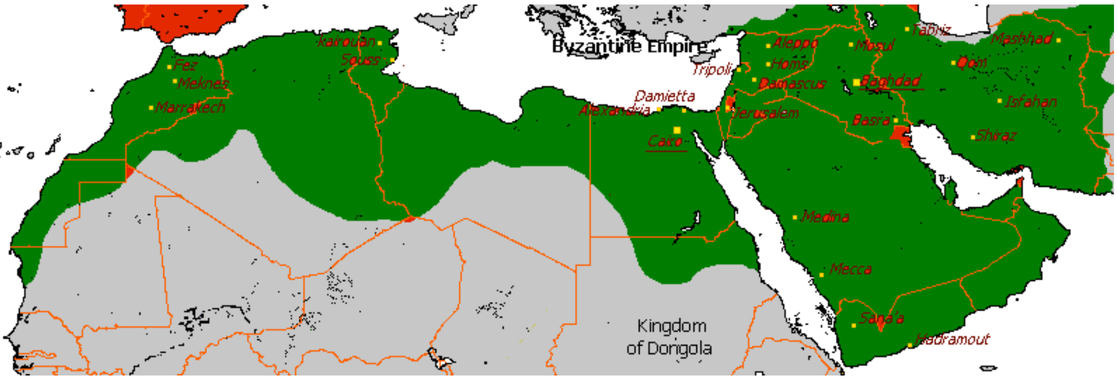


Figure 3 Map of the Islamic Empire in the 9th century.

The Abbasid caliphate was finally abolished when Hulagu, the Mongol ruler, captured Baghdād in A.D. 1258, destroying much of the city including its incomparable libraries. While the Abbasids ruled in Baghdād, a number of powerful dynasties such as the Fatimids (al-Fāṭimīyeen), Ayyubids (al-Aybūyīeen) and Mamluks (al-Mamālīk) held power in Egypt, Syria and Palestine. The most important event in this area as far as the relation between Islam and the Western world was concerned was the series of Crusades declared by the Pope and supported by various European kings. The purpose, although political, was outwardly to recapture the Holy Land and especially Jerusalem for Christianity. At the beginning there was some success and local European rule was set up in parts of Syria and Palestine. Muslims eventually prevailed and in A.D. 1187 Ṣalāh al-Dīn, recaptured Jerusalem and defeated the Crusaders.

2.1.3 Astronomy During the Early Days of Islam

During the early period of Islam, the Muslims were preoccupied with the struggle and the affairs of state. They were not able to pursue any significant scientific endeavors. Most scholars concerned themselves with theology and other religious studies that accompanied the establishment and transmission of this faith. Astronomy, which is a part of the scientific corps, suffered as a result of this neglect. Unfortunately before Islam, astronomy was associated with the practice of divination and also with the worship of idols, stars and planets (Shami, 1994). Therefore many early Muslims disassociated themselves from the study of astronomy fearing they would be tainted by having any connection with previous unholy practices. This does not mean that Islam prohibited the study of this science; however, this unease with astronomy at the beginning laid the road for Muslims to draw the distinction between astronomy and astrology. Islam was very clear in prohibiting divination and any other astrological practices but at the same time encouraging the science of astronomy for the benefit of mankind. However, this did not completely stop the practice of astrology by some Arab and Islamic scientists and rulers in Islamic societies (Sherem, 2003: 114).

2.1.4 Astronomy During the Umayyad Period

From the start of their rule the Umayyad experienced many internal uprising against their state. Most of the Umayyad Caliphs were mainly occupied with putting down these uprisings as well as trying to expand the borders of their empire eastward and westward. Therefore most of the rulers and caliphs in the Umayyad period were more preoccupied with politics then with aspects of social and cultural interests.

However there were some exceptions to this norm. We know from several historical references that one of Mu'aweyah's grandsons whose name was Khāled Ibn Yazīd Ibn Mu'aweyah had some interest in science (Shami, 1997: 97). It is said that he was one of the first to order scientific books to be translated for him from Greek. Unfortunately this early translation activity was restricted to a personal level and did not have any wide impact elsewhere. Therefore, the first century of Islamic rule was not very productive from an astronomical point of view.

2.1.5 Astronomy During the Abbasid Period

The Abbasid dynasty took over control of the Islamic empire from the Umayyad dynasty in A.D. 750 before which most of the expansions of the state had taken place. This Empire started to enjoy a relative period of stability as the authority of the Islamic empire was reaffirmed. Another important aspect of the Abbasid Empire was that it contained one of the most diverse cultures and ethnic groups that have ever been assembled in one state. It included the Arabs in Arabia, the Persians in Iran, The Turks in central Asia, the Berber in North Africa, the Indians on the Indian subcontinent, and the Chinese in Asia. This Empire also included many religions and sects under one roof such as Muslims, Christians, Jews, Sabians, Hindus, Buddhists and many more.

The Golden period of the Abbasid rule extends from the start of the rule of the first Caliph Abī al-'Abbās until the end of the rule of the Caliph al-Mutawakel in A.D. 861. During this period the Arabic language became the official language of the Empire. Arabic was the language of the Quran and it was used by almost all scholars and scientist as well as in the daily lives of many citizens in this vast Empire. The adoption and use of the Arabic language, not to mention the wide conversion to Islam, also helped in uniting the many cultural groups in the largest Empire that has ever existed in the history of mankind. For example, al-Ṣūfī wrote all his works in Arabic even though he was of Persian descent.

The scientific and astronomical interests of the Abbasid Dynasty started in the reign of the second Caliph, Abu J'afar al-Mansūr. This caliph was known for his love of science especially that which involved the stars and the study of the heavens. He was known to have surrounded himself with scientists, astronomers as well as astrologers whom he consulted in many of his affairs. Some of those scholars were: Nubūkhet and his son Sahl, Ibrahīm al-Fazārī, 'Ali al-Isterlābī and 'Umar Ibn al-Farkhan al-Ṭabarī. It is also well known that the caliph built the city of Baghdad and it is said that he consulted with one of his astrologers Nubūkhet regarding the location and time of building this city (Shami, 1994). However, Al-Mansur's legacy is that he was the first to order the translation of books on astronomy not to mention astrology from Greek and Indian to Arabic. This heralded the start of the translation movement that would later have a profound impact on the science of astronomy of that period.

By the time Hārūn al-Rashīd came to be the new Caliph in Baghdad in A.D. 786, scientists and scholars had become very common around the households and courts of the Caliph. Al-Rashīd followed in his family's footsteps and continued to encourage and provide for those scientists with generous funds and offers. Al-Rashīd did not stop there. He also established Dar al-Ḥikmah or 'House of Wisdom' which was a monumental step in building what was to become the first-known 'Research Institute' similar to the specialized research institutes of today (Abinda, 1999:185). Many important scholars worked at the Dar al-Ḥikmah, which also contained many books and scientific instruments from all scientific fields of study. It included also a specialized department for translation of all kinds of books from Greek, Indian, and Persian into Arabic. One of the most important books that was translated from Greek at the time of al-Rashīd was the *Almagest* of Ptolemy. This was considered by the Arabs to be one of the best books to have ever been written on astronomy and the main reference source for all their work on this subject (al-Bīrūnī, 1030. *al-Qānūn al-Mas'ūdī*).

From an astronomical point of view, this golden period in the reign of the Abbasid Dynasty produced many scientists and astronomers who made huge contributions to this science. These scientists produced new mathematical as well as astronomical theories. They also developed and constructed new astronomical instruments and observatories. They also wrote and corrected the works of the ancient Greek and Indian astronomers and produce new astronomical handbooks and tables by adopting new techniques in spherical trigonometric sciences, which they developed specially for this purpose. It is no secret that they inherited of the legacy of the Greek astronomical science but they also developed the science of astronomy to a new level that surpassed all those who came before them (Lyons, 2009).

The next Caliph who was also a great supporter of science was al-Ma'mūn, the son of al-Rashīd. He started his rule in A.D. 812. He also surrounded himself with many men of science and knowledge, especially in the sciences of astronomy. It is also known that he himself was a great enthusiast for this science and an amateur astronomer who was directly involved in many of the astronomical observations and discussions in this field. However al-Ma'mūn's rule was also considered a troubled time in regards to theological and philosophical struggle, which took place between the various Islamic religious schools of belief. Even though al-Ma'mūn was a patron of science, literature, theology and philosophy he was also known for his strict Islamic theological and philosophical ideas. He belonged to a school of thought called *al-Mu'tazilah*, which adhered to scientific logic and rationalism above everything. However some of the *al-Mu'tazilah's* beliefs were in opposition to the principles upheld by many Muslim Sunni theologians (Nagel, 1999: 118). He was also a supporter of the Shiite sects, even though the Abbasid and the majority of their subjects were predominantly of Sunni beliefs.

The second part of the Abbasid period started when the Caliph al-Mutawakel came to power in A.D. 847. This was the start of an age of decline for this Empire which lasted for up to four more centuries. During this period the Abbasid caliphs were under the control of the Turks then after that under the influence of the Buwayhid rulers, then later they fell to the Seljuk dominance in the region. Most of the caliphs were puppets in the hands of some ruler or sultan in some part of the Abbasid Empire. At this time another threat started to emerge in the east. The Mongol armies under the leadership of Jangis-Khan started to move westwards. The Mongol victories and occupation were usually accompanied by great massacres and atrocities. The armies of the Mongols destroyed many cities, such as Samarkand and Bukhara and killed thousands of people on their way towards the capital Baghdad. After Jangis-Khan died Hulaku took over power and continued with the same savage approach. In A.D. 1256 Hulaku surrounded Baghdad and burned the city killing most of its inhabitants in one of the biggest massacres in history. With the destruction of Baghdad all the libraries, places of education and learning, along with the greatest collection of books and works of science and literature, were destroyed. By destroying this city and killing the last Abbasid caliph al-Musta'sem the Abbasid Dynasty was finally at an end. As a result of the massacres by the Mongols, chaos and famine followed which temporary halted the progress of science in the region. However a man by the name of Naṣīr al-Dīn al-Ṭūsī was able to revive the science of astronomy. He was a fierce opponent to the Abbasid rule and a close friend of the Mongol ruler Hulaku. Al-Ṭūsī managed to save some books and works of science from the ruins of the destroyed city of Baghdad and he later convinced Hulaku who was addicted to astrology to build an observatory in Maragha, which was to become the center of astronomical research in the 13th century (Hoskin, 1997: 58).

By the end of the 14th century another wave of Mongol and Tatar occupation swept the area. This time it was under the leadership of Timor-Lank who took the city of Samarkand as his capital. Timor's armies also committed their own massacres while occupying the mid-eastern regions. They destroyed several cities and killed its people. Therefore no major scientists or astronomers emerged during this period with the exception of Ulugh Bēg who was one of the descendants of Timor-Lank in Samarkand (Abinda, 1999: 232).

2.1.6 Astronomy in Andalusia.

In A.D. 711 the Arabs invaded Andalusia (the Iberian Peninsula: Spain and Portugal) and created one of the strongest Empires Europe had known since the destruction of Rome by the Barbarian hordes. Spain prospered under the rule of the Umayyad, who established a Dynasty there after they had lost the caliphate in the east to the Abbasids. Islamic culture in Spain began to flourish in earnest during the reign of 'Abd al-Raḥmān the second of Cordoba. 'Abd al-Raḥmān actively recruited scholars by offering handsome inducements to live in what many from the lands in the East considered the 'provinces'. As a result, many scholars, poets, philosophers, historians and musicians migrated to Andalusia and established the basis of the intellectual tradition and educational system which made Spain so outstanding for the next 400 years (Hitti, 1949: 639). The court of Cordoba, like that of Baghdad, was open to Muslims, Jews and Christians alike. One prominent Bishop complained that young Christian men were devoting themselves to the study of Arabic, rather than to Latin (Hunke, 1964: 529). This is a reflection of the fact that Arabic was the international language of science in that era, just as English is today. Another result was that an infrastructure of libraries, mosques, hospitals and research institutions rapidly grew up and famous scholars in the East, hearing of these amenities, flocked to the West. They in turn attracted students of their own. One of the first mathematicians and astronomers of Andalusia was the 10th century scientist Maslamah al-Majrīṭī. He wrote a number of works on mathematics and astronomy, studied and elaborated the Arabic translation of Ptolemy's *Almagest* and enlarged and corrected the astronomical tables of al-Khawarizmī (Abinda, 1999: 238). Another leading mathematician and astronomer who flourished in Cordoba in the 11th century was al-Zarqālī, known in the Latin West as Arzachel. He combined theoretical knowledge with technical skill, and excelled at the construction of precision instruments for astronomical use. Al-Zarqālī contributed to the assembling of the famous Toledan Tables, which were a highly-accurate compilation of astronomical data at that time (Evans, 1998, 279). Many of his works were translated into both Spanish and Latin. Still another scientist was al-Bitrujī who was called Alpetragius by Latin scholars of the Middle Ages. He tried to develop a new theory of planetary movement while attempting to modify Ptolemy's model. Unfortunately al-Bitrujī's attempts were not very successful, however his works were studied by western philosophers and translated into Latin in the 13th century (Hoskin, 1991: 60). The influence of these scholars and their astronomical works was immense. Today many stars still bear the names given to them by these Arabic and Islamic astronomers, and many Arabic words- such as zenith, nadir and azimuth- are all still in use in our scientific vocabulary today.

2.2 Characteristics of Arabic and Islamic Astronomy

Ever since astronomy emerged in the Arabic and Islamic world it was divided into several fields. The first was Arabic folk astronomy which was related to the mansions of the Moon and the first appearance of each mansion and each lunar month. This science which was called *'Ilm al-Anwā'* was popular among many Arab and Islamic scholars, especially the *Fuqaha'* or the Islamic jurists and theologians. This Arabic folk astronomy will be discussed in more detail in the next section of this study. The second field of astronomy was the application of astronomy to aspects of religious practice as Islamic religious rituals brought into focus the importance of astronomy for Muslim communities. The third field of astronomy was mathematical astronomy which related to observation of the fixed stars and planets, mathematical calculations of planetary motions and use and construction of astronomical instruments. In his 'Introduction' in *The Book of the Fixed Stars* al-Ṣūfī divides astronomers into two types. The first "… took the road of the astronomers (*al-Munajjimīn*) utilizing picturesque celestial globes constructed by those who did not observe the stars with their own eyes. However they adopted the latitudes and longitudes which they found in books. They drew them on the globe without knowing which was false and which was true…the other party took the Arab method of the science of *al-Anwā'* and the Lunar mansions relying on what they found in books in this field. We have found in the science of *al-Anwā'* many books, the best and most complete in this art is the book by Abu Ḣanifa al-Dainaouri*."*

The word *'Ilm al-Nujūm* (science of the stars) was used by many Muslim scholars in the early Middle Ages to include both the science of astronomy and astrology. Astrology was referred to as *'Ilm Aḥkām al-Nujūm* (science of the decree of the stars) and also as *'Ilm al-Tanjīm* (science of divining by the stars). Astronomy was referred to as *'Ilm al-Falak* (science of the spheres) but more commonly as *'Ilm al-Hay'a* (science of the heavenly configurations). In the early classifications of the type of sciences the two disciplines were considered as branches of the same science (Shami, 1997: 45). It is only at a later date that astronomy became fully distinct from astrology. Astronomy was thereafter considered a mathematical science and astrology was shifted to the applied physical science (Saliba, 1994: 66). In the next few pages I will try to briefly examine the characteristics of these scientific fields in the development of Arabic and Islamic astronomy in the medieval era.

2.2.1 Religious Tradition in Arabic and Islamic Astronomy

The influence and contribution of Islam as a religion in the development of science in general and astronomy in particular has been a subject of fierce debate both by Muslim and non-Muslim writers alike. Some writers are of the opinion that religion put the brakes on the development of science (Huff, 1993: 235), whereas some believe that had it not been for religion, astronomy would not have progressed to what it is today (Chapman, 2002). However, there is no doubt that one of the reasons for the development of Arabic and Islamic science and astronomy is God's commandment to explore the laws of nature. The idea was to admire all creations for their complexity and to cherish the Creator for his ingenuity. Holding to these beliefs, Islamic contributions to science have covered many roots of thought, including mathematics, astronomy, medicine and philosophy (Iqbal, 2002).

> Read! In the name of your Lord who created. Created the human from something which clings. Read! And your Lord is Most Bountiful. He who taught (the use of) the Pen, Taught the human that which he knew not. (Qur'an:chapter 96,verse1-5)

> Verily (Behold) in the creation of the heavens and the earth, and the alternation of night and day - there are indeed signs for men of understanding; Men who remember Allah, standing, sitting, and lying down on their sides, and contemplate the creation of the heavens and the Earth (with the thought) "Our Lord! Not for nothing have You created (all) this. Glory to You! Give us salvation from the suffering of the Fire." (Qur'an: chapter 3, verse 190-191)

The above two verses are from the Qur'an, the Holy Book of Islam. The first verse is the first revelation which was given to the Prophet Muḥammad in the Qur'an. The first command in this verse is "Read". It is a command to read, write and learn all kinds of science and knowledge. The command in the next verse is to contemplate in the Heavens and the Earth. Of all the references in the Qur'an to scientific matters, the most numerous are to astronomy and cosmology, more specifically the creation and structure of the Universe, the Earth, the Sun and the Moon. A very interesting book was written on this subject by M. Bucaille (1987) titled *The Bible, The Qur'an, And Science* in which this area is described in detail. Bucaille identified more than forty verses in the Qur'an which provide information on astronomy and the concept of creation of the universe.

I do not intend here to present a theological study on Islamic religion for I can in no way give a detailed survey about such a complex structure and system of beliefs. However, in order to comprehend the importance of astronomical studies in the lives of Muslim scholars such as al-Ṣūfī we need a little background on Islamic theology. We have to understand the significance of the beliefs and rituals of this religion in order to understand the characteristics of Arabic and Islamic astronomy and the importance of astronomy to the Arabs and the Muslims. In no other religion has science especially the science of astronomy been a focal point of religious beliefs and practices. This is immediately reflected in almost all of the works of Arab and Islamic writers whereby they first dedicate their efforts to God and His Prophet at the beginning of their books. al-Ṣūfī also starts his book in this manner by saying the usual phrase of praise to God: "Thank *Allah* (God) the only one, the just. May the blessing and peace of *Allah* be on Muḥammad and his family."

The above verse and commands from the Qur'an cannot be ignored in the Islamic belief framework. Stemming from the first clause of the above system is the belief in the one God (Allah), and adherence to all God's wishes and commands. The first act of faith in Islam is the recognition, acceptance and observance of the obligatory religious rituals, which have been ordained by God. These are called the 'five pillars of Islam'. The first is *Islam*: It is the declaration of submission to the will of the creator and the recognition of the obligations towards Him. The second is *Ṣalāh*: These are the five obligatory daily prayer rituals. The third is *Ṣīam*: It is the fasting in the month of Ramadān. The fourth is *Zakāh*: It is an obligatory donation to the poor. And finally, the last is the *Haj:* which is the obligatory pilgrimage to the city of Makkah.

The five Islamic prayer times *Ṣalāh* are based on the astronomical position of the Sun in the sky. They were originally calculated (as was mentioned by the teachings of the Prophet Muḥammad) on the basis of the length of the shadow and the start and the end of the twilight during the day. Therefore the times of these prayers are not the same from one place to another, instead depending on the observer's latitude and longitude. The Muslims originally acquired the techniques to perform the mathematical calculations of finding the prayer times from the ancient Indian sciences. One of these early prayer timetables was written by al-Khawarizmī in Baghdad in the 9th century. In the 13th century the development of prayer timetables was institutionalized into an official organization called *al-Mūwaqqit* (Saliba, 1994: 79). These offices used to be part of the local mosques or religious schools and professional astronomers performed the observations and calculations of these prayer schedules using exact mathematical methods and instruments such as sundials, quadrants and astrolabes. From then on, Muslims excelled in the development of these astronomical timetables, especially in the major Islamic centers such as Baghdad, Damascus, Tunis, Cairo and later Istanbul. Very highly sophisticated tables were written based on special trigonometric functions that were developed specifically to solve the problems of spherical astronomy for any latitude (Kennedy, 1983).

In 638 A.D the second Caliph, ′Umar, first introduced the Islamic Calendar, which was purely based on lunar cycles. Omar consulted with his advisors on the starting date of the new Muslim chronology. It was finally agreed that the most appropriate reference point for the Islamic calendar was the *Hijrah*, which chronicles the migration of the Prophet Muḥammad from the city of Makkah to Madīnah in September A.D. 622. The Islamic calendar is purely a lunar calendar since intercalation was forbidden in the Qur'an; therefore the Muslim *Hijrī* year is shorter than the Gregorian year by about 11 days. The Islamic *Hijrī* calendar is usually abbreviated to A.H. (Anno Hegirae). The original Arabic names of the months in the Islamic (*Hijrī*) year were related to the seasons, however, by adopting a lunar calendar in which the months shift every year, important Muslim festivals, which always fall in the same *Hijrī* month, may occur in different seasons. For example, the *Haj* which is the yearly pilgrimage to the city of Makkah and *Ṣīam* or fasting in the month of Ramadān can take place in the summer as well as in the winter.

For religious reasons, the beginning of a *Hijrī* month is marked not by the start of a new Moon, but by the physical (i.e., an actual human) sighting of the crescent Moon at a given location. For example, the beginning of fasting in Ramadān is based on the local sighting of the new Moon. From an astronomical point of view, the calculation of the birth of the new Moon can be measured exactly. However, determining the visibility of the crescent is not as conclusive. Efforts to obtain an astronomical criterion for predicting the time of first lunar visibility go back to the Babylonian era, with significant improvements and work done later by Muslim and other scientists (King, 1993). These efforts have resulted in the development of a number of criteria for predicting first possible sighting of a lunar crescent. Early Muslim astronomers first implemented the visibility conditions, which they found in the ancient Indian astronomical sciences. They adopted the 48 minutes (12 equatorial degrees) condition of the setting time between the Sun and the Moon. If the difference in setting time was more than 48 minutes then the Moon could be visible. al-Khawarizmī used this method to compile astronomical tables. Later Muslim astronomers derived more complicated criteria for the crescent visibility (King, 2004).

The *Ka'bah* in the city of Makkah (in the country of Saudi Arabia today) is the most sacred sanctuary in Islam. Muslims are required to stand facing towards the *Ka'bah* during their *Ṣalāh* or prayer rituals five times a day. The *Ka'bah* in Islamic theology is considered the first shrine built for the worship of the one God, therefore it is considered a very holy place and the center of the world. This is evidenced in many works by Islamic geographers where they place the *Ka'bah* at the center of the inhabitable world (Nasr, 1976:37). Makkah is also the city where every Muslim is obliged to make pilgrimage at least once during their lifetime. The *Ka'bah*, also known by its other name the *Qiblah,* is a rectangular one-room building with the sides that are 22m (major axis) by 18 m (minor axis) in length. Its main axis is about 30 degrees counter-clockwise from the meridian. It is also believed that the walls of the *Ka'bah* are astronomically aligned with the major axis pointing towards the rising point of Canopus and the minor axis towards the summer sunrise and winter sunset (King, 1993). The direction of prayer for all Muslims, wherever they may be, has to be oriented towards the *Ka'bah*. Therefore mosques all over the world had to be built with their prayer walls facing the direction of the *Ka'bah*. Other important rituals in Islamic theology also involve the direction towards the sacred House. Therefore, finding the direction of the *Qiblah* is very important in performing many of the obligatory rituals ordained by Islam. Muslim geographers and astronomers starting from the 8th century took it upon themselves to find the best methods of *Qiblah* direction using the measurements of geographical coordinates and the mathematical science of geometry and trigonometry that they had inherited from the Greeks. In the ninth century many observations were conducted to find the coordinates of Makkah and Baghdad in order to find the most accurate *Qiblah* direction. Most of the famous astronomers and geographers at one time or another worked on and wrote treaties about this problem. One of these astronomers was the famous Muslim scientist al-Bīrūnī in the eleventh century and another was al-Khalīlī in the fourteenth century. al-Khalīlī wrote very accurate treatises giving *Qiblah* directions for each degree of latitude from 10 to 56 degrees and longitude from 1 to 60 degrees based upon exact formulae (Hoskin, 1997: 55).

2.2.2 Scientific Tradition in Arabic and Islamic Astronomy

When the Arabs came into contact with Greek science and philosophy there emerged a new breed of scholars in the Arab world called the *Falasifah* (Huff, 1993). The aim of these *Falasifah* (philosophers) was to live rationally in accordance with the laws that governed the Universe. Since they believed the God of the Greek philosophers to be identical with Allah, they studied the works of Greek philosophers such as Aristotle, Pythagoras and Plato. This Greek philosophy was referred to as the 'foreign sciences'. Arab and Islamic scientist became attracted to these foreign sciences as early as the 9th century. During the Abbasid rule an explosion of interest in the 'foreign science' had taken place as a result of the unprecedented translation movement. This phenomenon produced a large number of translations, especially of Greek scientific sources, which were mainly neglected in the Greek and Latin world (Iqbal, 2002). The translation of the *Almagest* and other works by Greek scientists laid the foundations of the scientific tradition of Arabic and Islamic astronomy. We should note here that the Greek scientific tradition considered philosophy to be an integral part of science. For example, to be a good astronomer you had to be a good philosopher (Saliba, 1994: 53). This concept was also reflected in the Arabic and Islamic scientific tradition.

The superiority of Aristotelian philosophy and the Ptolemaic system of astronomy were generally accepted by many Arabic and Islamic astronomers (Musa, 2001: 48). The geocentric model, whereby the Earth is a sphere which lies at the center of a spherical heaven which rotates about an axis that passes through the center of the Earth, was accepted as correct for over a thousand years by almost all Arabic and Islamic astronomers. The geometrical structure with the system of eight spheres was also regarded as representing the physical reality of the Universe. The culmination of Arabic and Islamic astronomy was in the development of the astronomical tradition of treatises called *Zīj* which were based on trigonometric and mathematical techniques. The term *Zīj* is probably originally Persian meaning a thread or cord (Kennedy, 1956:123), however it is commonly used to describe astronomical tables and handbooks. The earliest examples of these *Zīj (*Arabic plural is: *Azyāj)* were based on Persian and later on Indian sources. However, by the ninth and tenth centuries the *Zīj* followed the tradition of the *Almagest* and the Handy Tables of Ptolemy. Many aspects of mathematical astronomy as well as astrology were included in the texts and tables of these *Zījes*. A typical *Zīj* usually included:

-Information on chronology, including methods of converting dates from one calendar to another.

-Trigonometric functions, most commonly the sine function which replaced the Ptolemaic chord function.

-Information on spherical astronomy, which included solutions to problems of spherical astronomy such as transformation coordinates and time measurements.

-The equation of time, i.e. the difference between mean and apparent solar time.

-Planetary theory, which includes mean motion, planetary equations, latitudes, stations and retrograde motion.

-Parallax tables for determination the apparent position of the Moon.

-Tables of solar and lunar eclipse calculations.

-Lunar and planetary visibility, for predicting the date of first visibility of the lunar crescent and apparitions and disappearances of planets and stars.

-Mathematical geography, including lists of latitudes and longitudes of different known cities around the world.

-Tables of the fixed stars, including coordinates and magnitude estimates.

-Mathematical astrological tables.

Almost all astronomers produced a *Zīj* of some kind. The earliest of such treatises was *al- Zīj al-Mumtaḥen* which was produced in Baghdad under the patronage of al-Ma'mūn (Musa, 2001). Other important *Zījes* are *al-Zīj al-Sabi'* of al-Battānī, *al-Zīj al-Ḥakimī* of Ibn-Yunus, *al-Zīj al-Mas'ūdī* of al-Bīrūnī, *al-Zīj al-Ilkhanī* of al-Ṭūsī and *al-Zīj al-Ṣultanī* of Ulugh Bēg. In 1956 Kennedy published a list of 125 Arabic *Zījes;* however we now know of more than 200 *Zījes*, most of which are unfortunately not extant today.

Most of the entries in the astronomical tables or *Zījes* were expressed in standard medieval Arabic alphanumerical notation (Table 1). This continued to be the standard format for most astronomical tables, which were to be written for many centuries to follow. The table below shows these letters and their corresponding numeric values.

Table 1: Arabic Alphanumerical Notation and their Corresponding Numeric Values.

1 ا 2 ب	10 ي 20 ك	100 ق 200 ر
3 ج 4 د	30 ل 40 م	300 ش 400 ت
5 ه	50 ن	500 ث
6 و 7 ز	60 س 70 ع	600 خ 700 ذ
8 ح 9 ط	80 ف 90 ص	800 ض 900 ظ
		1000 غ

Arabic and Islamic astronomers referred to all the celestial bodies they saw in the sky by the term *Kawākib*. This term in our modern technical vocabulary is translated as 'Planets'. However Arabic and Islamic astronomers referred to the planets as *al-Kawākib al-Sayārah* i.e. wandering stars and to the stars as *al-Kawākib al-Thābitah* or the fixed stars. Both the term *Nujūm* (stars) and *Kawākib* were used to designate stars. al-Ṣūfī also uses the term *Kawākib* for constellations and he even named the 48 star constellations *as al-Kawākib al-Thamāniyah wa-al-Ārba'een*. As for the number of these fixed stars, Arab and Islamic astronomers identified about 1025 different stars. However, in this regards al-Ṣūfī says:

> “Many people believe that all the stars in the sky which are called fixed amount to 1025 stars. But this is an obvious mistake for those earlier scientist have observed this number of stars and they divided them into 6 divisions of brightness, and they made the brightest as the first magnitude and the one less as the second magnitude then the one below that as the third magnitude until they reached the sixth magnitude. They found the number of stars below the 6th magnitude to be more than they could count so they left them. This fact can be confirmed when we look at any of the constellations and its well-known stars; we find around those stars many stars which are not counted as part of the constellation”.

Therefore Arabic and Islamic astronomers were obviously well aware of the vast numbers of stars in the heavens but they kept cataloging only those stars as per the tradition of the *Almagest*. They also kept using the 6-magnitude system which was developed by Hipparchus. In his catalogue al-Ṣūfī lists 1025 stars which can be see by naked eye; 360 of these are in northern constellations, 346 are in the zodiac constellations, 316 are in the southern constellations and 3 additional stars of the Arabic asterism *al-Thafīra*. As for al-Bīrūnī, he lists 1029 stars which were between the 1st and the 6th magnitudes (Bīrūnī, 1030).

Arabic and Islamic astronomers built many astronomical observatories and constructed many astronomical instruments, such as sundials, astrolabes, quadrants, celestial globes and armillary spheres, which were used to conduct important observations at that time. One of the first observatories was al-Shamāsīyah Observatory which was built around A.D. 829 by the Caliph al-Ma’mūn east of Baghdad. It was attended by many astronomers including the sons of Mūsā Ibn Shākir, Sanad Ibn ‘Alī, al-‘Abbas al-Jawharī, Yehyā Ibn Abū Manṣūr as well as the famous astronomer al-Faragānī (Musa, 2001: 236). Al-Ma’mūn also built another observatory overlooking the city of Damascus whose main purpose was to observe the Sun and the Moon (Sayili, 1960). Al-Battānī was one of the greatest observational astronomers in the early period of Arabic and Islamic astronomical history. His observational program lasted for more than 30 years in the city of Raqqa in the north of Syria. It is believed that he spent his own money building and using instruments in his private observatory (Sayili, 1960: 98). Al-Ṣūfī also built his own observatory in the city of Shiraz. The details of al-Ṣūfī’s observatory and observation program will be discussed in another section of this study. Jabal al-Muqattam observatory was another important observatory built on a small mountain east of the city of Cairo. The astronomer ‘Alī Ibn Yunus supervised the construction and made his own observations at this observatory (Sayili, 1960). However the most important of the Arab and Islamic observatories was no doubt the observatory of Maragha. It was built during the rule of Hulagu in the period A.D. 1259-1266. Maragha Observatory was built on a large hill on the outskirts of the city of Maragha in the Iranian province of Azerbaijan. The observatory was officially funded by the state. Therefore it continued to function for a relatively long time after the death of its official backer Hulaku. This was the first example of such an act, where state backing continued even after the death of the prince or ruler. Naṣīr al-Dīn al-Ṭūsī supervised the construction of the observatory and was the first curator and astronomer at this observatory. Many other important astronomers also worked at this observatory, including Mu'ayyad al-Dīn al-'Urḍī and al-Fakher al-Maraghī. Al-Ṭūsī also added a library which contained thousands of books and references mainly on astronomy and other related sciences (Sayili, 1960: 194). Another important observatory was built by the prince-astronomer Ulugh Bēg in the city of Samarkand in A.D. 1420. It was considered the most famous of the observatories in the Islamic period after Maragha Observatory. This observatory was also known to have had very large and accurate astronomical instruments which Ulugh Bēg used to make very accurate observations of the positions of the stars (Knobel et al., 1917).

There are no references to organized or dedicated observatories in Morocco or in Andalusia like those in the East. However we know of several private efforts and observation programs that were performed in these areas. It is well known that starting from the 10th century the astronomer al-Majrīṭī was conducting his own astronomical observations (Shami, 1997: 198). al-Zarqālī was another of those astronomers; in the 11th century he published his famous *Ṭulaiṭula Zīj* which was translated into the Toledan tables and was widely used in the Latin west in the Middle Ages (Chabas et al., 2003). There is also a dubious reference to the fact that the Minarets of the Mosques of Seville and Cordova were used as observation decks; but history scholars are still debating the truth of the source of this reference (Evans, 1998).

2.2.4 Astrology in Arabic and Islamic Astronomy

Astrology as defined by the ninth century astrologer; Abū Ma'shar "…is the knowledge of the effect of the powers of the stars at a given time as well as the future time." Abū Ma'shar was supposed to have studied astrology until he became an atheist (Saliba, 1994: 68). The early history of astrology in Islam was closely connected with divination and there is no denying that some Arabs had much interest in astrology before and after the time of the prophet Muḥammad (Shami, 1994). The prophet said: "…whoever studies anything of the stars (*nujūm*) would have studied magic…", and he also said: "…that whoever consults an astrologer or seer asking to know the future then he is fighting God." The position of Islam is very clear in this regard but this did not deter some Muslim scientists and even rulers from practicing astrology in all the periods of Islamic rule. However, tension developed between

Islam as a religion and the foreign sciences, in as much as those sciences had any bearing on religious metaphysical questions. The most obvious grounds for conflicts between religion and these foreign sciences were in the field of astrology, for astrology as a discipline violates directly religious dogma in many matters such as the eternity of the world, the problem of free will and predestination (Nagel, 1999).

The negative Muslim attitude toward astrology took on a new form in the ninth century, by which time the translations of books were almost completed. Astrology was now seen as part of the a coherent but foreign body of Greek philosophy, primarily that part which dealt with the problems as the eternity of the world and free will. Early Islamic philosophers and scientists were strong supporters of this Greek tradition; for example al-Kindī was both a philosopher and an astrologer and was considered the spokesman for the foreign sciences (Saliba, 1994: 55). However, by the tenth and eleventh centuries the majority of philosophers and theologians had taken a clear negative stand against astrology. Several treatises by al-Farābī, Ibn Sīnā, al-Ghazālī, Ibn Rushd and many others were written which clearly rejected astrology (Shami, 1997: 305).

During the ninth and tenth centuries the religious attacks on astrology began to endanger the astronomers, whose profession had previously been conceived to be the same as that of the astrologer. For the sake of survival the astronomers of the eleventh and twelfth centuries began a process of redefinition of their field that entailed a rejection of the astrologer's craft and a greater emphasis on religious matters. Therefore the theologian's main argument centers on the idea that because of this confrontation, scientist and astronomers have been forced to become increasingly critical of foreign philosophical and astrological claims. As a result the office of the *Mūwaqqit* (timekeeper) was introduced into the bureaucracy of the mosque, the main center of the Islamic community, during the thirteenth century (Hoskin, 1997: 55). Most of the astronomical texts thereafter were written by such *Mūwaqqits*.

In this new environment Islamic astronomy was finally freed from political patronage, the *Mūwaqqits* could then in principle direct their attention to any astronomical problem and they no longer had to produce astrological texts and were able to be more responsive to the religious need of society. The astronomers, freed from the earlier respect for Greek science, with their discipline now accepted by society under the rubric of *Mīqāt*, found that they were able to formulate their astronomy on new philosophical principles. In that, they were probably under the influence of the Islamic philosophical tradition in which truth was supposed to be within a system that is consistent, harmonious and well articulated, with religion having an essential position in that system. The old Greek dictum of 'saving the phenomena' was not considered to be sufficient, for at times the phenomena were saved at too high a cost by contradicting the physical world and its mathematical representation. A few problems were identified in the major texts of Greek astronomy, such as the *Almagest* mainly the problem of the equant, which can make sense only as a mathematical point and not as a physical one. Therefore several Muslim astronomers tried to construct new planetary models. One of the earliest criticisms of the Ptolemaic system came from Ibn al-Haytham in the eleventh century and culminated in the work of Ibn al-Shātir who worked as a *Mūwaqqit* at the Umayyad mosque in Damascus and whose work showed many points of similarity between that of Copernicus who lived 150 years later (Kennedy et al., 1976).

2.2.3 The Decline of Arabic and Islamic Astronomy.

The decline of Muslim scientific and astronomical activity after a brilliant and successful start has attracted the attention of a number of Muslim writers and historians since the 17th century. One of the most preferred explanations for the decline was political causes such as the Crusades in the twelve-century and the destruction of libraries and men of knowledge by the Mogul invasion in the thirteen-century. Another explanation attributes the decline to economic factors such as the decline of the importance of the Silk Road, and the accompanying shift of economic power away from Islamic countries towards Europe as a result of the geographic discoveries that took place in the 15th and 16th centuries.

Huff (1993), a leading figure in the field of comparative historical study of science, states that Muslims had made a brilliant start in the Middle Ages, and quickly gained and established a clear superiority over China, India and Europe in almost all fields of science, but that their activity started to decline after the 12th century. He includes al-Kindī, al-Farābī, al-Rāzī (Alrazes), Ibn Sīnā (Avicenna), al-Bīrūnī, and Ibn Rushd among the Muslim philosophers who contributed to the development of early modern science. He states that the philosophers could not maintain influence in their societies after some of their ideas became the targets of the theologians' attacks, causing the former to lose the general support of the Muslim population. In this period, the theologians used the opinions of al-Ghazālī and Ibn Taymīya to attack philosophers. According to Huff, the Muslim philosophers did not have clearly defined and valid social roles in society. Those who studied philosophy and science mostly had additional duties to perform. For example, Ibn-Rushd was also a jurist, and Ibn al-Shātir was a *Mūwaqqit* preparing prayer timetables for the daily prayers of Muslims. Huff also notes the negative role of the doctrines developed by the theologians, which rendered systematic studies of nature a meaningless activity. Lastly, he states that in the Medieval

Muslim world, the legal and social institutions were not developed to support the activities of Muslim scientists.

Some of the general reasoning in the above studies of Huff might be justified. In his studies the main blame was directed towards the theologians-philosophers debate- mainly the attack of al-Ghazālī on the philosophers in the 12^{th} century. However, other recent studies conducted by Kennedy (1976) and Saliba (1994) regarding the problem of the decline of Islamic science – including Islamic astronomy – do not attribute the decline to the attacks of the theologians on the philosophers. Although these attacks incontestably took place, the decline could not be blamed on those theologians such as al-Ash'arī and al-Ghazālī. These recent studies in Islamic theoretical astronomy have shown that the most original astronomical works began to emerge almost a full century after the death of al-Ghazālī and culminated in the fourteenth century in the works of the Damascene *Mūwaqqit*, Ibn al-Shātir. The religious leaders' attacks were mainly leveled at the astrologers and not at the astronomers, and especially those astronomers who wanted to be astrologers, the implication being that atheism was a natural end of such studies. Their rejection centered on the astrologer's main claim, namely the ability to foretell the future in a world predetermined by the stars.

Therefore the decline of Islamic astronomical science could not be attributed to the theologians' attacks on the astronomers and philosophers because astronomical research continued to flourish long after the majority of these attacks were made. It is also arguable that were it not for those attacks, Islamic scientists would not have been freed from the confines of Greek philosophy. And by taking this argument further one must wonder how much the European scientific revival owes its origin to this theologian-philosopher debate in as much as it opened up new horizons and avenues for exploration. Some historians have claimed that scientific thought in Europe only developed from the ancient Greeks, in an attempt to blur the effects of Islam on the Renaissance, the Reformation and the subsequent scientific endeavor. This opinion has long lost its historical credibility, but there are still some who would like to defend it. A simple question should be sufficient to bring this claim into perspective: Why had the Europeans been unable to start the Renaissance and develop their scientific thinking much earlier, as they had access to the works of the ancient Greek philosophers and scientist in their hands for over a thousand years? Why did Europe wait another 1200 years for the Muslim development of scientific thought and philosophy? Ancient Greek thought by itself does not provide the concepts and motivation to initiate such a scientific enterprise. A much stronger motivational effort was required to start this endeavor. This was the motivation of belief initiated by Islam and the Qur'an in the minds of Arabs, Muslims and non-Muslims in the Middle Ages.

2.3 Old Arabic Astronomical Traditions

Before Islam the Arabs in the Northern Arabian Peninsula were generally nomadic people who wondered in the desert mostly during the night escaping from the high temperature. They had very few urban settlements because of the environmental challenges which were forced on them. These Arabs had a very basic knowledge of astronomy. They recognized and named some of the constellations or asterisms in the sky. This knowledge was believed by most scholars to be essential in helping them find their way in the desert. They also recognized the movements of the Sun, the Moon and the planets and they used them to develop their calendar which was a simple system based on a 12-month lunar visibility. They did not have any organized studies of the movement of the planets and position of the stars, and they did not use any astronomical instruments or mathematical tools. However, surprisingly early on they managed to recognize the difference between the length of the solar and lunar year and they developed a simple intercalation method whereby every couple of years they would readjust their calendar to compensate for this difference. Intercalation usually depended on the whims of the prevailing political ruler or social condition at the time. However, the Arabs who populated the southern peninsula (Yemen today) were relatively civilized compared to there northern cousins. These southern Arabs were well known for building important cities, castles and water dams (e.g. *Mā'reb* dam which collapsed around B.C. 120). They were also known for their craftsmanship, art and science. These people had a well-established social and political system that was well developed in the region. However, the bulk of the astronomical and astrological knowledge that we have comes from the northern Arabs who have been described as '*Arab al-Jāhilīyah'*, meaning the misguided and/or illiterate Arabs. This terminology was first used in the Qur'an and by the Prophet Muḥammad to describe the misguided ways of those people. This was the overall picture described by almost all historians when they came to depict the astronomical knowledge of the Arabs in the fourth century before Islam (Musa, 2001).

This is an oversimplification of the Arabic astronomical knowledge base especially when it comes to the Moon. Lunar astronomical science was an important tool used by the ancient Arabs just as it was used by many other ancient civilizations in the Middle East region (Boukahi, 2007). This astronomical information was merged with a form of astrological-meteorological experience that came to be known as the *Anwā'*. The *Anwā'* was used as a meteorological system for predicting the weather and identifying the beginning of the seasons in order to specify the dates of festivals, holidays, pilgrimage and the best times for traveling and commerce. With the coming of Islam the study of the lunar cycle became important, with references in the Qur'an such as: "He it is who made the Sun a source of light and the Moon shedding luster, and ordained for it stages (*Manāzil*), that you might learn the method of calculating the years and determining time.” (Qur’an: chapter 10, verse 6). Another verse describes the Moon and the mansions by saying: “We have appointed stages (*Manāzil*) for the Moon, till it wanes into the shape of an old dry branch of a palm tree.” (Qur’an: chapter 36, verse 39). Arabic and Islamic scholars took these references as meaning the lunar stations, and the *Anwā’* was expanded further within the ancient Arabic astronomical tradition.

The bulk of the astronomical and astrological knowledge about the lunar mansions and the *Anwā’* comes from the poetic and literary corpus that is found in Arabic literary and historical references. An example is provided by one of the old poets who said: “When the full Moon occults the Pleiades - the cold arrives at the beginning of winter”. Another example is: “When the full Moon occults the Pleiades the Sun is in Scorpio”. This astronomical phenomenon can only happen in November, when the winter cold begins (al-Bīrūnī). Another literary form was called the *Saja‘*. These were sayings or proverbs- some of which were in the *Anwā’* astronomical tradition. For example one old Arabic *Saja‘* says: “When *al-Buṭain* rises, debts are paid, finery appears, and the perfumer and the smith are pursued”. This saying describes the rising of the lunar mansion *al-Buṭain* in the month of May. This is when pasture dries up and the Arabs group together in encampments. Families and friends meet together again, they dress up, put on perfume and they fulfill old obligations (Ibn Qutayba).

2.3.1 Lunar Mansions and *Anwā’* in Arabic Astronomical Tradition

Many ancient civilizations, including the Indians, the Chinese and the Mayans, were well aware of the motion of the Moon in the heavens. Nearly every ancient culture worshiped the Moon at one time. Even today people still celebrate the Moon by holding feasts, dances, and rituals during some specific lunar phases (Verdet, 1987:67). Similarly, for the Arabs the Moon was one of the early clocks, and also one of several natural cues used by them to predict events such as winter, seasonal rains and the harvest (Varisco, 1997:24). They even worshiped the Moon as well as other astronomical bodies such as the Sun, Venus, Sirius, Saturn and Jupiter at one time (Nami, 1986:133). They also constructed idols that they worshiped in the name of these astronomical bodies such as: *Wad*, *al-Iat* and *al-‘Izzah*. It was said that the God idol *Hubal,* which was the main idol worshiped prior to the emergence of Islam, was a Moon God (Abinda, 1999:146).

The Moon is the Earth’s nearest neighbor in space. It completes one orbit against the stars (the sidereal month) every 27days, 7hours, 43 minutes. The Moon’s orbit does not coincide exactly with the apparent orbit of the Sun in the sky. They are tilted at an angle of approximately 5 degrees to one another. The Moon shifts position from one star to the next towards the east every night until it catches up to the first star from the east after approximately 28 days (Lunar month). Therefore when we divide the circular orbit, which is 360 degrees by 28 days, we find that the Moon shifts position towards the east by approximately 13 degrees every night. In order to systemize this lunar motion, the Arabs divided the apparent path of the Moon in the sky into 28 divisions. These 28 divisions are called '*Manāzil al-Qamar'* (Lunar Mansions). Another name for these lunar stations was '*Nujūm al-Ākhed'* which is translated as 'the stars that take', i.e. the Moon takes these positions every 24 hours. The Arabs developed this special lunar zodiac and divided the motion of the Moon during the lunar month into the 28 lunar stations that lay at an equidistance position so that on average the Moon spends one night in every position. They chose 28 asterisms (star groupings) for these positions not far from the ecliptic to be the landmarks for the location of the Moon in any day of the lunar month. Some of these stations do not exactly lie on the ecliptic because the orbit of the Moon does not correspond exactly to the path of the ecliptic. These mansions or stations are not all equal in size because the Arabs chose the most prominent stars or asterisms that can be clearly identified by the naked eye. In any one night we can see only 14 lunar stations out of the total 28 and the other 14 can not be seen. Therefore, every time one station disappears in the west another appears in the east. This newly-appearing station was called '*al-Raqīb'* translated to 'waiting'. Therefore, this *Raqīb* station can be considered as the 15th lunar stations in the station's order. This is similar to the 12 solar zodiac signs that we know today. Every time one signs disappears in the west another appears in the east. Therefore every one of these constellations would equal two and a third lunar stations. While the Moon shifts from one lunar station to another in one night the Sun on the other hand takes 13 days to move from one station to another. Therefore the Sun spends 13 days in any one station (or fairly close to it). The Sun completes its apparent motion moving between these 28 stations in one year. After one year the Sun returns back to the same position that it started from. Therefore these lunar mansions were also used as a solar calendar for all the seasons. This calendar system was used to predict the weather, fix the dates of important social and religious events and it gradually developed to become an integral part in the lives of the Arabs throughout the year.

The term *Anwā'* (singular *Naw'*, verb *Nā'*) according to most Arabic and Islamic scholars is the term used to describe the twenty-eight astronomical lunar mansions or stations. According to the definition of Dr Varisco (1997) "…the *Anwā'* were described as asterisms or star groupings along the Zodiacal belt, the annual risings and settings of which were used to mark times for rain, wind, heat and cold. Some Arabs went so far as to attribute these *Anwā'* with the power over rain." The exact meaning of the word *Anwā'* is still debated by linguistics. Some considered that the verb *Nā'* means to rise up with difficulty, implying that the star rises up in the morning with difficulty where it can barely be seen near the eastern horizon. The ancient Arabs believed that this term means to go down or to sway down and that it should only refer to the setting of a star and not to its rising. Therefore the verb *Nā'* is considered a homonym (Varisco, 1997). However, most Arab astrologers attributed the *Naw'*, to the rising mansion because they believed that the power or force of the mansion was when it was still young and rising while the setting mansion was a week mansion with no power (Abinda, 1999). This confusion or difference in explanation of rising and setting has been found in the classical poems and verses of the Arabs. However there was a clear consensus by most Arabic and Islamic scholars later in the 9th and 10th centuries, that *Nā'* referred to both the celestial setting of a star (or asterism) on the western horizon and at the same time the rising of the corresponding *Raqīb* star in the east (al-Bīrūnī). Al-Ṣūfī also confirms this meaning that *al-Anwā'* or *Naw'* "…is when a star sets in the west at dawn and when it's *Raqīb* (corresponding star) rises in the east from under the light (of the Sun)." Therefore, the *Naw'* is the first time of the year when a particular station rises from the east in the morning and when the Sun is to be found in that station and blocks it in the morning. At this same time another station sets in the western horizon. Therefore the *Naw'* is the term used to describe a specific time of year that corresponds to the first rising or setting of a particular station only once a year. For example the lunar mansion of *al-Thurayyā* (the Pleiades) rises in the east in the morning of 13 May and sets in the evening in the eastern horizon on 13 November (Abinda, 1999). The other known confusion in the *Anwā'* system was the duration of the rising or setting of the lunar mansions. Some made it to be 13 days which is the time of rising or setting of one star mansion to next while others only attributed it to the start of the first rising of the mansions. Others assigned different durations for every mansion (al-Thaqefī). When this period is over this mansion ceases to affect the weather. Therefore the duration or the power of the mansion sometimes differs from 13 days to a few days or sometimes only one day.

2.3.2 The Lunar Mansions in Arabic Tradition

The table 2 below summarizes the lunar mansions according to Arabic tradition. The names of the lunar mansions are based on al-Ṣūfī's description in his book. I have included the corresponding modern assigned names, HR number, the time of rising and setting, the weather condition and duration that were attributed for these mansions according to the *Anwā'* tradition.

Table 2: Summary of the Lunar Mansions According to Arabic Tradition.

Number	Name of	Present day	Rising	Setting	Assigned	Weather

	Lunar Mansion	designation (HR number)	date	date	Duration	condition
1	*al-Sharaṭān*	β γ Aries 553, 546	16 April	19 Oct	3	Spring equinox
2	*al-Buṭain*	ε δ π Aries 887, 951, 836	29 April	31 Oct	3	Little rain
3	*al-Thurayyā*	Pleiades 1145,1156,1178,1188, 1149,1165,1142	13 May	11 Nov	5-7	Rain
4	*al-dabarān*	α Taurus 1457	26 May	24 Nov	1-3	Heat, wind
5	*al-Haq'a*	λ φ1 φ2 Orion 1879, 1876, 1907	9 Jun	7 Dec	6	Heat, no rain
6	*al-Han'a*	γ ξ Gemini 2421, 2484	22 Jun	20 Dec	3	Heat
7	*al-dhirā'*	α β Geminorum 2891, 2990	4 Jul	2 Jan	3-5	Rain expectation
8	*al-Nathra*	ε γ δ Cancer 3429, 3449, 3461	17 Jul	15 Jan	7	Rain
9	*al-Ṭarf*	χ Cancer λ Leo 3262, 3773	1 Aug	28 Jan	6	Rain
10	*al-Jabha*	ζ γ η α Leo 4031, 4057, 3975, 3982	14 Aug	10 Feb	3	Rain
11	*al-Zubra*	δ θ Leo 4357, 4359	28 Aug	23 Feb	4	Rain
12	*al-Ṣarfa*	β Leo 4534	9 Sep	7 Mar	3	Temperate
13	*al-'Awwā'*	β η γ δ ε Virgo 4540, 4689, 4825, 4910, 4932	22 Sep	20 Mar	3	Good weather
14	*al-Simāk*	α Virgo 5056	5 Oct	3 Apr	4	Water gets cold
15	*al-Ghafr*	ι χ λ Virgo 5338, 5315, 5359	18 Oct	17 Apr	1-3	Cold, dry
16	*al-Zubānā*	α β Libra 5531, 5685	31 Oct	30 Apr	3	Rain
17	*al-Iklīl*	β δ π Scorpio 5984, 5953, 5944	13 Nov	13 May	4	Heavy rain
18	*al-Qalb*	α Scorpio 6134	30 Nov	26 May	3	Winter, cold
19	*al-Shawla*	λ ν Scorpio 6527, 6027	9 Dec	9 Jun	1-3	Winter, cold
20	*al-Na'āim*	σ φ τ ζ γ δ ε η Sagittarius 7121, 7039, 7234, 7194, 6746, 6859, 6879, 6832	22 Dec	23 Jun	6	Water freezes
21	*al-Balda*	Relatively empty star field surrounded by 6 stars in Sagittarius in the shape of a small	4 Jan	6 Jul	1-3	Water freezes

		arc 7341, 7304, 7264, 7217, 7150, 7145				
22	*Sa'd al-dhābiḥ*	α β Capricorn 7754, 7776	17 Jan	19 Jul	1	End of winter
23	*Sa'd al-Bula'*	μ ε Aquarius 7990, 7950	30 Jan	1 Aug	1	Temperate
24	*Sa'd al-Su'ūd*	46 Capricorn β ξ Aquarius 8311, 8232, 8264	12 Feb	14 Aug	3	Grain comes out
25	*Sa'd al-Akhbiya*	γ π ζ η Aquarius 8518, 8539, 8559, 8597	25 Feb	27 Aug	3	Good weather
26	*al-Fargh al-Muqaddam (al-Fargh al-Awwal)*	α β Pegasus 8781, 8775	9 Mar	10 Sep	3	Spring
27	*al-Fargh al-Mu'akhkhar (al-Fargh al-Thānī)*	ε φ Pegasus 8308, 9036	22 Mar	23 Sep	4	Spring
28	*Baṭn al-Ḥūt*	β Andromeda 337	4 Apr	6 Oct	3	Spring

2.3.3 The Literary Sources on Old Arabic Tradition

Arab and Islamic scholars wrote many books on the subject of the *Anwā'* and the lunar mansions. They collected most of the old sayings and poems which allude to this Arabic tradition and the knowledge of the stars and the *Anwā'*. Unfortunately many of these books have been lost, and few of the remaining extant works have been published. The rest are kept in libraries all over the world. However, the names and authors of many of these books have been mentioned in bibliographical and historical references such as the *al-Fahras* by al-Nadīm, *al-Āthār al-Bāqiyah* by al-Bīrūnī and *Wafīyāt al-A'yān* by Ibn Khalkān not to mention by our author al-Ṣūfī himself. The most important authors and their books on the *Anwā'* tradition were:

-Abū Yehyā Ibn Kunāsa (died A.D. 823). His book on *Anwā'* was mentioned by al-Ṣūfī as well as by al-Bīrūnī.

-Ibn al-Ā'rābī (died A.D. 845). His book on *Anwā'* was mentioned by al-Ṣūfī as well as by Ibn Khalkān.

-Ibn Qutayba al-Daīnawari (died A.D. 890). His book on *Anwā'* was mentioned by al-Nadīm as well as by Ibn-Khalkān. This is one of the most important books on this subject and which is still extant today.

-Abū Ḥanīfa al-Daīnawari (died A.D. 895). His book on *Anwā'* was mentioned by al-Ṣūfī, al-Nadīm as well as by al-Bīrūnī. This is another of the important books on the *Anwā'* as mentioned by al-Ṣūfī and it is also extant today.
-al-Zajjāj (died A.D. 928). His book on *Anwā'* was mentioned by al-Nadīm as well as by Ibn-Khalkān.
-Ibn Durāyd (died A.D. 933). His book on *Anwā'* was mentioned by al-Nadīm as well as by Ibn-Khalkān.

2.3.4 The Origin of the Arabic Lunar Mansion System

The origin of the Arabic lunar mansions system is still a debatable topic among scholars of ancient astronomy. Similar 28 lunar stations have been found in Indian, Chinese and other historical records since 3000 B.C. These lunar mansions have not been found as part of Babylonian or other Middle Eastern astronomy up to now, but this does not mean that such a system was not at one time a part of these astronomical sciences. The Babylonians might have used a similar lunar zodiac system which we still have not been able to locate up to now in our excavations of Babylonian archeological artifacts. Many historians believe that we still do not know very much about the origins of the ancient sciences in the Middle Eastern civilizations. Another questionable presumption is that the origin of the Arabic lunar mansions lies in the Indian zodiacal system (eg. See Varisco, 1997:7). However this view is not accepted by many contemporary astronomical historians, nor by some medieval Arab scholars such as al-Bīrūnī. A simple question which comes to mind is how the Arabs adopted such a zodiacal system from the Indians when they could have adopted the Babylonian or the Assyrians numerical and calendar systems which were much more accessible to them.

Another very common misconception in history is that many historians believe that the term 'Arabs' is used to describe the Arabian tribes who populated the Arabian Peninsula in the 7th century (Hitti, 1943:10). This over-simplification of the origins of the Arabs and the Arabic language echoes many deeply-rooted convictions in ancient historical studies. Historians and scholars of ancient civilizations have divided the people who have lived in the area into several ancient civilizations, mainly the Sumerians, Acadians, Babylonians, Assyrians, Hebrews, Caledonians, Canaanites, Egyptians and finally the Arabs. Many of these scholars wrongly believed that these civilizations should be considered separate cultures, because they have separate languages and are dissimilar in their social, cultural and religious beliefs (Hitti, 1949:36). Other historians go as far as to state that the inhabitants north of the Arabian Peninsula became Arabs following the Islamic conquests (Qubaisi, 1999:90) The main reason for this misconception is that some historians wrongly consider that the origin of the Arabic language goes back to the 'Adnannite' *('Andān*) and 'Qahtannite' (*Qahṭān*) tribes who spoke the Arabic language according to the dialect of the tribe of '*Quraīsh'*. This Arabic dialect was the one used in the Qur'an which was revealed to the prophet Muḥammad in A.D. 610, who himself was a member of the Quraīsh tribe. This classical Arabic dialect is now commonly referred to as *al-'Arabīya al-Fuṣḥá*. The Adnannite tribes were settlers in the northern areas of the Arabian Peninsula while the Qahtannite were in the southern parts (Yemen today). However, it is a known fact that other important Arabic tribes before the spread of Islam were also found in other areas such as '*al-Manāthira'* in Iraq and '*al-Ghassāsina'* in Syria. Therefore the origin of the Arabic tribes cannot be confined only to these tribes because the locality of the ancient Arabic language extended to a far greater geographical area in the Middle East and as far as Northern Africa. The dominance of the Arabic language in the *al-'Arabīya al-Fuṣḥá* dialect was no doubt due to the importance of the Qur'an, the spread of Islam and the dominance of the Arabian tribes who ruled the Islamic Empire after the death of the prophet Muḥammad.

Contemporary studies in Arabic linguistic and lexicographical analysis have shown that the similarities between the classical Arabic dialect of *al-'Arabīya al-Fuṣḥá* and the northern dialects of the ancient culture such as the Assyrians and the Babylonians (67% similar) far exceed the similarities between the classical and the ancient southern Arabic dialects of the Yemen region (only 49% similar) (Qubaisi, 1999:92). This implies that the cultural interaction between the Adnannite tribes and the northern ancient civilizations was more common then it was between the Adnannite and the southern Arabic tribes of the Arabian Peninsula. These studies reveal that the difference between these civilizations is mainly in the different dialects which they spoke, while the origin of all these languages is an old form of ancient 'Semitic' or 'Arabic' dialect, which is unknown today. These studies also show that the difference in the dialects between these civilizations and the variations in the method of writing does not mean that their origin is dissimilar. For example we know that Arabic was written by different methods such as Cuneiform and Indian letters even though the basic language was the same. This proposal goes against the convictions of historians of ancient civilizations like Leo Oppenheim (1964) who wrote: "…one should mention in this enumeration of Semites in Mesopotamia that contact with the Arabs of the desert, prior to their irruption into Mesopotamia and the adjacent regions in the seventh century A.D. was in the main, only slightly and incidental. "

Such studies based on Arabic linguistics have a profound impact on the study of the history of astronomy of ancient civilizations leading up to the beginning of early Arabic and Islamic astronomy. The cultural interaction between the ancient civilizations does not stop with the passage of time although it might have experienced some highs and lows depending on the economical, social and cultural circumstance of the era. Therefore, when we know that these ancient civilizations are but a continuity of one original root we can understand the significance of the interactions, the relationships and the way of life of the numerous civilizations of this region. When we consider the geographical distribution of the Arabic language and the Middle Eastern ancient civilizations that populated this region then we can piece together some of the evidence of the cultural exchange between these civilizations and the origin of the ancient Arabic system of lunar mansions and the *Anwā'* tradition. This topic is still being debated between historians of ancient civilizations and hopefully there will be new studies to answers such questions in the future.

2.4 The *Almagest* from Ptolemy to al-Ṣūfī

> "...the *al-Magestī* is considered the foundation of this science and its author is the main authority among its people. It is called in Greek 'The Syntaxis' meaning 'Compilation'…" (al-Bīrūnī, 1030; al-Qānūn al-Mas'ūdī)

At the beginning of his major astronomical treatise, al-Bīrūnī, who is considered one of the most important Arab scientists of the medieval era, attributed the roots of all the science of astronomy to this one book called the *Almagest*. In his brief comment al-Bīrūnī also commended the author of this book as being the chief among his peers. So what is the *Almagest* and who was the author of this most important book in the history of astronomy?

2.4.1 Ptolemy and the *Almagest*

"The *Almagest* is a complete exposition of mathematical astronomy as the Greeks understood the term…" as Toomer (1998: 1) very briefly explains in his English translation of the *Almagest*. It is a mathematical as well as an astronomical treatise, detailing the motions of the Stars, the Sun, the Moon and the five known planets at that time. It is the most important sources of information on ancient Greek astronomy. It also provides information on many Greek mathematicians and astronomers. It summarized in one book all the ideas of ancient Greek scholars, such as Aristotle, Pythagoras, Apollonius and Hipparchus. The *Almagest* also included a catalog of stars which might have been originally compiled by Hipparchus in 130 B.C. However, since Hipparchus' books are no longer extant, astronomers use the *Almagest* as the source for information on Hipparchus' works.

The *Almagest* was originally named '*μαθηματική σύνταξις*' i.e. '*Syntaxis Mathematica*' or '*The Mathematical Compilation*'. It might have also have been named by its long title as: *The 13 books of Mathematical Compilation of Claudius Ptolemy*. However it was also titled '*Hè Megalè Syntaxis*' or the '*The Great Compilation*'. The title of this book was translated by the Arabs to '*al-Kitāb al-Magestī* ' i.e. '*The Great Book*'. The Arabs added the Arabic article '*al*' to the word '*Magestī'* which was later corrupted by Medieval Latin writers to simply read the '*Almagest*' (Evans, 1998: 23).

Very little is known about the life of Ptolemy. However we know that his full name was 'Claudius Ptolemaeus'. He lived and worked all his life in Greco-Roman Egypt from A.D. 83 until his death in approximately A.D. 168. He was either of Greek origin or a Hellenized Roman-Egyptian working in the library of Alexandria which was the largest and most important center of learning at that time. Some medieval writers wrongly wrote that Ptolemy was related to the Greek Ptolemaic kings of Egypt and thus some painters drew Ptolemy with a crown on his head (Hoskin, 1997: 42). Al-Nadīm listed many treatises which were written by Ptolemy on a variety of subjects. However, three major works stand out which are as important to the study of the history of science as the *Almagest*. These major works are: the *Geography*, which is a thorough discussion on the geographic knowledge of the ancient world, with coordinates of the major places in terms of latitude and longitude; the *Tetrabiblos* (meaning the Four Books) which is an astrological treatise consisting of Four Books on astrology; and a major treatise on Optics (Berggren et al., 2000: 21). He also wrote many other treatises on astronomy which are still extant today to some degree such as: *The Handy Tables, The Planetary Hypotheses, The Analemma*, and *The Planisphaerium* (Evans, 1998).

All the observations which were quoted in the *Almagest* cover a period from A.D. 127 to A.D. 141. However the *Almagest* was written by Ptolemy before the *Geography*, the *Tetrabiblos*, *The handy tables* or *The Planetary Hypotheses* because it was quoted in these works. The *Almagest* was also dated to the reign of the Roman Emperor Antoninus (A.D. 138-161). Ptolemy adopted the beginning of the reign of Antoninus as the epoch of his star catalogue. The date of the *Almagest* has recently been more precisely established by N. T. Hamilton. Ptolemy set up a public inscription at Canopus which was a port town in Egypt in A.D. 147/148 as a dedication in the tenth year of Emperor Antoninus. Hamilton found that the version of Ptolemy's models set out in the Canopic inscription was earlier than the version in the *Almagest*. Therefore with all the above evidence the *Almagest* could not have been written before approximately 150 A.D. (Toomer, 1998: 1).

During the ninth century, when the Arabic translation movement began, the *Almagest* was one of the first books to be translated from Greek into Syriac and into Arabic. The Arabs called it the *Almagest* because they were so impressed with its content and its comprehensive information on the subject of astronomy. It was first translated at the time of the Abbasid Caliph, al-Rashīd. The first person to recognize the importance of this book was the first Vizier of al-Rashīd who was called Yehyā Ibn Barmak. He ordered several translators to translate it in to Arabic but their first attempt was not very successful. It was not to the liking of the Vizier. He then gave it to the two main caretakers of *Dar al-Ḥikmah* by the name of Sālem and Abū Hassan who had more knowledge of astronomy and they made a better job the next time round as al-Nadīm wrote in his *al-Fahras*. Under the patronage of another Abbasid Caliph, al-Ma'mūn, the son of al-Rashīd, another translation was made by al-Ḥajjāj in A.D. 827. Then in A.D. 880 Isḥaq Ibn Ḥunāyn also made another effort to translate the

Almagest which was later revised by Thābit Ibn Qurra in A.D. 901. Only the last two Arabic translations are still extant today. At present there are 14 manuscripts containing the Arabic translation of the *Almagest* which can be found in various libraries (Kunitzsch, 2004). Several decades later Gerard of Cremona probably used copies of the two Arabic versions when he made in Toledo in A.D. 1175 his translation of the *Almagest* into Latin (Kunitzsch, 1986). This Latin translation became a unique book, which influenced the study of astronomy in Europe until the 15th and 16th centuries, even after the original Greek copy of the *Almagest* was first printed in Venice in 1515 and later in Basel in 1538 (Knobel et al., 1915). In the last century the *Almagest* was again translated into French by Halma in 1813 and into German by Karl Manitius in 1912 which was later revised by O. Neugebauer in 1963. In the last few decades the *Almagest* has been re-studied by Kunitzsch in his 1974 German edition, *Der Almagest*. However, the most up to date English translation was done by Toomer in 1984 based on the Greek text established by Heiberg in 1898. This important translation by Toomer has been re-printed several times since then.

2.4.2 The History of the Star Catalogue

The world's first star catalogues were compiled by the Chinese in the 4th century B.C. (Kanas, 2007:18). However in the Western world the first stellar observations were made by Timocharis in the 3rd century B.C. Then Hipparchus compiled his own star catalogue more than a century later relying on Timocharis' data and on Babylonian observations (Evans, 1998). Hipparchus had discovered that the longitude of the stars had changed over time since Timocharis' observations. This led him to determine the first value of the precession of the equinoxes. In A.D. 150 Ptolemy published his star catalogue and he fixed the precession rate at 1 degree in 100 years which was later modified by Arab astronomers at the time of al-Ma'mūn to 1 degree in 66 years. Ptolemy's star catalogue is to be found in books VII and VIII of his *Almagest*. It contains a catalogue of 1022 stars which included the stars' descriptions, positions and magnitudes grouped into 48 constellations for the epoch of A.D. 137. This catalogue became the standard star catalogue used in the Western, Arab and Islamic worlds for over a thousand years.

In the 9th century al-Battānī compiled his star catalogue for the epoch A.D. 880. However his catalogue only contained 533 stars. He applied the most up to date precession rate at that time of 1 degree in 66 years thereby adding 11 degrees 10 min on Ptolemy's longitude values (Nallino, 1899). Several years later al-Ṣūfī compiled his famous '*Book of the Fixed Stars*'. It was a complete star catalogue based on Ptolemy's results in the *Almagest*. He also applied the precession rate of 1 degree in 66 years and he added 12 degree 42 min to

Ptolemy's longitude values. Decades later in A.D. 1030, al-Bīrūnī included a star catalogue in his famous book *al-Qānūn al-Mas'ūdī*. He again applied the same precession rate as al-Ṣūfī and added 13 degrees for his catalogue. However, in A.D. 1274 Naṣīr al-Dīn al-Ṭūsī modified the precession rate to 1 degree in 70 years. This more accurate constant was used in the last of the great Islamic compilations which was done by Ulugh Bēg. This star catalogue was based on Ptolemy's as well as on al-Ṣūfī's works.

Ever since the Arabs started to study and comprehend the *Almagest* they started to draw attention to some of the imperfections and irregularities in Ptolemaic astronomy. By the ninth century many Arabic texts started to emerge under the titles of '*Shukūk'* or 'doubts' concerning Ptolemy's system of deferents and epicycles. Among such early authors who draw attention to such inconsistencies was Thābit Ibn Qurra. Other such texts were compiled by Ibn al-Hytham in the Eastern Islamic states (Hoskin, 1999: 61). One of Thābit Ibn Qurra's main claims to fame was in raising the question of the variation of precession and by developing the theory of trepidation to solve this problem. The theory of trepidation was not adopted by eastern Arabic and Islamic astronomers like al-Battānī and al-Ṣūfī. However it was welcomed by many Arabic and Islamic astronomers in Andalusia where by it was incorporated into the influential Toledan Tables and included in Peter Apian *Cosmography* as late as A.D. 1524. Figure 1 shows Peter Apianus' Universe with the nested celestial spheres including the mechanisms of trepidation and precession.

2.4.3 Accusation Against Ptolemy Star Catalogue

Even though Ptolemy mentioned in the *Almagest* that he compiled his star catalogue based on his own observations, many scholars believed that his catalogue was mostly based on Hipparchus' catalogue made 266 years earlier. One of the first astronomers to point this out was al-Ṣūfī. However, he mentions that Ptolemy relied on Menelaus' observations 41 years before the epoch of the *Almagest* and Ptolemy simply added 25 minutes to Menelaus' longitudes. On average the star longitudes in Ptolemy's catalogue all have a systematic error of approximately one degree. This is mainly due to the fact that the Ptolemy's measurement of precession was low: 1 degree in 100 years instead of the modern value of 1 degree in 72 years. This error can be explained if Ptolemy used the coordinates of Hipparchus and added 2 degrees 40 minutes to account for precession from Hipparchus' date to Ptolemy's.

In A.D. 1598 Tycho Brahe commented that the star catalogue in the *Almagest* had been compiled through the conversion of Hipparchan stellar coordinates. Tycho calculated the accurate value of precession without the use of the stellar coordinates of the *Almagest* which could not have been made earlier by Arab astronomers. The Arabic and Islamic astronomers based their calculations on the *Almagest* and thus could not discover the systematic error in Ptolemy's longitude, even though they recognized earlier on that Ptolemy's value of precession was incorrect. However, some Arab and Islamic astronomers -among them al-Ṣūfī- held the view that Ptolemy's catalogue was merely a continuation of an earlier one. This argument was re-affirmed further by Halley in 1718, Lalande in 1757 and Laplace in 1797. In the 19th century this dispute intensified even further with J.B Delambre's investigation of the history of the *Almagest*. Delambre wrote that: "…one could explain everything in a less favorable, but all the simpler manner, by denying Ptolemy the observation of the stars and equinoxes, and by claiming that he assimilated everything from Hipparchus, using the minimal value of the latter for the precession motion." (Grasshoff, 1990: 29). In 1915 Knobel and Peters (1915) who made an important study on Ptolemy's catalogue finally concluded that Ptolemy only added 2 degrees 40 minutes to Hipparchus longitudes.

However not all scholars in this field held the above opinion. In 1901 Franz Boll established from newly-discovered manuscripts that Hipparchus' catalog only contained 850 stars. Then in 1917 Dreyer argued that the major source of error in Ptolemy's catalog was the defect in his solar theory. The final step in Ptolemy's rehabilitation was made by Heinrich Vogt in 1925. Vogt showed clearly in his important paper that by considering Hipparchus' Commentary on Aratus and Eudoxus and making the reasonable assumption that the data given there agreed with Hipparchus' star catalogue, then Ptolemy's star catalogue cannot have been produced from the positions of the stars as given by Hipparchus, except for a small number of stars where Ptolemy does appear to have taken the data from Hipparchus. After this paper the arguments started to shift in favor of Ptolemy and that the star catalog was actually compiled by him as he said in the *Almagest*.

Unfortunately this was not always to be the case. The strongest accusations of forgery made against Ptolemy came from R.R. Newton in his book '*The Crime of Claudius Ptolemy*' published 1977. Newton wrote that every observation claimed by Ptolemy in the *Almagest* was fabricated and he strongly accused Ptolemy of committing a scientific crime: "…a crime committed by a scientist against fellow scientists and scholars, a betrayal of the ethics and integrity of his profession that has forever deprived mankind of fundamental information about an important area of astronomy and history. Instead of abandoning the theories, he deliberately fabricated observations from the theories so that he could claim that the observations prove the validity of his theories."

Regardless of the evidence produced by Tyco Brahe, Delambre, Vogt, Neugebauer, Pedersen, Newton and many others it is certain that a substantial proportion of Ptolemy's star catalogue was grounded in Hipparchus' observations whose data were also taken from the Babylonians. Ptolemy's intention was to develop a comprehensive theory of celestial phenomena. He had no access to the methods of data evaluation which modern astronomers now have. Ptolemy was forced to choose the most reliable measurements from the available data he had access to. As a final comment, and in Ptolemy's defense, I would like to quote the Epigram which was written by Ptolemy himself in the *Almagest*: "I know that I am mortal and a creature of a day, but when I search out the massed wheeling circles of the stars, my feet no longer touch the Earth, but side by side with Zeus himself, I take my fill of ambrosia, the food of the Gods."

3 Al-ṢŪFĪ'S BIOGRAPHY

3.1 A Short Biography

Al-Ṣūfī and his '*Book of the Fixed Stars*' have a very important place in the history of Arabic observational astronomy. Surprisingly we know very little about al-Ṣūfī's life and career. However from Hājī Khalīfa's (A.D. 1601-1658) book *Kashef al-Thonūn wa Asamī al-Kutub wa al-Funūn* we know that al-Ṣūfī's full name was: 'Abd al-Raḥmān, Abū al-Ḥusaīn, Ibn ′Umar, Ibn Muḥammad, Ibn Sahl al-Rāzī known as Abū al-Ḥusaīn al-Ṣūfī.

Hājī Khalīfa also wrote that al-Ṣūfī was the '*Munajjem'* of Baghdad who served Aḍud al-Dawla and died in A.H. 374. In Arabic the word *Munajjem* both means an 'astrologer' or an 'astronomer'. However I prefer to use here the word 'astronomer' even though al-Ṣūfī was also an astrologer in his capacity as astronomer/astrologer royal to the Buwayhid *Amīr* (Prince) Aḍud al-Dawla as we will later see. Hājī Khalīfa also mentioned the city of Baghdad; however there is no other record that states that al-Ṣūfī was ever in Baghdad even though Baghdad was the political capital as well as the cultural center of that period.

The earliest biographical reference to al-Ṣūfī is found in *al-Fahras* (al-Nadīm, A.H. 377/A.D. 988). This is one of the most important historical and biographical books in Arabic history, which was written one year after al-Ṣūfī's death. In this book al-Nadīm wrote that al-Ṣūfī was "…one of the most important astronomers who served Aḍud al-Dawla." However there is no mention of al-Ṣūfī's birth or death or any other information. In another historical record, which is the famous chronology of Ibn al-Āthīr (A.H. 630) we find one sentence which mentions al-Ṣūfī: "…in this year (A.H. 376) Abū al-Ḥusaīn, ′Abd al-Raḥmān, Ibn ′Umar, al-Ṣūfī the astronomer to Aḍud al-Dawla died. His birth was in Rayy in the year A.H. 291." A few years later in another biographical book, which is *Akhbār al-'Ulamā' Bi Akhbār al-Ḥukamā'* by al-Qifṭī (A.H. 646/A.D. 1248) we find the most detailed record on al-Ṣūfī. In his book al-Qifṭī wrote:

> " 'Abd al-Raḥmān, Ibn 'Umar, Ibn Muḥammad, Ibn Sahl, al-Ṣūfī, Abū al-Ḥusaīn al-Rāzī, is the honored, the perfect, the most intelligent and the friend of the King Aḍud al-Dawla Fanakhasrū Shāhenshāh Ibn Būwayh. He is the author of the most honored books in the science of astronomy. He was originally from Nisā and is of a Persian descent. He was born in Rayy. When Aḍud al-Dawla was referring to knowledge and teachers he used to say: "…my teacher in al-Zīj is the honored Ibn al-A'lām and my teacher in the

fixed Stars, their location and movements is al-Ṣūfī". Among his works are: *Kitāb al-Kawākib al-Thābitah Muṣawaran, Kitāb al-Urjūza fi al-Kawākib al-Thābitah Muṣawaran and Kitāb al-Tathkira wa Maṭareh al-Shu'a'*. Hilāl Ibn al-Muḥsin said in his book: "in the year A.H. 376 in the 13th of Muḥarram on Tuesday Abū al-Ḥusaīn, Abd al-Raḥmān, Ibn 'Umar al-Ṣūfī the astronomer to Aḍud al-Dawla died. He was born in Rayy in the night of Saturday the 14th of Muḥarram in the year A.H. 291."

From the above record we can deduce several facts about al-Ṣūfī's life. The title '*al-Rāzī*' means that he is from the town of Rayy. The city of Rayy was a major city in northern Iran, estimated to be more than five thousand years old. However, the city gradually lost its importance after the Mongol invasion. It is south east of what is now called Tehran the capital of modern day Iran and it is now a suburb of this city. Rayy was home to many important individuals and scholars in the Arabic and Islamic Empires. Many of those had the title of *al-Rāzī*. One example of such a scholar was the famous medical doctor 'Rhazes'. Al-Ṣūfī's family was originally from Nisā or the city of Nisabour in western Khurasan Province in modern-day Iran. Al-Ṣūfī was also a Persian not an Arab even though he wrote all his works in Arabic, which was the preferred language of most scholars and writers at that time. According to al-Qifṭī al-Ṣūfī was born on Saturday the 14th of Muḥarram in the year A.H. 291. This date corresponds to a Tuesday on the 6th of December in the year A.D. 903. He died on the Tuesday the 13th of Muḥarram in the year A.H. 376 which corresponds to Tuesday the 25th of May A.D. 986. The location of his death is not known, but most probably it was Shiraz. He lived to be 83, which is a fairly good old age for his time. From the introductory chapter of this work we know that he spent most of his life between the provinces of Rayy and Fars and in the cities of Rayy, Isfahan and Shiraz in Iran. In his work al-Ṣūfī wrote that he made his observations from Shiraz where he also must have constructed his observatory. He also wrote that he visited Daīnawar, which was the home of the famous scholar and astronomer Abū Ḥanīfa al-Daīnawari. He also visited Isfahan to research a celestial globe constructed by another important astronomer of that period.

Figure 4 is a depiction of an astronomer using a Triquetrum or a parallectic ruler. This figure was mistakenly identified as al-Ṣūfī (Figure 4) however this drawing was taken from an image (Figure 5) of a manuscript found in Istanbul University. It was a depiction of astronomers working at the Istanbul Observatory, which was constructed by Taqī al-Dīn in A.D. 1575. There are no portraits of al-Ṣūfī. This is not a surprise because we seldom find any portraits of people during that time. This is because it is not allowed to draw a portrait of a person in Islamic religion.

Figure 4: A Depiction of an Astronomer Using a Triquetrum or a Parallectic Ruler.

Figure 5: Image found in a Manuscript in the Istanbul University.

Al-Ṣūfī lived and died during the period and rule of the Buwayhid (*Būwayh* or Buyid) dynasty during the 10th century. Al-Ṣūfī clearly mentioned that his book was dedicated to the Buwayhid ruler, Aḍud al-Dawla.

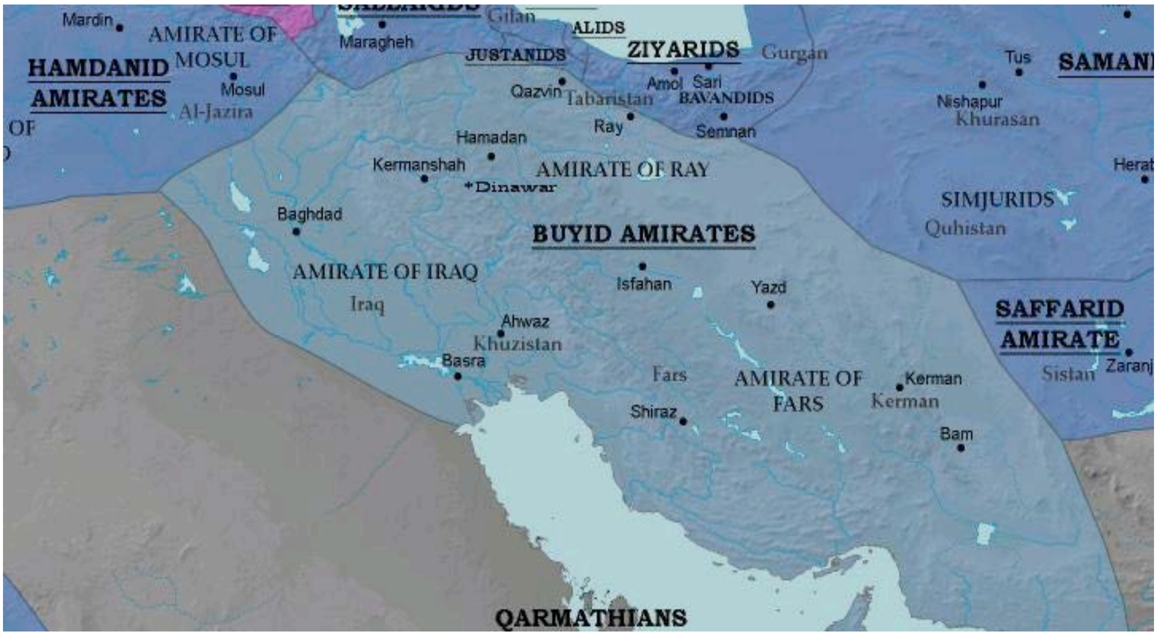


Figure 6: Map of the Buwayhid Emirates during the 10th century.

The Buwayhids Dynasty also known as Buyids was a Persian Shī'ah Dynasty that originated in Dylaman. The Dailam or Daylam or Deylamite were an Iranian people from northern Iran, from al-Borz Mountains and along the shore of the Caspian Sea. The Buwayhids founded a confederation that controlled most of modern-day Iran and Iraq in the 10th and 11th centuries. The three founders of the Buwayhids confederation were 'Ali Ibn Būwayh and his two younger brothers, Ḥasan and Aḥmad. They were originally soldiers in the service of the Samanids and Ziyarids. Over the next nine years the three brothers gained control of the main provinces of Iran and Iraq. The Buwayhids revived symbols and practices of Persia's Sassanid Dynasty. For example, 'Aḍud al-Dawla used the ancient Sassanid title *Shāhenshāh* which means (king of kings). The main Buwayhids *Amīrs* who ruled the area during the life of al-Ṣūfī were:

1- Būwayh Ibn Fanakhasrū
He was the father of 'Alī, Ḥasan and Aḥmad**.**

2- 'Imād al-Dawla (died in A.D. 949) ('Alī Ibn Būwayh)
He was the founder of the Buwayhid dynasty
He was ruler of Fars (capital Shiraz) from A.D. 934-949.

3- Rukn al-Dawla (died in A.D. 976) (Ḥasan Ibn Būwayh)

He was the first Buwayhid ruler of northern and central Iran.

4- Mu'iz al-Dawla (A.D. 945-967) (Aḥmad Ibn Būwayh)

He was the first of the Buwayhid rules of Iraq (Baghdad).

5- 'Iz al-Dawla (A.D. 967-978) (Bākhtyār Ibn Aḥmad)

He was the Buwayhid ruler of Iraq after his father Mu'iz al-Dawla

6- 'Aḍud al-Dawla (A.D. 936-983) (Fanakhasrū Ibn Ḥasan)

He was the ruler of the Buwayhid Dynasty in Fars/Iran as well as in Iraq.

7- Sharaf al-Dawla (A.D. 960-989) (Shirdīl Abū al-Fawāris Ibn Fanakhasrū)

He was ruler of Fars and Kerman (A.D. 983-989), as well as Iraq (A.D. 987-989).

He was the eldest son of 'Aḍud al-Dawla .

8- Ṣamṣām al-Dawla (A.D. 963-998) (Marzubān Ibn Fanakhasrū)

He was the Buwayhid ruler of Iraq (A.D. 983-987), as well as Fars and Kerman (A.D. 989-998). He was the second son of 'Aḍud al-Dawla.

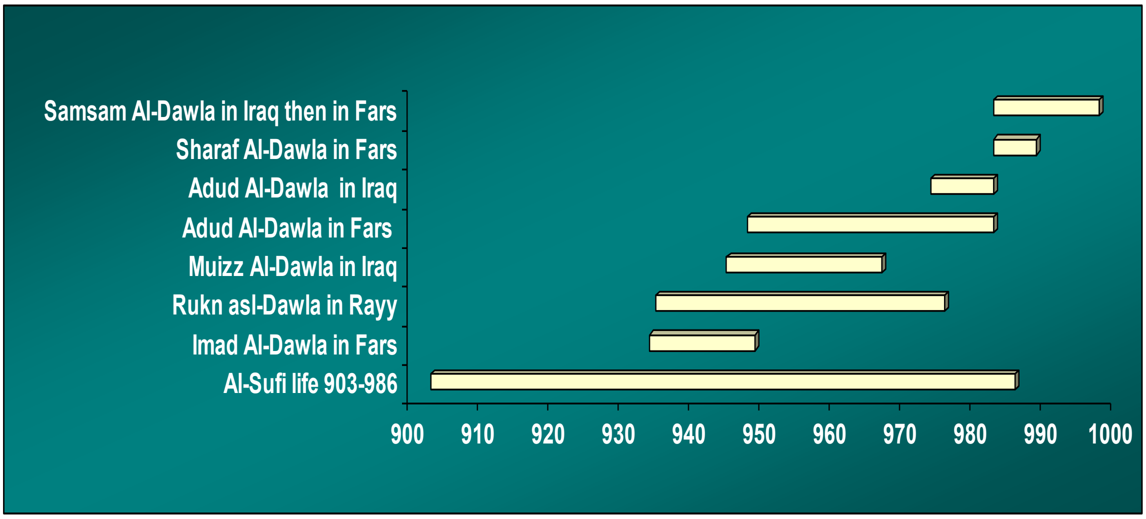


Figure 7: Time Line of al-Ṣūfī's Life and the Buwayhid Rulers.

From the time line of al-Ṣūfī's life and the relevant Buwayhid rulers in figure 7 we see that al-Ṣūfī lived throughout most of the rule of these major Buwayhid rulers. However, the most significant scientific contributions of al-Ṣūfī were made during the reign of 'Aḍud al-Dawla. The *Book of the Fixed Stars* was written in A.D. 964 and dedicated to ‘Aḍud al-Dawla who was the ruler of Fars during that time in the city of Shiraz. However al-Ṣūfī also dedicated other books to other members of the Buwayhid Dynasty.

Like most Daylamites at the time, the Buwayhids were originally Zāydi or ‘Fiver Shī’ah (one of the branches of the Shī’ah sect). After taking power in Iran and Iraq, they began to lean closer to the ‘Twelver Shī’ah sect, due to political considerations. ‘Aḍud al-Dawla, as other Buwayhids rulers before him, rarely attempted to enforce a particular religious view upon his subjects, who were predominantly Sunnī. This might have been reflected on al-Ṣūfī who was most probably a Sunnī Muslim. This can be deducted from al-Ṣūfī’s name itself. We know that his father’s name is ‘Umar. This definitely signifies that he must have been originally a Sunnī Muslim rather than a Shī’ah because Shī’ahs were in conflict with the third Caliph ‘Umar; therefore the name ‘Umar was seldom used by the Shī’ah.

The name al-Ṣūfī is a very important indicator of the personal status of al-Ṣūfī during this period. Generally the ‘al-Ṣūfī’ title signifies that a person who holds this title is part of an Islamic religious ‘*Ṣūfī’* order or maybe he is a descendent of a family which was part of a ‘*Ṣūfī’* order. The *Ṣūfī* movement is an Islamic philosophical and religious discipline whose objectives are the reparation of the heart and dedicating oneself entirely to worshiping God through self-denial and living with minimal material comforts. This movement has spanned several continents and cultures throughout the Islamic world. Its origin at the beginning was Arabic. However it quickly spread to Persian, Turkish and other cultures in the Islamic empire. Sufism was divided into many Sunnī as well as Shī’ah orders who trace their origins either to ‘Alī or the other original three Caliphs after the prophet Muḥammad. The word *Ṣūfī* either refers to the simple cloaks which were made of ‘*Ṣouf’* or ‘Wool’ which these early Muslim ascetics wore, or possibly to the word ‘*Ṣafa’* which means ‘purity’ of the heart. During the 10th century some of the *Ṣūfī* orders evolved to include some Neo-Platonic philosophical ideas together with Gnosis beliefs. This movement also incorporated *Ṣūfī* beliefs with the sciences of alchemy, numerology and astrology (Aassi, 1994). Two of the most important *Ṣūfī* leaders of this movement were Thū al-Nūn al-Masrī (died A.D. 859) and Jáber Ibn Ḥayyān (died A.D. 815). Jáber Ibn Ḥayyān, who was later called ‘Geber’ in the west, was also given the title of ‘al-Ṣūfī’. Since al-Ṣūfī was given this religious honorary title then we assume that he must have been influenced by such *Ṣūfī* movements and by some of the leaders of these orders in his area. The most probable person might have been Yūsuf Ibn al- Ḥusaīn al-Rāzī (died A.D. 916) who was a student of Thū al-Nūn al-Masrī. Yūsuf Ibn al-Ḥusaīn al-Rāzī resided in Rayy which was the birthplace of al-Ṣūfī and where we assume al-

Ṣūfī spent the early part of his life. Mansūr al-Ḥallāj was another important Persian *Ṣūfī* poet who lived during the early years of al-Ṣūfī's life. He was executed in A.D. 922 in Baghdad for heresy by the Abbasid Caliph al-Muqtadir for his disputed self-proclaimed divinity after a lengthy investigation and trial.

3.2 Al-Ṣūfī's Contemporaries and other More Ancient Individuals

In his book al-Ṣūfī mentioned several important individuals and scholars. He also mentioned some of their works which he commented upon and sometimes criticized. The main person whom al-Ṣūfī mentions was Ptolemy. Al-Ṣūfī refers to Ptolemy by name 119 times in his '*Book of the stars*'. I have already written about Ptolemy in an earlier section of this study. The other Greek astronomers which were mentioned in al-Ṣūfī's book were Timocharis and Menelaus. I have also mentioned these two astronomers in the same section on Ptolemy. Al-Ṣūfī also mentioned some other important individuals in his book and these were:

3.2.1 'Aḍud al-Dawla:

'Aḍud al-Dawla was the son of Rukn al-Dawla. His first name was Fanakhasrū Ibn Ḥasan. He was given the title of 'Aḍud al-Dawla by the Abbasid caliph in A.D. 948. He was made *Amīr* of the Provence of Fars after the death of his childless uncle 'Imād al-Dawla. In A.D. 974 'Aḍud al-Dawla was sent by his father to Iraq to crush a rebellion by his cousin 'Iz al-Dawla. After defeating his cousin's forces, he claimed the Emīrate of Iraq for himself, thus angering his father for some time until the relationship eventually went back to normal. After his father's death he became the senior *Amīr* of the Buwayhids, controlling Fars, Iraq and most of the other provinces in Iran. 'Aḍud al-Dawla was credited with sponsoring and patronizing many scientific projects during his time. He ordered an observatory to be built in Isfahan under the guidance of al-Ṣūfī. 'Aḍud al-Dawla considered al-Ṣūfī to be his teacher in the position of the fixed stars, their location and movements as he said. 'Aḍud al-Dawla was a great patron of astronomy and himself an accomplished scholar and astronomer. In his book al-Ṣūfī clearly mentions that '*The Book of the Fixed Stars*' was dedicated to 'Aḍud al-Dawla. He also founded the *Bimāristān-i Aḍudi* (hospital) in Rayy, which is where the great medical doctor al-Rāzī (Rhazes) worked. 'Aḍud al-Dawla died in A.D. 983 and is buried in the city of Najaf in Iraq. He is widely regarded as the greatest ruler of the Buwayhid dynasty.

3.2.2 Al-Battānī

Al-Battānī, known in the West as al-Bategnius, was a famous astronomer and mathematician. He has been recognized as the greatest astronomer of his time and one of the greatest of the Middle Ages. His full name was Abū 'Abdullah Muḥammad Ibn Jāber Ibn Sinān al- Battānī. He was born in A.D. 858 near the city of Battān in the state of Harrān in present day Syria and died in A.D. 929 in the city of Samarra in Iraq. He was originally of the *Sabi'* sect but he converted to Islam in his life time. His father was the famous scientist Jāber Ibn Sinān. Al-Battānī wrote many books on astronomy and trigonometry. His most famous book was an astronomical treatise with tables, which was translated into Latin in the twelfth century and is known by the title '*De Scienta Stellarum - De Numeris Stellarum et motibus.*' His treatise on astronomy was extremely influential in Europe until the Renaissance and was translated into several languages. Al-Ṣūfī mentioned al-Battānī many times in the introductory chapter to his book. However, al-Ṣūfī also condemned al-Battānī as an observer by stating that his catalog was but a copy of Ptolemy's *Almagest* with the correction for precession.

3.2.3 Abū Ḥanīfa al-Daīnawari

Abū Ḥanīfa al-Daīnawari was a famous Persian scholar from the city of Daīnawar which is a city between Hamadan and Kermanshah in present day Iran. His full name was Abū Ḥanīfa Aḥmad Ibn Dāwoud al-Daīnawari. He was born in A.D. 828 and died in A.D. 896 at Daīnawar. He wrote many treatises on many subjects such as astronomy, agriculture, botany, geography and history. His most renowned contribution is his Book of Plants (*Kitāb al-Nabāt*) for which he is considered to be the founder of Arabic botany. His work on Arabic Astronomical Tradition, the Book on al-Anwā' (*Kitab al-Anwā'*) is also a very well known work which al-Ṣūfī considered to be the best-written book on this subject which shows that he was as well versed as others in the history of Arabic tradition, Arabic poetry and prose. However al-Ṣūfī criticized al-Daīnawari for his mediocre knowledge of the stars and their movements. He also mentioned that al-Daīnawari did not actually observe the stars but he only confirmed what was written on this subject before him. Al-Ṣūfī reached this conclusion after he read al-Daīnawari's book even though he visited the home of al-Daīnawari himself and saw where he used to make his observations.

3.2.4 Ibn al-A'arabī

Ibn al-Ā'rabī was a famous Arab linguistic and scholar. His full name was Abū 'Abdullah Muḥammad Ibn Ziyād al-Ā'rabī al-Kūfī. He was born in A.H. 150/A.D. 767 and died in A.H. 231/A.D. 845 in the city of Sāmurra' at an old age of eighty-one according to al-Nadīm. Al-Nadīm also wrote in his book that al-Ā'rabī lectures were usually attended by more than one hundred people and he used to give his talks without a book in his hands. This is an indication of the extent of his knowledge in his field of Arabic linguistics and that he also knew a lot about Arabic Poetry. Al-Ā'rabī has also written a book on al-Anwā'. Al-Ṣūfī mentioned that al- Daīnawari quoted many things from al-Ā'rabī in his own book on al-Anwā'. However al-Ṣūfī also criticized both al-Daīnawari and al-Ā'rabī for their lack of knowledge in this field.

3.2.5 Ibn Rawāha

According to al-Ṣūfī Ibn Rawāha was a known astronomer from the city of Isfahan. al-Ṣūfī describes his first encounter with Ibn Rawāha in the year A.H. 337/A.D. 948 when he was in Isfahan with his teacher Abū al-Faḍel. Al-Ṣūfī mentioned that he saw Ibn Rawāha using an astrolabe which was in his possession. However al-Ṣūfī criticized Ibn Rawāha because he did not know the difference between the various stars on the astrolabe. Twelve years later in the year A.H. 349/ A.D. 960. Al-Ṣūfī again met Ibn Rawāha, this time in the presence of ʻAḍud al-Dawla, and he again criticized him for the his lack of knowledge of the stars in the sky. This last encounter encouraged al-Ṣūfī to start writing his ʻ*Book of the Fixed Stars*', which was to be finished 4 years later in A.D. 964. Ibn Rawāha was not mentioned in any of the main biographical references but only by al-Ṣūfī in the introductory chapter to his book.

3.2.6 Ibn Kunāsa

Ibn Kunāsa was another famous scholar in the field of Arabic astronomical tradition. His full name was Abū Muḥammad ʻAbdullah Ibn Yehyā, and he was known by the name of ʻIbn Kunāsa'. According to al-Nadīm, Ibn Kunāsa was born on A.H. 123/A.D. 740 and died in A.H. 207/A.D. 822 in the city of Kūfa. He was originally from the city of Kūfa but he lived and studied in Baghdad. Al-Nadīm wrote that Ibn Kunāsa was also a writer and a poet who wrote a book on *al-Anwā'* and *Kitāb Ma'ni al-She'er* (The Meaning of Poetry) and another book on the Qur'an and poetry, among many others. However al-Ṣūfī also criticized Ibn Kunāsa along with al-Ā'rabī for writing about the stars which indicated their lack of knowledge in this area. Al-Ṣūfī also mentioned that al-Daīnawari referred to wrong information from the book of Ibn Kunāsa regarding the path of the Moon and the degree the Moon travels from the ecliptic.

3.2.7 Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn

In the history of Arabic astronomy there were two important individuals who went by the name of Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn. Both of these lived in the same region during the period of al-Ṣūfī. The first was Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn Ibn Ḥamīd known by the name of Ibn al-Ādamī. According to Ibn al-Qifṭī he (Ibn al-Ādamī) died in A.H. 308/A.D. 920; however, there is no other historical reference which mentioned when he was born or where he died. Ibn al-Qifṭī also wrote: "He (Ibn al-Ādamī) was an important scholar and a well known researcher in the field of astronomy. He started to compose his large Zīj; however, he died before he finished it. It was completed by his student al-Qāsem Ibn Muḥammad Ibn Hāshem al-Madāinī, known as al-ʻAlawī, and he called it: *Nuthum Kitāb* *al-'Ukad.* This book was a complete reference, which contained the basic science of astronomy and the calculation of the movement of the stars according to the (Indian) concept of the Sind-Hind. This book also contained new ideas on the orbits of the stars (theory of trepidation), which no one else mentioned before him. Before this book was written the idea regarding this moment of the stars was not understood until this book was written which explained this strange movements". The other reference identifies Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn Ibn al-'Amīd (A.D. 930-970) (Kunitzsch, 1970). Ibn al-'Amīd was the vizier of Rukn al-Dawla in Rayy and later he served his son 'Aḍud al-Dawla in Iraq. He is also known for his interest in astronomy and according to al-Bīrūnī (*al-Qānūn al-Mas'ūdī* and *Taḥdīd al-Āmākin*) he patronized the building of an observatory in Rayy in A.D. 950. However it is not clear whether he also contributed to the actual astronomical observations at this observatory or not. Al-Ṣūfī mentioned Abū al-Faḍel twice in his introductory chapter. He referred to him as *al-Raees* or the 'chief' as well as the most honored *Ūstāz* or master or teacher. Al-Ṣūfī first mentioned that he visited the city of Daīnawar with his teacher Abu al-Faḍel in the year A.H. 335/ A.D. 946. Then, two years later, in the year A.H. 337/A.D. 948 he visited Esfahan with his teacher again. Either the extract from Ibn al-Qifṭī was wrong since al-Ṣūfī mentioned that he was with Abū al-Faḍel in the years A.H. 335 and A.H. 337 or Abū al-Faḍel is Muḥammad Ibn al-Ḥusaīn Ibn al-'Amīd as Kunitzsch mentioned (Kunitzsch, 1970).

3.2.8 'Alī Ibn 'Isā al-Harrānī

There is no mention in any of the historical books or any of the Arabic biographical references about 'Alī Ibn 'Isā al-Harrānī except the extract from al-Ṣūfī's book. Al-Ṣūfī considers al-Harrānī on the same level as al-Battānī and the composers of *Zīj al-Mumtaḥen*. However al-Harrānī did not escape also from al-Ṣūfī's criticism. Al-Ṣūfī mentioned that he saw a large celestial sphere that was constructed by al-Harrānī who must have been an important astronomer or an instrument maker. However al-Ṣūfī identified several mistakes on this sphere: the positions or names of some of the important stars had been wrongly drawn.

3.2.9 Asḥab al-Mumtaḥen (the composers of *al-Mumtaḥen Zīj*)

The *Mumtaḥen Zīj* was one of the first astronomical works to be produced in the Abbasid period at the time of the Abbasid caliph al-Ma'mūn. It was composed by a group of astronomers under the leadership of the able astronomer Yehyā Ibn Abi Mansūr (Musa, Ali, 2001:295). They especially revised the *Almagest* precession rate from 1 degree in 100 years to 1 degree in 66 years.

3.2.10 Al-Hajjāj Ibn Yūsuf Ibn Maṭar

al-Hajjāj Ibn Yūsuf Ibn Maṭar was an Arab mathematician who was born in A.D. 786 and died in Baghdad in A.D. 833. He was the first to translate Euclid's Elements from Greek to Arabic. He also translated Ptolemy's *Almagest* at the time of the Abbasid Caliph al- Ma'mūn. The Arabic copy of al-Hajjāj's translation of the *Almagest* is still extant today. Al-Ṣūfī relied on this translation in his work according to his own admission in the introductory chapter of his book. However, he also mentions that the copy of al-Hajjāj's translation which he had, contained a mistake which was probably due to an error made by the copyist. The Bibliotheque Nationale de Tunisie contains a manuscript of al-Hajjāj's *Almagest* which was copied in A.H. 478 / A.D. 1085 from a copy of Abū al-Ḥusaīn al-Ṣūfī (Shaboh, 1989).

3.2.11 'Utāred Ibn Muḥammad

" 'Utāred Ibn Muḥammad al-Ḥāseb was a famous astronomer of his time…" is what was written about him by Ibn al-Qifṭī. Al-Nadīm also mentioned 'Utāred in his book. He wrote that Utāred was a mathematical astronomer and an honored scholar who wrote several books which are: *Kitāb al-Jafer al-Hindi, Kitāb al-'Amal Bi al-Īsterlāb, Kitāb al-'Amal Bi thāt al-Ḥalak, Kitāb Tarkīb al-Āflāk, Kitāb al-Marāyā al-Muḥarraka*. However, neither of the above biographers mentioned his birth or his death. Al-Ṣūfī criticised 'Utāred and al-Battānī for writing about the stars relying on the books they found without actually making any observations themselves.

3.2.12 Nabonassar (Nabūkhat Nassar)

Nabonassar was the ruler of Babylon in B.C. 747. He was an army commander who won control of Assyria and Babylon and ruled as a vassal king in the Assyria Empire until his death in B.C. 734. Ptolemy made a list of ancient kings called the 'Canon of Kings' which was used in chronological calculation to help date astronomical phenomena. Ptolemy made the start of his chronological calculation from the first year of the reign of Nabonassar which corresponds to 26 February B.C. 747 of the Julian calendar. This date was used by Ptolemy because it was the earliest date that an astronomical observation was available to him. These astronomical observations were to be found in a collection of clay tablets called the Babylonian Chronicles which record events beginning in the reign of Nabonassar. The dates in the Canon are considered by most historians to be fairly accurate from B.C. 747 onward.

3.2.13 Alexander the Great (Thū al-Qarnaīn)

Alexander the Great was the King of Macedonia in ancient Greece. He was born in Greece in B.C. 356 and died in Babylon, in present day Iraq, in B.C. 323. His successful military campaigns led to the conquest of most of the known world which were mainly in Asia Minor, Egypt, Arabia, the Middle East and reached as far as the India sub-continent. His conquests started the era of Greek cultural influence over those conquered lands especially in Egypt and the Middle East. He is identified in Arabic traditions as *Thū al-Qarnaīn* which means ‘The Two-Horned One’. This is possibly because of a horn-headed figure that appeared on coins minted during his rule and the rule of his successors in ancient Middle East. The reference to *Thū al-Qarnaīn* also appears in the Qur’an which some believe refers to Alexander the Great. However, many Muslim scholars disagree that Alexander was *Thū al-Qarnaīn*. The reason for this is that *Thū al-Qarnaīn* is described in the Qur’an as a monotheist believer who worshipped Allah (the one and only God), whereas Alexander was a polytheist.

3.3 All of the Main Known Works by al-Ṣūfī

Al-Ṣūfī was basically renowned as an observational astronomer and an instrument maker rather than a theoretician or mathematical astronomer as ‘Aḍud al-Dawla mentioned. Al-Ṣūfī must have written many books or treatises on observation and astronomical instruments, however very few of his works have reached us. The ‘*Book of the Fixed Stars*’ was the main work which al-Ṣūfī was famous for as we can see in our present study. However we also know of two extant works on observational instruments. The first is a treatise on the astrolabe and the other is a work on the celestial globe. In his biographical book *Akhbār al-‘Ulamā’ Bi Akhbār al-Ḥukamā’* al-Qifṭī lists only three works by al-Ṣūfī. However, from other historical records we know that al-Ṣūfī also wrote a Zīj, which is an astronomical handbook. Unfortunately this no longer exists. Al-Ṣūfī was also the astrologer to the Buwayhid rulers; therefore he must have written several treatises on this subject, but we know very little about these. In his capacity as the astrologer royal to ‘Aḍud al-Dawla he cast the horoscope for this ruler. This horoscope is to be found in the book *Dustūr al-Munajjimīn* which is a collection of astrological treatises written in the 10th century (Kennedy and Destombes, 1966). ‘Aḍud al-Dawla, like many other rulers of that period was very much interested in astrology. An exert in al-Qifṭī’s book states that ‘Aḍud al-Dawla frequently visited Abū al-Faḍel Ja’far the son of the caliph al-Muktafī who was an astrologer, in order to get astrological predictions. I have listed below all the main works by al-Ṣūfī along with a brief description on each:

a) *Kitāb al-Kawākib al-Thābitah*

This is the *Book of the Fixed Stars* with pictures of the constellations. This was the main work which al-Ṣūfī was famous for and which is the topic of our present study. This work was mentioned in many Arabic historical and biographical references such as al-Qifṭī, al-Nadīm and Hājī Khalīfa.

b) *Kitāb al-Urjūza fi al-Kawākib al-Thābitah Muṣawaran*

This is a poem on the fixed stars. It is called ‘*al-Urjūza by Ibn al-Ṣūfī’* which means ‘*The Poem by Ibn al-Ṣūfī*’. It is composed of 495 verses which are divided into 48 stanzas, one for each constellation. Every stanza describes the constellation in a simple and easy to understand language. The style is not exactly a literally poetic style therefore it is called “Urjūza’ which means ‘Prose’ rather then a poem. The writer was trying to compose an easy to memorize poem and not a scientific piece of work; therefore it does not include much detailed scientific information on many of the constellations. Al-Qifṭī attributed this poem to al-Ṣūfī however this poem was written by the son of al-Ṣūfī and not by al-Ṣūfī himself. The first 6 verses from this poem clearly identify the person who wrote this poem and to whom it was attributed. The second verse explains that this poem was written by Abū ‘Alī the son of Abū al-Ḥusaīn al-Ṣūfī. The fourth verse states that this poem was dedicated to Shāhenshāh Abū al-Ma‘ali Fakher al-Din, who was the second son of Rukn al-Dawla. Fakher al-Dawla took power in Rayy in A.D. 976 after his father’s death. He took the title of *Shāhenshāh* in A.D. 984 until his death in A.D. 997; therefore this poem must have been composed some time between A.D. 984 and A.D. 997 and most probably after al-Ṣūfī’s death in A.D. 986. However, another reference in the Encyclopedia Iranica (Kunitzsch, 1970) identifies Shāhenshāh Abū al-Ma‘ali Fakher Din Allah as the Artuqid ruler in A.D. 1143; thus Kunitzsch rejects the claim that this poem was ever written during the time of al-Ṣūfī or by his son. A copy of this poem is to be found at the end of the below-mentioned manuscripts of al-Ṣūfī’s *Book of the Fixed Stars*. This is why there was sometimes a little confusion as to who wrote this poem. This also explains another confusion, which is the name of al-Ṣūfī because he was referred to as Ibn al-Ṣūfī in many historical reference works.

- Vatican Library, Manuscript: MS Rossi 1033, Copy dated A.H. 621/A.D. 1224
- Paris Bibliotheque Nationale, Manuscript: Arab 979, Copy date unknown
- Munich library , Manuscript: Arab 870, Copy date unknown

c) *Kitāb al-Tathkira wa Matāreh al-Shu’a’*

The title of this book as mentioned in the biographical work of al-Qifṭī, is ‘*The Book of Information and Projection of the Rays*’. Unfortunately it is no longer extant. It is not entirely clear whether is was one book with the above name or two different books ‘*Kitāb al-Tathkira*’ and ‘*Matāreh al-Shu’a*’ since it is no longer available. This book was on astrology which included mathematical tables and instructions using a specific method of calculating astrological charts. The concept of ‘projection of the rays’ is a little-understood astrological method which was also mentioned by many who wrote on astrology such as al-Khawarizmī, al-Ṣūfī and, later on, al-Bīrūnī (Kennedy, 1972). A reference to this concept with a table that was attributed to al-Ṣūfī is to be found in al-Bīrūnī’s book al-Qānūn al-Mas’ūdī (A.D. 1030).

d) *Kitāb al-Madkhal Fi 'Ilm al-Āḥkām*

This book is entitled *Kitāb al-Madkhal Fi 'Ilm al-Āḥkām* or '*Introductory Book to the Science of Astrology*'. This is one of the unpublished books of al-Ṣūfī that is listed by A. Sezgin (Geschichte des Arabischen Schrifttums GAS V, 1975).

e) *Fi Sharḥ al-'Amal bi al-Kura*

This book is entitled: '*Fi Sharh al-'Amal bi al-Kura*' or '*On the Explanation of the Use of the Celestial Globe*'. There are only two extant manuscripts of this book-both in the Saray library in Istanbul. This work was dedicated to Ṣamṣām al-Dawla, therefore this book might have been written after Ṣamṣām al-Dawla assumed ruler-ship of Iraq province in A.D. 983, toward the end of al-Ṣūfī's life. A critique on this book was published by Kennedy (1990) who summarized the various chapters.

f) *Kitāb al-'Amal bi al-Isṭerlāb*

This book is entitled: '*Kitab al-'Amal bi al-Isṭerlāb*' or the '*Book on Using the Astrolabe*'. There are seven incomplete manuscripts of this book in libraries in Paris, Istanbul, Tehran and St Petersburg (previously Leningrad). This book was one of the most exhaustive books ever written on this subject in the Middle Ages. It contained 1760 mostly short chapters on almost all aspects of construction and use of this instrument. It was dedicated to Sharaf al-Dawla the son of 'Aḍud al-Dawla at the time when Sharaf al-Dawla was still the *Amīr* of Kerman before the death of his father. A critique on this book was also published by Kennedy and Destombes (1966) who point to the influence of Indian astronomy on al-Ṣūfī's work even though al-Ṣūfī is better known for his star catalog which was based on Ptolemy's work. This shows that al-Ṣūfī was well informed on both Greek and Indian astronomy, not to mention his knowledge of Arabic tradition.

g) *Zīj al-Ṣūfī*

The Zīj of al-Ṣūfī was first mentioned by the important astronomer Ibn-Yūnus in Cairo-Egypt in A.D. 1000. Ibn-Yūnus makes a reference in his great book *al-Zīj al-Kabīr al-Hākimī* to the solar mean motion which he found in al-Ṣūfī's Zīj (Kennedy, 1956). Another reference to the Zīj of al-Ṣūfī is also to be found in Abraham Ibn 'Ezra's book *Libre de Rationibus Tabularum*. Even though Ibn 'Ezra must have had a copy of al-Ṣūfī's Zīj and he mentions several parameters such as the motion of the Sun, the length of the lunar year and mean motion of Saturn, most of these were not exactly correct. For example Ibn ‘Ezra quotes a value of 92:39 deg for the ‘excess of revolution’ which al-Ṣūfī mentions as 93 deg in his treatise on the Astrolabe. Ibn ‘Ezra also mentioned that al-Ṣūfī used a constant of precession of 1 deg every 70 years which is obviously an incorrect statement since al-Ṣūfī used the value of 1 deg every 66 years (Samso, 1994). Therefore, from the above references we can assume that the Zīj of al-Ṣūfī was a well known astronomical treatise which was widely circulated during that period; however, it is no longer extant (Mercier, 1987).

3.4 Al-Ṣūfī's Observatory.

Arabic and Islamic astronomers were well known for their accurate observations of the sky. Their astronomical observations and results for the positions of the planets, Sun and Moon are proof of the accuracy of their results. Many observatories have been built throughout the Islamic world such as Qāsūon Observatory in Damascus, al-Shamāsīya Observatory in Baghdad and Ibn-Yūnus Observatory in Cairo. Many prominent scientist and astronomers such as al-Khawarizmī, al-Battānī, Ibn-Yūnus as well as al-Ṣūfī were appointed to observe the night sky, develop new research methods and construct new astronomical instruments. These observatories were influenced by early ancient observations and instruments constructed by the Greeks, Babylonians, Indians and the Persians. During the 10th century the main observatories, which were patronized by royal kings and princes, reached a new stage of development whereby they became specialized institutions dedicated to research in astronomy. However, these observatories were not administratively organized until the next century after the construction of al-Ṣūfī's observatory (Sayili, 1960).

Around the 10th century, al-Ṣūfī became by far one of the greatest of those observational astronomers who was lucky to have had the patronage of an important ruler of that period. His early observations were probably made in his home city of Rayy. It is also believed that he must have spent his own money on the construction of astronomical instruments as did many astronomers before him. Al-Bīrūnī writes in *al-Qānūn al-Mas'ūdī* (A.D. 1030) and in another treatise *Taḥdīd al-Āmākin* that Ibn al-'Amīd ordered the construction of a mural quadrant in the city of Rayy in A.D. 950. This instrument was used by Abū al-Faḍel al-Hirawī and Abū Ja'far al-Khāzin to measure the obliquity of the ecliptic. If Ibn al-'Amīd was the person to whom al-Ṣūfī refers as his teacher Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn then he must have known about this instrument and was probably one of the important people who worked at this observatory in the city of Rayy. A mural quadrant is an angle-measuring device mounted on or built into a wall which was oriented on the meridian. A similar instrument was used by Tycho Brahe at his observatory in Uraniborg as pictured in the figure 8 below.

Figure 8 A Mural Quadrant Instrument Mounted or Built into a Wall

Al-Bīrūnī stated in his book *Taḥdīd al-Āmākin* that al-Ṣūfī built an observatory under the patronage of ʻAḍud al-Dawla in Shiraz where he must have made most of his observations. Al-Ṣūfī mentioned in his ʻ*Book of the Fixed Stars*ʼ in the chapter on the constellation Taurus that the observations he made were from the third climatic zone. This most probably corresponds to the city of Shiraz (Latitude: 29:53. Longitude: 52:58). He also measured the obliquity of the ecliptic from the year A.D. 965 until A.D. 970 from the same city. The observations of al-Ṣūfī and measurements of the obliquity were also later favorably mentioned by Ibn-Yūnus. Al-Bīrūnī also said that al-Ṣūfī observed the vernal equinox and the autumnal equinox from the city of Shiraz. The instrument which was utilized for this observation was an equatorial ring, similar to the one in figure 9, with a diameter of about 250 cm, having a 5 min subdivision on its scale. This instrument was considerable in size and was thus called the ʻ*Aḍudī* Ring after the ruler ʻAḍud al-Dawla who must have also participated at this Observatory along with many important astronomers of that time such as al-Quhī, al-Sijzī, Ibn Yumn al-Yūnānī and Gulām Zuḥal. The ʻ*Aḍudī* Ring was also mentioned in al-Ṣūfī's book in the chapter of constellation Argo Navis, where it was used to determine the latitude of the city of Shiraz as 29 deg and 36 min. The ʻ*Aḍudī* Ring was also mentioned in other historical references such as the work of al-Nasawī and by the astronomer Ghīyāth al-Dīn al-Kashī (Sayili, 1960:105).

The Arabs and Muslims also developed and constructed many astronomical instruments which were used to conduct important observations during the Middle Ages. It is also a well-known fact that many different instruments were used in those observatories

(Sayili, 1960:307). Even though these instruments might have been old Babylonian, Indian or Greek inventions, the Arabic and Islamic astronomers developed the instruments taking them to new levels of sophistication as well as inventing new types of astronomical instruments. From the few available treaties written by al-Ṣūfī on the astrolabe and the celestial globe and from the available historical records, we know that al-Ṣūfī used several observational instruments such as a sundial, a quadrant, an astrolabe, a globe, a five-meter diameter equinoctial armillary sphere and different sized Rings.

Al-Qifṭī wrote that Ibn Sunbūdī, who was considered to be an able an astronomer and an instrument maker, saw at the Cairo library in A.D. 1043 a celestial globe made of silver which was constructed by al-Ṣūfī for ʻAḍud al-Dawla. According to Ibn Sunbūdī the weight of this globe was three hundred *dirham* and it was purchased for three thousand *dīnār*. It must have been a considerable piece of work, but unfortunately it is no longer available today. Al-Qifṭī also states that this Ibn Sunbūdī also saw in Cairo another celestial globe made of copper by Ptolemy which had been in the possession of Prince Khāled Ibn Yazīd Ibn Mu'aweyah.

Figure 9 An equatorial ring

3.5 The Importance of al-Ṣūfī in the History of Astronomy

Al-Ṣūfī's work has been mentioned throughout history. Many of the most influential Arabic and Islamic scientists, scholars and astronomers have based their work and astronomical observations on al-Ṣūfī's work. Al-Ṣūfī was also mentioned by Western scholars as well as by modern astronomers. Throughout history al-Ṣūfī's name was sometimes miss-spelled or miss-written. He has been referred to by various names such as Esophi by Leo Africanus, and Azophi by the Spanish Jewish astronomer Ibn 'Ezra (Kunitzsch, 1986). He was again mentioned by the name Azophi by the 16th century European map makers Albrecht Durer and by Peter Apian (Kunitzsch, 1987). Even though al-Ṣūfī's name only appears once as Abolfazen in the Alfonsine Tables, he was many times referred to throughout the whole work as one of the 'learned men' (Samso, 1994). Al-Ṣūfī's influence on astronomy and stellar nomenclature can also be traced to other cultures as far as East Africa, the Comoros Islands and Madagascar (Brown, 2009).

I have tried to list below some of the important scholars and astronomers who have made use of al-Ṣūfī's work, starting from the 11th centaury after al-Ṣūfī's death and up to the beginning of the 20th century. I have included the contribution which al-Ṣūfī made to the work of these scientists. This list by no means cites all the references which include al-Ṣūfī's work but it covers a few important examples of the influence which al-Ṣūfī and his book has had in the history of astronomy over the past 10 centuries.

a) Al-Bīrūnī

Abū al-Raīḥān al-Bīrūnī was born in Khawarizm (now in present Uzbekistan) in A.D 973 and died in A.D. 1048 in Ghazna (now in present Afghanistan). He was an outstanding astronomer, mathematician, physicist, physician, geographer, geologist and historian. His great contributions in so many diverse fields earned him the title the 'Master' or 'Professor par excellence'. Some historians have called the period of his activity as the 'Age of al-Bīrūnī'. Al-Bīrūnī wrote many important books on astronomy and other related subjects some of which are:

- *Al-Āthār al-Bāqīya* is a treatise on timekeeping written in A.D. 1000. Al-Bīrūnī mentions al-Ṣūfī several times in this book in the last chapter on the lunar mansions. He remarks that the information he has on this subject was collected from several books such as the works of Ibn-Kunāsa, Al-Daīnawari and al-Ṣūfī. This book also includes a table of the Arabic lunar mansions with star magnitudes as mentioned by Abū al-Ḥusaīn al-Ṣūfī.

- *Al-Tafhīm Li Awa'el Sinā't al-Tanjīm* is a book that is an introduction and a summary on mathematics, astronomy and astrology written in A.D. 1029. While commenting on the Arabic name of the constellation Andromeda al-Bīrūnī makes a reference to the way al-Ṣūfī depicts this constellation.
- *Al-Qānūn al-Mas'ūdī Fi al-Haya' Wa al-Nujūm* was written in A.D. 1030. This book was dedicated to Sultan Masūd al-Ghaznawī. It discusses several theories on trigonometry, astronomy, solar and lunar and planetary motions, and also contains a collection of twenty-three observations of equinoxes. In this book we find many references to the observations made by al-Ṣūfī. Al-Bīrūnī also included a star catalog based on that produced by al-Ṣūfī. He even made a comparison of the star magnitudes between Ptolemy and al-Ṣūfī, however he also criticized al-Ṣūfī for not going further in correcting many of the mistakes which were found in the *Almagest*. The *al-Qānūn* of al-Bīrūnī also included astrological tables which were produced by al-Ṣūfī in his book *Matāreh al-Shu'a*'.
- *Taḥdīd al-Amākin* is a treatise on geography. In this book we also find references to the observation as well as the observatory of al-Ṣūfī and many other astronomers of that period.

b) Ibn-Yūnus

Ibn-Yūnus was an important mathematician and astronomer of the late 10th century. His name was Abū al-Ḥasan 'Alī Abū Sa'id 'Abd al-Raḥmān Ibn Aḥmad Ibn Yūnus al-Sadafī al-Masrī. He was born around A.D. 950 and died in A.D. 1009 in the city of Cairo. He worked as an astronomer for the Fatimid Dynasty for twenty-six years during the reign of the Caliph al-'Azīz and then al-Ḥākim. Ibn-Yūnus dedicated his most famous astronomical work, *al-Zīj al-Kabīr al- Ḥākimī,* to the Fatimid caliph al-Ḥākim Bi *Ā*mr Allah. In this *Zīj* we find references to al-Ṣūfī's *Zīj* and praise for al-Ṣūfī's observations which Ibn-Yūnus must have used for his own calculations (Sayili, 1960).

c) Bahā' al-Dīn al-Karaqī

Al-Karaqī wrote his *Montaha al-Idrāk fi Taqāsīm al- Āflāk*. This book contains a catalog of eighty-one stars which were based on al-Ṣūfī's book. Al-Karaqī adjusted his data for precession for his epoch of 1 October A.D. 1112 by adding 2 deg 15 min to al-Ṣūfī's longitudes. A copy of this book is found at the library of Berlin (manuscript MS Ahlwardt 5669) (Kunitzsch, Encyclopedia Iranica).

d) Al-Ṭūsī

Al-Ṭūsī was another important Persian mathematician and astronomer of the 13th century. He was also known as a biologist, chemist, philosopher, physician, scientist and theologian. His full name was Muḥammad Ibn Muḥammad Ibn al-*Ḥ*asan al-Ṭūsī better known as Naṣīr al-Dīn al-Ṭūsī. He was born in A.D. 1201 in the city of Ṭūs (Khorasan Province) and died in A.D. 1274 in Baghdad. He was at first a member of the Isma'ilī sect and later he switched to the Twelver Shī'ah sect. At the beginning of the Mongol invasion he joined the ranks of the Ismaili order but later he joined the forces of Hulagu-Khan after the Mongols occupied the Alamut castle which was an Isma'ilī stronghold. Al-Ṭūsī later befriended Hulagu-Khan and convinced him to construct an observatory to establish accurate astronomical tables for the purpose of astrological predictions. In A.D. 1259 al-Ṭūsī finished the construction of this most advanced observatory in the city of Maragha which was the capital of the Ilkhanate Empire during this period. Al-Ṭūsī produced his famous work *Zīj al-Ilkhānī* based on the observations made at this observatory. *Zīj al-Ilkhānī* contained the most accurate and extensive astronomical tables for the positions of the stars based on the catalog of al-Ṣūfī.

Figure 10 The Final Page of the Manuscript OR5323 Preserved at the British Library.

Al-Ṭūsī also made a Persian translation of al-Ṣūfī's book which was later used by Ulugh Bēg (Kunitzsch, 1986). The above figure 10 is the final page of the manuscript OR 5323 preserved at the British library in London and dating from the 14th century A.D. This manuscript has the seal of Hulagu which indicates that it was one of the manuscripts that was available in the library of this Mongol ruler and therefore must have been also available to al-Ṭūsī.

e) Ulugh Bēg

Ulugh Bēg was the Timurid ruler who lived in the capital city of Samarkand in the 15th century. His name was Mirza Muḥammad Taregh Ibn Shahrokh known under the title of Ulugh Bēg which means the 'Great Ruler'. He was born in Sultaniyeh in Persia in A.D. 1393 and was killed by his son on A.D. 1449 and is buried in Samarkand. He was also famous as an astronomer and mathematician during that period. In A.D. 1428 he built an enormous observatory where he compiled, in A.D. 1437, the *Zīj al-Ṣultānī*. This Zīj contained a star catalog with 994 stars which was considered the best star catalog since the work of al-Ṣūfī. Ulugh Bēg mentioned that "…we have observed all the stars except 27 stars which were too far to the south to be visible at the latitude of Samarkand, and we have taken these 27 stars from the work of 'Abd al-Raḥmān al-Ṣūfī." (Knobel, 1917). In Knobel's study of the magnitude of the stars in Ulugh Bēg's catalog he concluded that Ulugh Bēg did not observe the magnitudes of any stars and those he gives were simply copied from the magnitudes in al-Ṣūfī's Catalog. On the other hand, Kunitzsch mentions that Ulugh Bēg used al-Ṭūsī's Persian translation to compile his catalog rather then al-Ṣūfī's original Arabic text. However, another study of the magnitude system in old catalogs showed the independence of the catalogs of al-Ṣūfī and Ulugh Bēg. Even though Ulugh Bēg was influenced by al-Ṭūsī's Persian translation as well as al-Ṣūfī original Arabic work, he did not entirely duplicate their catalogs (Fujiwara, 2004).

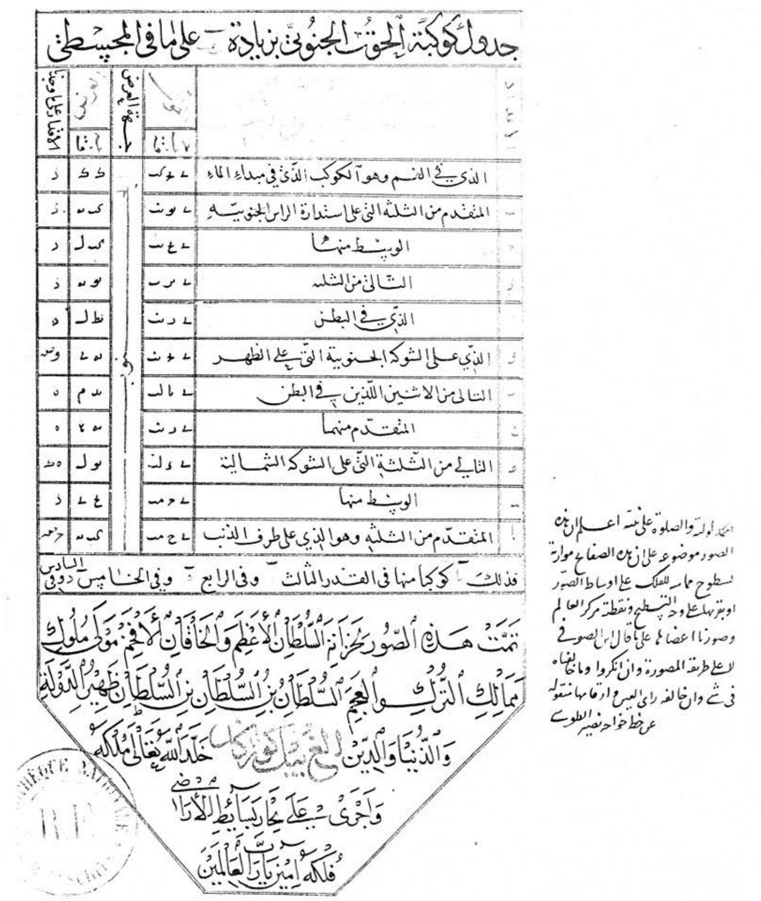


Figure 11 The Final Page of the Manuscript MS5036 Preserved in Paris.

The above Figure 11 is the final page of the manuscript MS5036 preserved in Paris. It is Ulugh Bēg's personal copy of al-Ṣūfī's *Book of the Fixed Stars*. The statement at the end of this manuscript relates that this copy was produced for the library of King Ulugh Bēg. The statement next to the table asserts that the pictures were drawn according to the instructions of Ibn al-Ṣūfī and the data were taken from the copy of Khawājā Naṣīr al-Dīn al-Ṭūsī. This is a very interesting manuscript in that it shows how information was transferred from al-Ṣūfī to al-Ṭūsī until it reached Ulugh Bēg. We also have here an early example of a mistake in that al-Ṣūfī is referred to by the name of 'Ibn al-Ṣūfī'.

f) Zakarīyā Ibn Muḥammad al-Qazwīnī

Al-Qazwīnī was a Persian physician, astronomer, geographer, judge and writer. He was born in the city of Qazwīnī in A.D. 1203 and died in A.D. 1283. His full name was Abū Yehyā Zakarīyā Ibn Muḥammad al-Qazwīnī. He wrote several books but the most famous was his Cosmography called '*Ajā'eb al-Makhlūqāt wa Ghrā'eb al-Mawjūdāt* (*Marvels of Creatures and Strange Things Existing*). This work was very popular and was frequently quoted throughout the Arab and Islamic world. It is preserved today in many copies in many libraries and it was also translated into Persian and Turkish. The descriptions of the forty-eight constellations in this book were taken directly from al-Ṣūfī's book however al-Qazwīnī does not mention al-Ṣūfī or the sources of his information. Another of al-Qazwīnī's work was his geographical dictionary called, *Athār al-Bilād wa-Akhbār al-'Ibād (Monument of Places and History of God's Slaves).*

g) The Authors of Alfonsine Treatises

The Alfonsine Treatises were a collection of about 30 treatises written in the city of Toledo in Spain by the order of the Castilian King Alfonso the 10th (Chabas et al., 2003). The most important of these treatises was the Alfonsine Tables which was a book or a *Zīj* on astronomy compiled mainly to correct anomalies in the previous Tables of Toledo written by Gerard of Cremona and based on the work of al-Zarqālī. Another of those treatises was a collection of books called '*the Four Books on the Eighth Sphere*' also called *Libros de las Estrellas Fixas (Books on the Fixed Stars)*. These works were not only a translation but rather a summary or a compilation in which al-Ṣūfī was the main source used (Samso, 1994). The first draft of these works were made in Toledo in A.D. 1256 by Yehudah Ibn-Mosheh and Guilleb Arremon Daspa but were later revised in A.D. 1276 again by Yehudah Ibn-Mosheh with the help of Joan de Mesina and Joan de Cremona. Most of the Alfonsine Treatises were originally written in Spanish but many were later translated into Latin. The Alfonsine Treatises were the most popular astronomical books in Europe until the late 16th century. According to Samso (1994) the '*Four Books on the Eighth Sphere*' might be considered one of the sources through which al-Ṣūfī's star catalog could have been introduced into Europe despite the fact that it was written in Spanish and not Latin. *ḥ*

h) Aḥmad Ibn Mājid

Aḥmad Ibn Mājid, known as the 'lion of the sea', was one of the most famous Arab seafarers of the Indian Ocean in the 15th century. He was born in Julfar near Rās al-Khaīmah in present day United Arab Emirates. He wrote more than 40 treatises on navigation in the Arab and Indian Ocean. Ibn Mājid was known to have guided Vasco da Gama from the coast of East Africa to Calicut in India in A.D. 1498. Ibn Mājid knew the work of al-Ṣūfī and quoted him in his book '*Kitāb al-fawā'ed Fi Osūl 'Ilm al-Bahr wa al-Qawā'd*' (Kunitzsch, Encyclopedia Iranica). The interaction and works of such Arab seafareres and traders helped to spread Arabic astronomy such as the astronomy of al-Ṣūfī through out the cultures surrounding the Indian Ocean.

i) Albrecht Durer

Albrecht Durer was a well-known German painter and printmaker. He was regarded as one of the greatest artists of the Renaissance in Northern Europe. He also produced theoretical treatises on geometry, mathematics, prospective and ideal proportions. He was also known for making the first printed star maps in Europe. Albrecht Durer was born in the city of Nuremberg on the 21st of May 1471 and died on the 6th April 1528.

The Figure 12 shows the northern star chart printed by Durer in Nuremberg, Germany in 1515. The chart consisted of a pair of woodcuts depicting the northern and southern sky with the constellation figures known to European astronomers at that period. All previous European and Arabic star charts were individually hand-drawn, and hence restricted to single copies. In the corners of the northern chart, Durer draws four figures. The first was Aratus Cilix' (Aratus of Cilicia). The second was 'Ptolemeus Aegyptus' (the Egyptian Ptolemy). The third was 'M. Mamlius Romanus' (the Roman Marcus Manilius). And finally on the bottom right of the chart we find 'Azophi Arabus' (the Arab al-Ṣūfī).

Figure 12 Northern Star Chart Printed by Durer in Nuremberg, Germany, in 1515

Figure 13 Apian's Star Charts Drawn in the Form of an Eight-Sided Astrolabe

j) Peter Apian

Peter Apian was a German mathematician, astronomer and cartographer. He was born in Leisnig in Germany on the 16th of April 1495 and died in Ingolstadt on the 21st of April 1552. He wrote his *Cosmographicus liber* in 1524 and his *Astronomicum Caesareum* in 1540. These were important works on astronomy that were very popular until the 17th century. Apian also produced several works on mathematics and astronomy such as sine tables, and manuals on the use of instruments such as sundials, as well as measuring instruments used for calculating time and distance. He was also one of the first astronomers to discover that a comet's tail always points away from the Sun. The *Astronomicum Caesareum* included star charts which were probably derived from the earlier works of Durer. Apian's charts were drawn in the form of an eight-sided astrolabe, complete with handles (Figure 13). Apian's star charts introduced many star names which were taken from Arabic sources. Apian wrote in his book that he knew al-Ṣūfī's book on the constellations and he mentioned al-Ṣūfī by the name of 'Azophi'. An earlier star chart also produced by Apian in 1533 depicts the figure of the constellation Ursa Major as three female figures in front of another woman sitting on a chair. This constellation in Arabic tradition was referred to as '*Banāt Na'esh'* (The Daughters of the Bier or Coffin). Durer's work was the source that Apian used for drawing this constellation (Kunitzsch, 1987). Therefore, Apian as well as Durer before him must definitely have had original Arabic copies of al-Ṣūfī's book which they extensively utilized in their astronomical work and star charts.

k) Christian Ludwig Ideler

Christian Ludwig Ideler was a German chronologist and astronomer. He was born near Perleberg in Germany on the 21st of September 1766 and died in Berlin on the 10th of August 1846. In 1825 he published his great work, *Handbuch der mathematischen und technischen Chronologie* in two volumes. It was re-edited in 1831 as Lehrbuch der Chronologie. Ideler's other work, which deals with the history of astronomy, was his important book Untersuchungen über den Ursprung und die Bedentung der Sternnamen: Ein Beytrag zur Geschichte des gestirnten Himmels which he published earlier in 1809. As the title implies, this is an investigation on the origin of the names of stars and a history of the celestial sky. Ideler mentions al-Ṣūfī and his work as many as 30 times in this major reference on the history of stellar astronomy. Kunitzsch (1979) who is the best know authority on ancient stellar nomenclature, believes Ideler's book to be the best written reference on this subject. This is despite the fact that many other works were written later on the origin of stellar names, including the famous book by Richard Hinckly Allen (*Star Names and their Meanings*) which also utilized the work of al-Ṣūfī.

l) Friedrich Wilhelm August Argelander

Friedrich Wilhelm August Argelander was a Prussian astronomer known for his work on determinations of stellar brightness, positions and distances. He was born in the city of Memel in the Kingdom of Prussia (now in Lithuania) on the 22nd of March 1799 and died in Bonn on the 17th of February 1846. Between 1852 and 1859 Argelander together with A. Kruger and E. Schonfeld produced the famous star catalog known as the *Bonner Durchmusterung* which gave the positions and magnitudes for more than 324,000 stars. This catalog is considered to be the last major star map published without the use of photography. In the French translation of al-Ṣūfī's book Schjellerup makes a comparison between the stellar magnitudes of Ptolemy, al-Ṣūfī and Argelander which were the most up-to-date values at that time.

m) Peters and Knobel

Christian Heinrich Friedrich Peters was a German-American astronomer and one of the first astronomers to discover asteroids. He was born on the 25th of September 1813 and died on the 18th of July 1890. Edward Ball Knobel was an English businessman and amateur astronomer. He was born in London on the 21st of October 1841 and died on the 25th of July 1930. He was the President of both the British Astronomical Association and the Royal Astronomical Society. Peters and Knobel were interested in the works of Ptolemy and the early Arabic and Persian astronomers. In 1915, after Peters' death, Knobel published a collated study of Ptolemy's star catalog and in 1917 Knobel again published a collated study of Ulugh Beg's star catalog, both of which were based on Peters' earlier unpublished notes and studies. In his study of Ulugh Bēg's star catalog Knobel identifies two important works on observational astronomy which the Arabs left to posterity. The first was the *Hakemite Tables* of Ibn Yūnus, the other was the *Uranometria* of 'Abd al-Raḥmān al-Ṣūfī which, as he mentioned, must be considered a work of the highest value.

3.6 A Crater on the Moon and a Main Belt Asteroid Named al-Ṣūfī

Finally, to end this section on al-Ṣūfī's biography and bibliography on a light note, I include below a brief description on the crater on the Moon named 'Azophi' and the main belt asteroid designated as '12621 al-Ṣūfī'.

a) A Crater on the Moon Named 'Azophi'

In 1651 Johann Baptist Riccioli published one of the first detailed maps of the Moon the *Almagestum Novum* (Sky&Telescope, April 2009). Riccioli adopted the names of 247 scientist and philosophers for the lunar craters most of which we still in use today. He named one of the craters 'Azophi' (Figure 14). In 1935 the International Astronomical Union's Committee on Lunar Formations published their report in which they re-confirmed the name of the crater 'Azophi' to commemorate the name of this important astronomer in the history of astronomy. The members of this committee were: Mary, Blagg; K. Müller; W. H.Wesley; S.A Saunder and Franz, J. London. Their report was published by P. Lund, Humphries and Co. in 1935.

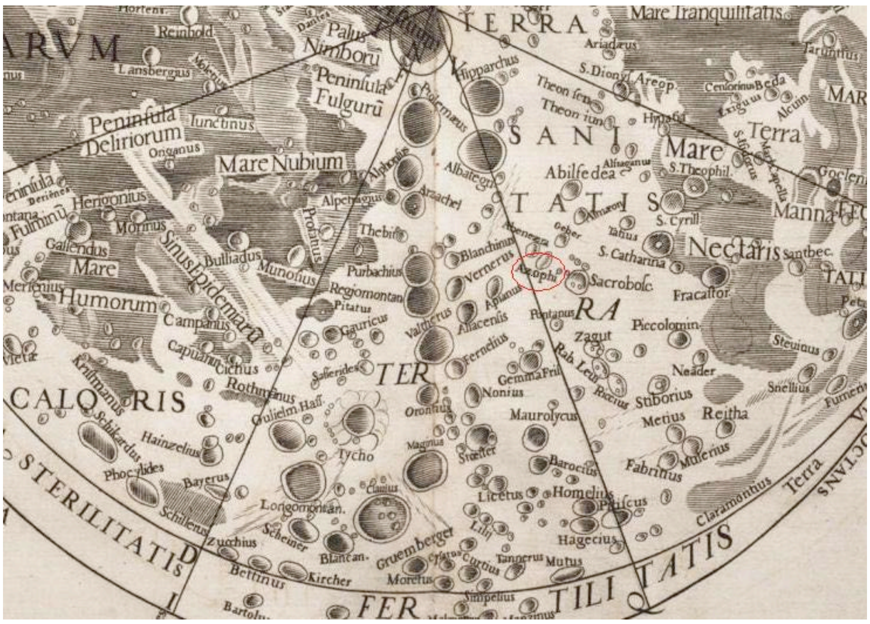
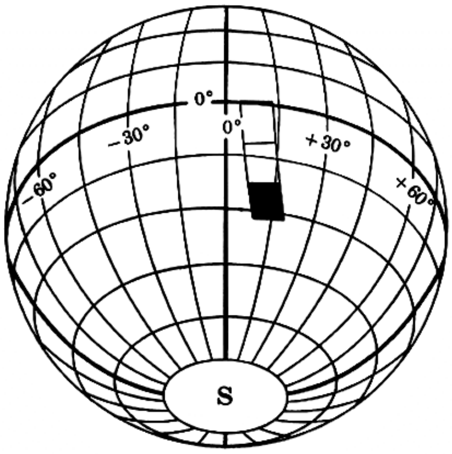


Figure 14 Riccioli map of the Moon with Azophi name highlighted in red.

I have identified the location of the 'Azophi' lunar crater in Figure 15 and included below is a modern photograph of it in Figure 16.



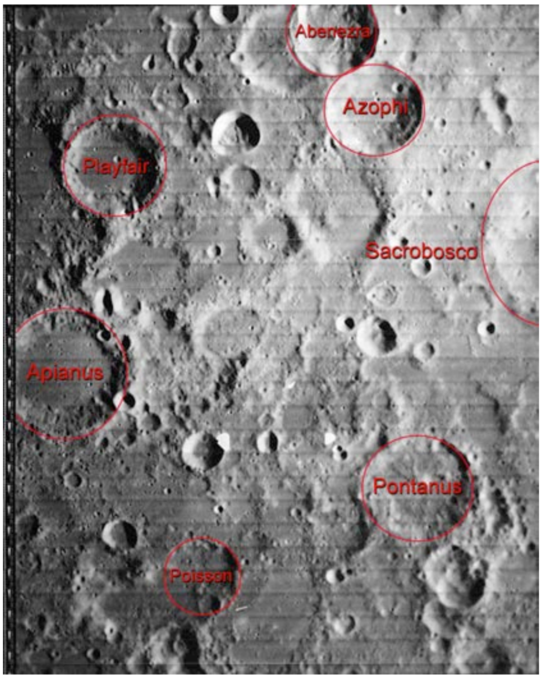


Figure 15 Location of the Azophi Moon Crater Figure 16 Modern Picture of Azophi Crater

b) The Main-Belt Asteroid “12621 al-Ṣūfī”

In 24th of September 1960 C.J. van Houten and I. van Houten-Groeneveld discovered on a Palomar Schmidt plate taken by T. Gehrels a minor planet which was designated ‘6585 P-L’. It was later called ‘12621 al-Ṣūfī’ by the International Astronomical Association (IAA). ‘12621 al-Ṣūfī’ is a main-belt asteroid with an orbital period of 1998.1141133days (5.47years). (Nasa website ttp://ssd.jpl.nasa.gov/sbdb.cgi?sstr=12621)

4.1 al-Sufi Introductory chapter

Folio 1 (Manuscript: Marsh 144)

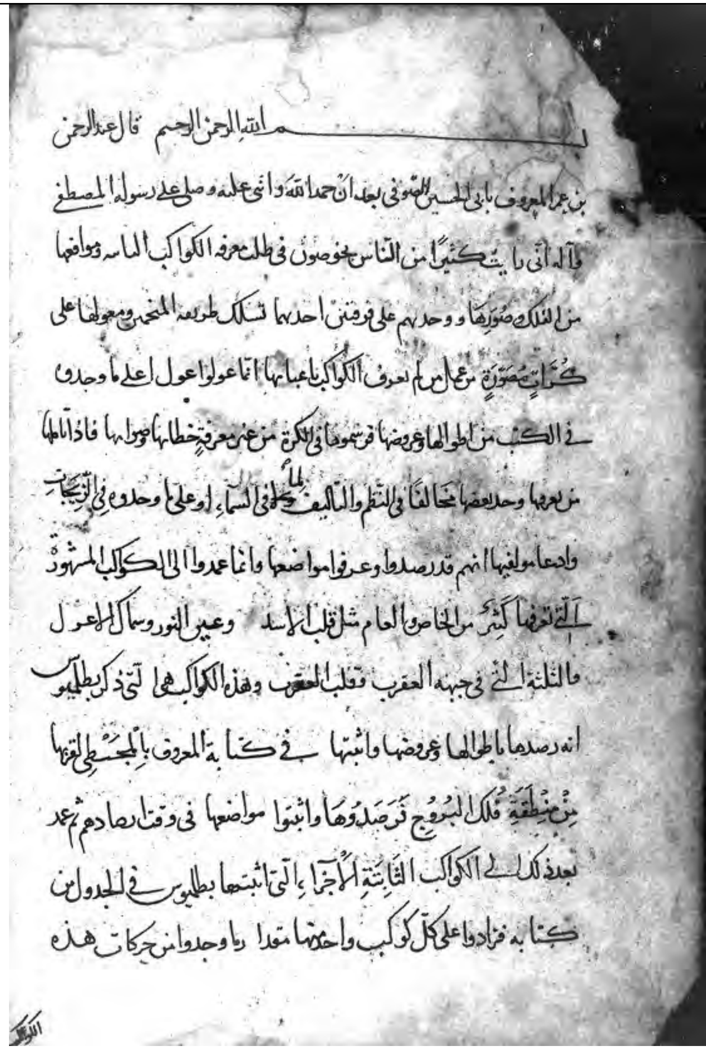
In the name of Allah, the most Gracious most Merciful.

ʼAbd al-Raḥmān Ibn ʻUmar better known as Abū al-Ḥusaīn al-Ṣūfī said after he thanked Allah (God) and praised him and prayed for the blessing and peace on his prophet (Muḥammad) *al-Muṣṭafa* (the chosen).

I have seen many people delve into the knowledge of the fixed stars, their positions and their (constellation) images and I found them to be two groups:

The first (group) took the road of the *Munajjimīn* (astronomers) utilizing picturesque celestial globes constructed by those who did not observe the stars with their own eyes. However they adopted the latitudes and longitudes which they found in books. They drew them on the globe without knowing which was false and which was true.

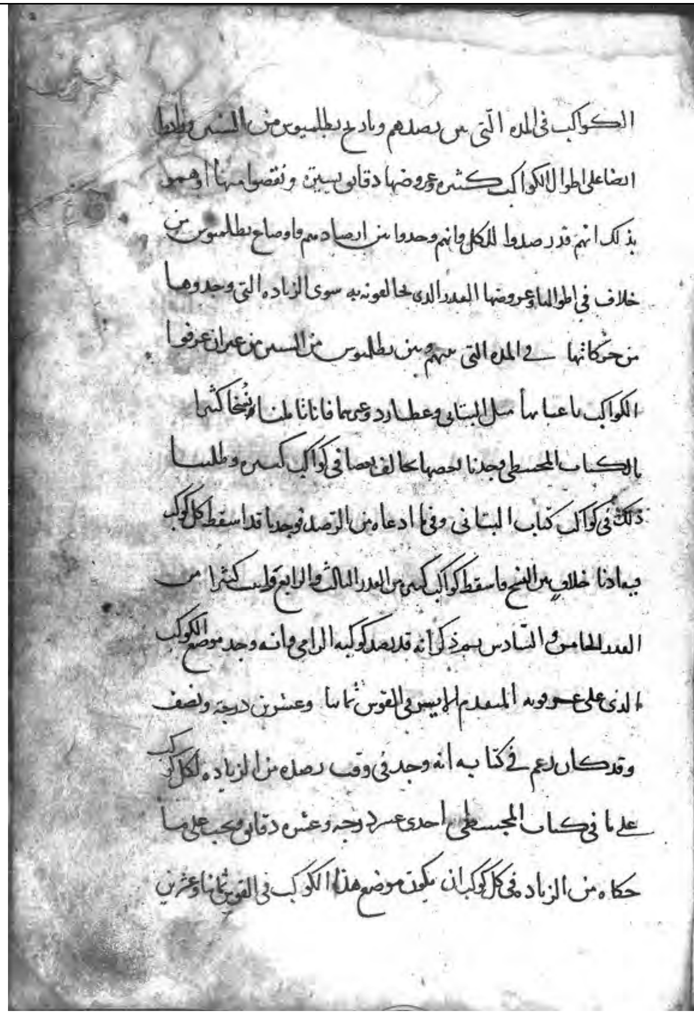
If somebody who knows (these stars) he will find that some are incorrectly drawn and composed from what is to be found in the sky or from what is to be found in the astronomical tables (*Zījāt*). Those composers claimed that they have observed them and that they know their positions. However they have relied on the famous stars which are known by many people like *Qalb al-Asad* (Regulus), *ʻAin al-Thawr* (Aldebaran), *al-Simāk al-A'zal* (Spica) as well as the three stars on the forehead of Scorpio (HR5984, 5953, 5944). All these stars have been mentioned by Ptolemy who said that he observed their latitudes and longitudes and confirmed this in his famous book *Almagest* to be close to the zodiac region. They (*Munajjimīn)* claimed to have observed and authenticated these positions at the time of their observation. They turned then to the other fixed stars which had been determined by Ptolemy in the tables of his book. They added on every one of these stars the difference in years for the movement of the stars……



Folio 2

…..from the date of their observation and the date of Ptolemy. They also added or subtracted several minutes from the latitudes and longitudes of many stars in order to make the illusion that they observed all these (stars) themselves. They claimed that they found from their own observations differences in latitudes and longitudes from those of Ptolemy's in addition to the yearly (precession) movement between their time and the time Ptolemy. However, these (astronomers) such as *al-Battānī*, *'Utāred* and others, did not observe those stars by their own eyes.

We have seen many copies of the book of the *Almagest* and we found (the positions) of many stars (in these copies) contradict each others. We then looked in *al-Battānī's* book, and what he claimed to have observed himself, and we found that he dropped those stars which had the slightest difference in the various copies (of the *Almagest*). Therefore he dropped many stars of the 3^{rd} and 4^{th} magnitudes while he kept many in the 5^{th} and 6^{th} magnitudes. He also mentioned that he observed the constellation Sagittarius and he found the coordinate of the star which is on the forward left hock to be twenty-eight and a half deg. And then he claimed in his book that he found at the time of his observation that the addition (due to precession) on every star on what was in Ptolemy's *Almagest* to be eleven deg and ten min. Based on what he (*al-Battānī*) said, with the addition on every star, the coordinate of this star at the time of his observation should have been twenty-eight deg and fifty min.

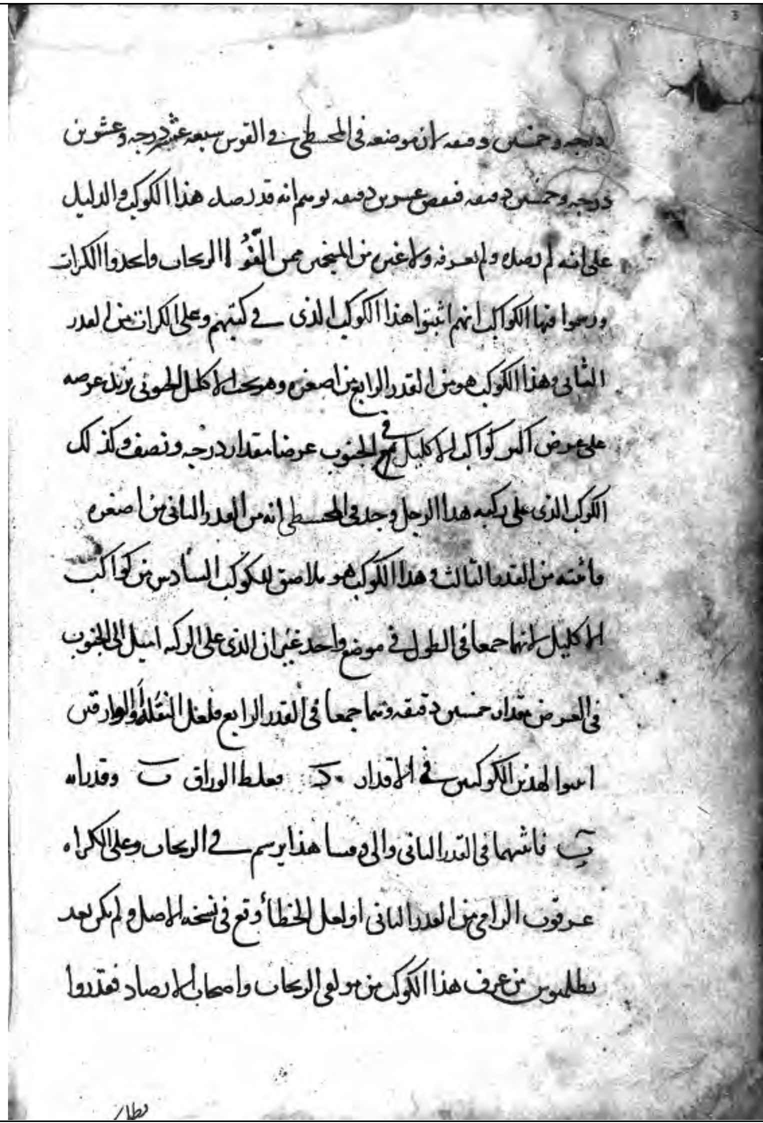


Folio 3

This is because its coordinates in the *Almagest* is seventeen deg and forty min in Sagittarius. By reducing these twenty min he (*al-Battānī*) makes the illusion that he observed this star. The (other) proof that neither he nor the other astronomers, who wrote astronomical tables and constructed and drew on the celestial globes, observed this star is that they confirmed in their books and on the globes that it is of the 2nd magnitude. However this star is less then the 4th magnitude. This star is under the constellation Corona Australis and its latitude is greater than the latitude of the southernmost star in the constellation Corona Australis by one and a half deg.

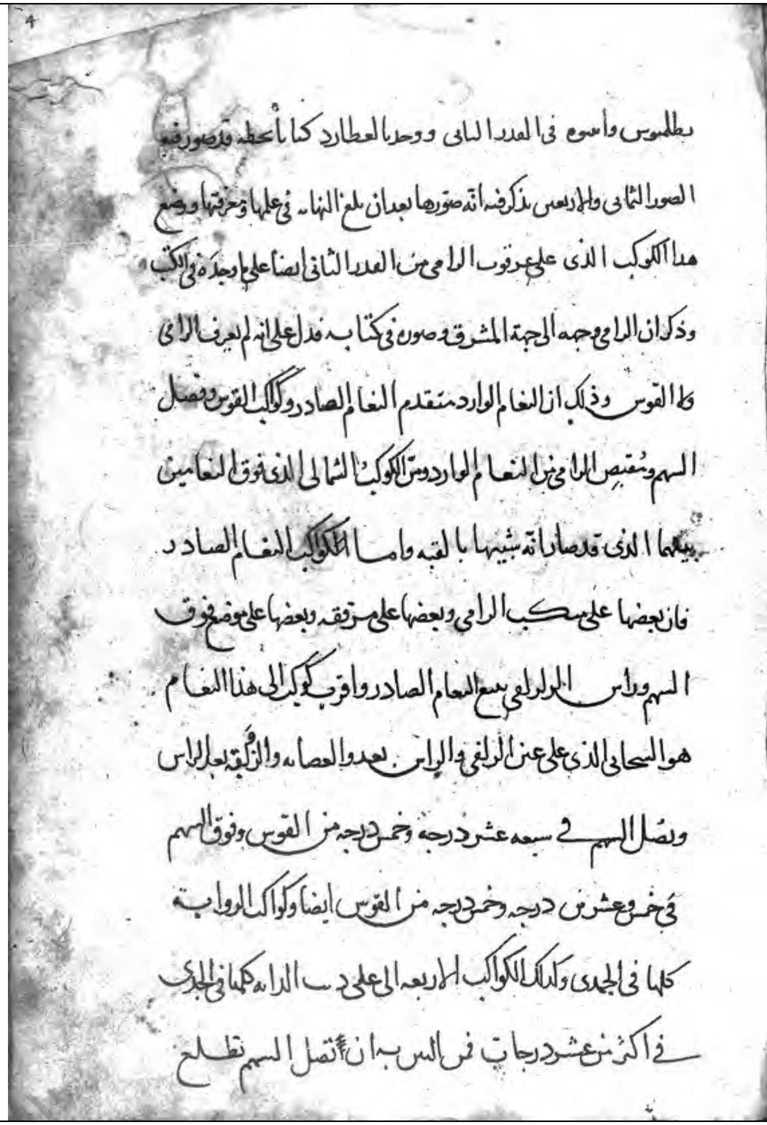
Also the star on the knee of this man (Sagittarius) is found in the *Almagest* to be less then the 2nd magnitude but was confirmed (by *al-Battānī*) as the 3rd magnitude. This star is close to the sixth star in the constellation of Corona Australis and they are all on the same latitude however this star which is on the knee is closer to the south in latitude by fifty min. All those stars are of the 4th magnitude.

Possibly the copiers and book-makers confirmed these two stars to be of the 4th magnitude but a copier made a mistake and set them to be of the 2nd magnitude. Until today the star of the left hock of Sagittarius is still copied and drawn on the celestial globes as the 2nd magnitude. However, the mistake was perhaps made in re-copying the original (*Almagest*) whereby compilers of tables and observers who came after Ptolemy did not know this star but they merely copied Ptolemy's (magnitude) and set this star to be of the 2nd magnitude.



Folio 4

We found a book written by ‘*Utāred* in his own handwriting where he drew the forty-eight constellations stating that he drew these after he reached the highest level in this science and knowledge. He (also) placed this star on the hock of Sagittarius in the 2nd magnitude from what he found in books.
He (‘*Utāred*) mentioned that Sagittarius faces the east and he drew it in his book as such. This shows that he did not know Sagittarius nor the (stars) of the Bow (HR6859, 6879, 6913) because *al-Na‘ām al-Wārid* (asterism containing the Bow and the Arrow) is in front of *al-Na’ām al-Ṣādir* (asterism on the chest of Sagittarius). And the stars of the Bow, the star on the point of the Arrow (HR6746) and the star on the hand of Sagittarius (HR6859) are all part of *al-Na’ām al-Wārid* and are part of the northern star (HR6812) which resembles *al-Qubba* (a dome) which is above and between the two *Na’ām*.
Moreover, the stars of *al-Na’ām al-Ṣādir* are on the elbow of Sagittarius, some on the palm and some in a position above the arrow. The head of Sagittarius comes after *al-Na’ām al-Ṣādir*. The closest star to this *Na’ām* (*al-Ṣādir*) is a nebulae located in the eye of Sagittarius. It is followed by the head (of Sagittarius) then *al-‘Isāba* (an asterism in Sagittarius). After the head comes *al-Thuāba* (an asterism in Capricorn).
The star on the point of the Arrow (HR6746) is located seventeen and a fifth (12 min) of a deg in the Bow. The star above the arrow is located twenty-five and a half deg in the bow. The stars of *al-Thuāba* are all part of the constellation Capricorn. The four stars on the tail of *al-Thuāba* are also all in Capricorn as far as ten deg. Therefore it is obvious that the star on the point of the Arrow rises before the star above the Arrow and the star above the Arrow (rises) before *al-Thuāba* and the head (of Sagittarius rises) before the tail.



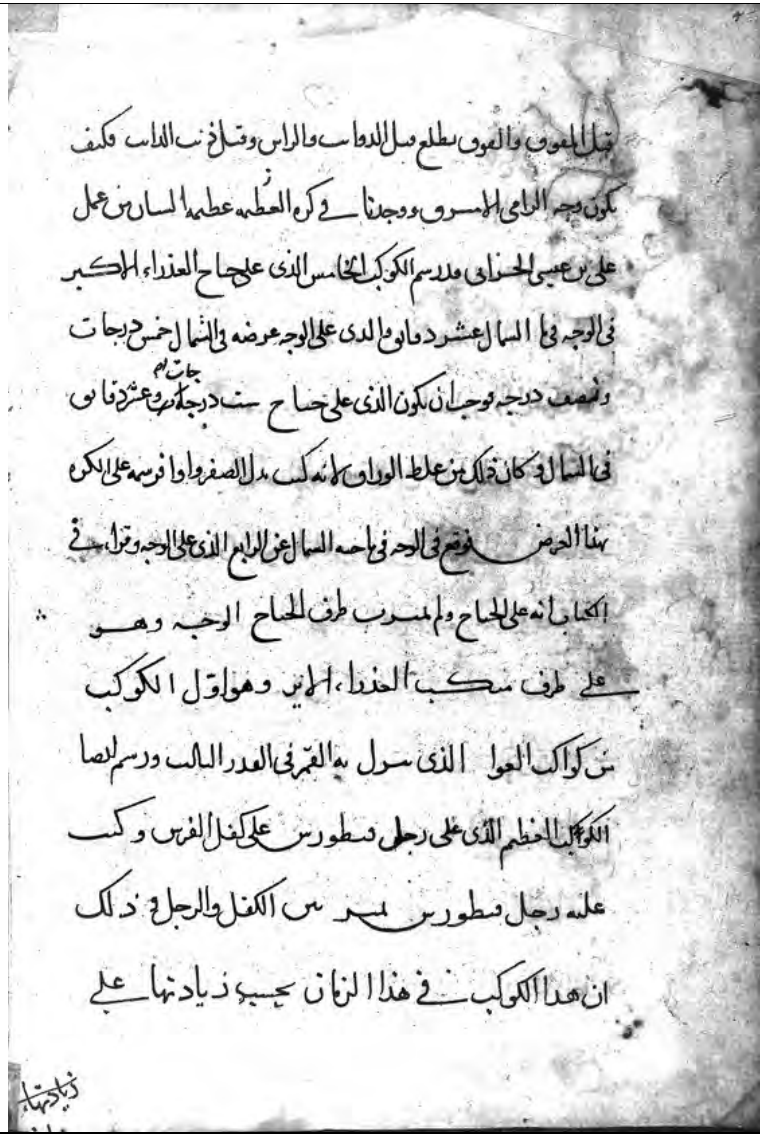
Folio 5

So how can the head of the Sagittarius face the east?

We also found on a large celestial globe, which was made by *‘Alī Ibn-‘Isa al-Harrānī,* that the fifth star on the left wing of Virgo was drawn on the face (of Virgo) and north of the fourth star on the face (of Virgo). This is wrong because the latitude of this star which is located on the wing is ten deg in the northern direction while the latitude of the star on the face is five and a half deg towards the north. Therefore the star which is on the left wing should be south of the star which is on the face by a distance of five and a third of a degree.

He (*‘Alī Ibn-‘Isa al-Harrānī*) found in a copy of Ptolemy’s book, which was translated by *al-Hajjāj*, the latitude of the star on the wing to be six deg and ten minutes towards the north. This is a mistake by the copier because he wrote (the letter) *wāw* (و) (*wāw*=8) instead of zero. He then transferred this on the globe with this latitude which corresponded to the position on the face in the north close to the fourth star on the face of Virgo. He read in the book that it is on the wing but he did not distinguish between the tip of the wing and the face. This (star) is close to the left hand of Virgo and it is the first star of the constellation *al-‘Awwā* (Bootes) which is a Lunar mansion. It is of the third magnitude.

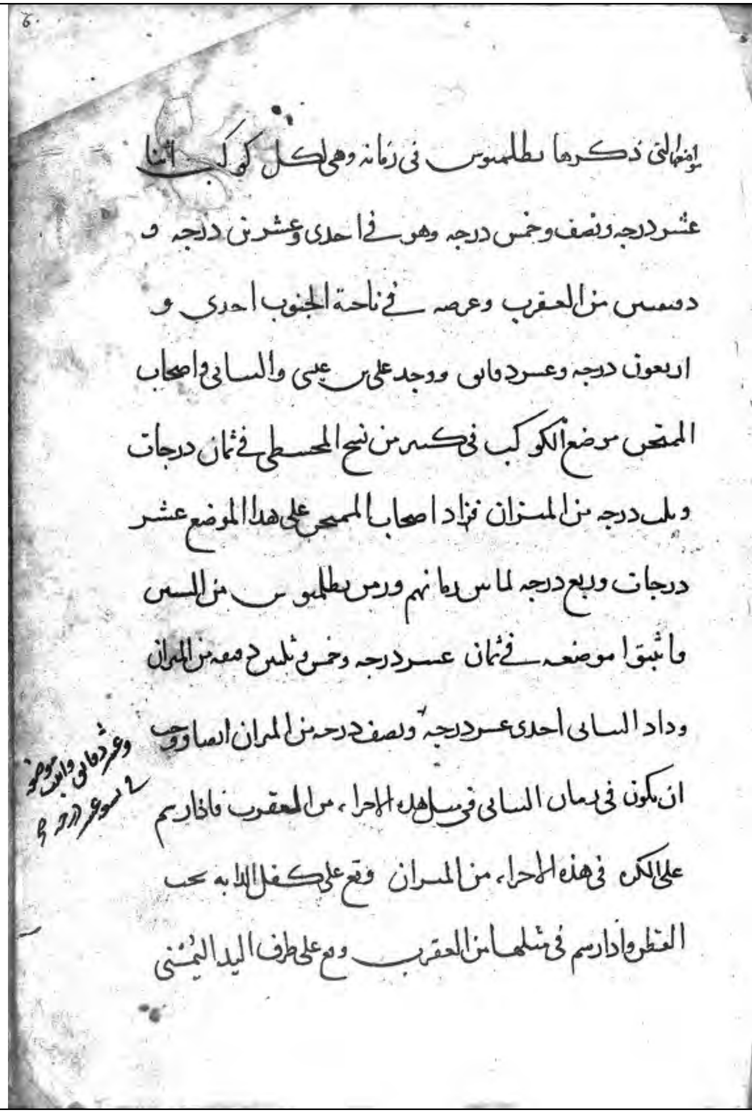
He ((*‘Alī Ibn-‘Isa al-Harrānī)* also drew the bright star which is on the Leg of Centauries on the End of Pegasus and he wrote on it the leg of Centauries and he did not distinguish between the (location of the) End and the Leg.



Folio 6

Because the (coordinate) of this star in our time, after we take what was mentioned by Ptolemy in his time and add an amount of twelve and a half deg and a fifth of a deg, becomes twenty-one deg and two min in the constellation of Scorpio and its latitude towards the south is forty-one deg and ten min.

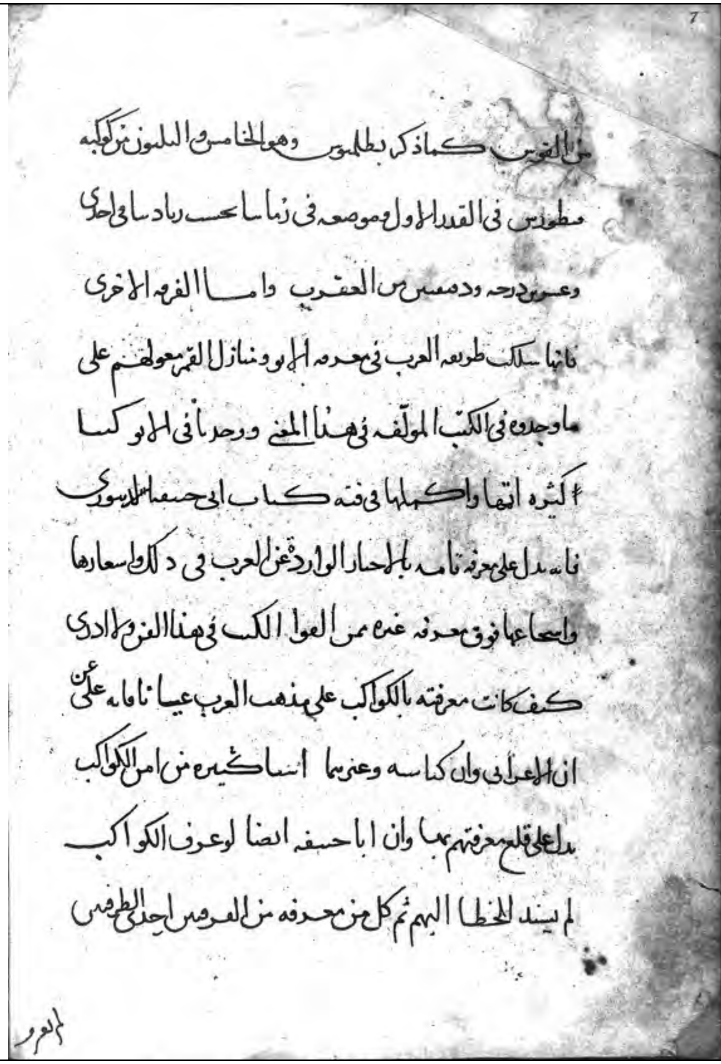
'*Alī Ibn-'Isa*, *al-Battānī* and the authors of *al-Mumtaḥen* tables all found the position of this star in many copies of the *Almagest* to be eight and a third of a deg in the constellation Libra. The authors of *al-Mumtaḥen* added to this position ten and a quarter of a deg accounting for the difference in year between their time and the time of Ptolemy. They confirmed its position to be eighteen deg and thirty-five min in the constellation Libra. While al-Battānī added eleven deg and ten min and confirmed the position at nineteen deg and a half in Libra also. However it is supposed to be at the time of al-Battānī at the same coordinates but in Scorpio because its position at the time of Ptolemy was eight and a third of a deg in Scorpio. Therefore if it is drawn on the globe on the constellation Libra it falls on the End the animal under the horse. And if it is drawn in Scorpio it will fall on the edge of the right hand of the constellation Sagittarius as mentioned by Ptolemy.



Folio 7

It is the thirty-fifth star in the constellation of Centauries. It is of the 1st magnitude and its position in our time after our addition is twenty-one deg and two minute in Scorpio.

Whereby the other group took the Arab method of the sciences of *al-Anwā’* and the Lunar mansions relying on what they found in books in these fields. We have found in the science of *al-Anwā’* many books, the best and most complete in this art was the book by Abū Ḥanīfa al-Daīnawari. This (book) shows his complete knowledge of Arab poetry and prose as was reported by the Arabs, more than any other writer who had written in this art. However I do not know how was his knowledge in the Arab method by way of star observation. Because he (al-Daīnawari) reports from Ibn al-Ā’rabī, Ibn Kunāsa and others many things about the stars which showed their little knowledge in this field. Therefore if Abū Ḥanīfa also knew about these stars then he would not re-copy the mistakes from them.



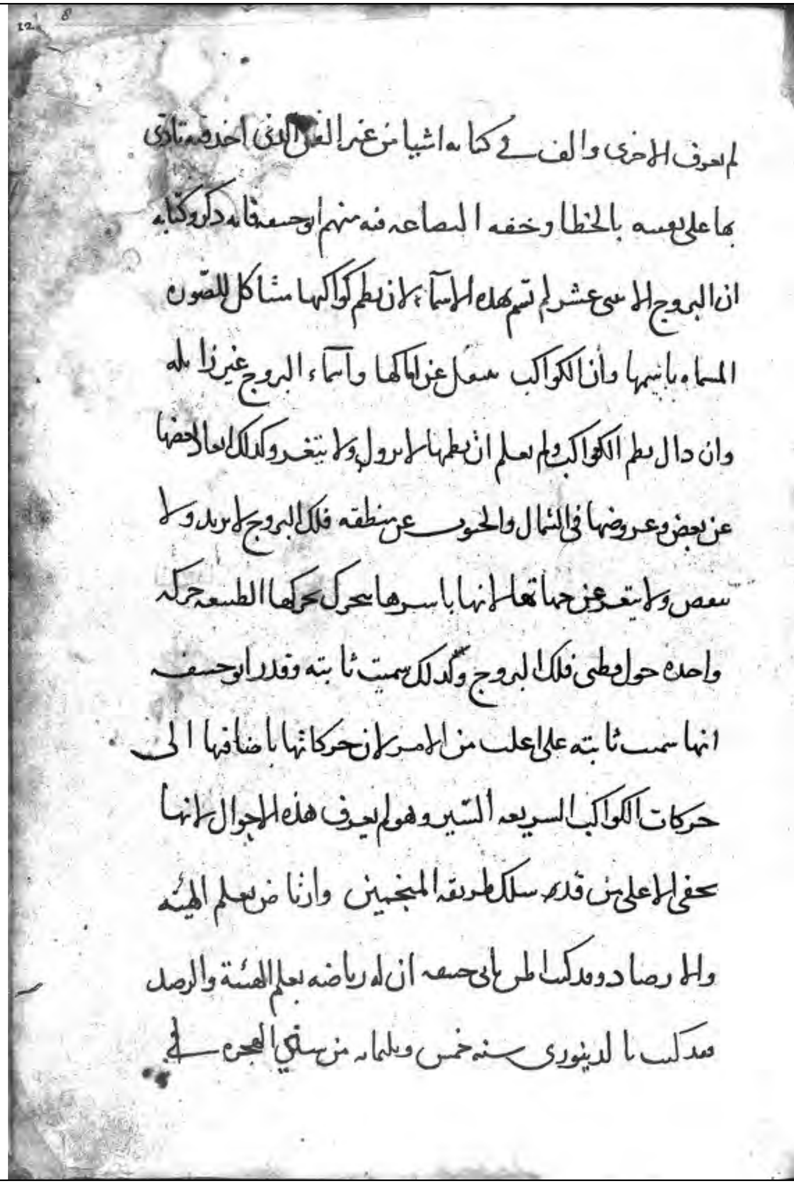
Folio 8

Who ever knew from the two groups (*Munajjimīn* or the Arabs) about one (scientific) method did not know the other. When they wrote in their books things not of their art they brought about on themselves the mistakes and showed their little understanding in this field.

One of those was Abū Ḥanīfa because according to his book he did not know that the twelve constellations of the zodiac were called by these names because they formed images (in the sky) of the same name. The stars move from their positions where as the names of these constellations do not change even when the stars change position. He did not know that the (constellation) formation do not change or disappear nor do the star positions change relative to each other. The star's latitude in the north and south from the zodiac also do not increase or decrease or change because (the stars) normally move in their entirety with one movement around the two ecliptical poles that is why they were called fixed (stars).

Abū Ḥanīfa must have thought that they were named fixed stars because their movements are slow compared to the movements of the fast moving planets. He did not know this information because it is only known to those who have taken the way of the astronomers and accepted the science of astronomy and observation.

I always had the impression that Abū Ḥanīfa knew the science of astronomy and observation for I visited Daīnawar in the year H.A. 335


لم يعرف الاخرى والف في كتابه اشيا من غير العلم الذي اخذ فيه فنادى
بها على نفسه بالخطا وخفه البضاعة فيه فمنهم ابو حنيفة فانه ذكر في كتابه
ان البروج الاثني عشر لم تسم بهذه الاسماء لان نظم كواكبها مشاكل للصور
المسماة باسمها وان الكواكب تنتقل عن اماكنها واسماء البروج غير زائلة
وان زال نظم الكواكب ولم يعلم ان نظمها لا يزول ولا يتغير وكذلك ابعاد بعضها
عن بعض وعروضها في الشمال والجنوب عن منطقة فلك البروج لا يزيد ولا
ينقص ولا يتغير عن حالها لانها باسرها تتحرك حركتها الطبيعية حركة
واحدة حول قطبي فلك البروج ولذلك سميت ثابتة وقدر ابو حنيفة
انها سميت ثابتة على اعتقاد من الامر لان حركاتها بالاضافة الى
حركات الكواكب السريعة السير وهو لم يعرف هذه الاحوال لانها
تخفى الا على من قد سلك طريقة المنجمين وانا من يعلم الهيئة
والارصاد وقد كنت اظن ان ابا حنيفة ان له رياضة بعلم الهيئة والرصد
فدخلت الدينوري سنة خمس وثلثمائة من سني الهجرة

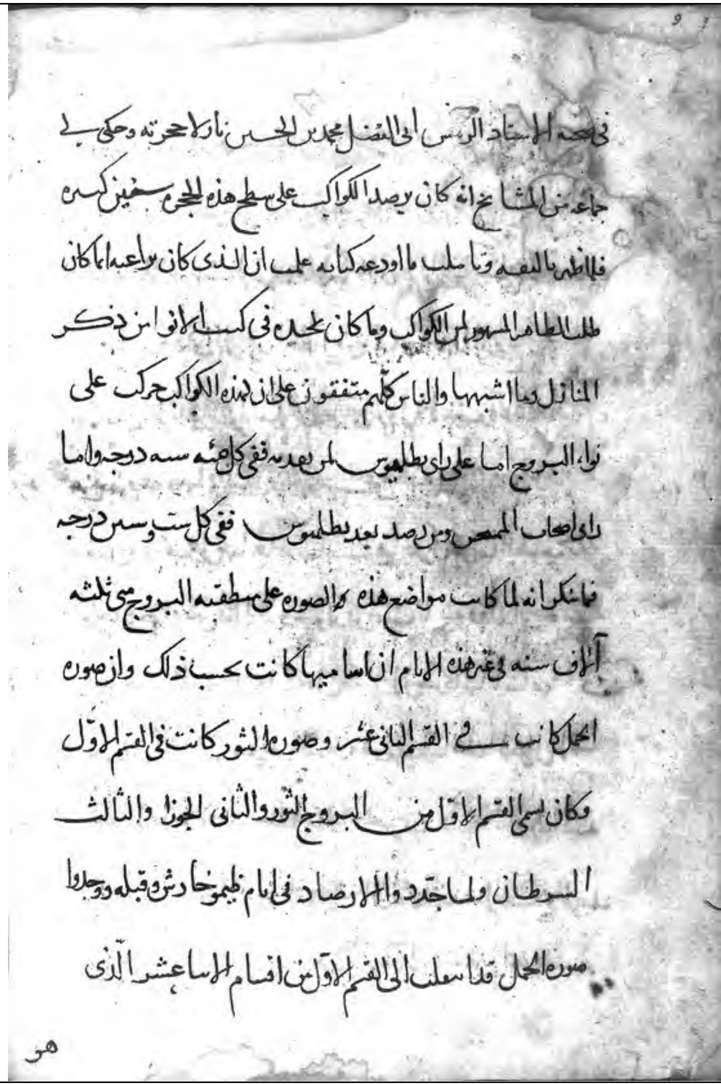
Folio 9

…..with the company of the grand professor Abū al-Faḍel Muḥammad Ibn al-Ḥusaīn, God prolong his life, and he was staying at his (Abū Ḥanīfa*)* house. I was told by some old people that Abū Ḥanīfa used to make his observation of the stars for many years from the roof of this house. However when his book was known and I saw what it contained, I realized that his only concern was what was famous and obvious of the stars as well as what he found in the books of *al-Anwā'* which mentioned the Lunar mansions and what was related to them.

Every body agrees that the stars move with respect to the ecliptic. According to Ptolemy and those who came before him they believed it (precession movement) was 1 deg every 100 years. However the authors of *al-Mumtaḥen* tables and those who came after Ptolemy confirmed it to be 1 deg every 66 years.

It is obvious that the divisions of the zodiac constellations 3000 years ago were not the same as today therefore their names were not the same. Therefore the constellation Aries was in the twelfth division and constellation Taurus was in the first division. The first division of the zodiac was named Taurus and the second was Gemini and the third Cancer.

When the star observations were renewed at the time of Timocharis and before, they (early Greek astronomers) found that the constellation Aries has shifted position to the first of the 12 zodiac divisions which is after the intersection point.



في صحبه الاستاذ الرئيس ابي الفضل محمد بن الحسين ادام الله عزته وحكى لي
جماعة من المشايخ انه كان يرصد الكواكب على سطح هذه الحجرة سنين كثيرة
فلما ظفرت بالنسخة وتأملت ما اودعه كتابه علمت ان الذي كان يراعيه انما كان
طلب الطالع المشهور من الكواكب وما كان يجده في كتب الانواء من ذكر
المنازل وما اشبهها والناس كلهم متفقون على ان هذه الكواكب تتحرك على
توالي البروج اما على راي بطلميوس ومن تقدمه ففي كل مائة سنة درجة واما
راي اصحاب الممتحن ومن رصد بعد بطلميوس ففي كل ست وستين درجة
فما ننكر انه لما كانت مواضع هذه الصور على منطقة البروج منذ ثلثة
آلاف سنة غير هذه الايام ان اساميها كانت بحسب ذلك وان صورة
الحمل كانت في القسم الثاني عشر وصورة الثور كانت في القسم الاول
وكان يسمى القسم الاول من البروج الثور والثاني الجوزاء والثالث
السرطان ولما تجدد الارصاد في ايام طيموخارس وقبله وجدوا
صورة الحمل قد انتقلت الى القسم الاول من اقسام الاثني عشر الذي
هو

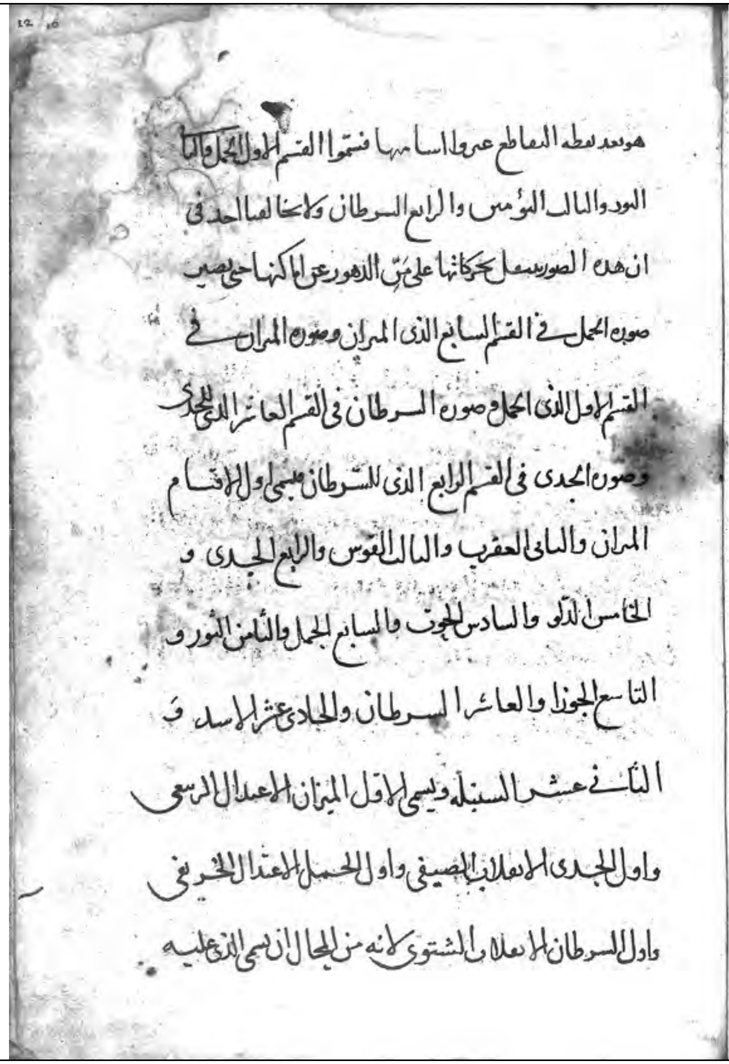
Folio 10

They renamed the first division Aries, the second Taurus, the third Gemini and the fourth Cancer.

And nobody disagrees with us that these constellations moved entirely through the ages from their positions until the constellation Aries fell in the seventh division which was originally for Libra, the constellation Libra fell in the first division which was for Aries, the constellation Cancer fell in the tenth division which was for Capricorn and the constellation Capricorn fell in the fourth division which was for Cancer.

Thereby if the first division is to be renamed Libra, the second Scorpio, the third Sagittarius, the fourth Capricorn, the fifth Aquarius, the sixth Pisces, the seventh Aries, the eighth Taurus, the ninth Gemini, the tenth Cancer, the eleventh Leo and the twelfth Virgo, then the beginning of Libra is to be renamed the spring Equinox, and the beginning of Capricorn the Summer Solstice and the beginning of Aries the spring equinox and the beginning of Cancer the winter Solstice.

However it is impossible to call the division which contains the constellation Capricorn as Cancer and the division which contains the constellation Cancer as Capricorn.



هو بعد بطه المقاطع عيروا اسامها فسموا القسم الاول الحمل والثاني
الثور والثالث التوأمين والرابع السرطان ولا اختلاف لنا احد في
ان هذه الصور تنقل بحركاتها على مر الدهور عن اماكنها حتى تصير
صورة الحمل في القسم السابع الذي للميزان وصورة الميزان في
القسم الاول الذي للحمل وصورة السرطان في القسم العاشر الذي للجدي
وصورة الجدي في القسم الرابع الذي للسرطان فيسمى اول الاقسام
الميزان والثاني العقرب والثالث القوس والرابع الجدي و
الخامس الدلو والسادس الحوت والسابع الحمل والثامن الثور و
التاسع الجوزا والعاشر السرطان والحادي عشر الاسد و
الثاني عشر السنبلة ويسمى اول الميزان الاعتدال الربيعي
واول الجدي الانقلاب الصيفي واول الحمل الاعتدال الخريفي
واول السرطان الانقلاب الشتوي لانه من المحال ان يسمى الذي عليه

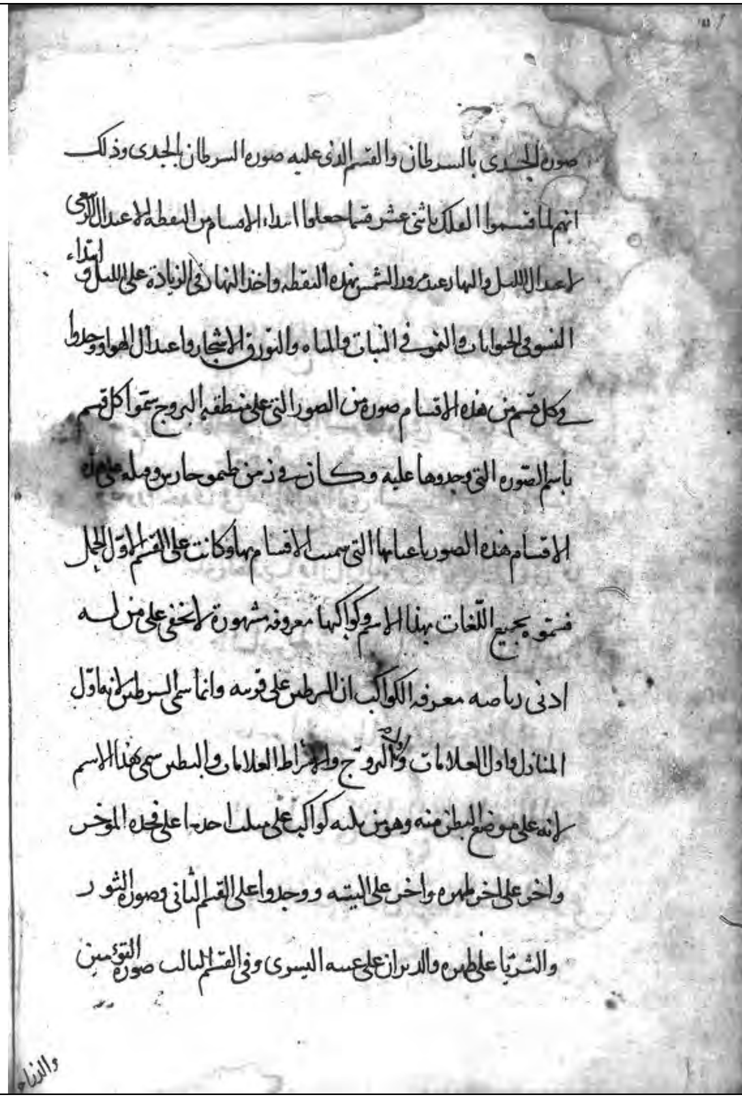
Folio 11

For when they divided the zodiac into the 12th divisions they made the beginning of these divisions at the spring Equinox. When the Sun passes this point, the night and day are equal. The day starts to exceed the night and the animals start mating and the plants and water grow and the leaves blossom and the air stabilize.

They (early Greek astronomers) also found in every division of the zodiac a constellation image and they named every division by the name of the image which was found in it. At the time of Timocharis and before him these divisions were the same as the constellations which were named after it. The first division contained the constellation Aries so they named it in all languages by this name. This is because its stars are well known and famous.

There is no doubt that whoever has any slight knowledge of the stars knows that *al-Sharaṭān* (*Anwā'* asterism) is on its (Aries) horn. It was named *al-Sharaṭān* because it is the first Lunar mansion and the first sign and the first zodiac constellation. For *al-Ashrāt* means "Sign" (in Arabic).

The *al-Buṭain* (*Anwā'* asterism) was named by this name because it was located on the stomach of Aries and it consists of three stars forming a triangle one on the rear thigh and another at the end of this back and the other on the tail.
They also found in the second division the constellation Taurus with *al-Thurayyā* (Pleiades) on its back and *al-Dabarān* on the left eye.

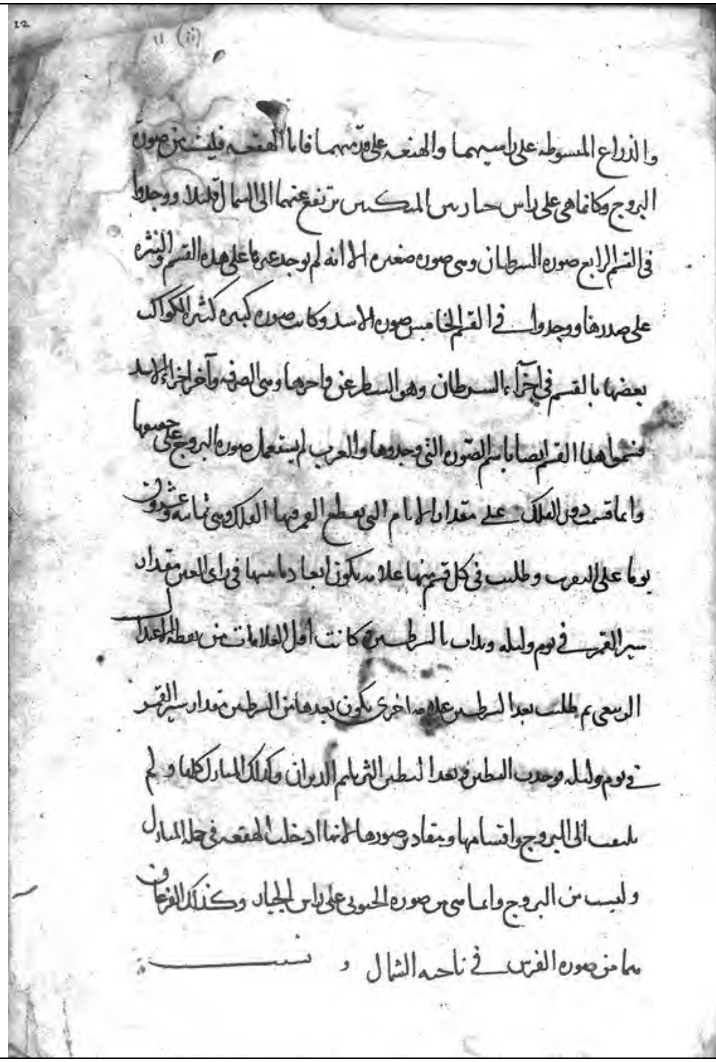

صورة الجدي بالسرطان والقسم الذي عليه صورة السرطان الجدي وذلك
انهم لما قسموا الفلك اثني عشر قسما جعلوا ابتداء الاقسام من النقطة الاعتدال الربيعي
لاعتدال الليل والنهار عند مرور الشمس بهذه النقطة واخذ النهار في الزيادة على الليل وابتداء
النشوء الحيوانات والنمو في النبات والماء والنور في الاشجار واعتدال الهواء ووجدوا
في كل قسم من هذه الاقسام صورة من الصور التي على منطقة البروج فسموا كل قسم
باسم الصورة التي وجدوها عليه وكان في زمن طيموخارس وقبله منطبقة على
الاقسام هذه الصور باعيانها التي سميت الاقسام بها وكانت على القسم الاول الحمل
فسمي بجميع اللغات بهذا الاسم وكواكبها معروفة مشهورة لا تخفى على من له
ادنى رياضة معرفة الكواكب ان الشرطين على قرنه وانما سمي الشرطين لانه اول
المنازل واول العلامات والبروج والاشراط العلامات والبطين سمي بهذا الاسم
لانه على موضع البطن منه وهو ثلاثة كواكب على مثلث احدها على فخذه المؤخر
والاخر على اخر ظهره والاخر على اليته ووجدوا على القسم الثاني صورة الثور
والثريا على ظهره والدبران على عينه اليسرى وفي القسم الثالث صورة التوأمين
والذراع

Folio 11 (ii)

In the third division they found the constellation Gemini and the *al-Dhirā' al-Mabsūṭa* (*Anwā'* asterism) on their (Gemini) heads and the *al-Han'a* on their feet. As for the *al-Haq'a* it is not found in the zodiac constellation for it is on the head of Orion between the shoulders a little higher to the left. They found in the fourth division the constellation Cancer. It is a small constellation but there is no other in that division. *Al-Nathra* (*Anwā'* asterism) is on the chest (of Cancer). They found in the fifth division the constellation Leo. It is a large constellation with many stars. *Al-Ṭarf* (*Anwā'* asterism) is located in this division and at the edge of Cancer and *al-Ṣarfa* is located at the other end and at the edge of Leo. They named this division also by the name of the constellation image they found in it.

The Arabs did not realistically use the zodiac constellation however they divided the ecliptic into the days the Moon crosses this orbit which is approximately 28 days. They assigned a sign for every division whereby the distance between these signs is equals to the progress of the Moon every day and night starting with *al-Sharaṭān* which was the first of these signs at the time of the equinox.

They tried then to located another sign after *al-Sharaṭān* whereby its distance from *al-Sharaṭān* is equal to the Moon progress in one day and one night and they found *al-Buṭain* then after *al-Buṭain al-Thurayyā* (Pleiades) then *al-Dabarān* and so on for are all the other Lunar mansions. They were not concerned with the zodiac constellations, their divisions and images. They included *al-Haq'a* to be of the Lunar mansions and not of the zodiac because it is part of the southern constellations located on the head Orion. This is also done for *al-Farghān* which is found in the constellation Equuleus towards the north.

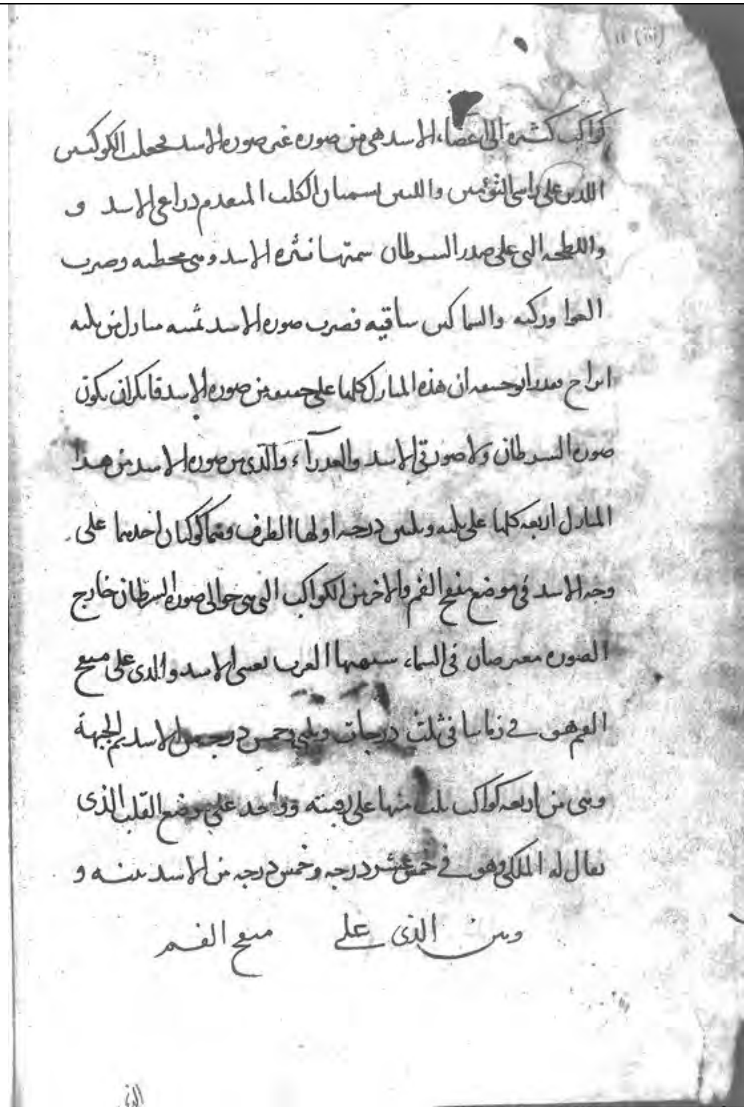


Folio 11 (iii)

They also included many stars to be part of Leo; however these are not in the constellation Leo. They (Arabs) located the two stars which are on the head of Gemini and which are called *al-Kalb al-Mutakadem* (the front dog) to be on the arms of Leo, and they named the nebulae on the chest of Cancer, *Nathrat al-Asad*. They assigned (the asterism) *al-'Awwā*, *Rakih* and *al-Simākain* on his (Leos) legs. Therefore they assigned to (the constellation) Leo eight mansions covering three constellations.

Abū Ḥanīfa considered all these mansions to be part of constellation Leo and he did not consider this image to be divided into three constellations every one with its own distinct name. He did not recognize the constellation Cancer, or the constellations Leo and Virgo.

There are four mansions which are in the constellation Leo spread within 30 deg. The first is *al-Ṭarf* (*Anwā'* asterism) which consists of two stars. The first star is on the face of Leo situated on the mouth. The other star is close to the constellation Cancer outside of the constellation (Leo), spread apart in the sky whereby the Arabs compared them to the eyes of a Lion. The coordinates of the star on the mouth in our time is 3 and 3/5 of a deg in Leo. Then we have *al-Jabha* (*Anwā'* asterism) which consists of four stars. Three stars are located on the neck (of Leo) and one on the heart. This (last) star is called *al-Malikī* which is located 15 and 1/5 of a deg in Leo. The distance between it and the star in the mouth of Leo is 11 and 1/3 of a deg.



Folio 12

Then we have *al-Zubra* which consists of two stars located on the back (of Leo). The distance between *al-Malki* and the brighter of the two stars of *al-Zubra* is a distance of 11 and 2/3 deg. It is 26 and 3/5 of a deg in Leo.
al-Sarfa consist of the bright stars on the tail (of Leo). It is 7 and 1/5 of a deg in Virgo. The distance between it and the brighter of the two stars of *al-Zubra* is 10 and 1/3 of a deg. All these locations are close to each other. The distance between each of them is approximately the angle the Moon travels in one day and one night.
As for *al-'Awwā* it consists of five stars located on the wing of Virgo. *Al-Simāk* is one of them which is a lone star on the left hand of Virgo. *Al-Rāmiḥ* is between the thighs of Bootes and is called *al-Ṣannāj* but it is not in and is not part of the main image of the constellation of Virgo.

He (Abū Ḥanīfa) thought that the sixth zodiac is part of the constellation Leo and he called the group of stars which are above the tail of Leo as the constellation Virgo. It was called by some astronomers *al-Ḍafira* because it looks like a *Sunbula* (leaf). He also mentioned something similar in the constellation Sagittarius where a similar asterism was named the Bow. However because there is a constellation named the Bow it was not named as such.

Folio 13

He named these stars which are in front of Sagittarius by this name because they looked like a Bow and which the Arabs call *al-Qilāda*. He did not know the Bow or the arrow or Sagittarius or any of the stars as per the method of the astronomers.

He also called the *al-'Awā'idh* and the most of what can be mentioned in this regards is that the astronomers call it the Head of the Dragon. They also called *al-Ridf* the tail of Cygnus. However since he (Abū Ḥanīfa) did not recognize the image of the constellation Cygnus, he described *al-Fawāris* but he did not know that it is of the same constellations and located on its wing.

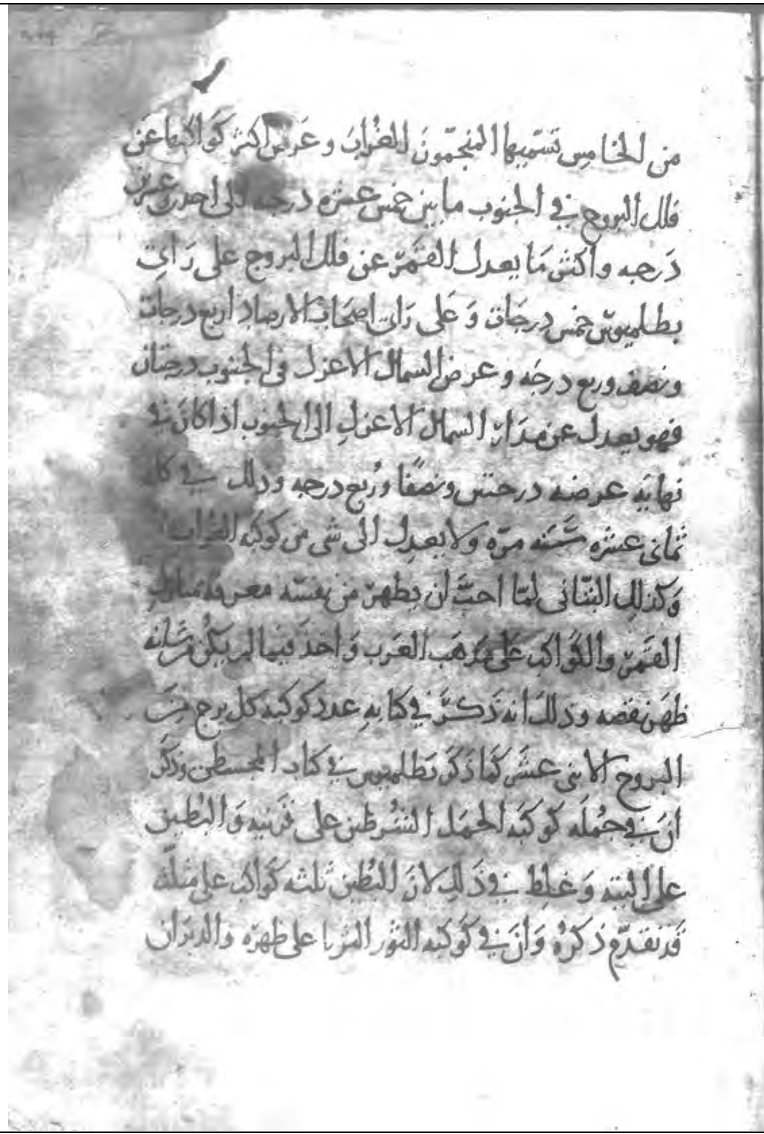
He also mentioned that *Banāt Na'esh al-Kubra* (The Great Daughters of the Bier or Coffin) consist of seven stars similar to the smaller (sisters). The astronomers call them the Great Bear. However he did not know that they are part of the constellation Ursa Major. He (also) mentioned that between '*Arsh al-Simāk al-A'zal* and *al-Zubānain*, and below them, there are bright stars randomly grouped called *al-Shamārīkh*. He was mentioning here the stars in the constellation Centaurs and Lupus. Then he mentioned *Hiḍār* and *al-Wazn* and that they were called *Muḥlifain* however he did not know that they were part of *al-Shamārīkh*. He (also) mentioned *al-Dhanbain* but he did not know that they are part of the constellation Draco.

He (Abū Ḥanīfa) also mentioned '*Arsh al-Simāk al-A'zal* relating from *Ibn Kunāsa* that the orbit of the Moon might come close to Leo where '*Arsh al-Simāk* is located. The number of these stars (of '*Arsh al-Simāk)* is seven. Five of which are bright and are of the 3rd magnitude……

Folio 14

…..one of the 4th magnitude and one of the 5th magnitude. The astronomers call them *al-Ghurāb* (constellation Corvus). He mentioned that the latitude of the furthest of these stars from the ecliptic towards the south is between 15 to 21 deg. However according to the opinion of Ptolemy the maximum the orbit of the Moon drifts from the ecliptic is 5 deg. And according to the opinion of (*al-Mumtaḥen*) observers it is 4 and ½ and ¼ of a deg. The latitude of *al-Simāk al-A’zal* south (of the ecliptic) is 2 deg. Therefore (the Moon’s) orbit is furthest from *al-Simāk al-A’zal* towards the south by 2 and ½ and ¼ of a deg. This occurs once in every 18 years. Therefore (the Moon) does not come close to the constellation Corvus.

Thus *al-Battānī* when he wanted to show that he knew the Lunar mansions and the stars as per the Arab method, he went into what was not his field which showed his weakness. He (*al-Battānī*) mentioned in his book the number of stars in the entire twelve zodiac constellation as were mentioned by Ptolemy in his book *Almagest*. He also mentioned that in the constellation Aries *al-Sharaṭān* is on the head and *al-Buṭain* is on the hand. However he was mistaken because *al-Buṭain* consists of three stars forming a triangle as was mentioned before.
(He mentioned) that al-Thurayyā is in the constellation Taurus located on its back and that *al-Dabarān* is located on its tail.


من الخامس تسميها المنجمون الغراب وعرض اكثر كواكبها عن
فلك البروج في الجنوب ما بين خمس عشرة درجة الى احدى عشرين
درجه واكثر ما يعدل القمر عن فلك البروج على راى
بطليموس خمس درجات وعلى راى اصحاب الارصاد اربع درجات
ونصف وربع درجه وعرض السماك الاعزل في الجنوب درجتان
فهو يعدل عن مدار السماك الاعزل الى الجنوب اذا كان في
نهاية عرضه درجتين ونصفا وربع درجه وذلك في كل
ثماني عشرة سنة مرة ولا يعدل الى شي من كوكب الغراب
وكذلك البتاني لما احب ان يظهر من نفسه معرفة منازل
القمر والكواكب على مذهب العرب واخذ فيما ليس من شانه
ظهر نقصه وذلك انه ذكر في كتابه عدد كواكب كل برج من
البروج الاثني عشر كما ذكر بطلميوس في كتاب المجسطي وذكر
ان في جملة كواكب الحمل الشرطين على قرنيه والبطين
على اليد وغلط في ذلك لان البطين ثلثة كواكب على مثلث
قد تقدم ذكره وان في كوكب الثور الثريا على ظهره والدبران

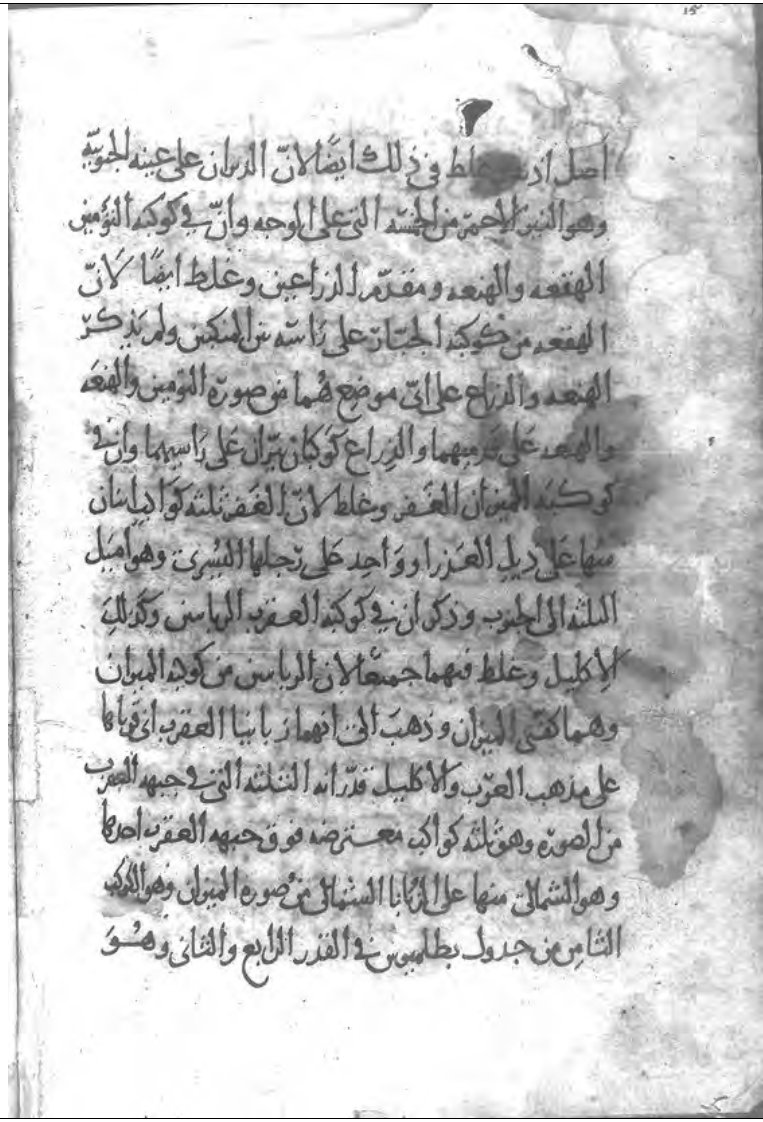
Folio 15

However he was mistaken in that also because *al-Dabarān* is located on its southern eye. It is the red and the brightest of the five stars on the face.

And (he mentioned) that in the constellation Gemini there are *al-Haq'a* and *al-Han'a* and the most forward of the two *al-Dhirāin*. However he was mistaken in this also because *al-Haq'a* is in the constellation Orion located on the head and between its shoulders. He did not mention the position of *al-Han'a* and *al-Dhirā'* in the constellation of Gemini. *Al-Han'a* and *al-Haq'a* are two stars on the feet (of Gemini). The *al-Dhirāin* are two bright stars on their heads.

Then he (*al-Battānī*) mentioned that in the constellation Libra there is *al-Ghafr*, but he was mistaken because *al-Ghafr* consist of three stars two of which are on the tail of Virgo and one on its left leg. (The last) is the one most oriented towards the south of the three stars (of *al-Ghafr*)

He also mentioned that in the constellation Scorpio there are the two *al-Zubānā* and *al-Iklīl* and he was mistaken in all those because the two *al-Zubānā* are located in the constellation Libra. They are on the shoulder of Libra. He went on saying that the two *al-Zubānā* are part of Scorpio and are located on its horn as per the method of the Arabs. We estimate that *al-Iklīl* consists of the three stars located on the horns and which are on the forehead of Scorpio and part of the main image of the constellation. These are the three stars crossing above the forehead of Scorpio. The first is the northernmost (star) on the northern arms in the constellation of Libra. It is the eighth star in Ptolemy's catalog and it is of the 4th magnitude.



Folio 16

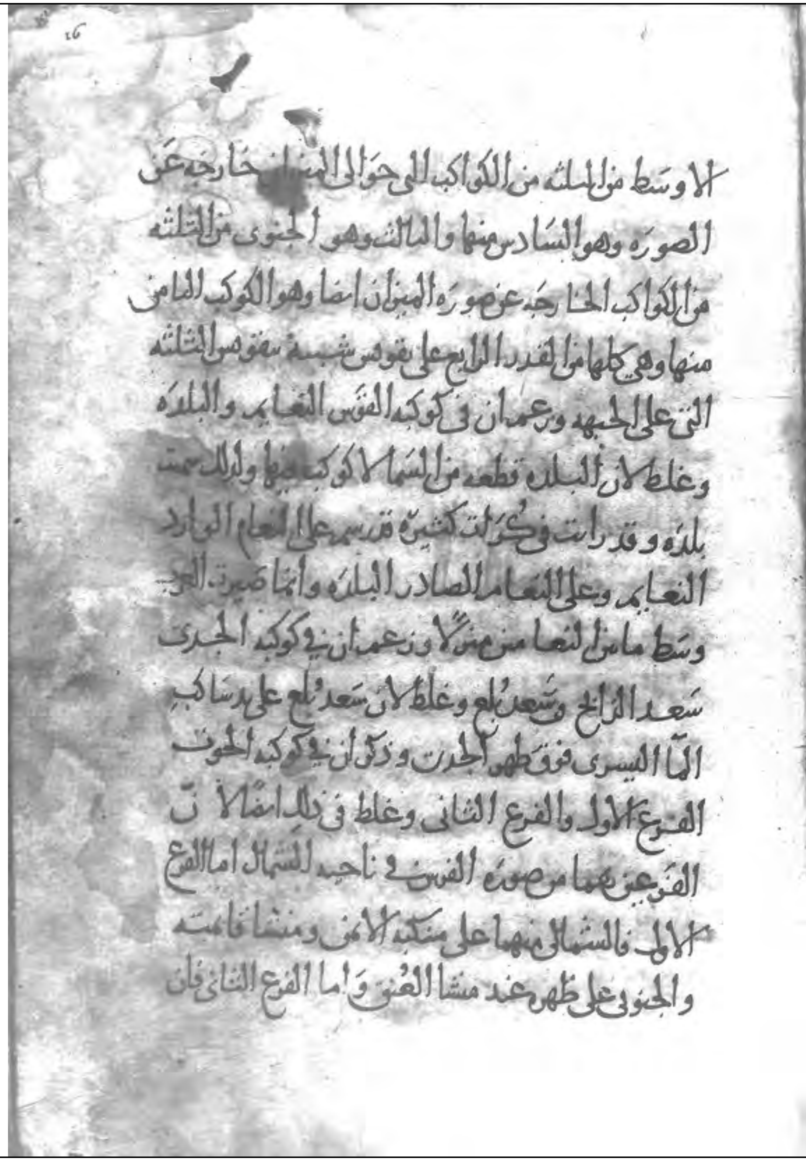
The second (star) is in the middle of the three and it is the sixth star around Libra outside of the constellation The third is the southernmost of the three and is the eighth of the stars outside of the constellation Libra also. They are all of the 4th magnitude forming an arc similar to the arc formed by the three (stars) on the forehead of Scorpio.

He (*al-Battānī*) pointed out that in the constellation Sagittarius there are *al-Na'ām* and *al-Balda* and he was mistaken because *al-Balda* is part of the sky which does not contain any star. That is why it was called *al-Balda*. I saw in many globes that *al-Na'ām* was drawn as *al-Na'ām al-Wārid* and *al-Na'ām al-Ṣādir* as *al-Balda*. The Arabs have assigned between the two *al-Na'ām* another mansion.

He mentioned that in the constellation Capricorn there is *Sa'd al-Dhābiḥ* and *Sa'd al-Bula'*, and he was mistaken because *Sa'd al-Bula'* is on the left arm of Aquarius above the constellation of Capricorn.

He (*al-Battānī*) mentioned that in the constellation Pisces there are *al-Fargh al-Awwal* and *al-Fargh al-Thānī* and he was mistaken in that also because those two *al-Fargh* are in the north of the constellation Pegasus.

As for *al-Fargh al-Awwal*, the northernmost (star of this asterism) is located on the beginning of the right leg and the southernmost star is located on the back on the beginning of the neck.


16

الاوسط من المثلثة من الكواكب التي حوالي الميزان خارجة عن
الصورة وهو السادس منها والثالث وهو الجنوبي من المثلثة
من الكواكب الخارجة عن صورة الميزان ايضا وهو الكوكب الثامن
منها وهي كلها من القدر الرابع على تقويس شبيه بتقويس الثلاثة
التي على الجبهة وزعم ان في كوكبة القوس النعايم والبلدة
وغلط لان البلدة قطعة من السما لا كوكب فيها ولذلك سميت
بلدة وقد رايت في كرات كثيرة قد رسم على النعام الوارد
النعايم وعلى النعام الصادر البلدة وانما صيرت العرب
وسط ما بين النعامين منزلا وزعم ان في كوكبة الجدي
سعد الذابح وسعد بلع وغلط لان سعد بلع على يد ساكب
الما اليسرى فوق ظهر الجدي وذكر ان في كوكبة الحوت
الفرغ الاول والفرغ الثاني وغلط في ذلك ايضا لان
الفرغين هما من صورة الفرس في ناحية الشمال اما الفرغ
الاول فالشمالي منهما على منكبه الايمن ومنشا قايمته
والجنوبي على ظهره عند منشا العنق واما الفرغ الثاني فان

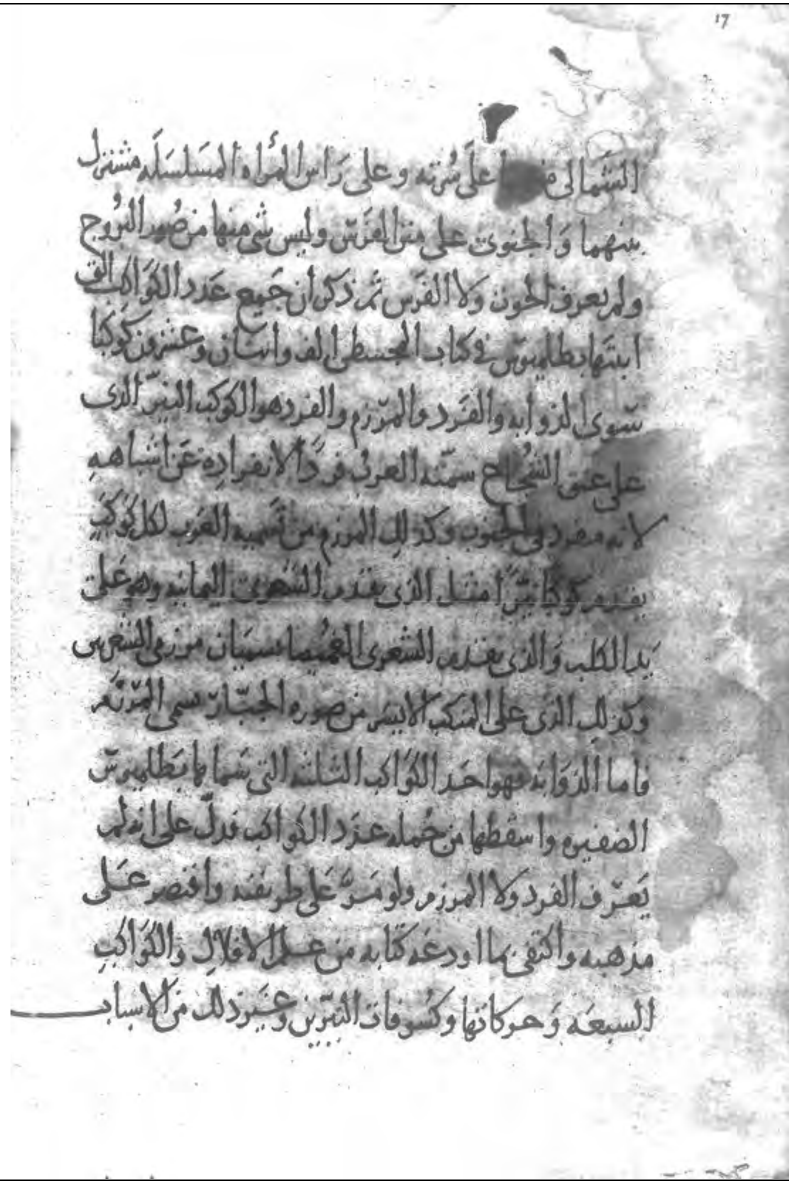
Folio 17

As for *al-Fargh al-Thānī* the northernmost star is located in the middle (of Pegasus) and on the head of Andromeda. It is the common (star) between them. The southernmost star is located in Pegasus. Neither of these two (asterism) are part of the zodiac constellation. He did not know the constellation of Pisces nor of Pegasus. Then he (*al-Battānī*) mentioned that the number of all the stars confirmed by Ptolemy in his *Almagest* are 1022 stars without (the asterism of) *al-Thuāba* and *al-Fard* and *al-Mirzam*.

Al-Fard is the bright star on the neck of (the constellation) Hydra. The Arabs call it *al-Fard* because it is remote from its fellow (stars) and it is on its own in the south. As for *al-Mirzam*, the Arabs call this name to every star which precedes a bright star. This is similar to the star which precedes the star *al-Shi'ra al-Yamāniya* (Sirius) located on the paw of Canis. The star which precedes the bright *al-Shi'ra* is also called *Mirzam al-Shi'ra*, and so is the star on the left hand of Orion is also called *al-Mirzam.*

As for *al-Thuāba* it is one of three stars that Ptolemy called *al-Dhafīra* and which was not mentioned as part of the number of stars.

This shows that he (*al-Battānī*) did not know *al-Fard* or *al-Mirzam.* If he stayed in his field and kept to what his book mentioned on the science of obits, the movements of the seven planets, the eclipse of the Sun and the Moon and the other matters of the stars….

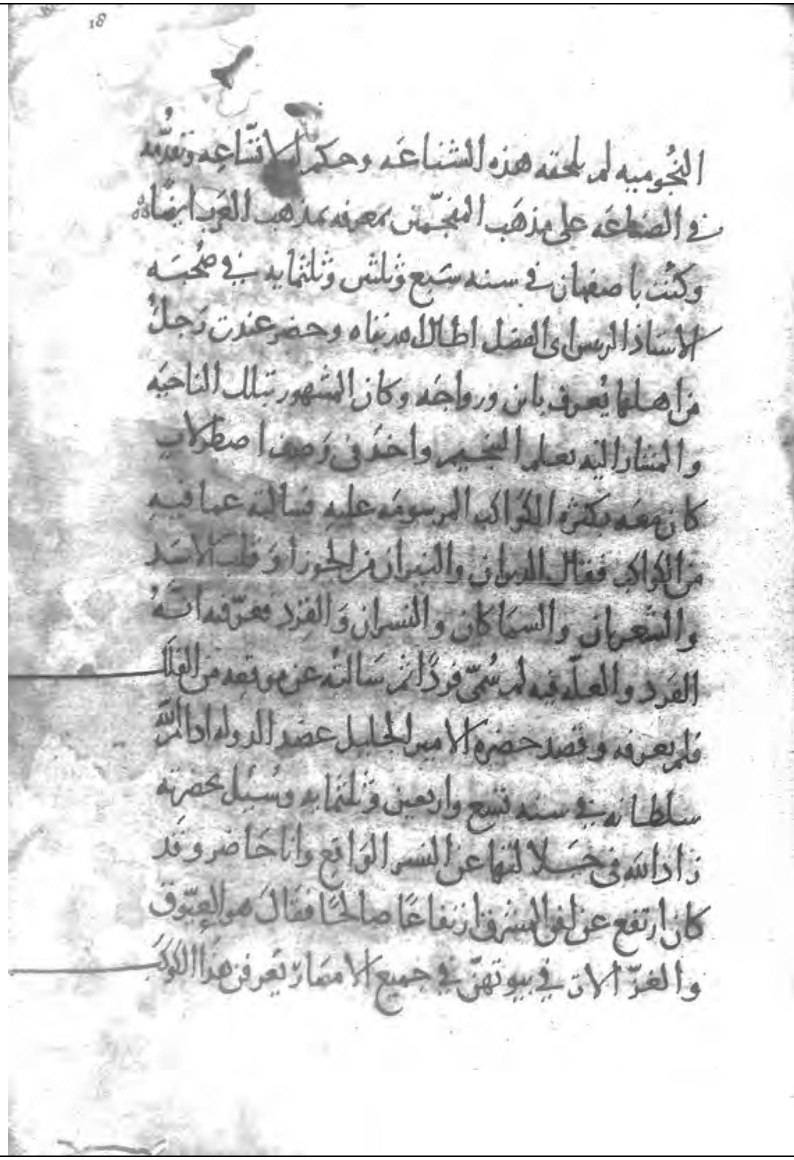

17
الشمالي ... على سرته وعلى راس المراة المسلسلة مشترك
بينهما والجنوبي على متن الفرس وليس شي منها من صور البروج
ولم يعرف الحوت ولا الفرس ثم ذكر ان جميع عدد الكواكب التي
اثبتها بطليموس في كتاب المجسطي الف واثنان وعشرون كوكبا
سوى الذوابة والفرد والمرزم والفرد هو الكوكب النير الذي
على عنق الشجاع سمته العرب فردا لانفراده عن اشباهه
لانه منفرد في الجنوب وكذلك المرزم من تسمية العرب لكل كوكب
يتقدم كوكبا نيرا مثل الذي يتقدم الشعرى اليمانية وهي على
يد الكلب والذي يتقدم الشعرى الغميصا يسميان مرزمي الشعريين
وكذلك الذي على المنكب الايسر من صورة الجبار سمي المرزم
فاما الذوابة فهو احد الكواكب الثلاثة التي سماها بطليموس
الضفيرة واسقطها من جملة عدد الكواكب فدل على انه لم
يعرف الفرد ولا المرزم ولو مر على طريقته واقتصر على
مذهبه واكتفى بما اودعه كتابه من علم الافلاك والكواكب
السبعة وحركاتها وكسوفات النيرين وغير ذلك من الاسباب

Folio 18

….he would not have been tainted with all this dreadful things and he would have kept his wide knowledge and importance in this science in the method of astronomers and not in the method of the Arabs.

I was in Isfahan in the year (A.H.) 337 in the company of the grand teacher *Abu al-Faḍel*, may God prolong his life. A man from that city known as Ibn Rawāha came to me. He was known in that area in the science of astrology. He started to describe in detail an Astrolabe which was with him and the stars which were drawn in it. I asked him what stars were drawn on it (the astrolabe) and he said *al-Dabarān*, the two bright stars of *al-Jauzā’* (Orion), *Qalb al-Asad* (Antares), the two *al-Shi’ra* (Sirius and Proycon), the two *al-Simāk,* the two *al-Nasr* and *al-Kurd*. I immediately knew that he was mentioning *al-Fard*. His mistake was that he did not name it as *al-Fard.* Then I asked him about its (*al-Fard’s*) position in the sky but he did not know it.

In the year A.H. 349, he (Ibn Rawāha) was visiting the grand prince ‘Aḍud al-Dawla, may God prolong his life, while I was present. He was asked in his presence about *al-Nasr al-Wāqi’* which had risen well above the eastern horizon and he said it was *al-‘Ayyūk*. However every woman in their homes in all the countries knows this star and they call it *al-Athāfī.*



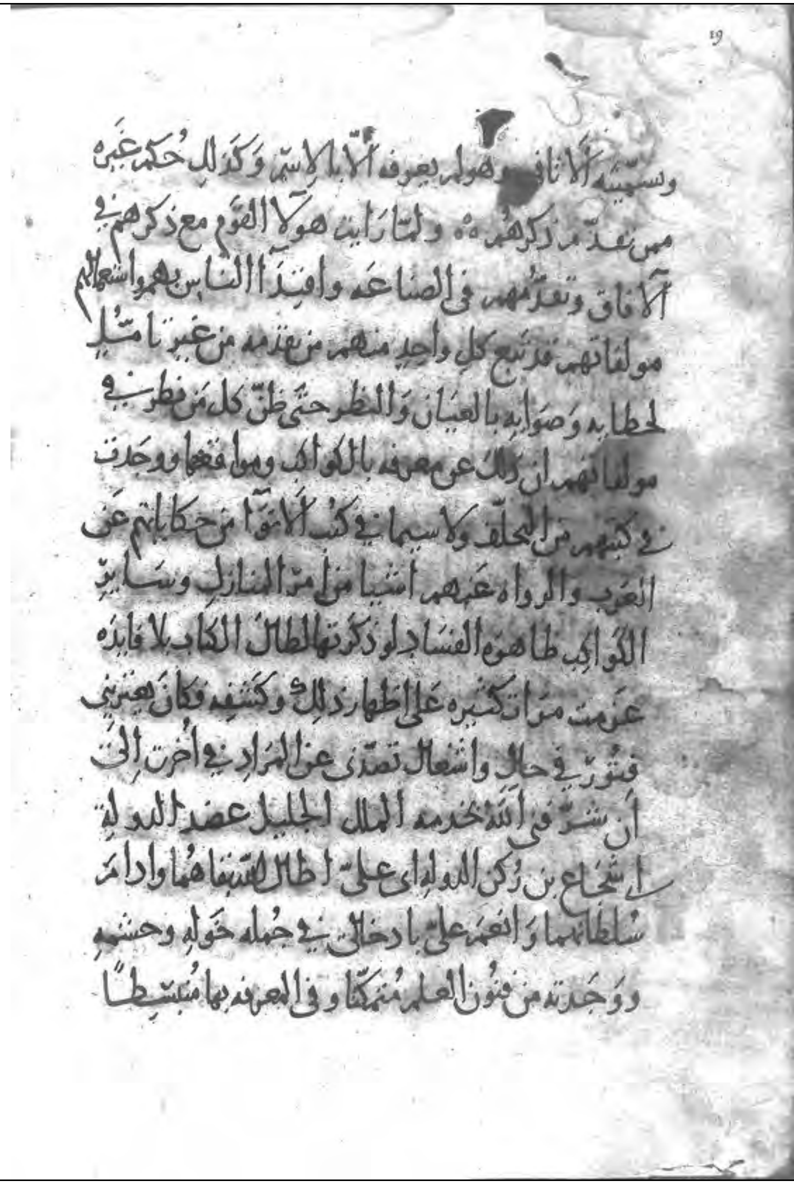
Folio 19

However he did not know it by name.

Such is the condition of all those people which were mentioned earlier. Therefore I saw that all these people who were well known and are leaders in this science and people follow them and use their books without knowing the right from wrong with respect to observation. Every body who read their books believed that they are well versed in the knowledge of the stars and their positions.

However I found in their books many errors especially in the books of *al-Anwā'* and the stories which they obtained from the Arabs, and those who copied from them. I found many bad things about the Lunar mansions and the rest of the stars which if I mention here I would prolong this book uselessly.

I wanted many times to reveal this and expose it but I either felt sluggish or I had many things which occupied me from this task until God honored me with serving the benevolent king 'Aḍud al-Dawla Abū Shuja' Rukn al-Dawla Abū 'Alī may God prolong their lives and their rule and (God) privileged me by accepting me in his ('Aḍud al-Dawla) patronage. I found him to be capable in all fields of science and strong in its knowledge….



Folio 20

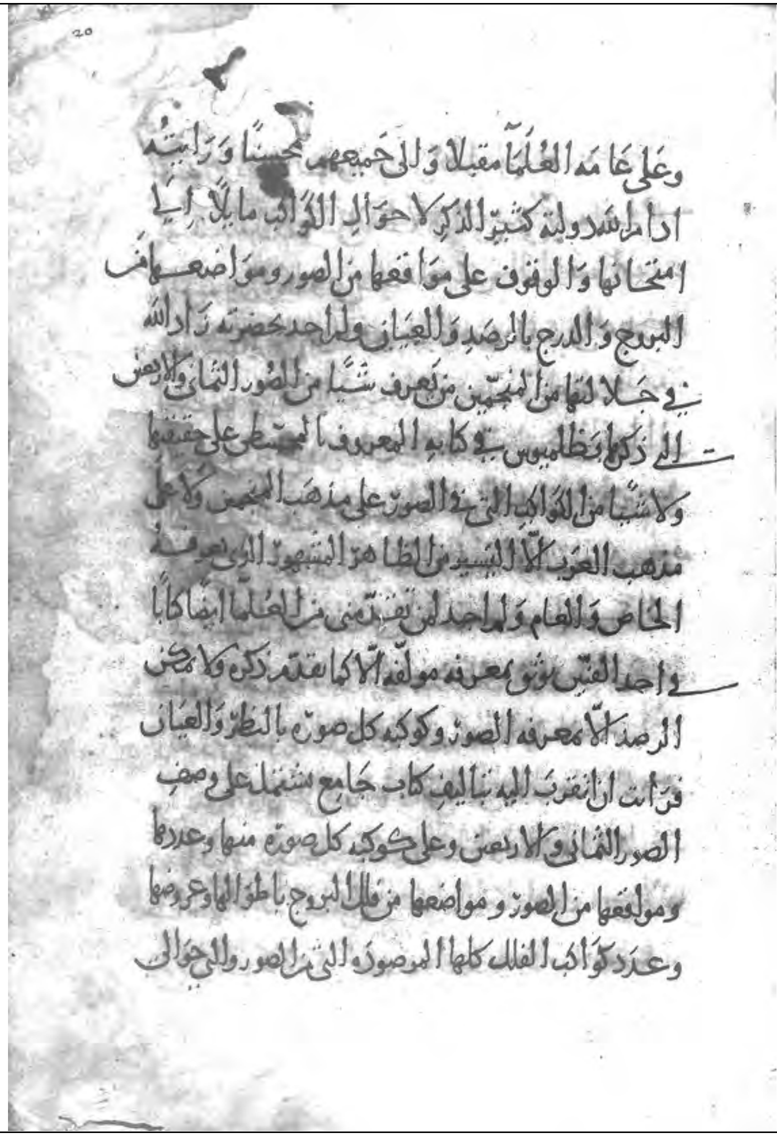
….and open and generous to all scientists.

I saw him, may God prolong his reign, always mentioning the stars leaning towards questioning and locating their positions in the constellations and their location on the zodiac by performing exact astronomical observation.

However I did not find in his presence, may God increase his signifance, any astronomers who knew any thing about the 48 constellations which Ptolemy mentioned in his well known book of the *Almagest*. Nor (did I find) any (who knew) of the stars that were mentioned by the astronomers or any (who knew of the stars) as per the method of the Arabs except the least bit of information which is well known to all the normal and expert people.

I also did not find from any of those scientist who came before me any book in either of the two arts of this science which confirms the knowledge of its writer except those that I mentioned before. And it is impossible to make any observation until the constellations and the stars in every constellation are known and confirmed by observation.

Therefore I saw fit to approach him (‘Aḍud al-Dawla) by writing a comprehensive book describing the 48 constellations, the number and location of each star in these constellations, their celestial positions in latitude and longitude as well as the total number of observed stars in the sky which form the main image of the constellations….



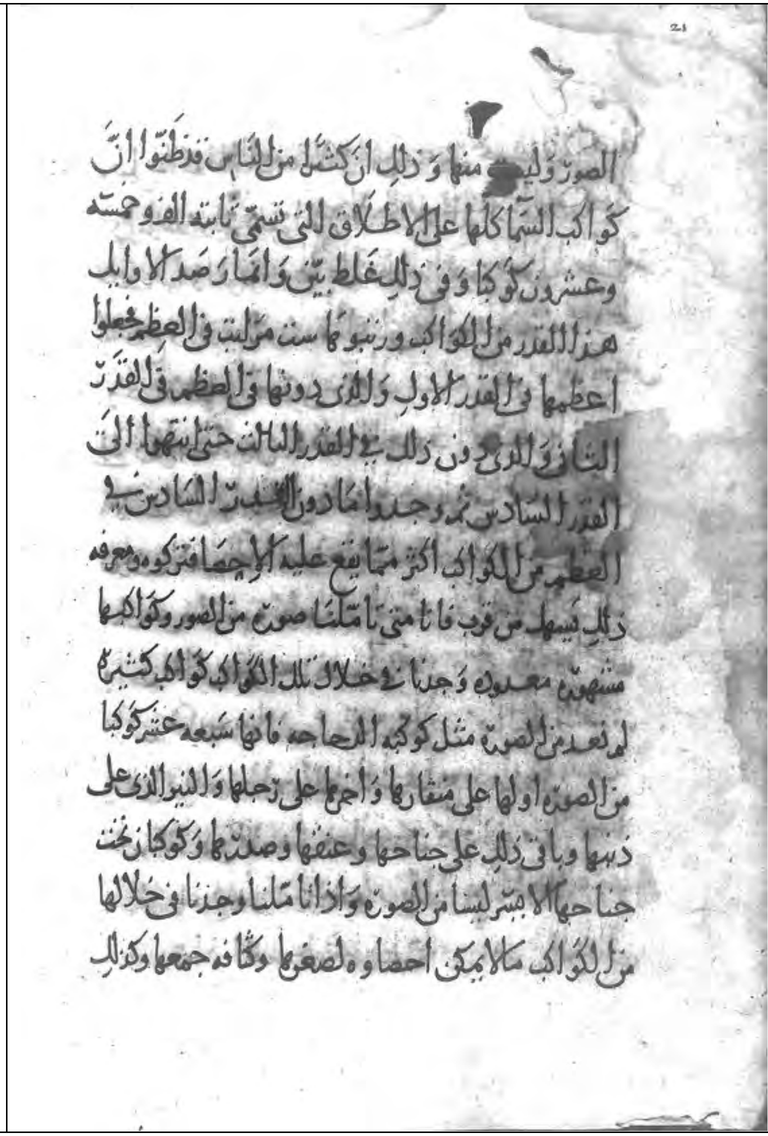
Folio 21

…..and those that surround them but are not part of them.

Many people believe that the total number of stars in the sky, which are called fixed stars, is 1025 stars. However this is an obvious mistake because ancient astronomers observed this number of stars and they divided them into 6 divisions of brightness.

They made the brightest as the 1st magnitude and those a little fainter in the 2nd magnitude then the one below that in the 3rd magnitude until they reached up to the 6th magnitude. They found the number of stars below the 6th magnitude more than they could count so they left them.
This fact can be confirmed when we look at any of the constellation and its well known stars. We find around those stars many other stars which were not counted and which are part of the same constellation.

For example in the constellation Cygnus there are 17 stars forming the constellation. The first (star) is on its beak and the last is the bright star on its leg and on its tail. The rest (of the stars) are on its wings, on its neck and on its chest. There are two stars under the left wing which are not part of the constellation. Therefore when we look closely we find many stars which we can not count because of their small sizes and their closeness together. This applies to all the other constellations.


21

الصور وليس منها وذلك ان كثيرا من الناس قد ظنوا ان
كواكب السما كلها على الاطلاق التي تسمى ثابتة الف وخمسة
وعشرون كوكبا وفي ذلك غلط بين وامارة ضد الا وايل
هذا القدر من الكواكب ورتبوها ست مراتب في العظم فجعلوا
اعظمها في القدر الاول والتي دونها في العظم في القدر
الثاني والتي دون ذلك في القدر الثالث حتى انتهوا الى
القدر السادس ثم وجدوا ما دون القدر السادس في
العظم من الكواكب اكثر مما يقع عليه الاحصا فتركوه ومعرفة
ذلك يسهل من قرب فانا متى تاملنا صورة من الصور وكواكبها
المشهورة المعدودة وجدنا في خلال تلك الكواكب كواكب كثيرة
لم تعد من الصورة مثل كوكبة الدجاجة فانها سبعة عشر كوكبا
من الصورة اولها على منقارها واخرها على رجلها والنير الذي على
ذنبها وباقي ذلك على جناحيها وعنقها وصدرها وكوكبان تحت
جناحها الايسر ليسا من الصورة واذا تاملنا وجدنا في خلالها
من الكواكب ما لا يمكن احصاوه لصغرها وكثافة جمعها وكذلك

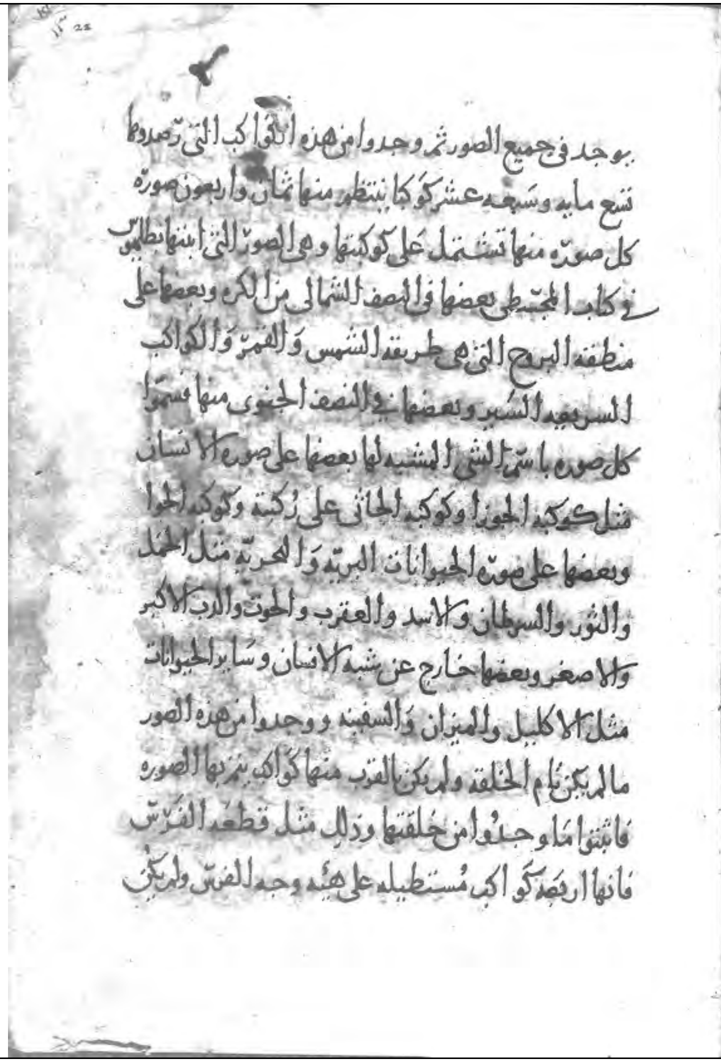
Folio 22

Then they (ancient astronomers) found that the number of observed stars is 917 stars which form the 48 constellations. Every constellation contains its own stars and these are the constellations which Ptolemy confirmed in the book *Almagest*.

Some (of these stars) are in the northern half of the sphere, some on the area of the zodiac which is on the path of the Sun, Moon and the fast moving stars (Planets), and some on the southern half of it (sphere).

They named every constellation according to what it resembles. some (they named) in the form of humans like the constellation Gemini, Hercules and Ophiuchus, some in the form of wild or marine animals such as Aries, Taurus, Cancer, Leo, Scorpio, Pisces and Ursa Major and Minor, and some not resembling Human beings and other animals such as The Corona, Libra and Argo Navis.

They (also) found that some of these constellations do not form complete images and there were no other surrounding stars to complete the image of the constellation. Therefore they confirmed what they found of its form. Such is the example of (constellation) Equuleus which consists of 4 stars forming a rectangle resembling the face of a horse.


بوجد في جميع الصور ثم وجدوا من هذه الكواكب التي رصدوها
تسع مايه وسبعه عشر كوكبا ينتظم منها ثمان واربعون صوره
كل صوره منها تشتمل على كوكبها وهي الصور التي اثبتها بطلميوس
في كتاب المجسطي بعضها في النصف الشمالي من الكره وبعضها على
منطقه البروج التي هي طريقه الشمس والقمر والكواكب
السريعه السير وبعضها في النصف الجنوبي منها فسموا
كل صوره باسم الشي المشبه لها بعضها على صوره الانسان
مثل كوكبه الجوزا وكوكبه الجاثي على ركبته وكوكبه الحوا
وبعضها على صوره الحيوانات البريه والبحريه مثل الحمل
والثور والسرطان والاسد والعقرب والحوت والدب الاكبر
والاصغر وبعضها خارج عن شبه الانسان وساير الحيوانات
مثل الاكليل والميزان والسفينه ووجدوا من هذه الصور
ما لم يكن تام الخلقه ولم يكن بالقرب منها كواكب يتم بها الصوره
فاثبتوا ما وجدوا من خلقتها وذلك مثل قطعه الفرس
فانها اربعه كواكب مستطيله على هيئه وجه الفرس ولم يكن

Folio 23

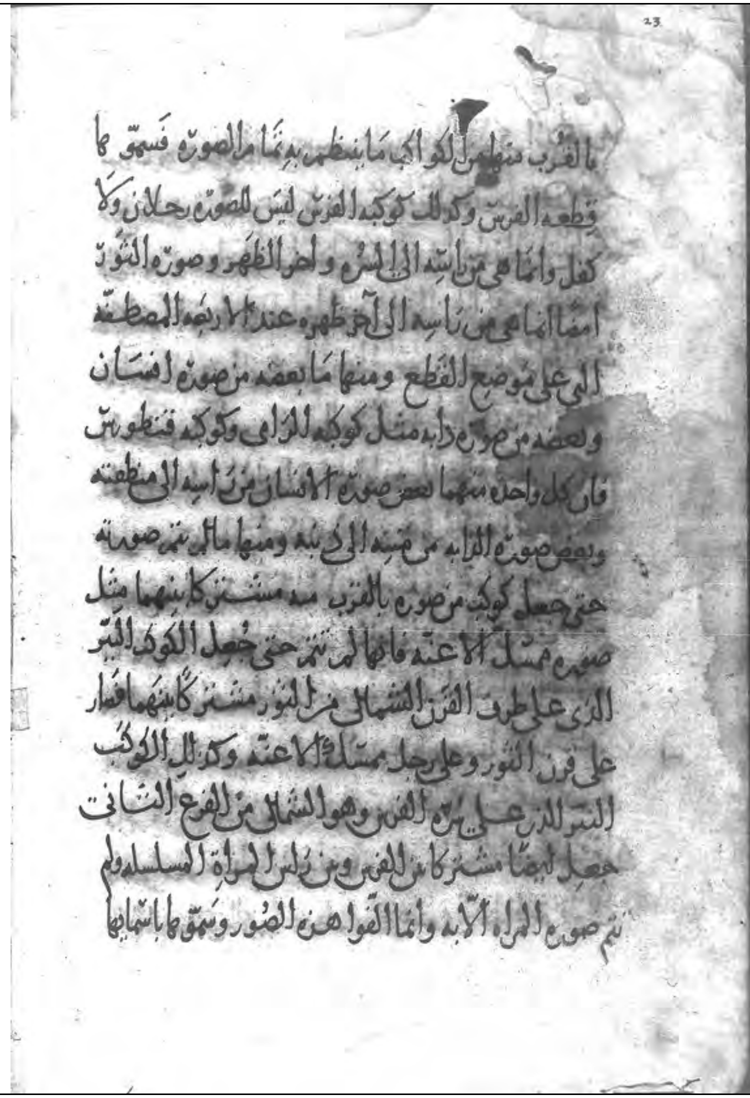
There were no surrounding stars to complete the image of the constellation so they named it Equuleus (section of a horse).

Another example is the constellation Pegasus because the image of this constellation does not include any legs or hind. It starts from its head until the navel reaching to the end of its back. The image of Taurus also starts from its head until the end of its back up to the four aligned stars on the cut-off section.

Some (constellations also) consist of part human form and part beast such as the constellations of Sagittarius and Centaurus. Because each one of these (constellations) consists of two parts the first is a human from which starts from its head until the middle and the second part resembles a beast which starts from its stomach until the tail.

Some (constellations) do not form a complete image until another star from another surrounding constellation is shared between the two. Such is the case of constellation Auriga because it is not complete until the bright star on the end of the northern horn of Taurus is shared between the two (constellations). Therefore it (the common star) is to be found on the horn of Taurus and on the leg of Auriga. Another example is the bright star on the middle of Pegasus which is the northern star of *al-Fargh al-Thānī*. This (star) is also shared between Pegasus and the head of Andromeda. This is because the image of the woman (Andromeda) is not complete without it.

When they (ancient astronomers) made up these constellations they named them by distinct names……


23

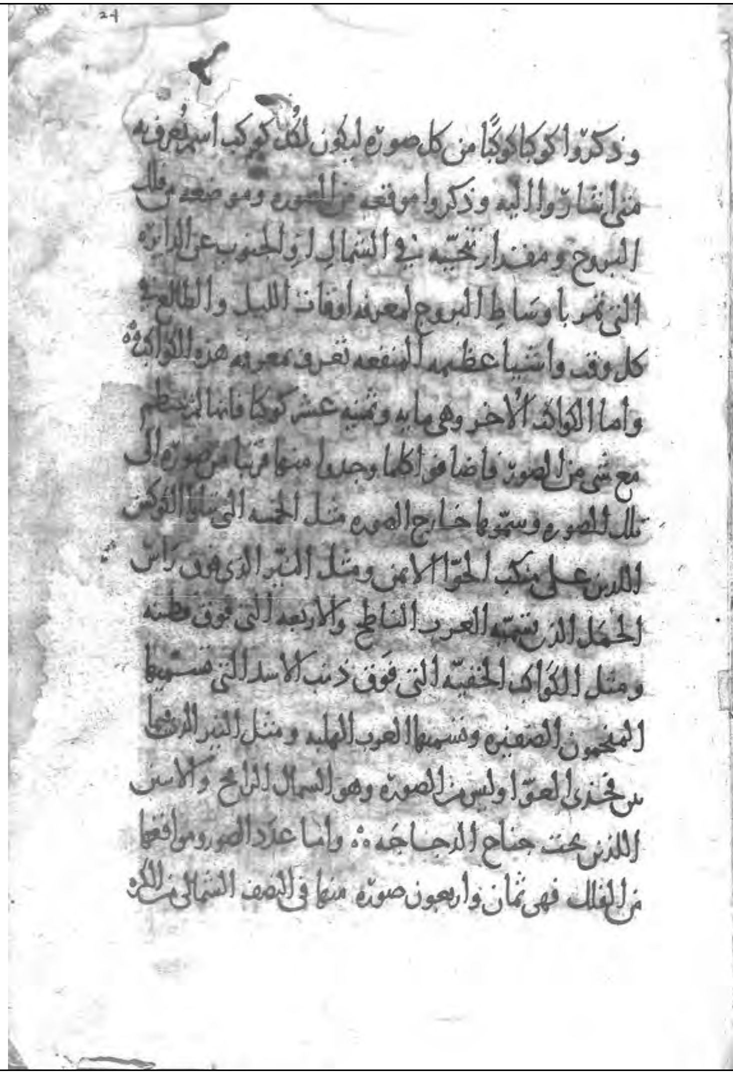
ما القرب منها من الكواكب ما ينتظم به تمام الصورة فسموها
قطعة الفرس وكذلك كوكبة الفرس ليس للصورة رجلان ولا
كفل وانما هي من راسه الى السرة واخر الظهر وصورة الثور
ايضا انما هي من راسه الى اخر ظهره عند الاربعة المنتظمة
التي على موضع القطع ومنها ما بعضه من صورة انسان
وبعضه من صورة دابة مثل كوكبة الرامي وكوكبة قنطورس
فان كل واحد منهما بعض صورة الانسان من راسه الى منطقته
وبعض صورة الدابة من منطقته الى ذنبه ومنها ما لم تتم صورته
حتى جعل كوكب من صورة بالقرب منه مشتركا بينهما مثل
صورة ممسك الاعنة فانها لم تتم حتى جعل الكوكب النير
الذي على طرف القرن الشمالي من الثور مشتركا بينهما فصار
على قرن الثور وعلى رجل ممسك الاعنة وكذلك الكوكب
النير الذي على سرة الفرس وهو الشمالي من الفرغ الثاني
جعل ايضا مشتركا بين الفرس وبين راس المراة المسلسلة ولم
تتم صورة المراة الا به وانما الفوا هذه الصور وسموها باسمائها

Folio 24

….. and they mentioned every star in each of these constellation so that every star can be individually recognized by its name when they need to point to it or when they mention its location in the constellation or its location on the zodiac or the deg of its movement from the north or the south from the circle which crosses the middle of the zodiac. This is done in order to know the time at night and the rising of the stars every day as well as many other great things which could be known by the knowledge of these stars.

As for the other stars they consist of 118 stars. They did not belong to any of the constellations. However they combined them with the constellations when ever they found them close to these constellations and they referred to them as outside of the constellations. Such is the example of the five (stars) which come after the two stars on the hand of Orion. Another example is the bright (star) which is above the head of Aries which the Arabs call *al-Nāṭiḥ* and the four (stars) above its stomach. Another example is the dim stars which are above the tail of Leo which are called by astronomers *al-Ḍafira* to which the Arabs call *al-Halba*. Another example is the bright star which is above the thighs of Bootes. It is not part of the constellation and is called *al-Simāk al-Rāmiḥ* as well as the two (stars) under the wings of Cygnus.

As for the number of constellations and their location on the sphere, for they are 48 constellations, …..



Folio 25

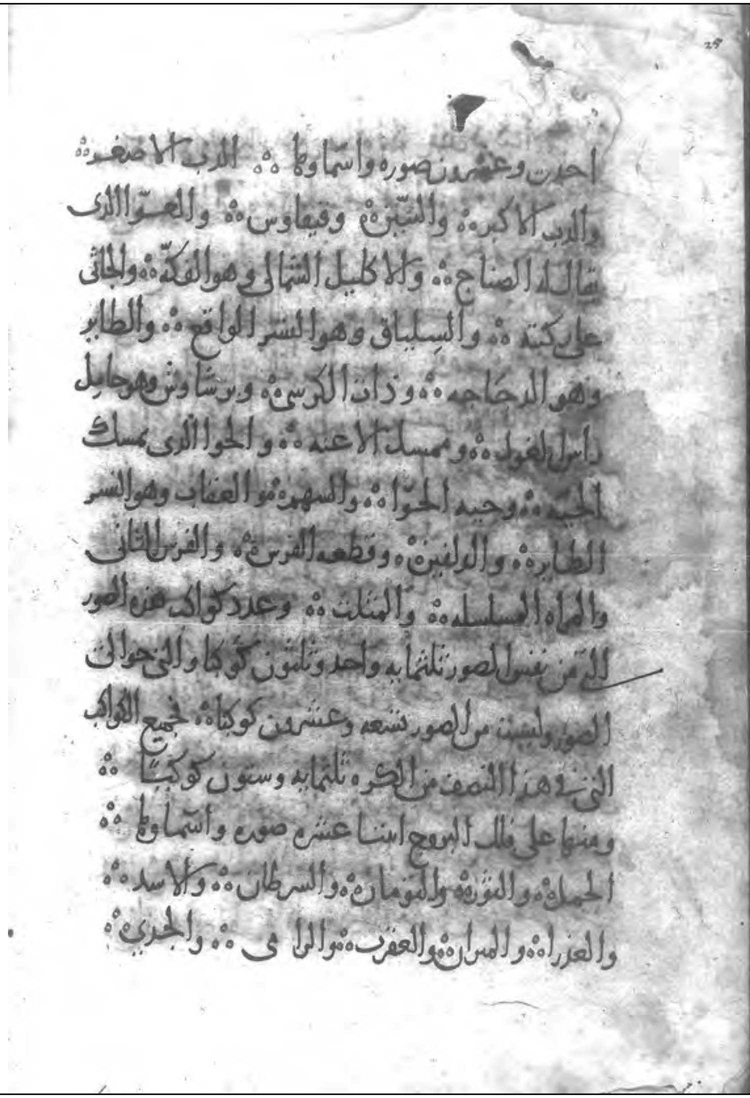
……21 of which are on the northern part of the sphere and they are named:

Ursa Minor, Ursa Major, Draco, Cepheus, Bootes, Corona Borealis, Hercules, Lyra, Cygnus, Cassiopeia, Perseus, Auriga, Ophiuchus, Serpens, Sagitta, Aquila, Dephinus, Equuleus, Pegasus, Andromeda and Triangulum.

The numbers of stars which are part of these constellations are 331. The number of stars surrounding these constellations and which are not considered part of these constellations are 29 stars. Therefore all the stars which are in this part of the sphere are 360 stars.

The number of (constellations) which are on the ecliptic are 12 constellations and they are named:

Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricorn, Aquarius and Pisces.



احدى وعشرون صورة واسماوها ؞ الدب الاصغر ؞
والدب الاكبر ؞ والتنين ؞ وقيقاوس ؞ والعواء الذي
يقال له الصايح ؞ والاكليل الشمالي وهو الفكة ؞ والجاثي
على ركبته ؞ والسلياق وهو النسر الواقع ؞ والطاير
وهو الدجاجة ؞ وذات الكرسي ؞ وبرشاوش وهو حامل
راس الغول ؞ وممسك الاعنة ؞ والحوا الذي يمسك
الحية ؞ وحية الحوا ؞ والسهم ؞ والعقاب وهو النسر
الطاير ؞ والدلفين ؞ وقطعة الفرس ؞ والفرس الثاني
والمراة المسلسلة ؞ والمثلث ؞ وعدد كواكب هذه الصور
التي من نفس الصور ثلثماية وواحد وثلثون كوكبا والتي حوالي
الصور وليست من الصور تسعة وعشرين كوكبا ؞ فجميع الكواكب
التي في هذا النصف من الكرة ثلثماية وستون كوكبا ؞
ومنها على فلك البروج اثنا عشر صورة واسماوها ؞
الحمل ؞ والثور ؞ والتوامان ؞ والسرطان ؞ والاسد ؞
والعذراء ؞ والميزان ؞ والعقرب ؞ والرامي ؞ والجدي ؞

Folio 26

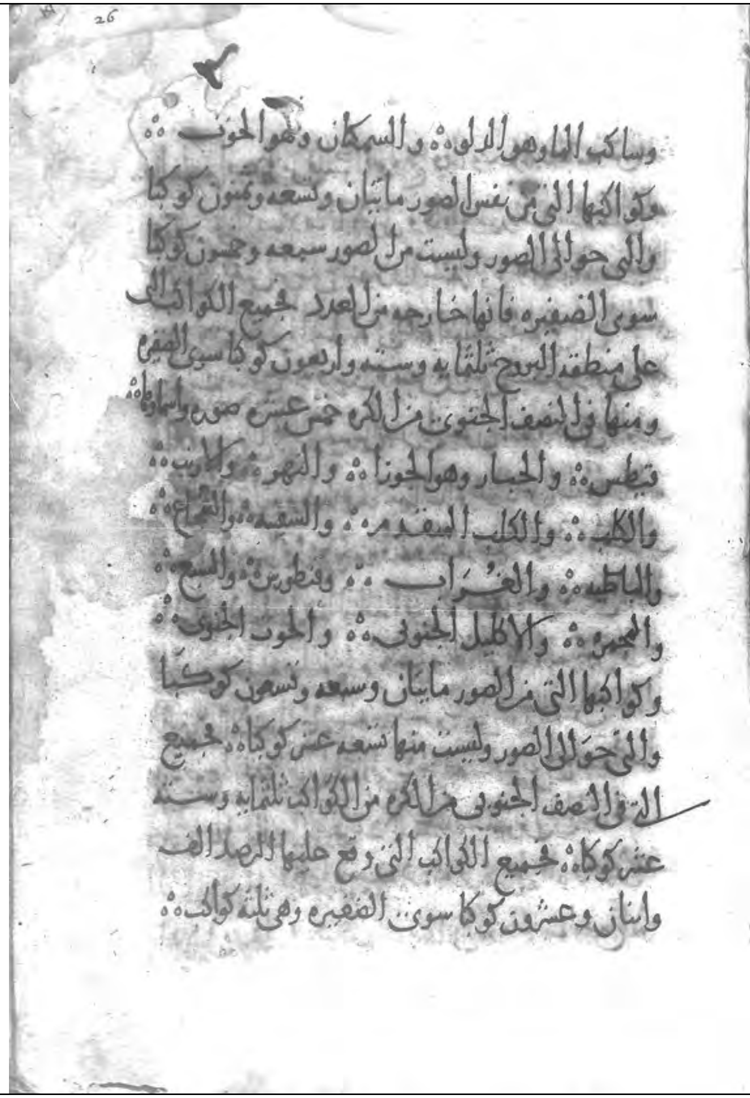
The numbers of stars which are part of these constellations are 289 stars. The number of stars surrounding these constellations and which are not considered parts of these constellations are 57 stars except (the stars of) *al-Ḍafira* because they were not counted. Therefore all the stars which are on the ecliptic are 346 stars except *al-Ḍafira*.

The number of (constellations) on the southern part of the sphere are 15 constellations and they are named:

Cetus, Orion, Eridanus, Lepus, Canis Major, Canis Minor, Argo Navis, Hydra, Crater, Corvus, Centaurus, Lupus, Ara, Corona Australis and Piscis Austrinus.

The numbers of stars which are part of these constellations are 297 stars. The number of stars surrounding these constellations and are not considered part of these constellations are 19 stars. Therefore all the stars which are in the southern part of the sphere are 316 stars.

Therefore all the stars which have been observed (by ancient astronomers) are 1022 stars except *al-Ḍafira* which consist of 3 stars.


26

وساكب الماء وهو الدلو ؛ والسمكتان وهو الحوت ؛
فكواكبها التي من نفس الصور مائتان وتسعة وثمانون كوكبا
والتي حوالي الصور وليست من الصور سبعة وخمسون كوكبا
سوى الضفيرة فانها خارجة من العدد فجميع الكواكب التي
على منطقة البروج ثلثمائة وستة واربعون كوكبا سوى الضفيرة
ومنها في النصف الجنوبي من الكرة خمس عشرة صورة واسماؤها
قيطس ؛ والجبار وهو الجوزاء ؛ والنهر ؛ والارنب ؛
والكلب ؛ والكلب المتقدم ؛ والسفينة ؛ والشجاع ؛
والباطية ؛ والغراب ؛ وقنطورس ؛ والسبع ؛
والمجمرة ؛ والاكليل الجنوبي ؛ والحوت الجنوبي ؛
وكواكبها التي من الصور مائتان وسبعة وتسعون كوكبا
والتي حوالي الصور وليست منها تسعة عشر كوكبا ؛ فجميع
التي في النصف الجنوبي من الكرة من الكواكب ثلثمائة وستة
عشر كوكبا ؛ فجميع الكواكب التي وقع عليها الرصد الف
واثنان وعشرون كوكبا سوى الضفيرة وهي ثلثة كواكب ؛

Folio 27

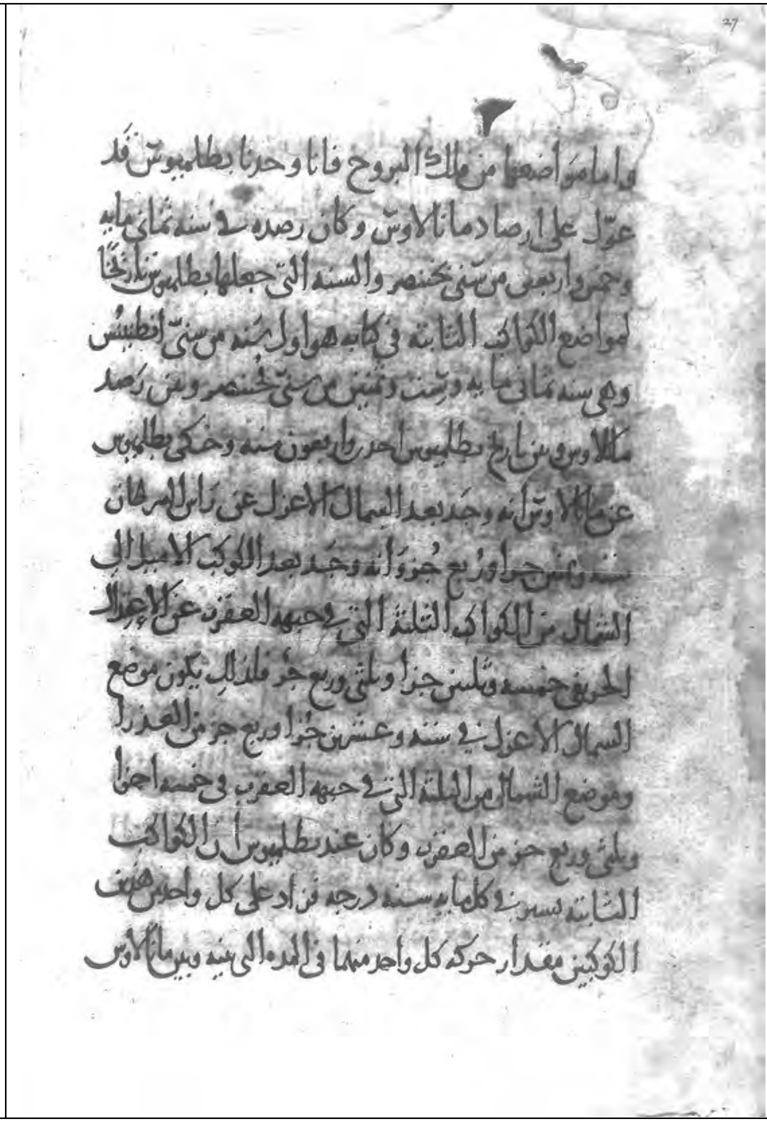
As for their locations on the ecliptic we have found that Ptolemy used the observations of Menelaus who made his observations in the year 845 of the year of *Naboukhat Nassar* (Nabonassar).

The year that Ptolemy made as reference for the location of the fixed stars in his book is the first year of the era of Antoninus (Roman emperor A.D. 138-161) which is in the year 886 of the era of *Naboukhat Nassar*.

The time difference between the observations of Menelaus and the date of Ptolemy is 41 years.

Ptolemy referred to Menelaus as saying that he found the distance between *al-Simāk al-A'zal* and the head of Cancer to be 68 and ¼ of a deg. And he found the distance of the northernmost star of the three (stars) on the forehead of Scorpio to the autumnal equinox to be 35 and 2/3 and ¼ of a deg. Therefore the position of *al-Simāk al-A'zal* should be 26 and ¼ of a deg in Virgo, and the position of the northernmost star of the three (stars) on the forehead of Scorpio is 5 and ¼ in Scorpio.

Ptolemy mentioned that the fixed stars move every 100 years by one deg. Therefore he added on every one of these stars the yearly amount for the (precession) movement between his own time and that of Menelaus…..


27
واما مواضعها من فلك البروج فانا وجدنا بطلميوس قد
عول على ارصاد مانالاوس وكان رصده في سنة ثماني مائة
وخمس واربعين من سني بختنصر والسنة التي جعلها بطلميوس تاريخا
لمواضع الكواكب الثابتة في كتابه هو اول سنة من سني انطنيس
وهي سنة ثماني مائة وست وثمانين من سني بختنصر وبين رصد
مانالاوس وبين تاريخ بطلميوس احد واربعون سنة وحكى بطلميوس
عن مانالاوس انه وجد بعد السماك الاعزل عن راس السرطان
ستة وستين جزوا وربع جزو وانه وجد بعد الكوكب الاشمالي
الشمالي من الكواكب الثلثة التي في جبهة العقرب عن الاعتدال
الخريفي خمسة وثلثين جزوا وثلثي وربع جزو فلذلك يكون موضع
السماك الاعزل في ستة وعشرين جزوا وربع جزو من العذرا
وموضع الشمالي من الثلثة التي في جبهة العقرب في خمسة اجزا
وثلثي وربع جزو من العقرب وكان عند بطلميوس ان الكواكب
الثابتة تسير في كل مائة سنة درجة فزاد على كل واحد من هذين
الكوكبين مقدار حركة كل واحد منهما في المدة التي بينه وبين مانالاوس

Folio 28

…….which is approximately 41 years and 25 minutes.

Therefore he placed *al-Simāk al-A'zal* at 26 and 2/3 of a deg in Virgo and the position of northernmost star on the forehead of Scorpio at 6 and 1/3 of a deg in Scorpio. Then he added this difference to all the stars which he cataloged in the book *Almagest*.

Then the authors of *al-Mumtaḥen* (tables) observed (the stars) and they found that they have moved from the positions which where mentioned by Menelaus by one deg every 66 years which was the time difference in years between their observations and the observation of Menelaus.

The time difference in years which we have adopted as reference for the position of the stars in this book, starting from the beginning of the year 1276 in the era of *Thū al-Qarnaīn* (Alexander the Great) (A.D. 964) and between the observations of Menelaus was 866 years.

The amount of the movement of the stars in these years is approximately 13 deg and 7 min every 66 years. Therefore if we subtracted from this the amount which Ptolemy added on every star which is 25 min……


من السنين وهي الاحدى واربعين سنة خمس وعشرون دقيقة
بالتقريب فوضع موضع السماك الاعزل في ست وعشرين
درجة وثلثي درجة من العذرا وموضع الكوكب الشمالي الذي في
جبهة العقرب في ست درجات وثلث درجة من العقرب ثم زاد
هذه الزيادة على جميع الكواكب ووضعها في كتاب المجسطي في
الجدول ثم رصد اصحاب الممتحن فوجدوها قد
تحركت عن مواضعها التي ذكرها مانالاوس في كل ستة وستين
سنة درجة في المدة التي بين ارصادهم وارصاد مانالاوس
من السنين وكان بين الوقت الذي جعلناه تاريخا لمواضع الكواكب
في هذا الكتاب وهو اول سنة الف ومائتين وست وسبعين من سني
ذي القرنين وبين رصد مانالاوس من السنين ثماني مائة وستة
وستون سنة فيكون حركات الكواكب في هذه السنين على ان
حركتها في كل ستة وستين سنة درجة ثلث عشرة درجة وسبع
دقائق بالتقريب فاذا انقصنا من ذلك مقدار ما قد زاده بطليموس
على كل كوكب وهو خمس وعشرون دقيقة بقي ما يجب ان زاد

Folio 29

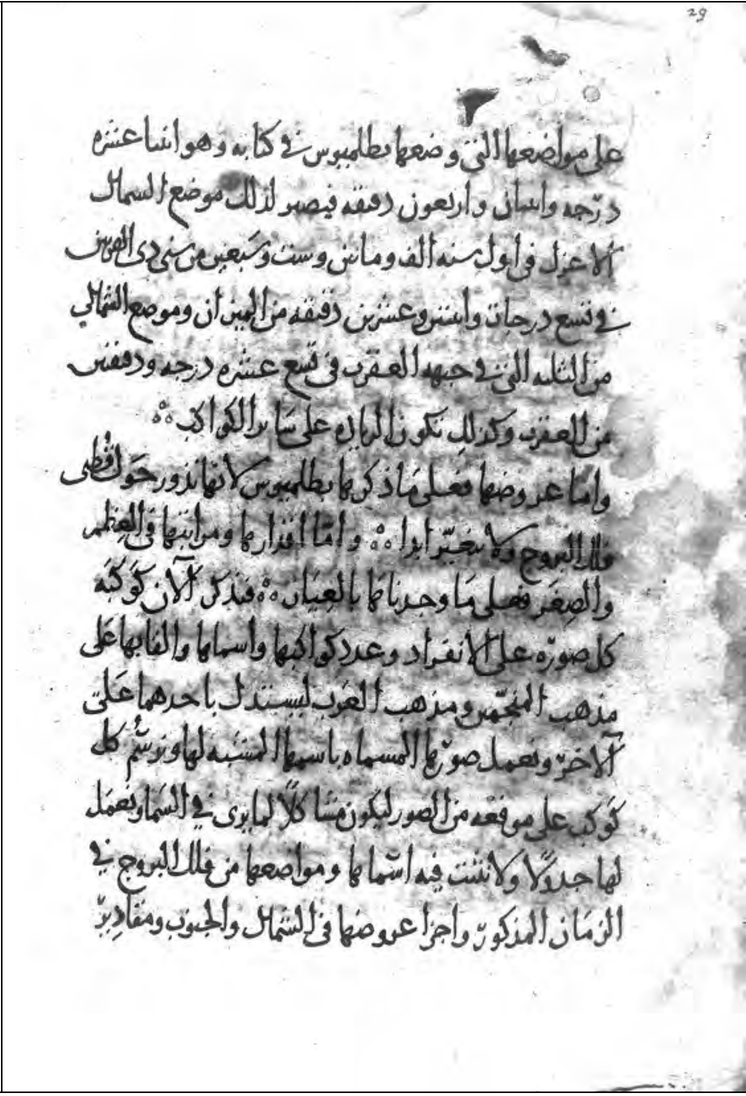
…..we are left with what is supposed to be added to the positions (of the stars) in Ptolemy’s book which is 12 deg 42 min.

Therefore the position of *al-Simāk al-A’zal* in the beginning of the year 1276 in the era of *Thū al-Qarnaīn* becomes 9 deg 22 min in Libra, and the position of the northernmost star of the three on the forehead of Scorpio becomes 19 deg and 2 min in Scorpio. This is the addition which should be applied to all the stars.

As for the latitudes, as Ptolemy mentioned, since they rotate around the poles of the ecliptic therefore they do not ever change.

As for the magnitudes (of the stars) and their level of brightness and dimness, which we observed our self, we will mention every constellation separately and the number of stars it contains and their names and aliases as per the method of astronomers and the Arabs so you can distinguish one from the other.

We will make images which correspond to their names. We will draw every star in the constellation as it is seen on the sky. We will compile for this a table which shows their names and location on the ecliptic at the time (see above) which includes the deg of the north and south latitudes as well as their magnitudes.


29

على مواضعها التي وضعها بطلميوس في كتابه وهو اثنا عشر
درجة واثنتان واربعون دقيقة فيصير لذلك موضع السماك
الاعزل في أول سنة ألف ومائتين وست وسبعين من سني ذي القرنين
في تسع درجات واثنتين وعشرين دقيقة من الميزان وموضع الشمالي
من الثلاثة التي في جبهة العقرب في تسع عشرة درجة ودقيقتين
من العقرب وكذلك تكون الزيادة على سائر الكواكب
وأما عروضها فعلى ما ذكرها بطلميوس لأنها تدور حول قطبي
فلك البروج ولا تتغير أبدا وأما أقدارها ومراتبها في العظم
والصغر فعلى ما وجدناها بالعيان فنذكر الآن كوكبة
كل صورة على الانفراد وعدد كواكبها وأسماءها وألقابها على
مذهب المنجمين ومذهب العرب ليستدل بأحدهما على
الآخر ونعمل صورة المسماة باسمها المشبه لها ونرسم كل
كوكب على موضعه من الصور ليكون مثالا لما يرى في السماء ونعمل
لها جدولا ونثبت فيه أسماءها ومواضعها من فلك البروج في
الزمان المذكور وأجزاء عروضها في الشمال والجنوب ومقاديرها

Folio 30

We will mark for every star on the list and on the constellation image a sign written by numerical letters indicating its position so that it is made easier when we point to it.

We will start by the closest to the known poles then those that follow it, one at a time, similar to what Ptolemy arranged in his book.

We will rely on God to guide and help us and what satisfies the prominent prince ‘Aḍud al-Dawla, may God prolong his life and assist him. May God be our helper and be our sustainer.

We will show first that what we refer to as north stars we mean by this the closest to the north ecliptic pole, and those we refer to as southern we mean by this the furthest from that same pole.

We will show this in the line where we mention the latitude of the stars in the table.

As for the stars to the north of the ecliptic, the more their latitude is greater then they are closer to the north ecliptic pole. We will refer to (such a star) as a northern star.

Where as those stars whose latitude is less then they are furthest from that pole. And we will refer to such a star as a southern star.

As for the star whose latitude is south of the ecliptic then the one whose latitude is less……


عظمها ونعلم على كل كوكب منها في الجدول وفي الصورة علامه
بحروف الجمل على مراتب موقعه من الجدول ليسهل اشارتنا
منها متى اشرنا اليه ونبدا باقربها الى القطب الظاهر ثم ما
تلاوه الاقرب فالاقرب على ما رتبه بطلميوس في كتابه ونستعين
بالله على التوفيق والعون على ما يرضي الامير الجليل
عضد الدوله اطال الله بقاه وتقرب اليه وهو حسبنا ونعم
الوكيل ونبين اولا ان الذي نسميه شماليا من هذه
الكواكب نريد بذلك الاقرب الى قطب فلك البروج الشمالي
والذي نسميه جنوبيا نريد الابعد من هذا القطب بعينه
ونبين ذلك من السطر الذي اثبتنا فيه عروض الكواكب من
الجدول وذلك ان الكواكب الشماليه عن فلك البروج كل
ما كان منها عرضه اكثر فهو اقرب الى قطب فلك البروج
الشمالي وهو الذي نسميه شماليا والذي يكون عرضه اقل
فهو ابعد من هذا القطب وهو الذي نسميه جنوبيا وكل كوكب
يكون عرضه جنوبيا عن فلك البروج فان الذي يكون اقل عرضا

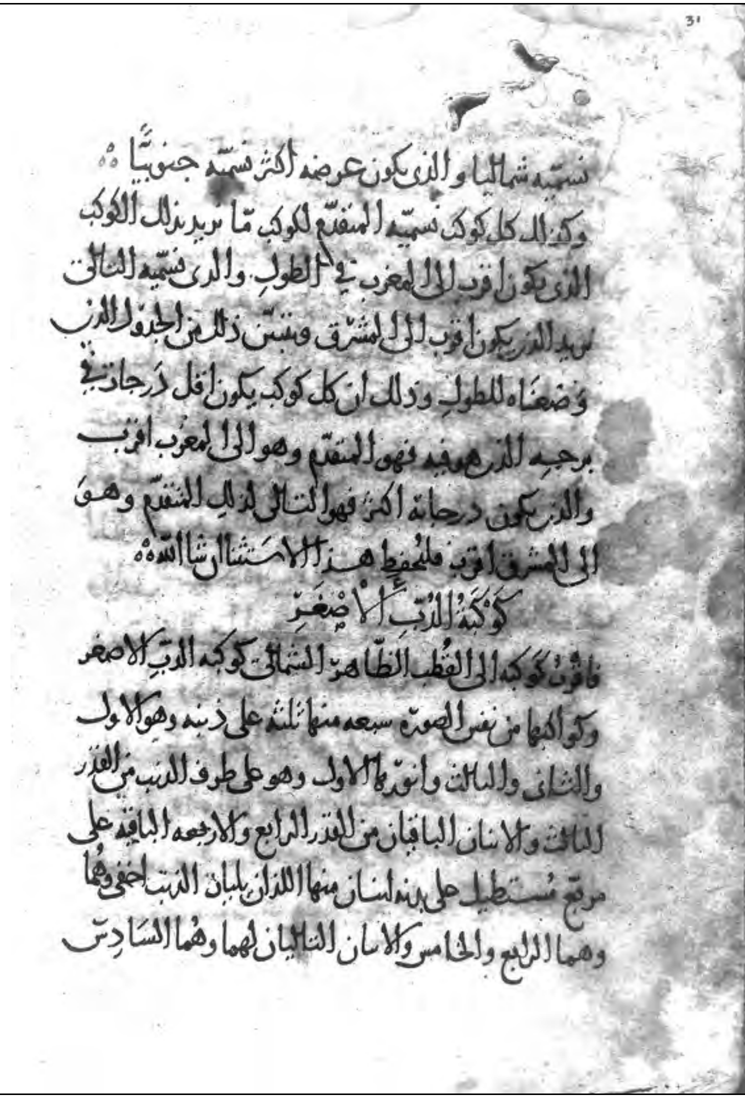
Folio 31

…….we will call northern and the one whose latitude is more then we will call southern.

As for the star we refer to as *al-Mutaqadem* (most-Advanced) to another, then this is the star that is closer to the west in longitude.
The (star) we refer to as *al-Tālī* (rear-most), we mean by this to be the (star) that is closer to the east.

We will show that in the list which we have compiled for the constellation longitude that every star which has the least number of degrees is the one that is closer to the west and the one for which the number degrees are greater is to the rear of this star and lies towards the east.

These (instructions) should be memorized by Gods will.



Folio 21 (Manuscript: MS5306)

The constellation Small Bear (*al-Dub al-Aṣghar)* (or Ursa Minor)

The closest constellation to the northern visible pole is the Small Bear constellation (Ursa Minor).
Its stars in the main picture are seven (in number). Three are on the tail: the first, second and third. The brightest is the first which is at the end of the tail and is of the 3rd magnitude. The remaining two (on the tail) are of the 4th magnitude.

The four remaining stars form a rectangle on the body. The two stars next to the tail are dimmer; these are the fourth and the fifth. The other two beyond them are the sixth and the seventh; these are brighter.

Ptolemy noted that the fourth and the fifth are both of the 4th magnitude while the sixth and seventh are of the 2nd magnitude.

However the fourth (star) is indeed of the 4th magnitude because it is similar to the two on the tail.


21

يكون دبجانة أكثر فهو الثاني لذلك المتقدم وهو الى المشرق
اقرب فليحفظ هذه الاشياء ان شاء الله تعالى

كوكبة الدب الأصغر

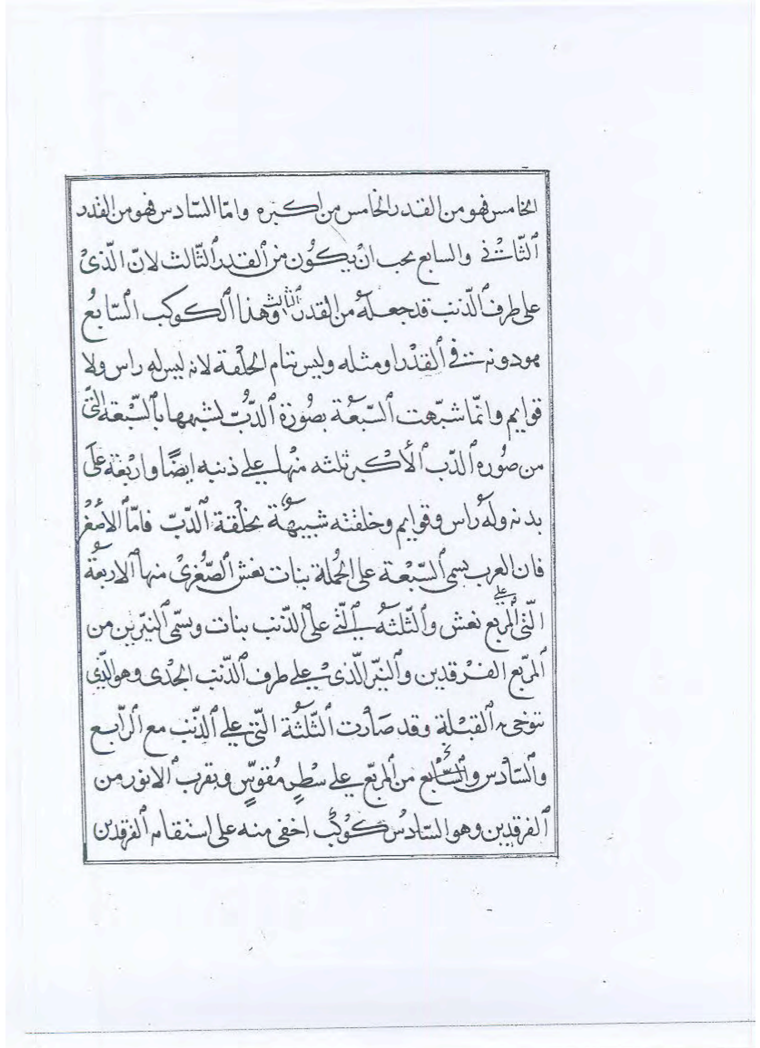
واقرب كوكبة الى القطب الظاهر الشمالي كوكبة الدب الأصغر
وكواكبها من نفس الصورة سبعة منها ثلثة على ذنبه وهي
الأول والثاني والثالث وانورها الأول وهو على طرف الذنب
من القدر الثالث والاثنان الباقيان من القدر الرابع والأربعة
الباقية على مربع مستطيل على بدنه اثنان منها اللذان يليان
الذنب أخفى وهما الرابع والخامس والاثنان التاليان لهما وهما السادس
والسابع انور وذكر بطلميوس ان الرابع والخامس جميعا من القدر
الرابع وان السادس والسابع جميعا من القدر الثاني فأما الرابع
فهو من القدر الرابع لانه مثل الاثنين اللذين على الذنب واما

As for the fifth it is greater than the 5th magnitude, while the sixth is of the 2nd magnitude. The seventh star must be of the 3rd magnitude because the one on the end of the tail is of the 3rd magnitude, and the seventh star is less in magnitude or similar (to that).

(The figure of the constellation) is not complete because it does not have a head or legs. These seven stars have been compared with the image of a bear because they are similar to the seven stars of the constellation (*al-Dub al-Akbar)* the Great Bear (Ursa Major). Three of these (stars) are also on the tail and four on the body. It has a head and legs and its shape resembles a bear.

As for the Small (Bear), the Arabs call the seven (stars) of the group *Banāt Na'sh al-Ṣugrha* (The Little Daughters of the Bier or Coffin). The four on the rectangle are the *Na'sh* (bier or coffin) and the three on the tail are the *Banāt* (the daughters). (The Arabs) call the two brightest stars of the rectangle *al-Farqadain* and the bright star on the end of the tail *al-Juday;* this (star) is used to locate the *Kiblah* (= the direction of Makkah).

The three stars on the tail, together with the fourth and sixth (the word "seventh" has been scratched out) form a curved line. Next to the brightest (star) of the *al-Farqadain*, which is the sixth, is a fainter star, on the same line as the *al-Farqadain* (but) not of the constellation.


الخامس فهو من القدر الخامس من اكبره واما السادس فهو من القدر
الثاني والسابع يجب ان يكون من القدر الثالث لان الذي
على طرف الذنب قد جعله من القدر الثالث وهذا الكوكب السابع
موصون في القدر او مثله وليس تام الحلقة لانه ليس له راس ولا
قوايم وانما شبهت السبعة بصورة الدب لشبهها بالسبعة التي
من صورة الدب الاكبر ثلثة منها على ذنبه ايضا واربعة على
بدنه وله راس وقوايم وخلقته شبيهة بخلقة الدب فاما الاصغر
فان العرب تسمي السبعة على الجملة بنات نعش الصغرى منها الاربعة
التي على المربع نعش والثلثة التي على الذنب بنات وتسمي النيرين من
المربع الفرقدين والنير الذي على طرف الذنب الجدي وهو الذي
تتوخى به القبلة وقد صارت الثلثة التي على الذنب مع الرابع
والسادس والسابع من المربع على سطر مقوس ويقرب الانور من
الفرقدين وهو السادس كوكب اخفى منه على استقامة الفرقدين

Folio 22

For Ptolemy mentioned it and specified it as outside the constellation, and of the 4th magnitude.

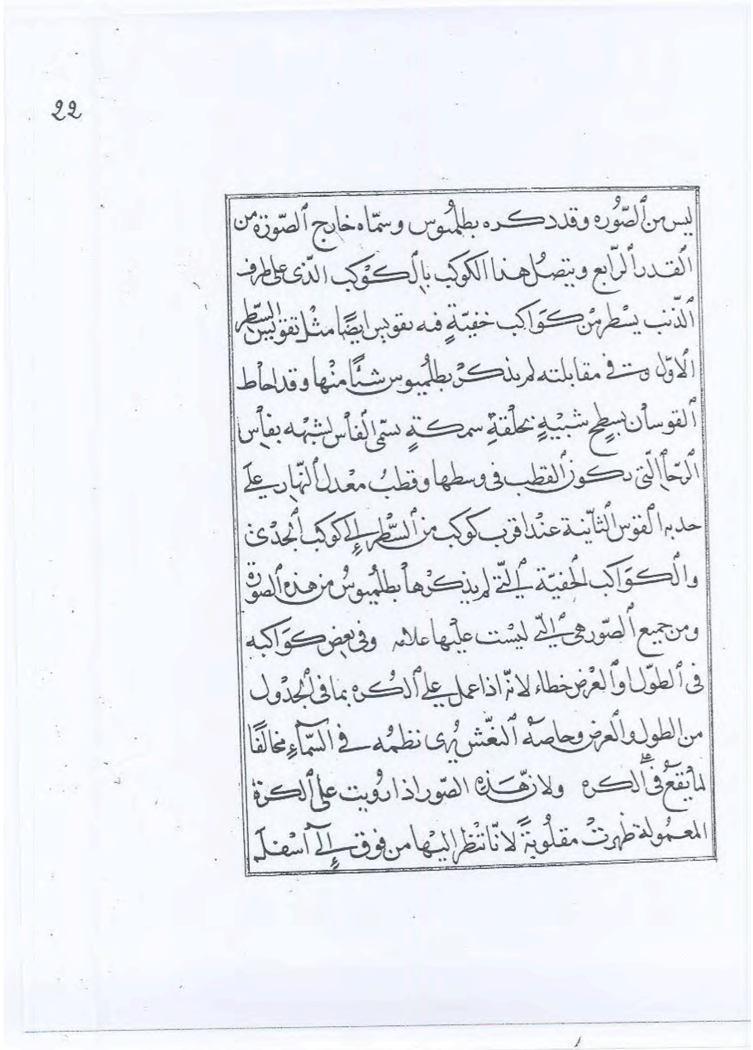
This star is connected with the star on the end of the tail, forming a line of dim stars which is curved like the first line. In his work, Ptolemy did not mention anything about this.

These two arcs enclose an area with the shape of a fish, called *al-Fa’s*; this may be compared with *Fa’s al-Raḥā*, where the pole is in the middle. (However), the equatorial pole is on the outside of the second arc, close to the nearest star on the line to the star *al-Juday*

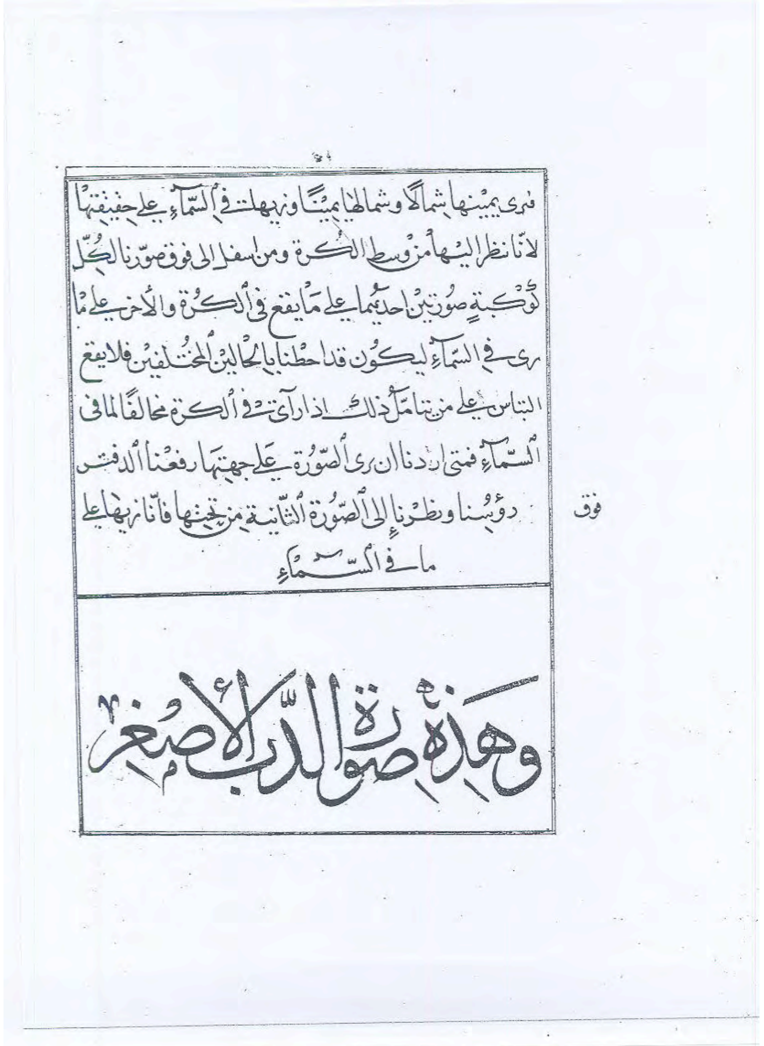
All the dim stars which Ptolemy did not include as part of this constellation as well as those in all the other constellations are all the ones which are unmarked. (al-Ṣūfī is probably referring here to the drawings of the constellation in his original book which is not extant)

In some of (Ptolemy’s) stars (charts) both the latitude and longitude are incorrect. This is because if they are marked on a (celestial) globe according to (Ptolemy’s) table of latitude and longitude, especially (the stars of) *al-Na’sh*, we notice that the image (of the constellation) in the heavens does not correspond with what is (seen) on the globe.

Furthermore, when these constellations are projected on the globe they are seen inverted, because we are viewing them from up towards down.


22

ليس من الصورة وقد ذكره بطلميوس وسماه خارج الصورة من
القدر الرابع ويتصل هذا الكوكب بالكوكب الذي على طرف
الذنب بسطر من كواكب خفية فيه تقويس ايضا مثل تقويس السطر
الاول وفي مقابلته لم يذكر بطلميوس شيئا منها وقد احاط
القوسان بسطح شبيه بحلقة سمكة تسمى الفاس لشبهه بفاس
الرحا التي يكون القطب في وسطها وقطب معدل النهار على
حدبة القوس الثانية عند اقرب كوكب من السطر الى كوكب الجدي
والكواكب الخفية التي لم يذكرها بطلميوس من هذه الصورة
ومن جميع الصور هي التي ليست عليها علامة وفي بعض كواكبه
في الطول والعرض خطاء لانه اذا عمل على الكرة بما في الجدول
من الطول والعرض وخاصة النعش يرى نظمه في السماء مخالفا
لما يقع في الكرة ولان هذه الصور اذا رويت على الكرة
المعمولة ظهرت مقلوبة لانا ننظر اليها من فوق الى اسفل

Hence we see its right as left and it’s left as right. For we see (the constellations) in the heavens as it should be because we are observing from the centre of the globe and from down towards up. For every constellation we have drawn two pictures: one as it is projected on the globe and the other as it is seen in the heavens. Hence we have covered both of the different cases, so there is no confusion for anyone who sees that what is viewed on the globe is different from what is in the heavens. When we want to see the constellation as it (really) is we lift the book over our heads and we look at the second picture (in the book). From beneath (the book) we are viewing (the constellation) as it is seen in the heavens. **This is the picture of the (constellation) Small Bear (*al-Dub al-Asghar)* (Ursa Minor)**	 فنرى يمينها شمالا وشمالها يمينا ونراها في السماء على حقيقتها لانا ننظر اليها من وسط الكرة ومن اسفل الى فوق وصورنا لكل كوكبة صورتين احديهما على ما يقع في الكرة والاخرى على ما يرى في السماء ليكون قد احطنا بالحالين المختلفين فلا يقع التباس على من يتامل ذلك اذا رأى في الكرة مخالفا لما في السماء فمتى اردنا ان نرى الصورة على جهتها رفعنا الدفتر فوق رؤسنا ونظرنا الى الصورة الثانية من تحتها فانا نراها على ما في السماء وهذه صورة الدب الاصغر

Folio 23

(Constellation) As seen on the globe

east

North constellation image south

west

(Constellation) As seen in the sky

east

South constellation image North

west

Table of the constellation Ursa Minor with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest

Number	Star Name	Longitude			Lat direction	Latitude		Mag
		zodiac	deg	min		deg	min	
1	The star on the end of the tail which is *al-Juday*	2(60)	12	52	N	66	00	3
2	The one next to it on the tail	2(60)	15	12	N	70	00	4
3	The one next to that before the place where the tail joins the body	2(60)	28	42	N	74	00	4
4	The southern most of the stars in the foremost side of the rectangle	3(90)	12	22	N	75	40	4
5	The northern most of those in the same side	3(90)	16	22	N	77	40	5k
6	The southern star in the rear side which is the brightest of *al-Farqadain*	3(90)	29	52	N	72	50	2
7	The northern one in the same side which is the dimmest of *al-Farqadain*	4(120)	08	52	N	74	50	3

7 stars, 1 is of the 2nd magnitude, 2 of the 3rd magnitude, 3 of the 4th magnitude, 1 of the 5th magnitude

The one underneath and not in the constellation

8	The southern star parallel to *al-Farqadain*	4(90)	25	42	N	71	10	4

Folio 24 (Manuscript: MS5036)

The constellation Great Bear (*al-Dub al-Akbar)* (or Ursa Major)

Its stars are twenty seven stars in the main picture and eight around the picture. They have (all) been mentioned by Ptolemy and the stars (marked by *) are not included (in the picture).

The first star of the constellation is the one on *al-Khaṭem* (the snout) and is of the 4th magnitude. The second and third are two close stars on its eyes. The fourth and fifth are also two close stars (located) on its forehead. The sixth is on the tip of its ear. All those five (stars) are of the 5th magnitude.

As for the seventh (star) it is the more advanced of the two stars in the neck which is less than 4th magnitude while the eighth follows the seventh on the neck and is also of the 4th magnitude.

In Ptolemy's book there is a mistake in the longitude or latitude of this star because if it is to be drawn on a globe its position would not correspond to what is seen in the sky.

The ninth is the northernmost of the two (stars) on the chest (and) is of the 4th magnitude.


24

كوكبة الدب الأكبر

كواكبه سبعة وعشرون كوكباً من الصورة وثمانية حوالي
الصورة قد ذكرها بطلميوس وليست منها ● وأول كوكب
من كواكب الصورة على موضع الخطم منه من القدر الرابع
والثاني والثالث كوكبان متقاربان على عينيه والرابع
والخامس كوكبان متقاربان أيضاً على جبهته والسادس على
طرف أذنه وهذه الخمسة كلها من القدر الخامس وأما السابع
فهو المتقدم من الاثنين اللذين على العنق من القدر الرابع أصغر
والثامن هو التالي للسابع على العنق أيضاً من القدر الرابع وفي
كتاب بطلميوس في طول هذا الكوكب أو عرضه خطاء
لأنه إذا رسم على الكرة يكون موقعه مخالفاً لما يرى في السماء
والتاسع هو الشمالي من الاثنين اللذين على الصدر من القدر الرابع

Additionally, the tenth is the southernmost of the two and is less than 4th magnitude.

The eleventh is (the star) on the left knee and is of the 3rd magnitude.

The twelfth and thirteenth are two close stars (located) on the left paw. The twelfth is a little further to the north and they are both less than 3rd magnitude.

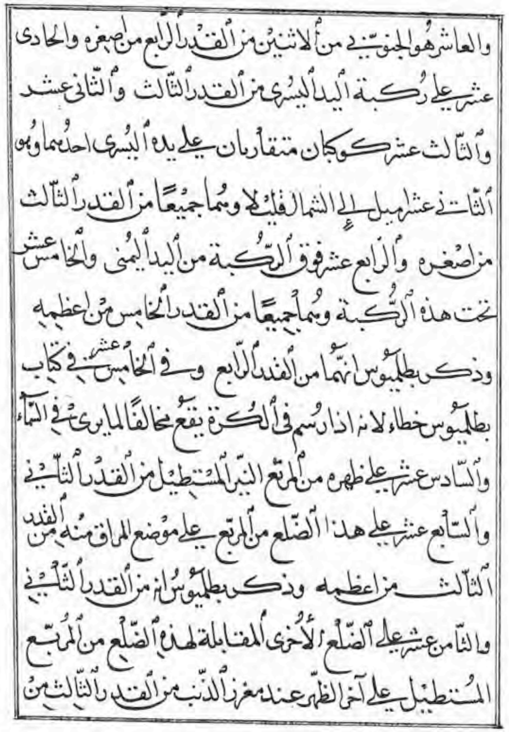
The fourteenth is above the right knee while the fifteenth is below the knee and these (stars) are all much greater than the 5th magnitude.

Ptolemy mentioned that these (stars) are of the 4th magnitude and in Ptolemy's book there is a mistake on the fifteenth (star) because if it is to be drawn on a globe its position would not correspond to what is seen in the sky.

The sixteenth (star) is on the back (of the constellation picture), which forms a part of a bright *al-Murabba' al-Mustaṭīl* (quadrilateral), and is of the 2nd magnitude.

The seventeenth (star) which forms the other point of the quadrilateral is located on *al-Mirāq* (the flank or groin). It is much greater than the 3rd magnitude; (however) Ptolemy mentioned that it is of the 2nd magnitude.

The eighteenth (star) is located on the other point of the quadrilateral facing this (previous) point. It is where the tail joins the body and is less than the 3rd magnitude.


والعاشر هو الجنوبي من الاثنين من القدر الرابع من اصغره والحادي
عشر على ركبة اليد اليسرى من القدر الثالث والثاني عشر
والثالث عشر كوكبان متقاربان على يده اليسرى احدهما وهو
الثاني عشر يميل الى الشمال قليلا وهما جميعا من القدر الثالث
من اصغره والرابع عشر فوق الركبة من اليد اليمنى والخامس عشر
تحت هذه الركبة وهما جميعا من القدر الخامس من اعظمه
وذكر بطلميوس انهما من القدر الرابع وفي الخامس عشر في كتاب
بطلميوس خطاء لانه اذا رسم في الكرة يقع مخالفا لما يرى في السماء
والسادس عشر على ظهره من المربع النير المستطيل من القدر الثاني
والسابع عشر على هذا الضلع من المربع على موضع المراق منه من القدر
الثالث من اعظمه وذكر بطلميوس انه من القدر الثاني
والثامن عشر على الضلع الاخرى المقابلة لهذا الضلع من المربع
المستطيل على آخر الظهر عند مغرز الذنب من القدر الثالث من

Folio 25

Ptolemy mentioned that it is of the 3rd magnitude.

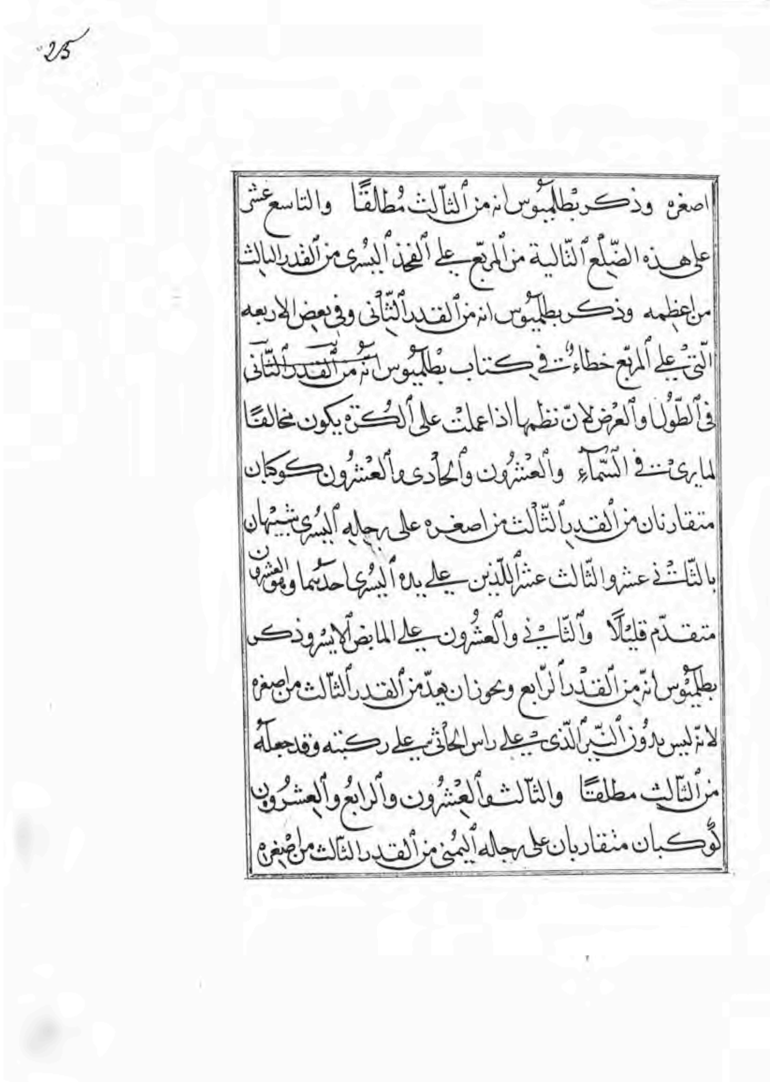
The nineteenth (star) is on the next point of the quadrilateral on the left thigh and it is much greater than the 3rd magnitude; (however) Ptolemy mentioned that it is of the 2nd magnitude.

In Ptolemy's book there are mistakes in the longitude and latitude of those stars of the quadrilateral because if they are to be drawn on a globe they would not correspond to what is seen in the sky.

The twentieth and twenty-first (stars) are two close stars (which are) less than the 3rd magnitude. They are located on the left leg (paw) and they are similar to the twelfth and thirteenth which are located on the left hind paws. The twentieth (star) is a little advanced (from the other).

The twenty-second is located on the left knee bend and Ptolemy mentioned that it is of the 4th magnitude. (However) it can be considered to be less than the 3rd magnitude because it less than the bright star on the head of (constellation) Hercules and Ptolemy made that (star) to be exactly of the 3rd (magnitude).

The twenty-third and twenty-fourth are two close stars which are located on the right hind paw (and are) less than the 3rd magnitude,


25

اصغره وذكر بطلميوس انه من الثالث مطلقا والتاسع عشر
على هذه الضلع الثالية من المربع على الفخذ اليسرى من القدر الثالث
من اعظمه وذكر بطلميوس انه من القدر الثاني وفي بعض الاربعه
التي على المربع خطاء في كتاب بطلميوس انه من القدر الثاني
في الطول والعرض لان نظمها اذا عملت على الكرة يكون مخالفا
لما يرى في السماء والعشرون والحادي والعشرون كوكبان
متقاربان من القدر الثالث من اصغره على رجله اليسرى يشبهان
بالثاني عشر والثالث عشر اللذين على يده اليسرى احدهما وهو العشرون
متقدم قليلا والثاني والعشرون على المابض الايسر وذكر
بطلميوس انه من القدر الرابع ويجوز ان يعد من القدر الثالث من اصغره
لانه ليس بدون النير الذي على راس الجاثي على ركبته وقد جعله
من الثالث مطلقا والثالث والعشرون والرابع والعشرون
كوكبان متقاربان على رجله اليمنى من القدر الثالث من اصغره

…. similar to the twelfth and thirteenth which are located on the left hind paw. The twenty-third is a little advanced to the north.

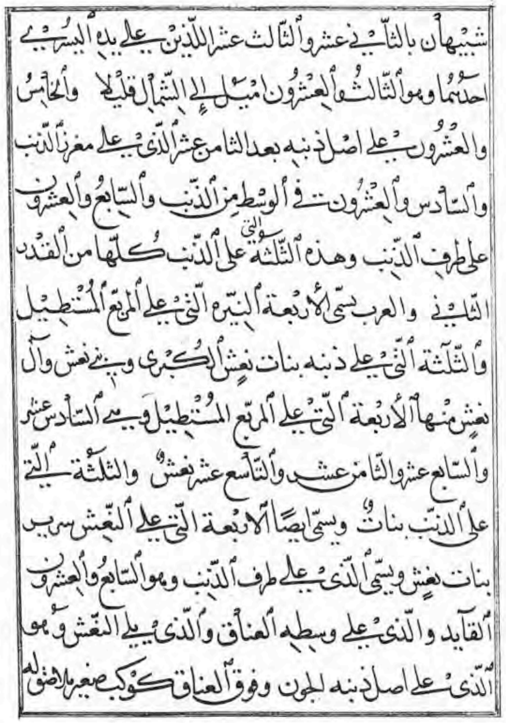
The twenty-fifth is located on the tail (and) is after the eighteenth (star) that is located where the tail joins the body.

The twenty-sixth is in the middle of the tail (while) the twenty-seventh is on the end of the tail, and these three which are on the tail are all of the 2nd magnitude.

The Arabs call the four bright (stars) on the quadrilateral and the three (stars) which are on the tail *Banāt Na'sh al-kubra* (The Great Daughters of the Bier or Coffin) or *Bani Na'sh* or *al-Na'sh*. (The clan of *al-Na'sh* or Bier)

The four (stars) on the quadrilateral, which are the sixteenth, the seventeenth, the eighteenth and the nineteenth, are (called) *al-Na'sh.*
The three (stars) on the tail are (called) *Banāt.* (daughters)
The four (stars) of *al-Na'sh* are also called, *Sarīr Banat Na'sh.* (The bed of the daughters of the Bier).
The twenty-seventh (star) on the end of the tail is called *al-Qā'īd* and the one in the middle (of the tail) *al-'Anāq*. (While) the one which follows *al-Na'sh*, and which is part of the main tail, is called *al-Jūn.*

Above *al-'Anāq* is a small star adjacent to it which the Arabs call *al-Suhā.*


شبيهان بالثاني عشر والثالث عشر اللذين على يده اليسرى
احدهما وهو الثالث والعشرون ميل الى الشمال قليلا والخامس
والعشرون على اصل ذنبه بعد الثامن عشر الذي على مغرز الذنب
والسادس والعشرون في الوسط من الذنب والسابع والعشرون
على طرف الذنب وهذه الثلثة التي على الذنب كلها من القدر
الثاني والعرب تسمي الاربعة النيرة التي على المربع المستطيل
والثلثة التي على ذنبه بنات نعش الكبرى وبني نعش وال
نعش منها الاربعة التي على المربع المستطيل وهي السادس عشر
والسابع عشر والثامن عشر والتاسع عشر نعش والثلثة التي
على الذنب بنات وتسمي ايضا الاربعة التي على النعش سرير
بنات نعش وتسمي الذي على طرف الذنب وهو السابع والعشرون
القايد والذي على وسطه العناق والذي يلي النعش وهو
الذي على اصل ذنبه الجون وفوق العناق كوكب صغير ملاصق له

Folio 26

In other Arab dialects it is (also) called by the name of: *al-Shita’* and al-*Saidaq* and *Nu’aish.* This star has not been mentioned by Ptolemy. This star is also used by people to test their eyesight, for they say I showed him *al-Suhā* and he showed me the Moon.

The six (stars) on the three feet, two stars of the same magnitude on every foot, are called *Kafazāt al-Ẓibā*. These (stars) are the twelfth and the thirteenth on the left hind paw, the twentieth and the twenty-first on the left paw, and the twenty-third and twenty-fourth on the right paw.

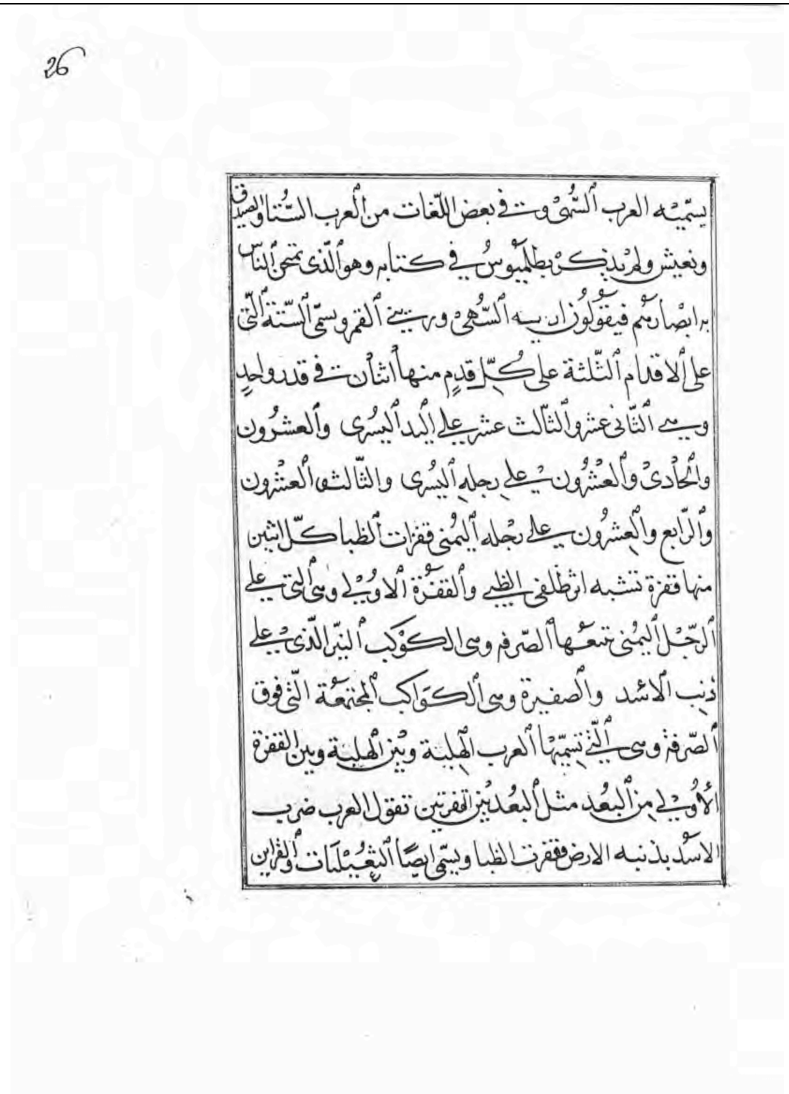
Each pair (of these stars) is (called) *Kafza* which are in the likeness of *Athar Zulfa al-Ẓibā* (the hoof trail or footprints of a gazelle).

The First *Kafza* is the one on the left paw. It is close to *al-Ṣarfa*, which is the bright star on the tail of (constellation) Leo, and *al-Thafīra,* which are a group of stars above *al-Ṣarfa that* are (also) named by the Arabs *al-Halba*.

The distance between *al-Halba* and the first *Kafza* is the same as the distance between the other two *Kafza.*

The Arab (folk tradition) says that when the lion hit his tail on the ground *al-Ẓibā* (the gazelle) jumped.

(*al-Kafazāt)* are also called *al-Thu’ailibān* and *al-Qarā’in.*


26

يسميه العرب السهى وفي بعض اللغات من العرب الشتا والصيدق
ونعيش ولم يذكره بطلميوس في كتابه وهو الذي يمتحن الناس
ابصارهم فيقولون اريه السهى ويريني القمر وسمي الستة التي
على الاقدام الثلثة على كل قدم منها اثنان في قدر واحد
وهي الثاني عشر والثالث عشر على اليد اليسرى والعشرون
والحادي والعشرون على رجله اليسرى والثالث والعشرون
والرابع والعشرون على رجله اليمنى قفزات الظبا كل اثنين
منها قفزة تشبه اثر ظلفي الظبي والقفزة الاولى وهي التي على
الرجل اليمنى تتبعها الصرفة وهي الكوكب النير الذي على
ذنب الاسد والصفيرة وهي الكواكب المجتمعة التي فوق
الصرفة وهي التي تسميها العرب الهلبة وبين الهلبة وبين القفزة
الاولى من البعد مثل البعد بين القفزتين تقول العرب ضرب
الاسد بذنبه الارض فقفزت الظبا ويسمى ايضا الثعيلبات والقراين

The seven stars on its neck, chest and knee which are the seventh, the eighth, the ninth, the tenth, the eleventh, the fourteenth and the fifteenth, all form a semi-circle called *Sarīr Banāt Na'sh* (The bed of the daughters of the Bier) and it is (also) called *al-Hawd*.

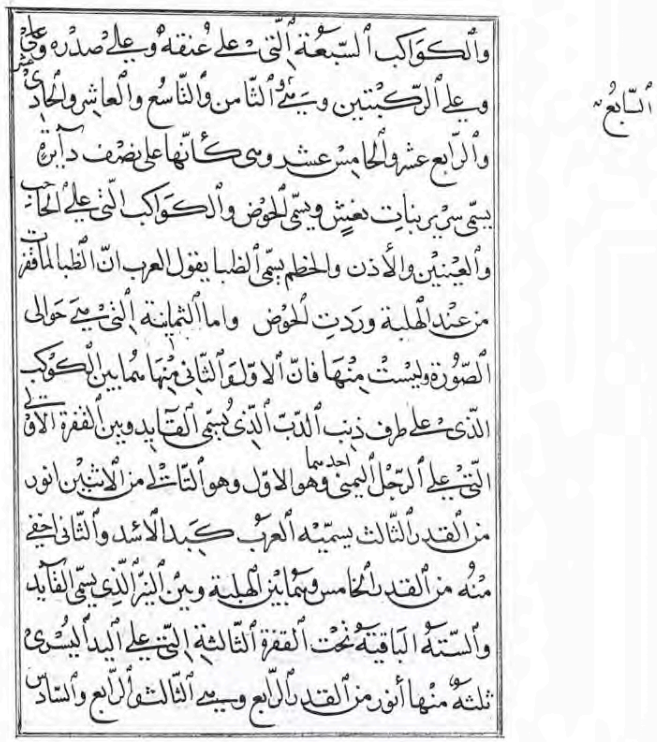
The stars on the eyebrow, the eyes, the ears and the snout are called *al-Ẓibā* (Gazelle).

The Arab (folk tradition) says that when *al-Ẓibā* (the gazelle) jumped from *al-Halba* it reached *al-Hawd*.

As for the eight (stars) which are not part of the constellation, the first and the second are between the star called *al-Qā'īd* , which is on the tail of the Bear, and the first *Kafza,* which is on the right leg.

The first which is in advance of the two is a bright (star) of the 3rd magnitude which the Arabs call *Kibd al-Asad.*
The second is dimmer (then the first) of the 5th magnitude.
These (stars) are between *al-Halba* and the bright (star) called *al-Qā'īd.*

The remaining six (stars) are under the third *Kafza,* which is on the left hand. Three of which are bright of the 4th magnitude, and they are the third, fourth and sixth.


والكواكب السبعة التي على عنقه وعلى صدره وعلى
وعلى الركبتين وهي الثامن والتاسع والعاشر والحادي عشر
والرابع عشر والخامس عشر وهي كأنها على نصف دائرة
يسمى سرير بنات نعش ويسمى الحوض والكواكب التي على الحاجب
والعينين والأذن والخطم يسمى الظبا يقول العرب ان الظبا لما قفز
من عند الهلبة وردت الحوض واما الثمانية التي هي حوالي
الصورة وليست منها فان الاول والثاني منها مما بين الكوكب
الذي على طرف ذنب الدب الذي يسمى القايد وبين القفزة الاولى
التي على الرجل اليمنى وهو الاول احدهما وهو المتقدم من الاثنين انور
من القدر الثالث يسميه العرب كبد الاسد والثاني اخفى
منه من القدر الخامس وهما بين الهلبة وبين النير الذي يسمى القايد
والستة الباقية تحت القفزة الثالثة التي على اليد اليسرى
ثلثة منها انور من القدر الرابع وهي الثالث والرابع والسادس
السابع

Folio 27

The remaining three are of the 6th magnitude.

Ptolemy mentioned that the third and the fourth are of the 4th magnitude while the remaining four which are the fifth, sixth, seventh and eighth were not considered to be 6th magnitude but are dimmer (stars).

The eighth (star) is a lone star between this *Kafza* and the open hand of Leo close to *al-Kafza*.

The third and fourth are part of *al-Ẓibā* while the remaining dim (stars) are the children of *al-Ẓibā*.

Another star of the 4th magnitude which was not mentioned by Ptolemy is located between the nineteenth star, which is on the left thigh of the stars of *Na'sh*, and the twenty-second, which is on the knee-bend. This (star) is further away to the east then the other two.

Between the first and second *Kafza* and (the stars) of *Na'sh* are (many) stars which form together with the twenty-second on the knee-bend, a circle (of stars). The brightest of these is the twenty-second which is on the knee-bend while the rest are of the 5th and 6th magnitude. Ptolemy has not mentioned any of them except the one on the knee-bend.
There are also many stars of the 5th and 6th magnitude located between and in advance of these two *Kafza*. (the first and second *Kafza*)


27

والثلثة الباقية من القدر السادس وذكر بطلميوس ان الثالث
والرابع من القدر الرابع والاربعة الباقية وهي الخامس والسادس
والسابع والثامن لم يعدها من الاقدار الستة وسماها خفية والثامن
منها هو المفرد الذي بين هذه القفزة وبين ذراع الاسد المبسوطة
يميل الى القفزة والثالث والرابع من جملة الظبا والباقية الخفية
وبين الكوكب التاسع عشر الذي على الفخذ اليسرى من كواكب
النعش وبين الثاني والعشرين الذي على المابض كوكب متاخر
عنهما الى المشرق من القدر الرابع لم يذكره بطلميوس وبين
القفزتين الاولى والثانية وبين النعش كواكب هي مع الثاني
والعشرين الذي على المابض على استدارة انورها هو الثاني والعشرون
الذي على المابض والباقي من القدر الخامس والسادس لم يذكر
شيء منها الا الذي على المابض وكذلك بين هاتين القفزتين
كواكب كثيرة متقدمة لهما فيها من القدر الخامس والسادس

Between the second of the two (stars) outside of the constellation close to *Kibd al-Asad* and (the star) on the knee-bend is a star which is less than the 5th magnitude. It is much closer to the second (star) that is outside the constellation.

Inside *al-Hawd* is a star that forms a *Muthallath* (triangle) with the seventh and the eighth, which form together with the ninth and the tenth another *Muthallath Munfareg* (obtuse triangle).

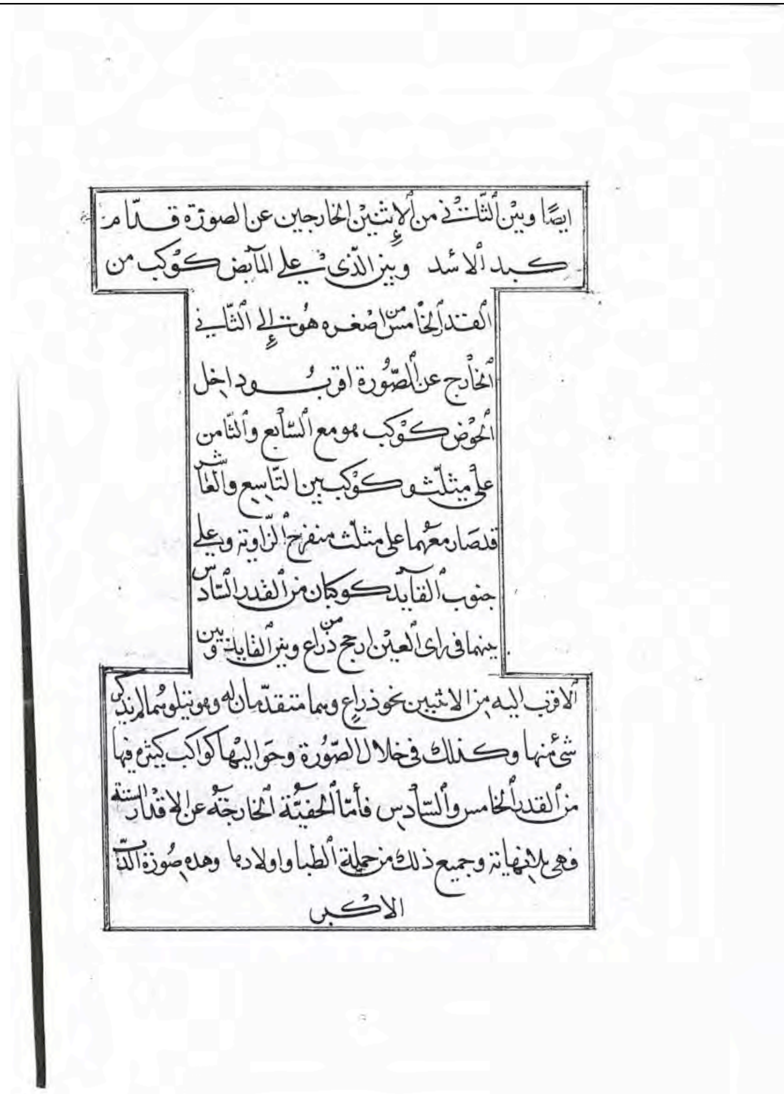
South of *al-Qā'īd* there are two stars of the 6th magnitude which were not mentioned (by Ptolemy). The distance between these two stars is estimated by eyesight to be a little more than (one) *dhirā'*. (1 *Thira* = 2 deg 20 min) The distance between *al-Qā'īd* and the closest one of the two is (also) close to a *dhirā'* and they are in advance of (*al-Qā'īd*).

Throughout (the main image of the) constellation and outside of it, there are many stars of the 5th and 6th magnitudes.

Additionally there are an infinite number of dim (stars) which are outside of the 6th magnitude (classification).

All of these can be considered to be part of *al-Ẓibā* and its children.

This is the picture of the (constellation) Great Bear (*al-Dub al-Akbar)* (Ursa Major)



ايضا وبين الثاني من الاثنين الخارجين عن الصورة قدام
كبد الاسد وبين الذي على المابض كوكب من
القدر الخامس اصغر منه هو الى الثاني
الخارج عن الصورة اقرب وداخل
الحوض كوكب هو مع السابع والثامن
على مثلث وكوكبين التاسع والعاشر
قد صار معهما على مثلث منفرج الزاوية وعلى
جنوب القايد كوكبان من القدر السادس
بينهما في راي العين ارجح من ذراع وبين القايد وبين
الاقرب اليه من الاثنين نحو ذراع وهما متقدمان له وهو يتلوهما لا يزيد
شي منها وكذلك في خلال الصورة وحواليها كواكب كثيرة فيها
من القدر الخامس والسادس فاما الخفية الخارجة عن الاقدار الستة
فهي بلا نهاية وجميع ذلك من جملة الظبا واولادها وهذه صورة الدب
الاكبر

Folio 28

The Great Bear (constellation) as seen on the globe

west

south constellation image north

east

as seen in the sky

west

north constellation image south

east

Folio 29

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Table of the constellation Ursa Major with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
		zodiac	deg	min		deg	min	
1	The star on the end of the snout.	3(90)	08	02	N	39	50	4
2	The more advanced of the two stars in the two eyes.	3(90)	08	32	N	43	05	5
3	The other one of the two.	3(90)	09	12	N	43	05	5
4	The more advanced of the two stars in the forehead.	3(90)	08	52	N	57	10	5
5	The other one of the two.	3(90)	09	22	N	47	05	5
6	The star on the tip of the advance ear.	3(90)	10	52	N	50	30	5
7	The more advanced of the two stars in the neck.	3(90)	13	12	N	43	50	4s
8	The other one of the two, longitude or latitude is wrong.	3(90)	15	12	N	44	20	4
9	The northern most of the two stars in the chest.	3(90)	21	42	N	42	05	4
10	The southernmost of them.	3(90)	23	42	N	44	05	4s
11	The star on the left knee.	3(90)	23	22	N	35	05	3
12	The northern most of the two in the front left paw. *al-Kafza*	3(90)	18	12	N	29	20	3s
13	The southern most of them. *al-Kafza*	3(90)	19	02	N	23	20	3s
14	The star above the right knee.	3(90)	13	22	N	36	05	5m
15	The star below the right knee.	3(90)	13	32	N	30	20	5m
16	The star on the back which is part of the quadrilateral.	4(120)	05	22	N	49	05	2
17	The one on the flank.	4(120)	04	52	N	45	30	3m
18	The one on the place where the tail joins the body.	4(120)	15	52	N	51	05	3s

Remaining of the constellation Ursa Major with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
19	The remaining one on the left hind thigh.	4(120)	15	42	N	46	30	3m
20	The more advanced of the two stars in the left hind paw. *al-Kafza*	4(120)	05	22	N	29	20	3s
21	The next one. *al-Kafza*	4(120)	06	52	N	28	15	3s
22	The star on the left knee bends.	4(120)	14	22	N	35	15	3s
23	The northern most of the two stars in the right hind paw. *al-Kafza*	4(120)	22	35	N	25	50	3s
24	The southernmost of them. *al-Kafza*	4(120)	23	02	N	25	00	3s
25	The first of the three stars on the tail next to the place where it joins the body. *al-Jūn*	4(120)	24	52	N	18	30	2
26	The middle one. *al-'Anāq*	5(150)	00	42	N	55	40	2
27	The third on the end of the tail. *al-Qā'īd*	5(150)	12	32	N	54	00	2
27 stars, 4 is of the 2nd magnitude, 11 of the 3rd magnitude, 5 of the 4th magnitude, 7 of the 5th magnitude								
The one underneath and not in the constellation								
1	The star under the tail at some distance towards the south.	5(150)	10	32	N	39	45	3
2	The rather faint star in advance of it.	5(150)	02	52	N	41	20	5
3	The southernmost of the two stars between the front legs of Ursa Major and the head of Leo.	4(120)	27	42	N	17	15	4
4	The one north of it.	4(120)	26	02	N	19	10	4
5	The next of the remaining three faint stars.	4(120)	25	52	N	20	00	6
6	The one in advance of this.	4(120)	24	52	N	22	45	4
7	The one in advance again of the latter.	4(120)	23	52	N	20	20	6
8	The star between the front legs (of Ursa Major) and Gemini.	4(120)	12	42	N	22	15	6
8 stars, 1 is of the 3rd magnitude, 3 of the 4th magnitude, 1 of the 5th magnitude, 3 of the 6th magnitude								


بقية كوكبة الدب الأكبر بزيادة يب مب على ما في المجسطي

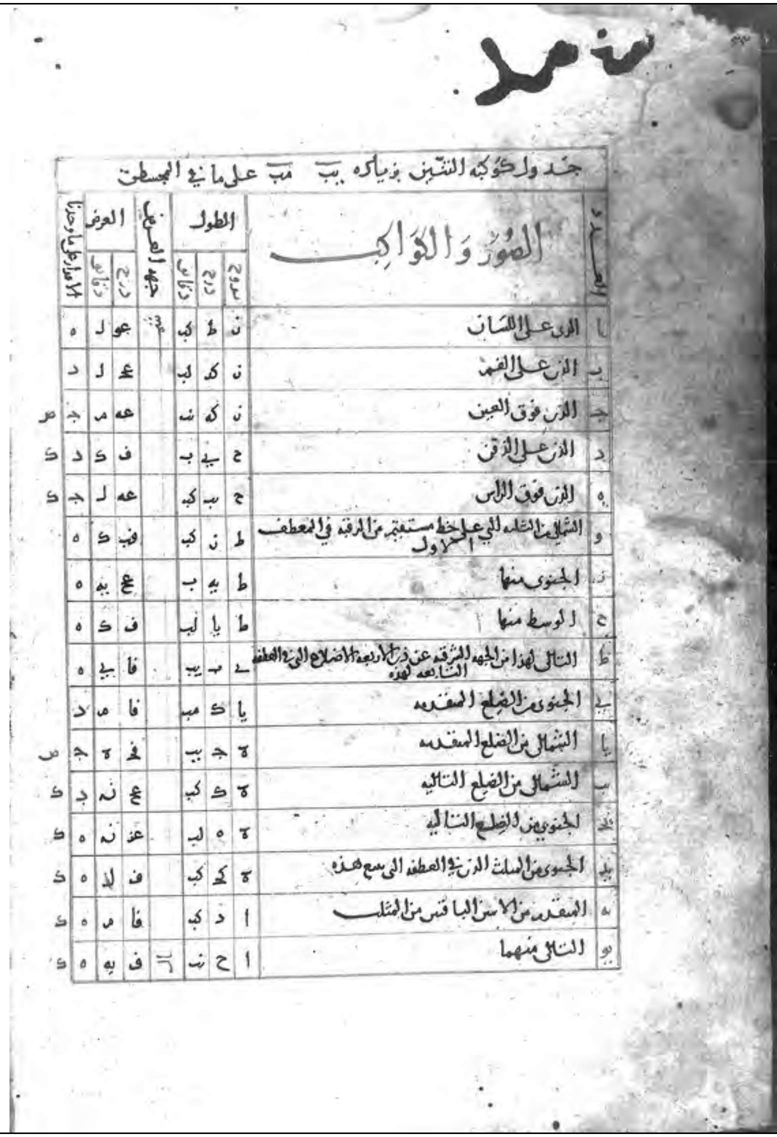
أسماء الكواكب

التي تحتها وليست من الصورة

Folio 55

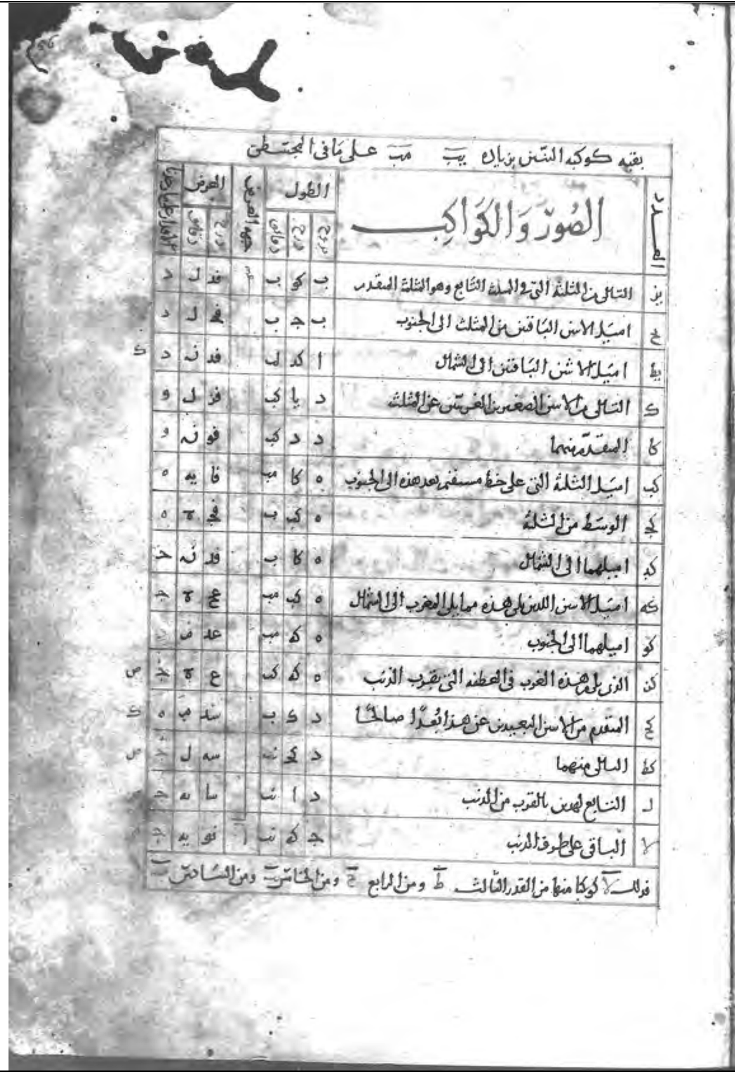
Table of the constellation Draco (*al-Tinnīn*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tongue	7(210)	9	22	N	76	30	5
2	The star on the mouth	7(210)	24	32	N	73	30	4
3	The star above the eye	7(210)	25	52	N	75	40	3(s)
4	The star on the jaw	8(240)	10	2	N	80	20	4(m)
5	The star above the head	8(240)	12	22	N	75	30	3(m)
6	The northern most of the 3 stars in a straight line in the first bend of the neck	9(270)	50	22	N	82	20	5
7	The southernmost of these	9(270)	15	2	N	78	15	5
8	The middle one	9(270)	11	32	N	80	20	5
9	The star to the rear and due east of the latter forming the advance side of the quadrilateral in the same bend	10(300)	2	12	N	81	10	5
10	The southern star of the advanced side	11(330)	20	42	N	81	40	4
11	The more northerly star of the advanced side	0	3	12	N	83	0	3(s)
12	The northern star of the rear side	0	20	22	N	78	50	4(m)
13	The southern star of the rear side	0	5	32	N	77	50	5(m)
14	The southern star of those forming the triangle in the next bend	0	23	22	N	80	30	5(m)
15	The more advanced of the other two stars of the triangle	1(30)	4	22	N	81	40	5(m)
16	The one to the rear	1(30)	8	52	N	80	15	5(m)

Note: the “bends” means the bends or twist of the image of the dragon.



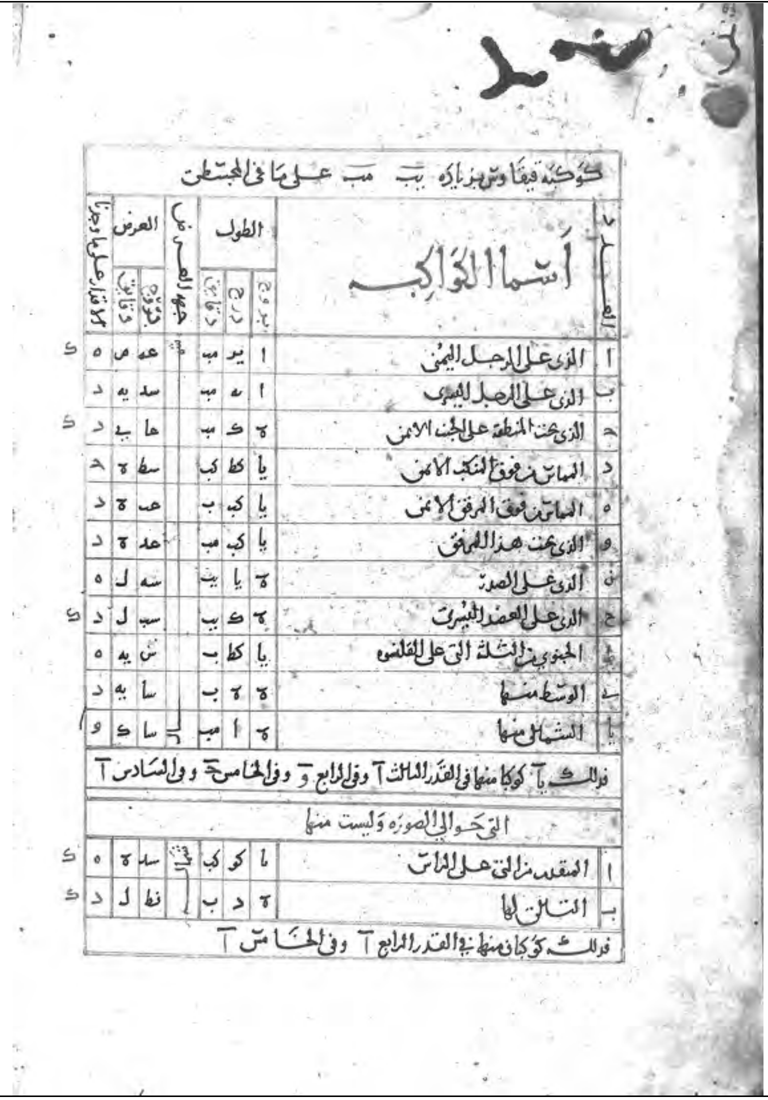
Folio 56

Remaining stars in the constellation Draco with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
17	The most advanced of the three stars in the next triangle which is in advanced of the last	2(60)	26	2	N	84	30	4
18	The southernmost of the other two forming the triangle	2(60)	3	2	N	83	30	4
19	The northernmost of the other two	1(30)	24	32	N	84	50	4(m)
20	The rearmost of the two small stars to the west of the triangle	4(120)	11	22	N	87	30	6
21	The one in advance	4(120)	4	22	N	86	50	6
22	The southernmost of the next 3 stars in a straight line	5(150)	21	42	N	81	15	5
23	The middle one of the three	5(150)	22	2	N	83	0	5
24	The northernmost of them	5(150)	21	2	N	84	50	3
25	The northernmost of the next 2 to the west	5(150)	22	42	N	78	0	3
26	The southernmost of these	5(150)	25	42	N	74	40	4
27	The star to the west of these in the bend by the tail	5(150)	25	22	N	70	0	3(s)
28	The advanced star of the two some distance from the latter	4(120)	20	2	N	64	30	5(m)
29	The rear star of these two	4(120)	23	52	N	65	30	3(s)
30	The star close to these by the tail	4(120)	1	52	N	61	15	3(s)
31	The remaining star on the tip of the tail	3(90)	25	52	N	56	15	3(s)
31 stars, 9 of the 3rd magnitude, 8 of the 4th, 12 of the 5th, 2 of the 6th.								



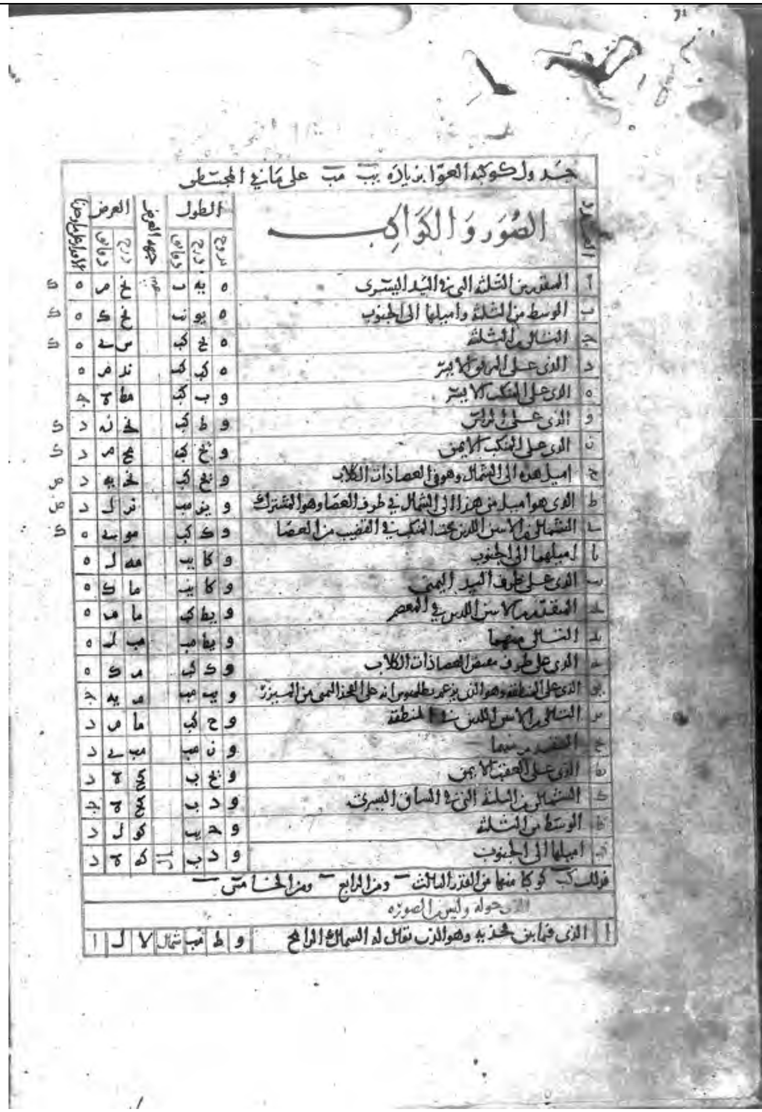
Folio 63

Constellation Cepheus (*Qīqāwūs*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the right leg	1(30)	17	42	N	75	90	5(m)
2	The one on the left leg	1(30)	15	42	N	64	15	4
3	The star under the belt on the right side	0	20	42	N	71	10	4(m)
4	The star over the right shoulder which touches the shoulder	11(330)	29	22	N	69	0	3
5	The star over the right elbow which touches the shoulder	11(330)	22	2	N	72	0	4
6	The one under that elbow	11(330)	22	42	N	74	0	4
7	The star in the chest	0	11	12	N	65	30	5
8	The star on the left arm	0	20	12	N	62	30	4(m)
9	The southernmost of the 3 stars on the tiara	11(330)	29	2	N	60	15	5
10	The middle one of the three	0	0	2	N	61	15	4
11	The northernmost of the three	0	1	42	N	61	20	6
11 stars, 1 is of the 3rd magnitude, 4 of the 4th magnitude, 3 of the 5th magnitude, 1of the 6th magnitude								
The ones surrounding the constellation but not in it.								
1	The one in advance of the tiara	11(330)	26	22	N	64	0	5(k)
2	The one to the rear of the tiara	0	4	2	N	59	30	4(m)
2 stars, 1 is of the 4th magnitude, 1of the 5th magnitude.								



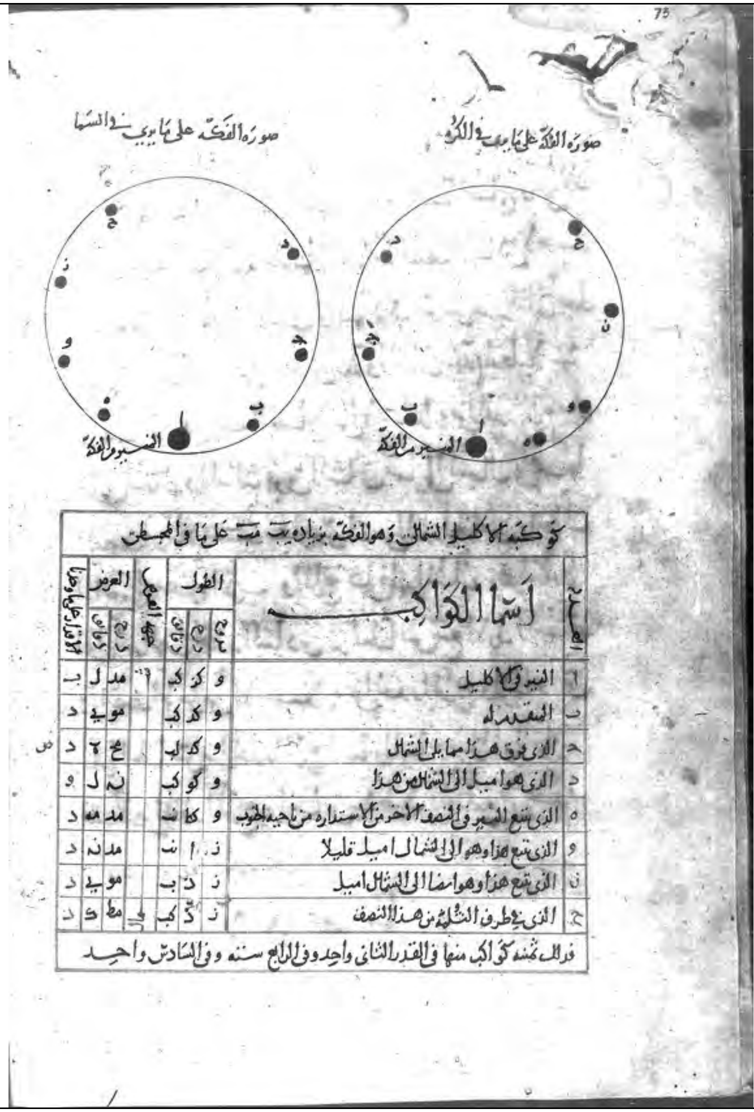
Folio 71

Table of the constellation Bootes (*al-'Awwā*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The most advanced of the three in the left arm	5(150)	15	2	N	58	40	5(m)
2	The middle and southernmost of the three	5(150)	16	52	N	58	20	5(m)
3	The rearmost of the three	5(150)	18	22	N	60	10	5(m)
4	The star on the left elbow	5(150)	22	22	N	54	40	5
5	The star on the left shoulder	6(180)	2	22	N	49	0	3
6	The star on the head	6(180)	9	22	N	53	50	4(m)
7	The star on the right shoulder	6(180)	18	22	N	48	40	4(m)
8	The one to the north of these on the staff	6(180)	18	22	N	53	15	4(s)
9	The one still farther to the north of this on the tip of the staff	6(180)	17	42	N	57	30	4(s)
10	The northernmost of the two stars below the shoulder in the club	6(180)	20	22	N	46	10	5(m)
11	The southernmost of them	6(180)	21	12	N	45	30	5
12	The star on the end of the right arm	6(180)	21	17	N	41	20	5
13	The more advanced of the two stars in the wrist	6(180)	19	22	N	41	50	5
14	The rearmost of them	6(180)	19	42	N	42	30	5
15	The star on the end of the handle of the staff	6(180)	20	22	N	40	20	5
16	The star on the right thigh in the apron	6(180)	12	42	N	40	15	3
17	The rearmost of the two stars in the belt	6(180)	8	22	N	41	40	4
18	The more advanced of them	6(180)	7	42	N	42	10	4
19	The star on the right heel	6(180)	18	2	N	28	0	4(k) or 4
20	The northernmost of the 3 stars in the left lower leg	6(180)	4	2	N	28	0	3
21	The middle one of the three	6(180)	3	12	N	26	30	4
22	The southernmost of them	6(180)	4	2	N	25	0	4
22 stars, 3 are of the 3rd magnitude, 9 of the 4th magnitude, 10 of the 5th magnitude.								
The ones surrounding the constellation but not in it.								
1	The star between the thighs called *al-Simāk al-Rāmiḥ*	6(180)	9	42	N	31	30	1


الصور والكواكب

Folio 73

Constellation Corona Borealis (*al-Iklīl Al-Shamālī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The bright star in the crown	6(180)	27	22	N	44	30	2
2	The star most in advance of all	6(180)	24	22	N	46	10	4
3	The one to the rear and to the north of this	6(180)	24	32	N	48	0	4(s)
4	The one to the rear and farther north than this	6(180)	26	22	N	50	30	6
5	The one to the rear of the bright star from the south	6(180)	29	52	N	44	45	4
6	The one farther to the rear of the latter, but close by	7(210)	1	52	N	44	50	4
7	The one farther to the rear of these	7(210)	4	2	N	46	10	4
8	The star to the rear of all the others in the crown	7(210)	4	22	N	49	20	4
8 stars, 1 is of the 2nd magnitude, 6 of the 4th magnitude, 1of the 6th magnitude								



Folio 83

Table of the constellation Hercules (*al-Jāthī ‘ala Rukbateh*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head	8(240)	0	22	N	37	30	3(s)
2	The star on the right shoulder by the armpit	7(210)	16	22	N	43	0	3
3	The star on the right upper arm	7(210)	54	22	N	40	10	3(s)
4	The star on the right elbow	7(210)	10	42	N	37	10	4(s)
5	The star on the left shoulder	7(210)	29	22	N	48	0	3
6	The star on the left upper arm	8(240)	4	42	N	49	30	5
7	The star on the left elbow	8(240)	10	22	N	52	0	4
8	The rearmost of the 3 stars in the left wrist	8(240)	18	12	N	52	50	4
9	The northernmost of the other 2	8(240)	54	22	N	54	0	4
10	The southernmost of them	8(240)	54	12	N	53	0	4
11	The star in the right side	7(210)	16	32	N	53	10	3
12	The star in the left side	7(210)	22	52	N	53	30	4
13	The one north of the latter on the left buttock	7(210)	22	42	N	56	10	5(s) or 6(m)
14	The one on the place where the thigh joins the same buttock	7(210)	28	52	N	38	30	5(s) or 6(m)
15	The most advanced of the 3 in the left thigh	7(210)	26	42	N	59	50	4(k)
16	The one to the rear of this	7(210)	28	2	N	60	20	5

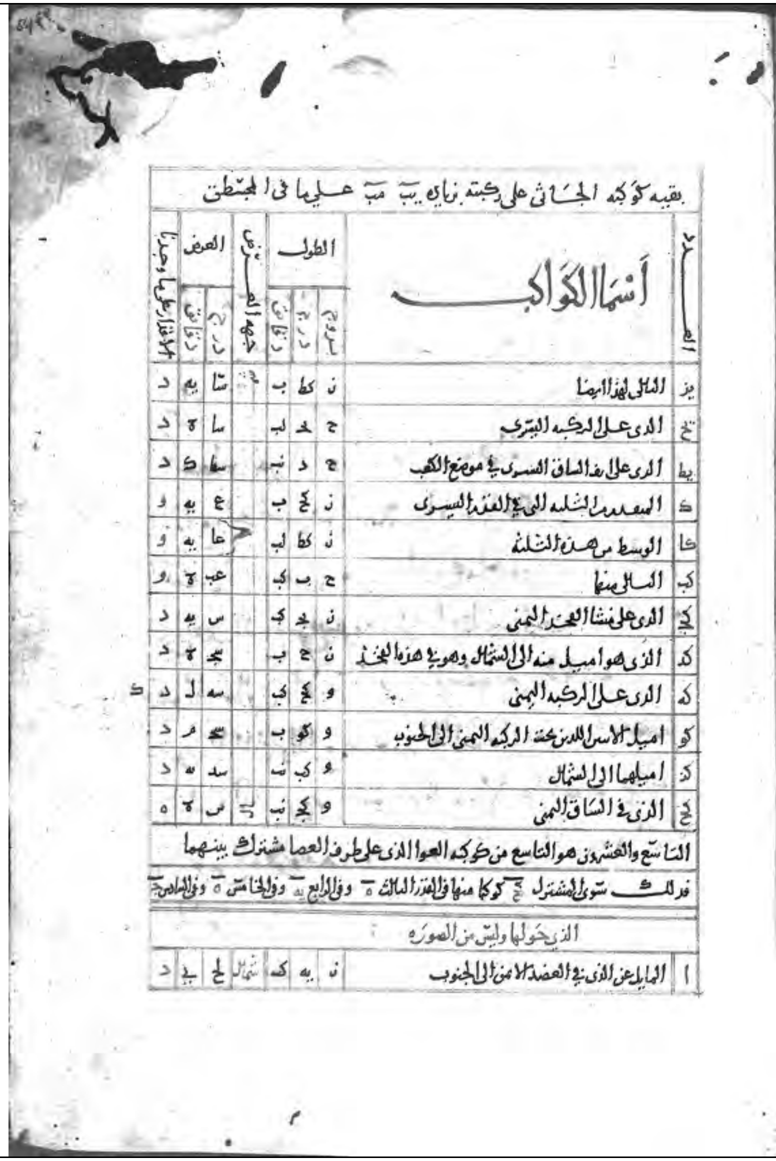

جدول كوكبة الجاثي على ركبته بزيادة يب مب على ما في المجسطي

أسماء الكواكب

Folio 84

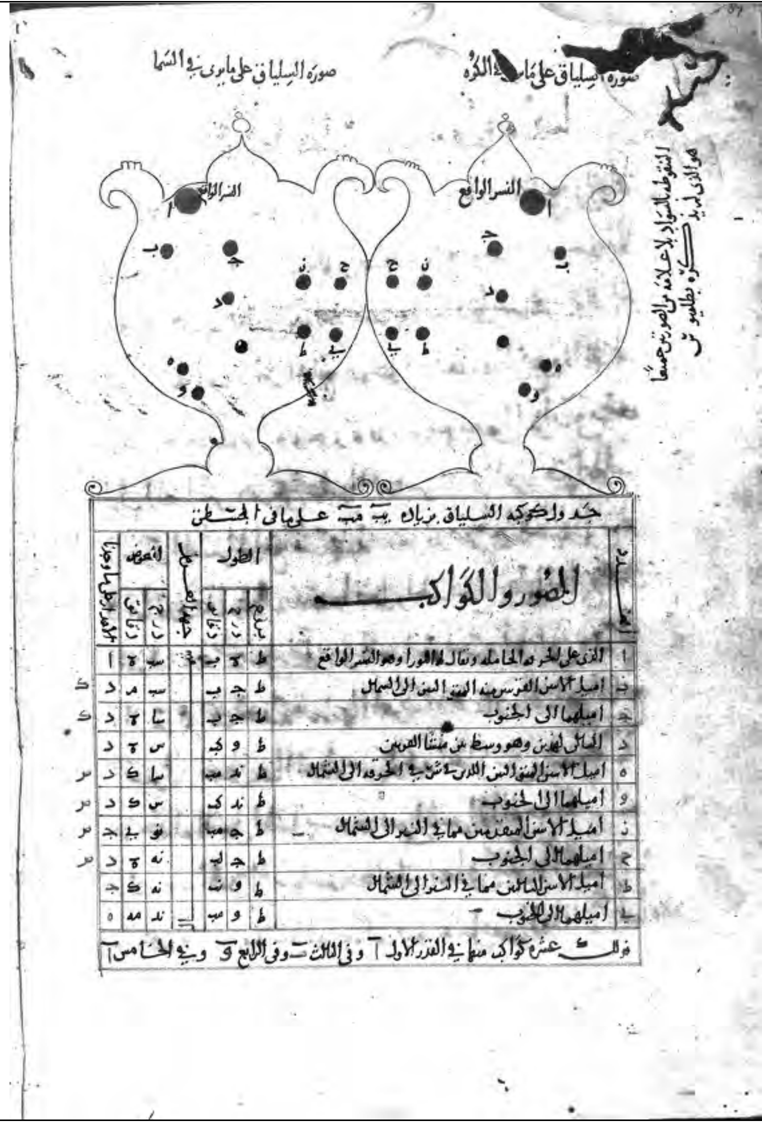
Remaining stars of the constellation Hercules with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Names	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
17	The one still further to the rear of this	7(210)	29	2	N	61	15	4
18	The star on the left knee	8(240)	53	32	N	61	0	4
19	The star on the left shin	8(240)	4	52	N	69	20	4
20	The most advanced of the 3 stars in the left foot	7(210)	28	2	N	70	15	6
21	The middle one of the three	7(210)	29	32	N	71	15	6
22	The rearmost of them	8(240)	2	22	N	72	0	6
23	The star on the place where the right thigh joins the buttock	7(210)	53	22	N	60	15	4
24	The star north of it in the same thigh	7(210)	8	2	N	63	0	4
25	The star on the right knee	6(180)	28	22	N	65	30	4 or 4(m)
26	The southernmost of the 2 stars under the right knee	6(210)	26	2	N	63	40	4
27	The northernmost of them	6(180)	22	52	N	64	15	4
28	The star in the right lower leg	6(180)	23	52	N	60	0	5
	The twenty-ninth is the ninth star in the constellation Bootes which is common to both							
28 stars except the common one. 5 of the 3rd magnitude, 15 of the 4th magnitude, 5 of the 5th magnitude, 3 of the 6th magnitude.								
The ones surrounding the constellation but not in it.								
1	The star south of the one in the right upper arm	7(210)	15	22	N	38	10	4



Folio 87

Table of the Constellation Lyra (*al-Silyāq*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The bright star on the shell called Lyra called *al-Nasr al-Wāqi‘*	9(270)	0	2	N	62	0	1
2	The northernmost of the 2 stars lying near the latter close together	9(270)	3	2	N	62	40	4(k)
3	The southernmost of them	9(270)	3	2	N	61	0	4(k)
4	The one to the rear of these in between the points where the horns of lyre are attached	9(270)	6	22	N	60	0	4
5	The northernmost of the 2 stars close together in the region to the east of the shell	9(270)	52	42	N	61	20	4(s)
6	The southernmost of them	9(270)	52	22	N	60	20	4(s)
7	The northernmost of the two advanced stars in the bridge	9(270)	3	42	N	56	10	3(s)
8	The southernmost of them	9(270)	3	32	N	55	0	4(s)
9	The northernmost of the two rear stars in the bridge	9(270)	6	52	N	55	20	3
10	The southernmost of them	9(270)	6	42	N	54	45	5 or 5(s)
10 stars, 1 is of the 1st magnitude, 2 of the 3rd magnitude, 6 of the 4th magnitude, 1of the 5th magnitude								



Folio 95

Constellation Cygnus (*al-Ṭā'er* also *al-Dajāja*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

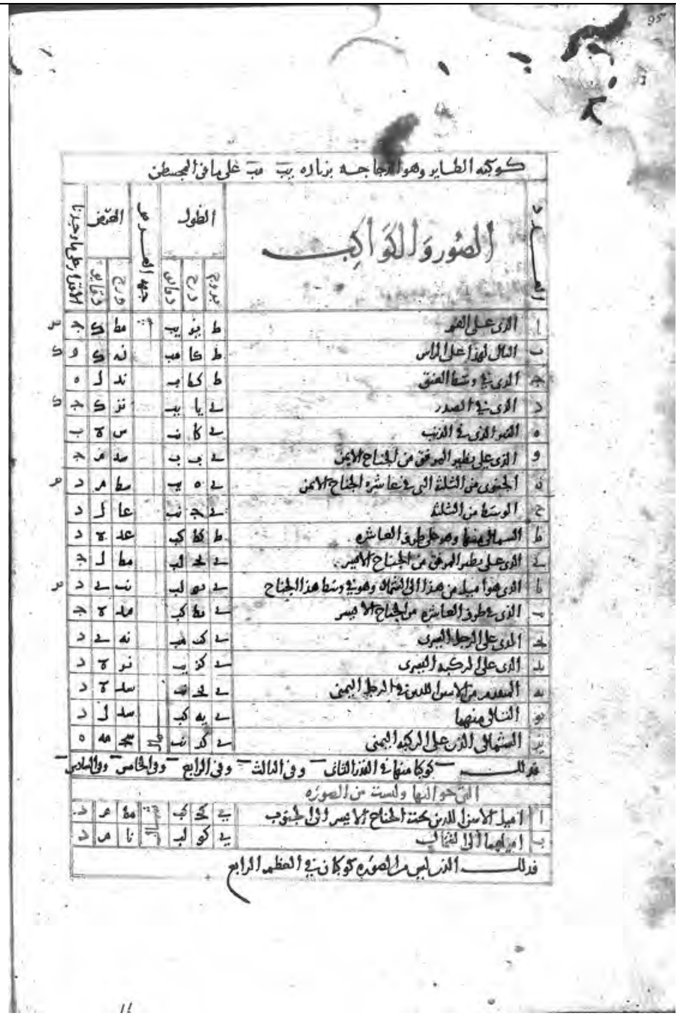
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the beak	9(270)	19	12	N	49	20	3(s)
2	The one to the rear of this on the head	9(270)	21	42	N	50	20	6(m)
3	The star in the middle of the neck	9(270)	29	2	N	54	30	5
4	The star in the breast	10(300)	11	12	N	57	20	3(m)
5	The bright star in the tail	10(300)	21	52	N	60	0	2
6	The star in the bend of the right wing	10(300)	2	2	N	64	40	3
7	The southernmost of the 3 in the right wing feathers	10(300)	5	12	N	69	40	4(s)
8	The middle one of the 3	10(300)	3	52	N	71	30	4
9	The northernmost of them on the tip of the wing feathers	9(270)	29	22	N	74	0	4
10	The star on the bend of the left wing	10(300)	13	32	N	49	30	3
11	The star north of this in the middle of the same wing	10(300)	16	32	N	52	10	4(s)
12	The star in the tip of the feathers of the left wing	10(300)	19	22	N	44	0	3
13	The star on the left leg	10(300)	22	42	N	55	10	4
14	The star on the left knee	10(300)	27	12	N	57	0	4
15	The more advanced of the 2 stars in the right leg	10(300)	33	52	N	64	0	4
16	The one to the rear	10(300)	15	22	N	64	30	4
17	The nebulous star on the right knee	10(300)	24	52	N	63	45	5

17 stars, 1 is of the 2nd magnitude, 5 of the 3rd magnitude, 8 of the 4th magnitude, 2 of the 5th magnitude. and 1 of the 6th magnitude

The ones surrounding the constellation but not in it.

1	The southernmost of the 2 stars under the left wing	10(300)	23	22	N	49	40	4
2	The northernmost of them	10(300)	26	32	N	51	40	4

Those stars that are not part of the constellation are 2 stars of the 4th magnitude.



Folio 104

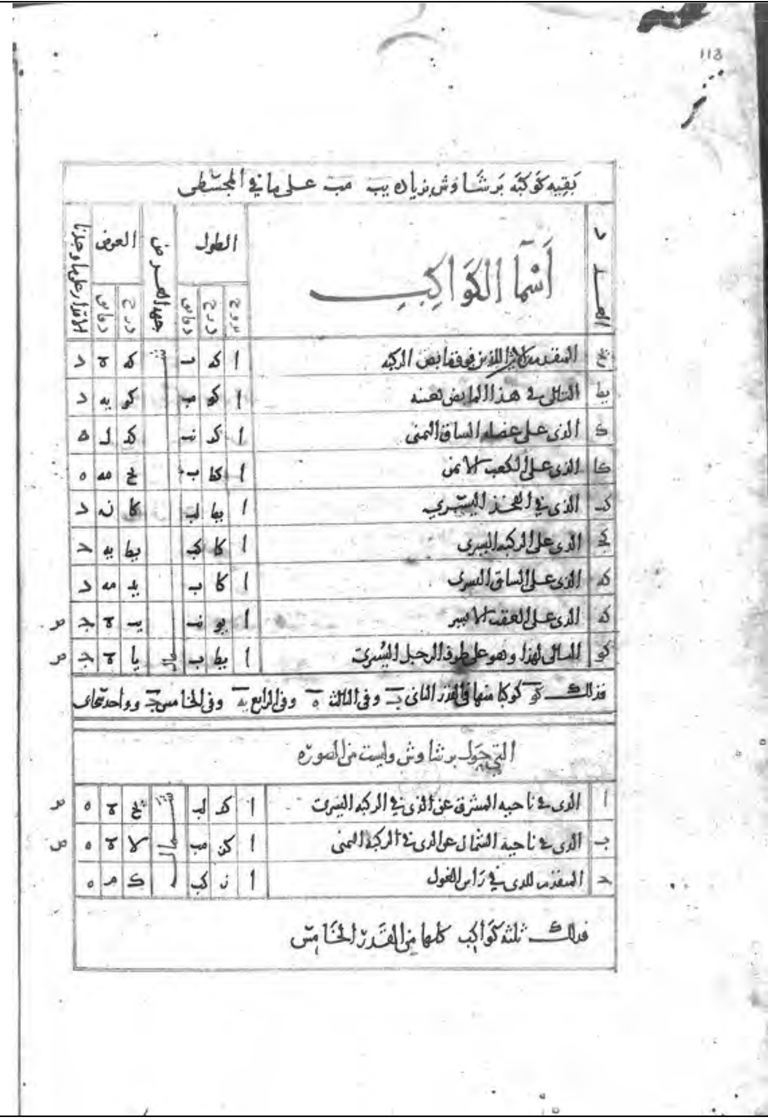
Constellation Cassiopeia (*Dhāt al-Kursīy*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head	0	20	32	N	45	20	4(k)
2	The star in the breast	0	23	32	N	46	45	3
3	The one north of that on the belt	0	25	42	N	47	50	4
4	The star over the throne just above the thighs	0	29	22	N	49	0	3(k)
5	The star in the knees	1(30)	3	22	N	45	30	3
6	The star on the lower leg	1(30)	9	42	N	47	20	4
7	The star on the end of the leg	1(30)	14	22	N	47	20	4(s)
8	The star on the left upper arm	0	27	22	N	44	20	4(s)
9	The star below the left elbow	1(30)	0	22	N	45	0	5
10	The star on the right fore arm	0	15	2	N	50	0	6
11	The star above the foot of the throne	0	27	42	N	52	40	4 or 4(s)
12	The star on the middle of the back of the throne called *al-Kaff al-Khaḍīb*	0	20	32	N	51	40	3
13	The star on the top of the throne back	0	16	2	N	51	40	6
13 stars, 4 of the 3rd magnitude, 6 of the 4th magnitude, 1of the 5th magnitude, 2 of the 6th magnitude								

Folio 117

Constellation Perseus (*Barshāūsh*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*									
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The nebulous mass on the right hand	1(30)	9	22	N	40	30	nebulous
2	The star on the right elbow	1(30)	13	52	N	37	30	4
3	The star on the right shoulder	1(30)	15	22	N	34	30	3(s)
4	The star on the left shoulder	1(30)	10	12	N	32	20	4(s)
5	The star on the head	1(30)	13	22	N	34	30	5
6	The star located between the shoulders	1(30)	14	12	N	31	10	4
7	The bright star in the right side	1(30)	17	32	N	30	0	2
8	The most advanced of the 3 stars next to the one in the side	1(30)	18	2	N	27	50	4
9	The middle one of the three	1(30)	19	42	N	27	40	4
10	The rearmost of them	1(30)	20	22	N	27	20	3
11	The star on the left elbow	1(30)	13	12	N	27	0	4
12	The star in the gorgon's head the bright one	1(30)	12	22	N	23	0	2(s)
13	The star in the gorgon's head the one to the rear of this	1(30)	11	52	N	21	0	4(s)
14	The star in the gorgon's head the one in advance of the bright star	1(30)	10	22	N	21	0	4(m)
15	The star in the gorgon's head the remaining one yet again in advance of this	1(30)	9	32	N	22	15	4
16	The star in the right knee	1(30)	27	32	N	28	15	4
17	The one in advance of this over the knee	1(30)	25	42	N	28	10	4

Folio 118

Remaining stars of the constellation Perseus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
18	The more advanced of the 2 stars above the bend in the knee	1(30)	25	2	N	25	0	4
19	The rearmost of them just over the bend in the knee	1(30)	26	42	N	26	15	4
20	The star on the right calf	1(30)	24	52	N	24	30	5
21	The star on the right ankle	1(30)	29	2	N	18	45	5
22	The star in the left thigh	1(30)	19	32	N	21	50	4
23	The star on the left knee	1(30)	21	22	N	19	15	3
24	The star on the left lower leg	1(30)	21	2	N	14	45	4
25	The star on the left heel	1(30)	16	52	N	12	0	3(s)
26	The one to the rear of this on the left foot	1(30)	19	2	N	11	0	3(s)
26 stars, 2 are of the 2nd magnitude, 5 of the 3rd magnitude, 15 of the 4th magnitude, 3 of the 5th magnitude and 1 nebula.								
The ones surrounding the constellation but not in it.								
1	The star to the east of the one on the left knee	1(30)	24	32	N	18	0	5(s)
2	The star to the north of the one in the right knee	1(30)	27	42	N	31	0	5(s)
3	The star in advance of those in the gorgon's head	1(30)	7	22	N	20	40	5
3 stars, all of the 5th magnitude.								



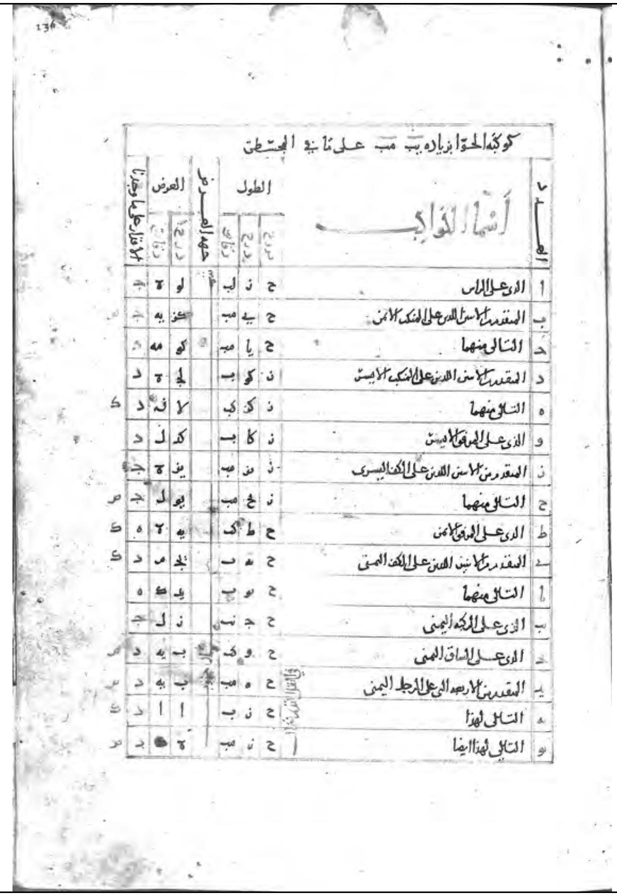
Folio 121

Constellation Auriga (*Mumsek al-A‘ina*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The southernmost of the two on the head	2(60)	15	12	N	30	0	4
2	The northernmost of these above the head	2(60)	15	2	N	30	50	5
3	The star on the left shoulder called *al-‘Ayyūq* (Capella)	2(60)	7	42	N	22	30	1
4	The star on the right shoulder	2(60)	15	32	N	20	0	2
5	The star on the right elbow	2(60)	13	52	N	15	15	5
6	The star on the right wrist	2(60)	15	32	N	13	20	3
7	The star on the left elbow	2(60)	4	42	N	20	40	4
8	The rearmost of the two stars on the left wrist which are called *al-Jadayain*	2(60)	4	52	N	18	0	4
9	The more advanced of these	2(60)	4	42	N	18	0	4
10	The star on the left ankle	2(60)	2	32	N	10	10	3(s)
11	The star on the right ankle which is applied in common to the horn of Taurus	2(60)	8	22	N	5	0	2
12	The one to the north of the latter in the lower hem of the garment	2(60)	8	42	N	8	30	6
13	The one north again of this on the buttock	2(60)	9	2	N	12	20	6
13 stars, 1 is of the 1st magnitude, 2 of the 2nd magnitude, 2 of the 3rd magnitude, 4 of the 4th magnitude, 2 of the 5th magnitude, 2 of the 6th magnitude.								

Folio 136

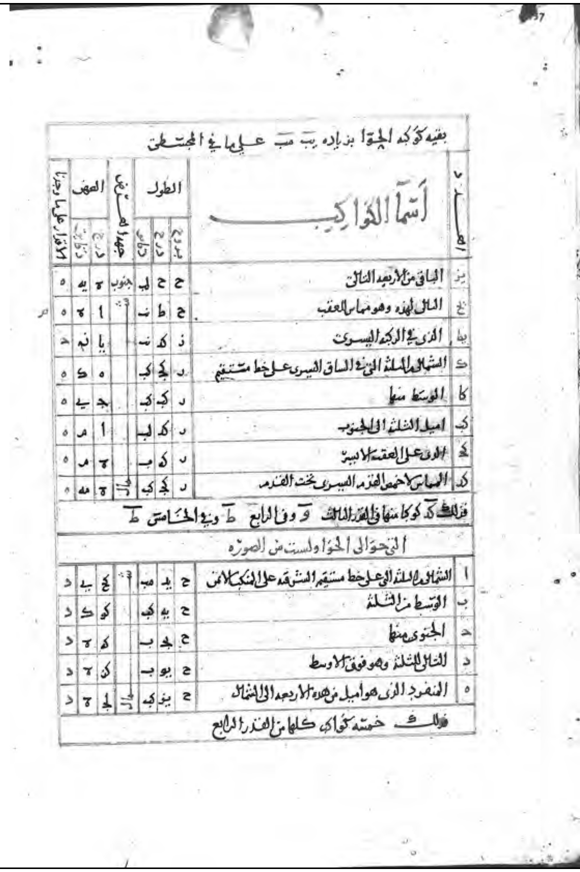
Constellation Ophiuchus (*al-Ḥawwā’*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head	8(240)	7	32	N	36	0	3
2	The more advanced of the 2 stars on the right shoulder	8(240)	10	42	N	27	15	3(s)
3	The rearmost of them	8(240)	11	42	N	26	45	4
4	The more advanced of the 2 stars on the left shoulder	7(210)	26	2	N	33	0	4
5	The rearmost of them	7(210)	27	22	N	31	50	3(s) or 4(m)
6	The star on the left elbow	7(210)	21	2	N	24	30	4
7	The more advanced of the 2 stars in the left hand	7(210)	17	42	N	17	0	3
8	The rearmost of them	7(210)	18	42	N	16	30	3(s)
9	The star on the right elbow	8(240)	9	22	N	15	0	5(m)
10	The more advanced of the 2 stars in the right hand	8(210)	15	2	N	13	40	4(m)
11	The rearmost of them	8(240)	16	2	N	14	20	5
12	The star on the right knee	8(240)	3	52	N	7	30	3
13	The star on the right lower leg	8(210)	6	22	N	2	15	5(m) or 4(s)
14	The most advanced of the 4 stars on the right foot	8(240)	5	42	S	2	15	5(k) or 4(s)
15	The one to the rear of this	8(240)	7	2	S	1	1	4(k)
16	The one to the rear again of that	8(240)	7	42	S	0	20	4(s)



Folio 137

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Remaining stars of the constellation Ophiuchus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
17	The last and rearmost of the 4	8(240)	8	32	S	0	15	5
18	The star to the rear of these which touches the heel	8(240)	9	52	N	1	0	5(s)
19	The star in the left knee	7(210)	24	52	N	11	50	3
20	The northernmost of the 3 stars in a straight line in the left lower leg	7(210)	23	22	N	5	20	5
21	The middle one of these	7(210)	22	22	N	3	10	5
22	The southernmost of the three	7(210)	24	32	N	1	40	5
23	The star on the left heel	7(210)	25	2	N	0	40	5
24	The star touching the hollow of the left foot	7(210)	23	22	N	0	45	5
24 stars. 6 of the 3rd magnitude, 9 of the 4th magnitude, 9 of the 5th magnitude								
The ones surrounding the constellation but not in it.								
1	The northernmost of the 3 to the east of the right shoulder	8(240)	14	42	N	28	10	4
2	The middle one of three	8(240)	15	22	N	26	20	4
3	The southernmost of them	8(240)	13	2	N	25	0	4
4	The star to the rear of these over the middle one	8(240)	16	2	N	27	0	4
5	The lone star north of these 4	8(240)	17	22	N	33	0	4
5 stars, all of the 4th magnitude.								


بقية كواكب الحوا بزيادة يب مب على ما في المجسطي
أسماء الكواكب
التي حوالي الحوا وليست من الصورة

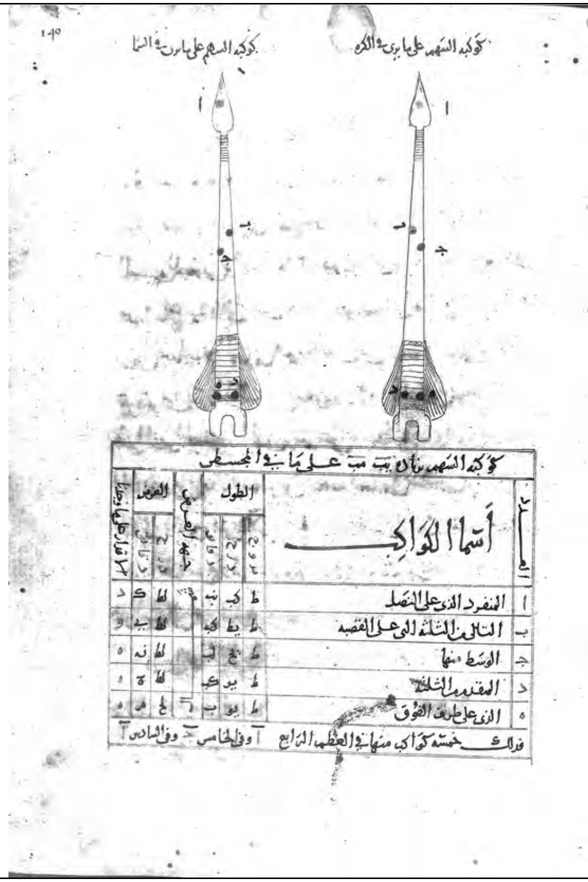
Folio 138

Constellation Serpens (*al-Ḥayya*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The stars on the quadrilateral in the head, the one on the end of the jaw	7(210)	1	32	N	38	0	4
2	The stars on the quadrilateral in the head, the one touching the nostrils	7(210)	4	22	N	40	0	4(s)
3	The stars on the quadrilateral in the head, the one in the temple	7(210)	7	2	N	36	0	3(s)
4	The stars on the quadrilateral in the head, the one where the neck joins the head	7(210)	4	42	N	34	15	3(s)
5	The stars on the quadrilateral in the head, the one in the middle of the quadrilateral in the mouth	7(210)	4	2	N	37	15	5
6	The star outside the head to the north of it	7(210)	5	52	N	42	30	4(s)
7	The one after the first bend in the neck	7(210)	4	22	N	29	15	3(s)
8	The northernmost of the 3 following this	7(210)	7	32	N	26	30	4
9	The middle one of the three	7(210)	7	2	N	25	20	3
10	The southernmost of them	7(210)	9	2	N	24	0	3(s)
11	The star after the next bend which is in advance of the left hand of Ophiuchus	7(210)	11	22	N	16	30	4
12	The star to the rear of those in the hand of Ophiuchus	7(210)	20	52	N	16	15	5
13	The one after the back of the right thigh of Ophiuchus	8(240)	6	22	N	10	30	4
14	The southernmost of the 2 to the rear of the latter	8(240)	9	42	N	8	30	4(m)
15	The northernmost of them	8(240)	10	32	N	10	30	4
16	The one after the right hand of Ophiuchus on the bend in the tail	8(240)	16	22	N	20	0	4
17	The one to the rear of this likewise on the tail	8(240)	21	22	N	21	15	4(m)
18	The star on the tip of the tail	9(270)	1	2	N	27	0	4
18 stars, 5 is of the 3rd magnitude, 11 of the 4th magnitude, 2 of the 5th magnitude.								


كوكبة حية الحوا بزياده يب مب علـى ما في المجسطي
اسما الكواكب

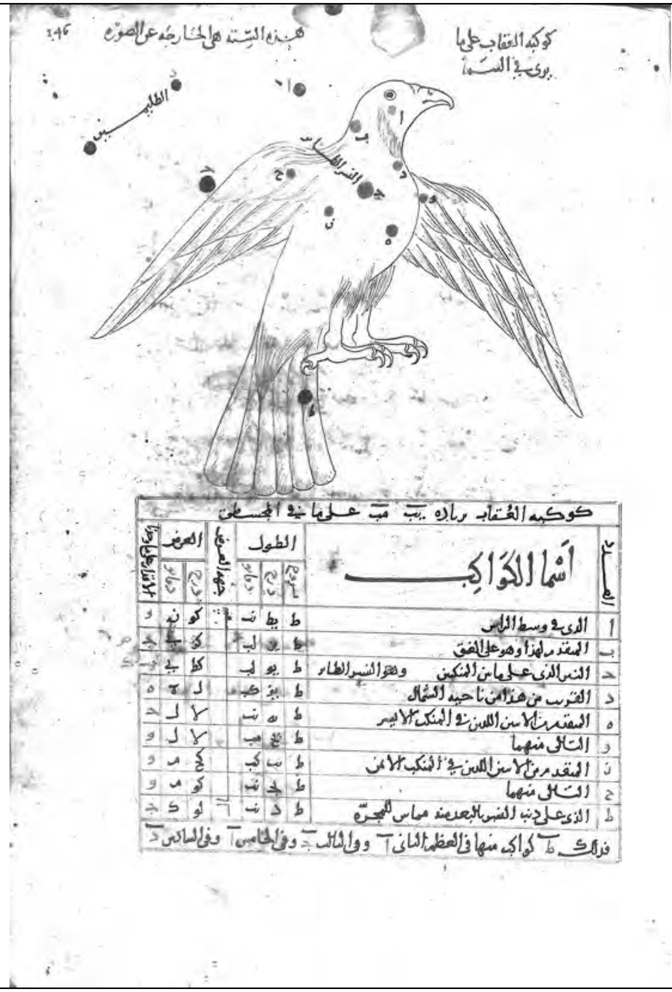
Folio 140

Constellation Sagitta (*al-Sahem*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The lone star on the arrow head	9(270)	22	52	N	39	20	4
2	The rearmost of the three stars in the shaft	9(270)	19	22	N	39	10	6
3	The middle one	9(270)	18	32	N	39	50	5
4	The most advanced of the three	9(270)	16	22	N	39	0	5
5	The star on the end of the notch	9(270)	16	2	N	38	40	5
5 stars, 1 is of the 4th magnitude, 3 of the 5th magnitude, 1 of the 6th magnitude								



Folio 146

Constellation Aquila (*al-ʻUqāb*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the middle of the head	9(270)	19	52	N	26	50	6
2	The one in advance of this on the neck	9(270)	17	32	N	27	10	3(s)
3	The bright star on the place between the shoulders called al-*Nasr al-Ṭā'er* (Aquila)	9(270)	16	32	N	29	10	2(m)
4	The one close to this towards the north	9(270)	17	22	N	30	0	5
5	The more advanced of the 2 in the left shoulder	9(270)	15	52	N	31	30	3
6	The rearmost of them	9(270)	18	42	N	31	30	6
7	The more advanced of the two in the right shoulder	9(270)	12	22	N	28	40	6
8	The rearmost of them	9(270)	13	52	N	26	40	6
9	The star some distance under the tail of Aquila touching the Milky Way	9(270)	4	52	N	36	20	3
9 stars 1 of the 2nd magnitude, 3 of the 3rd magnitude, 1 of the 5th magnitude, 4 of the 6th magnitude.								



Folio 147

The ones surrounding the constellation Aquila but not in it with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	the more advanced of the 2 stars south of the head of Aquila	9(270)	16	52	N	21	40	3(s)
2	the rearmost of them	9(270)	21	22	N	19	10	3
3	the star to the south and west of the right shoulder of Aquila	9(270)	8	42	N	25	0	3(s)
4	the one to the south of this	9(270)	10	52	N	20	0	4(s)
5	the one to the south again of the latter	9(270)	12	22	N	15	30	5
6	the star most in advance of all	9(270)	3	52	N	18	10	3(s)
6 stars, 4 of the 3rd magnitude, 1 of the 4th magnitude, 1 of the 5th magnitude								


147

التي حول النسر وليست من الصورة بزيادة يب مب على ما في المجسطي

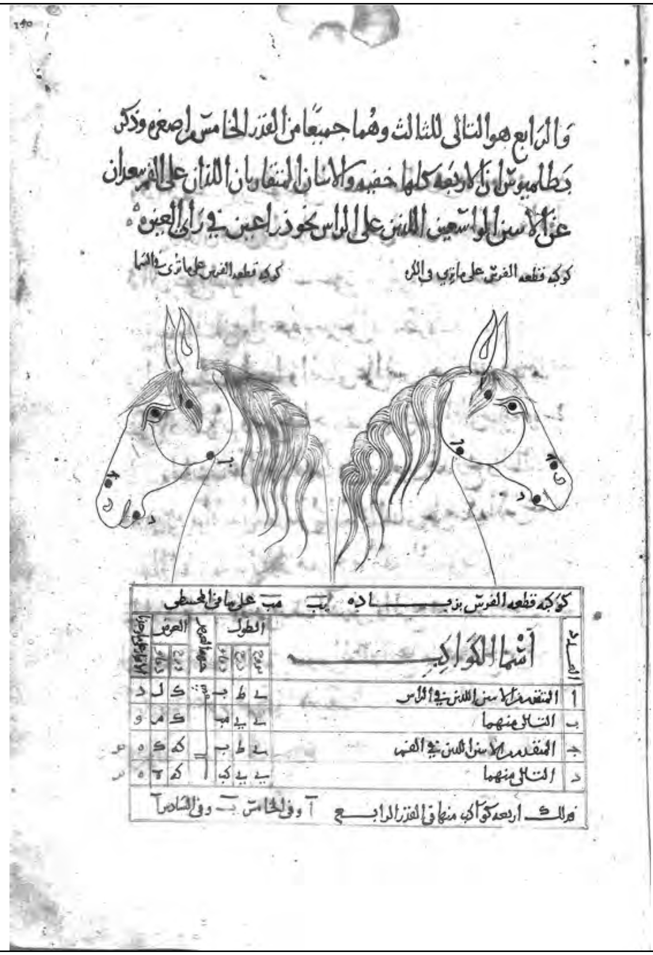
العدد	أسماء الكواكب	برج	درج	دقائق	جهة العرض	درج	دقائق	العظم على ما وجدنا
ا	المتقدم من الاثنين اللذين من ناحية الجنوب عن رأس النسر	ط	يو	نب		كا	م	ج
ب	التالي منهما	ط	كا	كب		يط	ي	ج
ج	الذي من ناحية الجنوب والمغرب عن المنكب الأيمن من النسر	ط	ح	مب		كه	٠	ج
د	الذي من ناحية الجنوب عن هذا	ط	ي	نب		ك	٠	د
ه	الذي هو أيضا عن هذا أيضا إلى الجنوب	ط	يب	كب		يه	ل	ه
و	المتقدم لجميعها	ط	ج	نب		يح	ي	ج
فذلك ستة كواكب منها من القدر الثالث د ومن الرابع آ ومن الخامس آ								

Folio 149

Constellation Delphinus (*al-Dalfīn*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The most advanced of the 3 stars in the tail	10(300)	0	22	N	29	10	4(m)
2	The northernmost of the other 2	10(300)	1	22	N	29	0	6
3	The southernmost of them	10(300)	1	22	N	27	45	6
4	The southernmost star on the advanced side of the rhombus	10(300)	1	12	N	32	0	3(s)
5	The northernmost star on the advanced side of the rhombus	10(300)	2	52	N	33	50	3(s)
6	The southernmost star on the rear side of the rhombus	10(300)	4	2	N	32	0	3(s)
7	The northernmost star on the rear side of the rhombus	10(300)	6	12	N	33	10	3(s)
8	The southernmost of the 3 stars between the tail and the rhombus	10(300)	0	12	N	34	0	6
9	The more advanced of the other 2 to the north	10(300)	0	12	N	31	50	6
10	The remaining rearmost one	10(300)	1	42	N	31	30	6
10 stars, 4 is of the 3rd magnitude, 1 of the 4th magnitude, 5 of the 6th magnitude								

Folio 150

Constellation Equuleus (*Quṭ‘at al-Faras*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The more advanced of the 2 stars in the head	10(300)	9	2	N	20	30	4
2	The rearmost of them	10(300)	10	42	N	20	40	6
3	The more advanced of the two stars in the mouth	10(300)	9	2	N	25	20	5(s)
4	The rearmost of them	10(300)	10	22	N	25	0	5(s)
4 stars, 1 of the 4th magnitude, 2 of the 5th magnitude, 1 of the 6th magnitude								



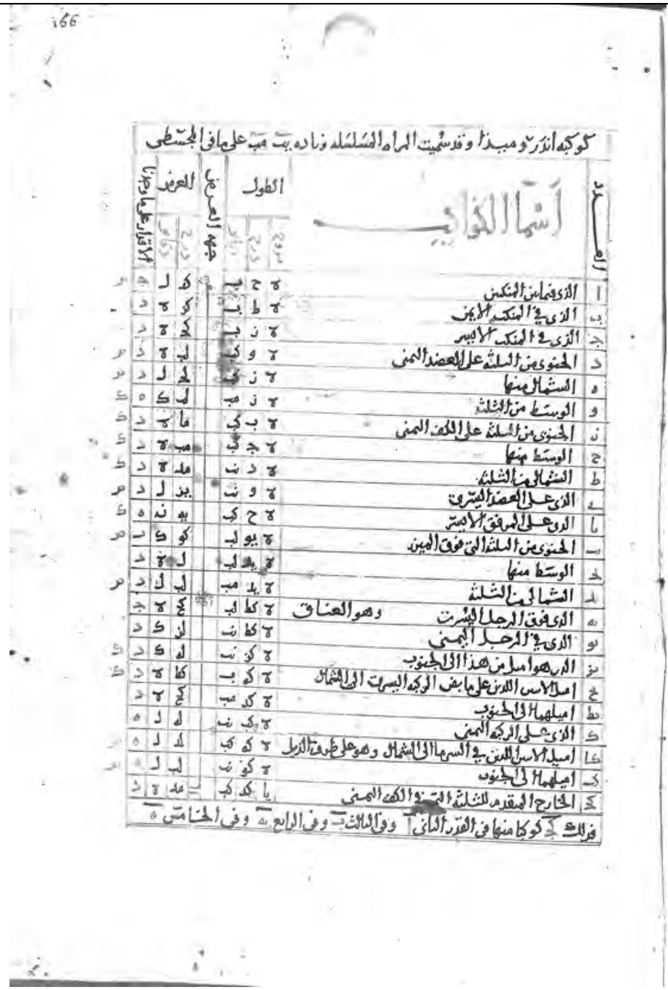
Folio 157

Constellation Pegasus (*al-Faras al-A'ẓam*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the navel which is applied in common to the head of Andromeda	0	0	32	N	26	0	2(s)
2	The star on the rump and the wing tip	11(330)	24	52	N	12	30	2(s)
3	The star on the right shoulder and the place where the leg joins it	11(330)	14	52	N	31	0	2(s)
4	The star on the place between the shoulders and shoulder part of the wing	11(330)	9	22	N	19	40	2(s)
5	The northernmost of the two stars in the body under the wing	11(330)	17	12	N	25	30	4
6	The southernmost of them	11(330)	17	42	N	25	0	4
7	The northernmost of the two stars in the right knee	11(330)	11	42	N	35	0	5 or 3
8	The southernmost of them	11(330)	11	12	N	34	30	5
9	The more advanced of the two stars close together in the chest	11(330)	8	52	N	29	0	4(k)
10	The rearmost of them	11(330)	9	42	N	29	30	4(k)
11	The more advanced of the 2 stars close together in the neck	11(330)	1	32	N	18	0	3(s)
12	The rearmost of them	11(330)	3	12	N	19	0	4(s)
13	The southernmost of the two stars on the mane	11(330)	4	2	N	15	0	6 or 5(s)
14	The northernmost of them	11(330)	3	12	N	16	0	6 or 5(s)
15	The northernmost of the two stars close together on the head	10(300)	22	2	N	16	50	3(s)
16	The southernmost of them	10(300)	20	42	N	16	0	5(s)
17	The star in the muzzle	10(300)	18	2	N	22	30	3
18	The star in the right hock	11(330)	6	22	N	41	10	4
19	The star on the left knee	11(330)	5	22	N	34	15	4
20	The star in the left hock	10(300)	25	2	N	36	50	4
20 stars, 4 is of the 2nd magnitude, 3 of the 3rd magnitude, 8 of the 4th magnitude, 5 of the 5th magnitude.								

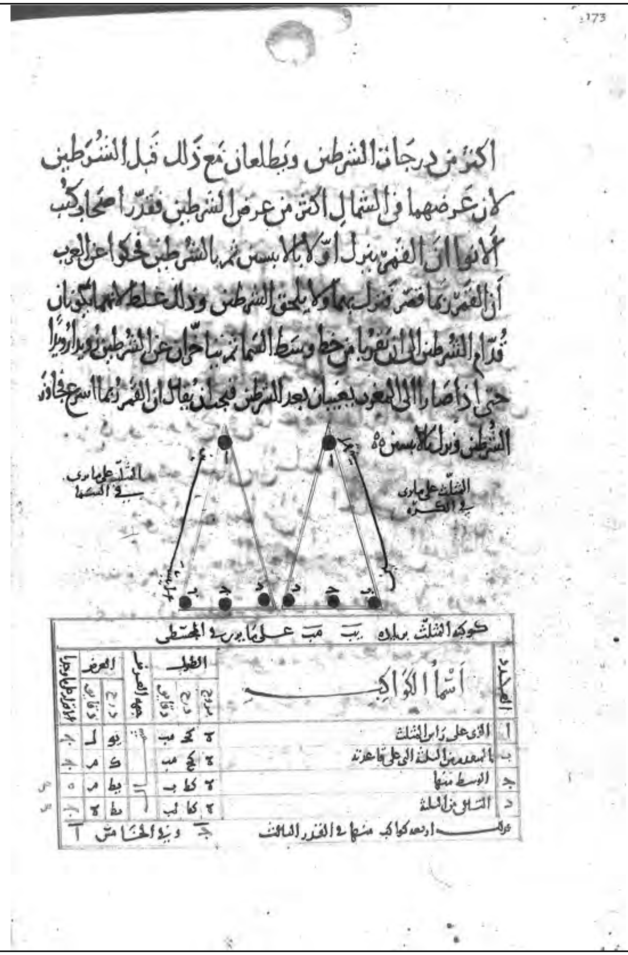
Folio 166

Constellation Andromeda (*al-Mara' Al-Musalsala*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the place between the shoulders	0	8	2	N	24	30	3(s)
2	The star in the right shoulder	0	9	2	N	27	0	4
3	The star in the left shoulder	0	7	2	N	23	0	4
4	The southernmost of the 3 stars on the right upper arm	0	6	22	N	32	0	4(s)
5	The northernmost of them	0	7	22	N	33	30	4(s)
6	The middle one of the three	0	7	42	N	32	20	5(m) or 5(s)
7	The southernmost of the 3 stars on the right hand	0	2	22	N	41	0	4(m)
8	The middle one of these	0	3	22	N	42	0	4(m)
9	The northernmost of the three	0	4	52	N	44	0	4(m)
10	The star on the left upper arm	0	6	52	N	17	30	4(s)
11	The star on the left elbow	0	8	22	N	15	50	5(m)
12	The southernmost of the 3 stars over the griddle	0	16	32	N	26	20	2(s)
13	The middle one of these	0	14	32	N	30	0	4
14	The northernmost of the three	0	14	42	N	32	30	4(s)
15	The star over the left foot called *al-'Anāq*	0	29	32	N	28	0	3
16	The star in the right foot	0	29	52	N	37	20	4
17	The one south of the latter	0	27	52	N	35	20	4(m)
18	The northernmost of the 2 stars on the left knee bend	0	25	2	N	29	0	4(m)
19	The southernmost of them	0	24	42	N	28	0	4
20	The star on the right knee	0	22	52	N	35	30	5
21	The northernmost of the 2 stars in the lower hem of the garment	0	25	22	N	34	30	5(s) or 6
22	The southernmost of them	0	26	52	N	32	30	5(s) or 6
23	The star in advance of the three in the right hand outside of it	11(330)	24	22	N	44	0	4(m) or 4
23 stars, 1 is of the 2nd magnitude, 2 of the 3rd magnitude, 15 of the 4th magnitude, 5 of the 5th magnitude.								



Folio 173

Constellation Triangulum (*al-Muthallath*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the apex of the triangle	0	23	42	N	16	30	3
2	The most advanced of the 3 on the base	0	28	42	N	20	40	3
3	The middle one of these	0	29	2	N	19	40	5(s)
4	The rearmost of the three	0	29	32	N	19	0	3(s)
4 stars, 3 of the 3rd magnitude, 1 of the 5th magnitude								



Folio 182

Table for the Constellation Aries (*al-Ḥamal*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The more advanced of the 2 stars on the horn	0	19	22	N	7	20	3(s)
2	The rearmost of them	0	20	22	N	8	20	3
3	The northernmost of the 2 stars on the muzzle	0	23	42	N	7	40	5(s)
4	The southernmost of them	0	24	12	N	6	0	4(s)
5	The star on the neck	0	19	12	N	5	30	5
6	The star on the rump	1(30)	0	22	N	6	0	6
7	The star on the place where the tail joins [the body]	1(30)	4	2	N	4	50	5
8	The most advanced of the 3 stars in the tail	1(30)	6	32	N	1	40	4
9	The middle one of the three	1(30)	8	2	N	2	30	4
10	The rearmost of them	1(30)	9	42	N	1	50	4
11	The star in the back of the thigh	1(30)	2	22	N	1	10	5
12	The star under the knee-bend	1(30)	0	42	N	1	30	5
13	The star on the hind hoof	0	27	42	N	5	15	4
13 stars, 2 is of the 3rd magnitude, 5 of the 4th magnitude,5 of the 5th magnitude, 1of the 6th magnitude								
The ones surrounding the constellation Aries but not in it.								
1	The star over the head, which Hipparchus [calls] 'the one on the muzzle'	0	23	22	N	10	0	3(k)
2	The 4 stars over the rump: the rearmost, which is brighter [than the others]	1(30)	4	22	N	10	10	4
3	The northernmost of the other 3, fainter stars	1(30)	4	2	N	12	40	5
4	The middle one of these three	1(30)	2	22	N	11	10	5
5	The southernmost of them	1(30)	1	52	N	10	40	5(s)
5 stars, 1 is of the 3rd magnitude, 1 of the 4th magnitude, 3 of the 5th magnitude.								

Folio 183 (Manuscript Marsh144)

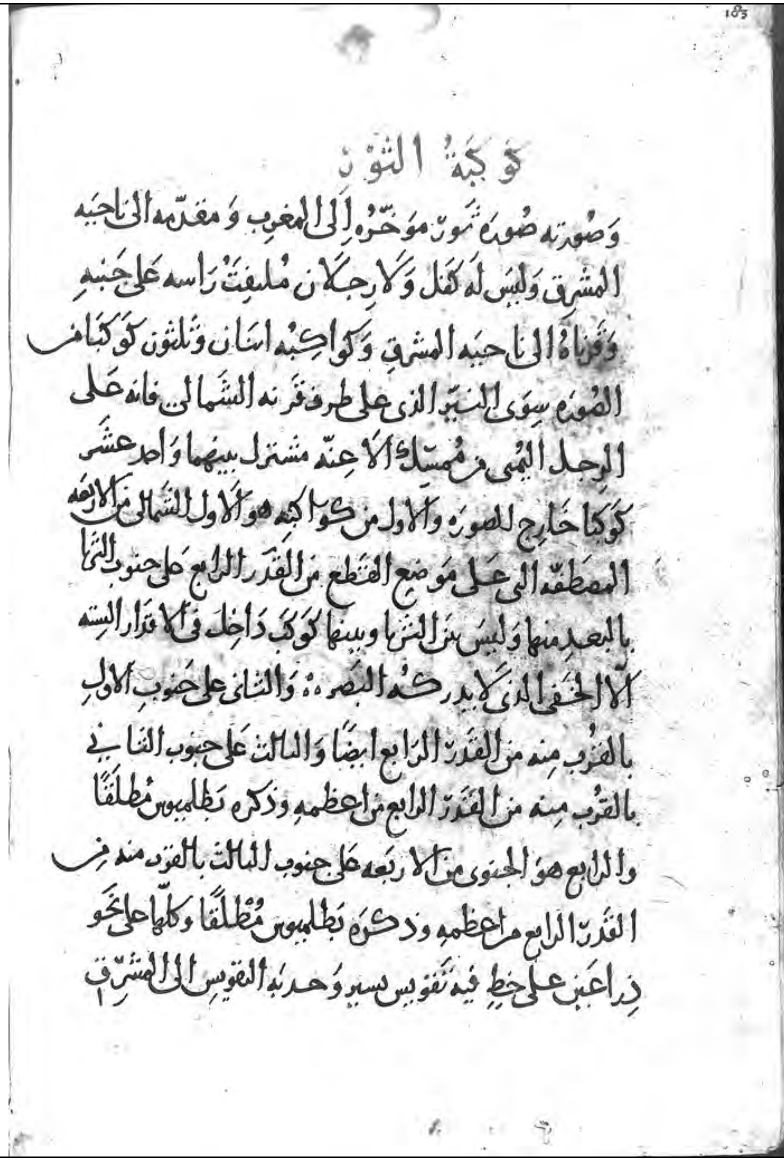
The constellation Taurus (*al-Thawr)*

Its image looks like a bull with its end (pointed) to the west and its front towards the east. It does not have a rump or legs. Its head is turned towards its side and its horns point towards the east.

Its stars are thirty-two stars in the main picture, except the bright (star) on the tip of its northern horn which is part of the right leg of *Mumsek al-A'ina* (constellation Auriga) and is common to both (constellations). There are eleven stars outside the picture (of the constellation).

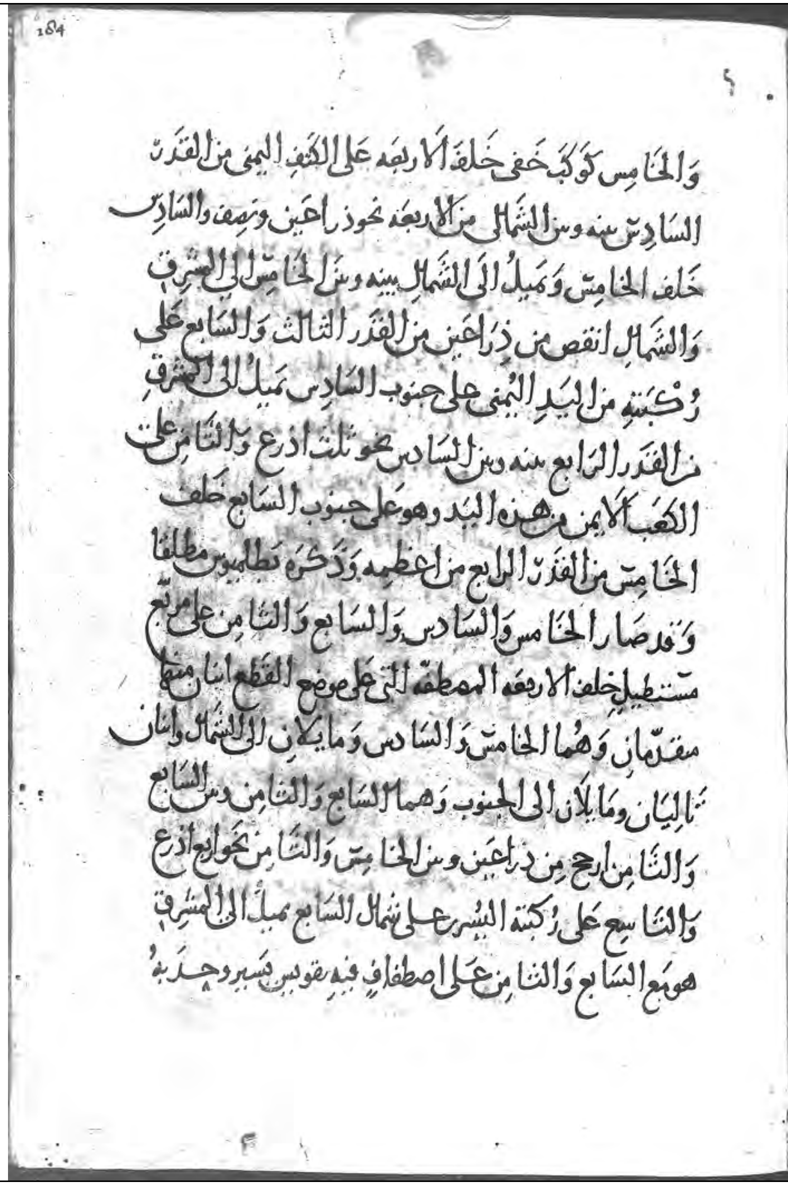
The first of its stars is the northernmost (star) of the four aligned on the cut-off position (where figure of bull is cut short) and is of the 4^{th} magnitude. It is far south of the Pleiades, and there are no stars between the Pleiades and this star which are as bright as the 6^{th} magnitude except the faint stars which are hardly seen.

The second (star) is south of the first, close to it, and is also of the 4^{th} magnitude.
The third is south of the second, close to it, and is much greater than 4^{th} magnitude, but it was mentioned by Ptolemy as 4^{th} magnitude exactly.
The fourth is the southernmost star of the four, south and close to the third, and is much greater then 4^{th} magnitude, but it was mentioned by Ptolemy as 4^{th} magnitude exactly.
(The four stars) all form a slightly curved line the size of two *dhirā'* (1 *dhirā'* = 2 deg 20 min, 2 *dhirā'* = 4 deg 40 min) with its curve pointed towards the east.


كوكبة الثور
وصورته صورة ثور مؤخره الى المغرب و مقدمه الى ناحيه
المشرق وليس له كفل ولا رجلان ملتفت راسه على جنبه
وقرناه الى ناحيه المشرق وكواكبه اثنان وثلثون كوكبا في
الصورة سوى النير الذي على طرف قرنه الشمالي فانه على
الرجل اليمنى من ممسك الاعنة مشترك بينهما واحد عشر
كوكبا خارج الصورة والاول من كواكبه هو الاول الشمالي من الاربعة
المصطفة التي على موضع القطع من القدر الرابع على جنوب الثريا
بالبعد منها وليس بين الثريا وبينها كوكب داخل في الاقدار الستة
الا الخفي الذي لا يدرك بالبصر. والثاني على جنوب الاول
بالقرب منه من القدر الرابع ايضا والثالث على جنوب الثاني
بالقرب منه من القدر الرابع من اعظمه وذكره بطلميوس مطلقا
والرابع هو الجنوبي من الاربعة على جنوب الثالث بالقرب منه من
القدر الرابع من اعظمه وذكره بطلميوس مطلقا وكلها على نحو
ذراعين على خط فيه تقويس يسير وحدبة التقويس الى المشرق

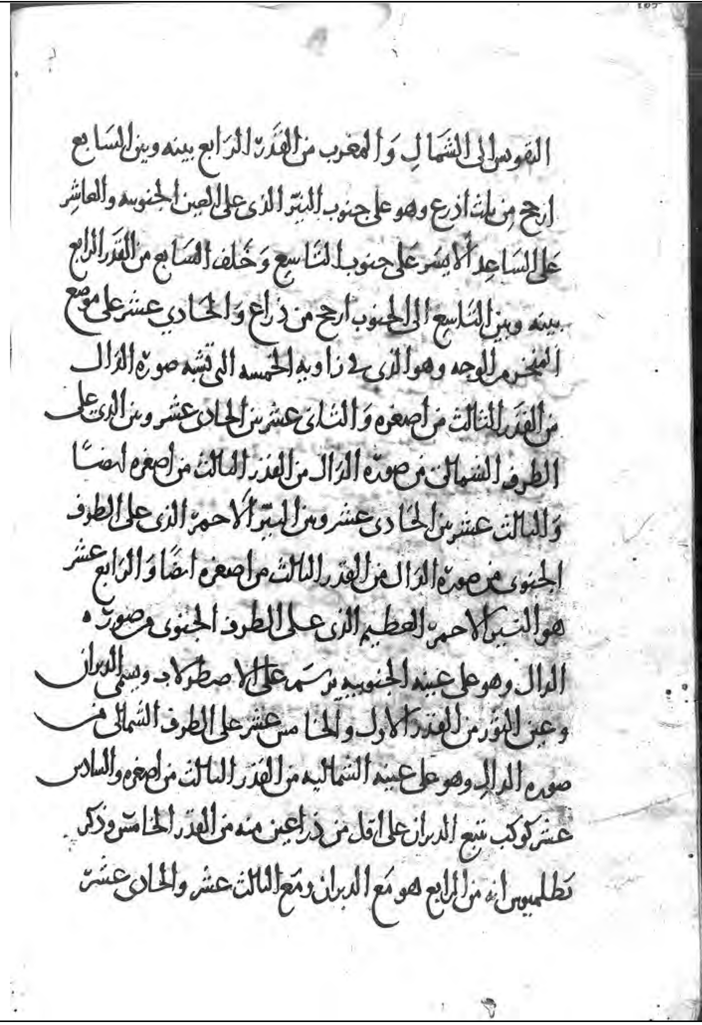
Folio 184

The fifth is a dim star behind the four (stars) on the right shoulder and is of the 6th magnitude. The distance between it and the southern of the four is two *dhirā’* and a half.
The sixth is behind the fifth towards the north. The south easterly distance between it and the fifth is less then two *dhirā’* and it is of the 3rd magnitude.
The seventh is on the left knee south of the sixth (star) towards the east and is of the 4th magnitude. The distance between it and the sixth (star) is around three *dhirā’*.
The eighth is on the right hock of this hand and it is south of the seventh behind the fifth, and is much more than 4th magnitude while Ptolemy mentioned it to be exactly (4th magnitude).
The fifth, sixth, seventh and eighth form a *Murabba’ Mustaṭīl* (quadrilateral) behind the four (stars) which are aligned on the cut-off position. Two stars are in front, those are the fifth and the sixth (and) oriented towards the north, and the other two are oriented towards the south and these are the seventh and the eighth. The distance between the seventh and the eight is slightly more than two *dhirā’*. The distance between the fifth and the eighth is around four *dhirā’*.
The ninth is on the left knee north of the seventh and is oriented towards the east. (The ninth) together with the seventh and the eighth (stars) form a line with a slight curve with its curve pointed towards the north-west.


184
والخامس كوكب خفي خلف الاربعة على الكتف اليمنى من القدر
السادس بينه وبين الشمالي من الاربعة نحو ذراعين ونصف والسادس
خلف الخامس ويميل الى الشمال بينه وبين الخامس الى المشرق
والشمال انقص من ذراعين من القدر الثالث والسابع على
ركبته من اليد اليمنى على جنوب السادس يميل الى المشرق
من القدر الرابع بينه وبين السادس نحو ثلث اذرع والثامن على
الكعب الايمن من هذه اليد وهو على جنوب السابع خلف
الخامس من القدر الرابع من اعظمه وذكره بطلميوس مطلقا
وقد صار الخامس والسادس والسابع والثامن على مربع
مستطيل خلف الاربعة المصطفة التي على موضع القطع اثنان منها
مقدمان وهما الخامس والسادس ومايلان الى الشمال واثنان
تاليان ومايلان الى الجنوب وهما السابع والثامن وبين السابع
والثامن ارجح من ذراعين وبين الخامس والثامن نحو اربع اذرع
والتاسع على ركبته اليسرى على شمال السابع يميل الى المشرق
هو مع السابع والثامن على اصطفاف فيه تقويس يسير وحدبته

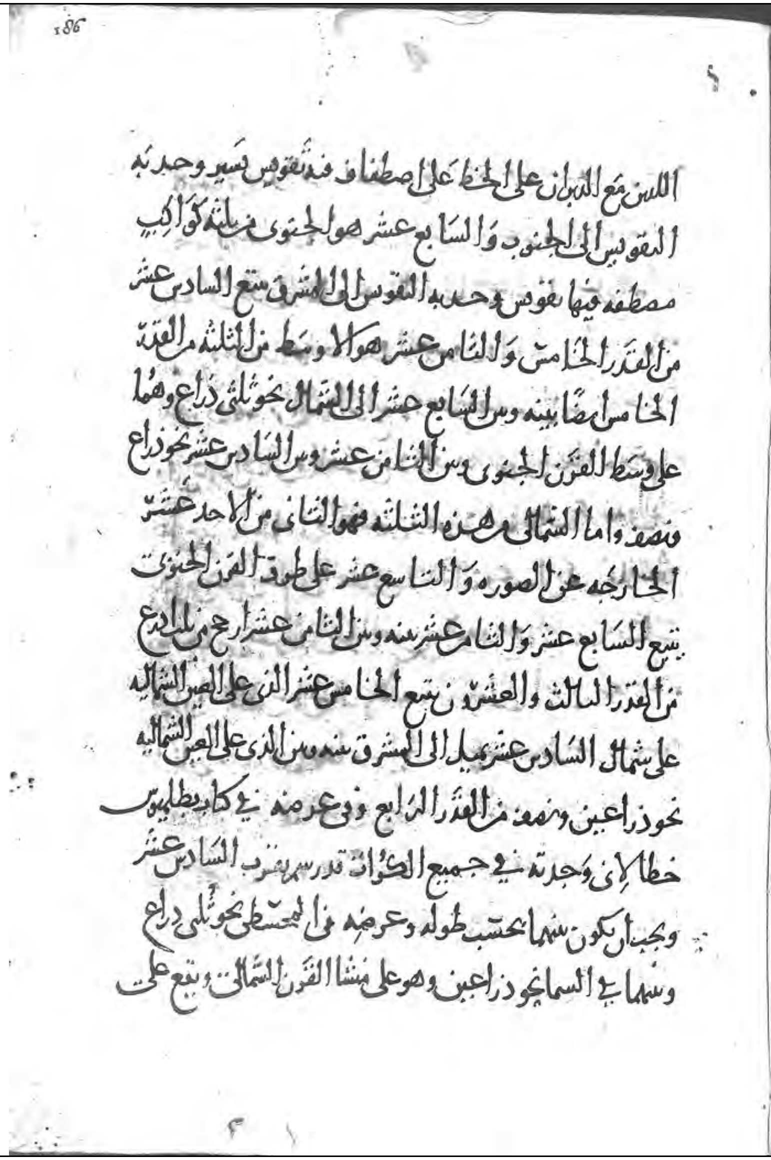
Folio 185

It (the ninth star) is of the 4th magnitude. The distance between it (the ninth) and the seventh (star) is slightly more than three *dhirā’*. It is south of the bright (star) which is on the southern eye.
The tenth is on the left leg south of the ninth and behind the seventh, and is of the 4th magnitude. The distance between it and the ninth to the south is around one *dhirā’*.
The eleventh is on the nose of the face and it is on the corner of the five (stars) which resemble *al-Dāl* (the Greek letter Δ), and it is less than 3rd magnitude.
The twelfth is between the eleventh and (the star) on the north edge of the stars that resemble *al-Dāl* and it is also less than 3rd magnitude.
The thirteenth is between the eleventh and the bright red (star) which is on the south edge of the stars that resemble *al-Dāl* and it is also less than 3rd magnitude.
The fourteenth is the large bright red (star) on the south edge of the stars that resemble *al-Dāl*. It is located on the south eye and is drawn on al-Isṭerlāb (the Astrolabe). It is called *al-Dabarān* (Aldebaran) and *Ain al-Thawr* (the eye of Taurus) and is of the 1st magnitude.
The fifteenth is on the north edge of the stars that resemble *al-Dāl*. It is located on the north eye and is less then 3rd magnitude.
The sixteenth star is distant from Aldebaran by less than two *dhirā’* and is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. (The sixteenth) together with Aldebaran and the thirteenth and eleventh (stars) which are close to Aldebaran form a line with a slight curve with its curve pointed towards the south.



Folio 186

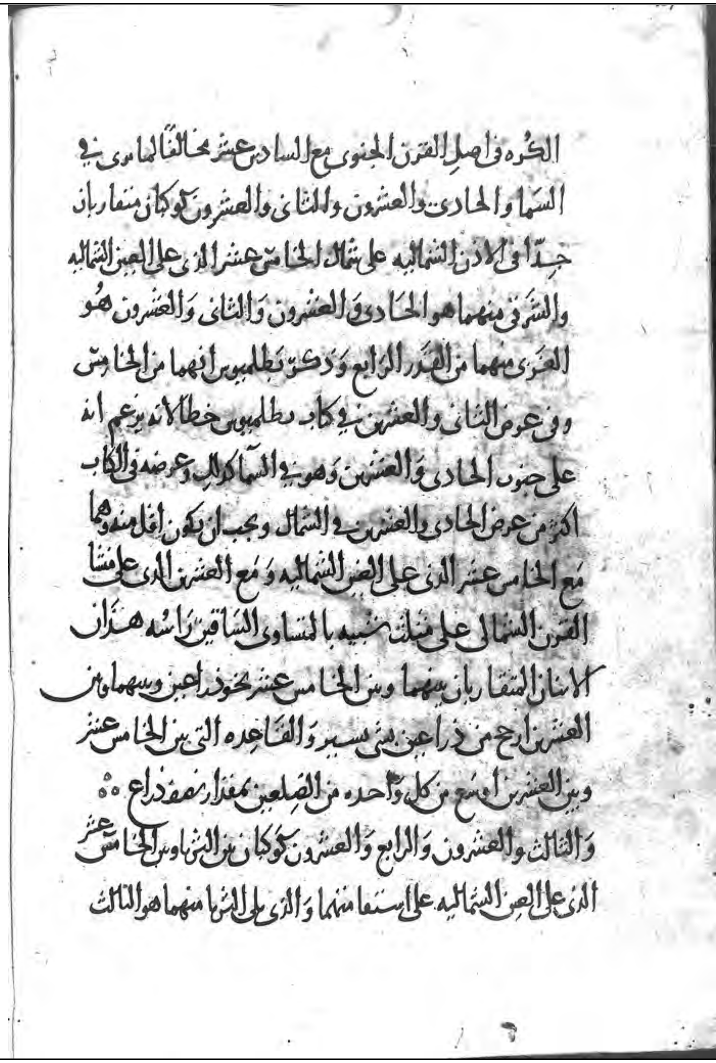
The seventeenth is the southern of three stars which form a line with a slight curve with its curve pointed towards the east. It follows the sixteenth and is of the 5th magnitude.
The eighteenth is the middle (star) of the three and is of the 5th magnitude also. The distance between it and the seventeenth towards the north is around a third of a *dhirā’*. Both are located in the middle of the southern horn.
The distance between the eighteenth and the sixteenth is around one *dhirā’ and* a half. As for the northern star of these three it is the second star from the eleven stars which are outside of the constellation.
The nineteenth is on the tip of the southern horn following the seventeenth and the eighteenth. The distance between it and the seventeenth and the eighteenth. The distance between it and the eighteenth is more than three *dhirā’ and* it is of the 3rd magnitude.
The twentieth follows the fifteenth which is on the northern eye. It is north of the sixteenth towards the east. The distance between it and the star on northern eye is around two and a half *dhirā’*, and it is of the 4th magnitude.
Its latitude in the book of Ptolemy is wrong because I found that it has been drawn on all globes next to the sixteenth star. For according to the longitude and latitude in *Almagest* the distance between them should be around a third of *dhirā’*, while the distance between them in the sky is around two *dhirā’*.


186

اللس مع اللذين على الخط على اصطفاف فيه تقويس يسير وحدبه
التقويس الى الجنوب والسابع عشر هو الجنوبي من ثلثة كواكب
مصطفة فيها تقويس وحدبه التقويس الى المشرق يتبع السادس عشر
من القدر الخامس والثامن عشر هو الاوسط من الثلثة من القدر
الخامس ايضا بينه وبين السابع عشر الى الشمال نحو ثلثي ذراع وهما
على وسط القرن الجنوبي وبين الثامن عشر وبين السادس عشر نحو ذراع
ونصف واما الشمالي من هذه الثلثة فهو الثاني من الاحد عشر
الخارجة عن الصورة والتاسع عشر على طرف القرن الجنوبي
يتبع السابع عشر والثامن عشر بينه وبين الثامن عشر ازيد من ثلث اذرع
من القدر الثالث والعشرون يتبع الخامس عشر الذي على العين الشمالية
على شمال السادس عشر يميل الى المشرق بينه وبين الذي على العين الشمالية
نحو ذراعين ونصف من القدر الرابع وفي عرضه في كتاب بطليموس
خطا لاني وجدته في جميع الكرات قد رسم بقرب السادس عشر
ويجب ان يكون بينهما بحسب طوله وعرضه في المجسطي نحو ثلثي ذراع
وبينهما في السما نحو ذراعين وهو على منشا القرن الشمالي ويتبع على

Folio 187

It (the twentieth star) is located on the tip of the northern horn, while on the globes it is located on the southern horn together with the sixteenth (star) contrary to what is seen in the sky.
The twenty-first and twenty-second are two very close stars located on the northern ear, north of the fifteenth star which is on the northern eye. The eastern of these two stars is the twenty first and the twenty second is the southern of the two, (and both) are of the 4th magnitude. Ptolemy mentioned that they are of the 5th (magnitude). The latitude of the twenty-second in Ptolemy's book is wrong because as he claims that it is south of the twenty-first, as it really is in the sky, however its latitude towards the north in (Ptolemy's) book is more than that of the twenty-first and it should be less.
Both (stars) together with the fifteenth star, which is located on the northern eye, and the twentieth star, which is located on the beginning of the northern horn, (all) form a *Muthallath* (triangle) similar to a *Mutasāwi al-Saqain* (Isosceles triangle) with these two close stars on its head.
The distance between (the two stars) and the fifteenth is around two *dhirā' and* between the twentieth is slightly more than two *dhirā'*.
The base between the fifteenth and the twentieth is wider then the two sides by half a *dhirā'*.
The twenty-third and the twenty-fourth are two stars located between *al-Thurayyā* (the Pleiades) and the fifteenth, which is on the northern eye on the same line.


الكره وأصل القرن الجنوبي مع السادس عشر مخالفا لما يرى في
السما والحادي والعشرون والثاني والعشرون كوكبان متقاربان
جدا على الأذن الشمالية على شمال الخامس عشر الذي على العين الشمالية
والشرقي منهما هو الحادي والعشرون والثاني والعشرون هو
الغربي منهما من القدر الرابع وذكر بطلميوس انهما من الخامس
وفي عرض الثاني والعشرين في كتاب بطلميوس خطأ لانه يزعم انه
على جنوب الحادي والعشرين وهو في السما كذلك وعرضه في الكتاب
اكثر من عرض الحادي والعشرين في الشمال ويجب ان يكون اقل منه وهما
مع الخامس عشر الذي على العين الشمالية ومع العشرين الذي على منشأ
القرن الشمالي على مثلث شبيه بالمتساوي الساقين رأسه هذان
الاثنان المتقاربان بينهما وبين الخامس عشر نحو ذراعين وبينهما وبين
العشرين ارجح من ذراعين بشي يسير والقاعده التي بين الخامس عشر
وبين العشرين اوسع من كل واحده من الضلعين بمقدار نصف ذراع
والثالث والعشرون والرابع والعشرون كوكبان بين الثريا وبين الخامس عشر
الذي على العين الشمالية على استقامتهما والذي يلي الثريا منهما هو الثالث

Folio 188

The one closer to *al-Thurayyā* (the Pleiades) is the twenty-third which is of the 5^{th} magnitude and this star together with the two close stars on the northern ear and with the twentieth on the beginning of the northern horn are on a straight line.

The straight line that connects it with the twentieth passes between the two close stars.

The twenty-fourth is located in the middle of the distance between the twenty-third and the fifteenth and it is of the 6^{th} magnitude.

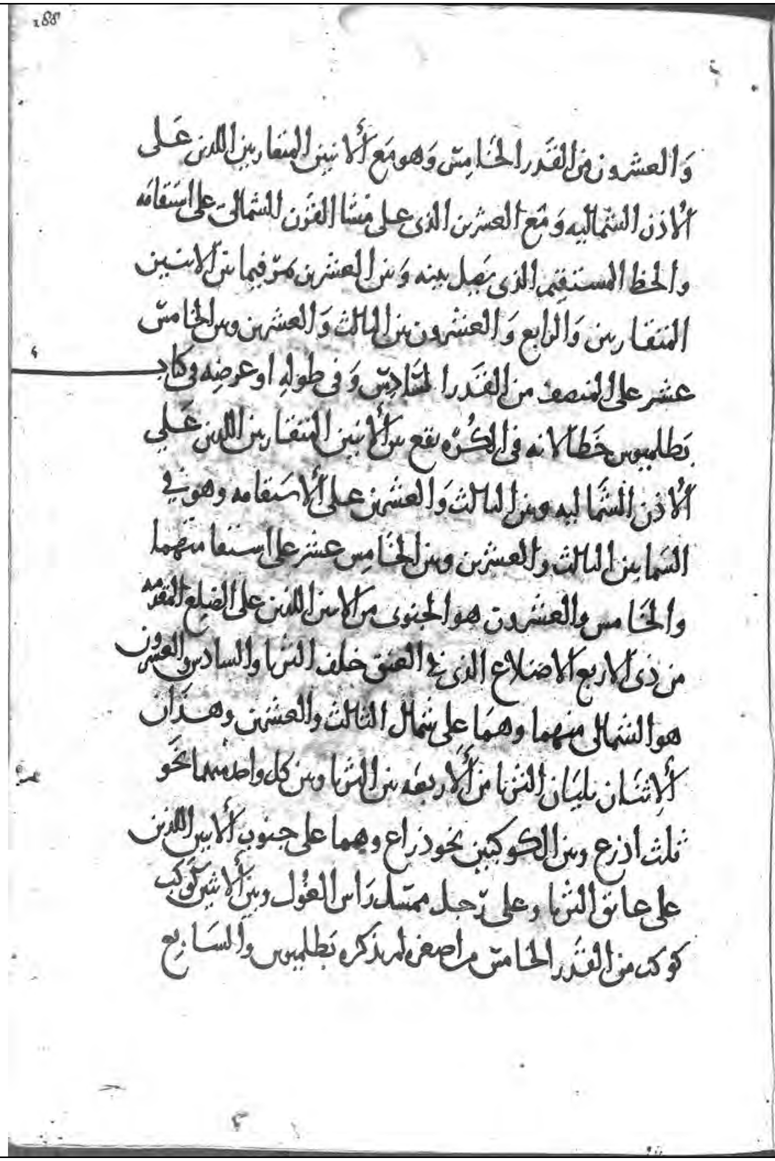
Its longitude or latitude in the book of Ptolemy is wrong because (as per Ptolemy if it is to be drawn) on a globe it forms a straight line between the two close stars on the northern ear and the twenty-third while in the sky it is located on a straight line between the twenty-third and the fifteenth.

The twenty-fifth is the southern of the two stars located on the front side of the four sided (quadrilateral). It is located on the neck behind *al-Thurayyā* (the Pleiades).

The twenty-sixth is the northern of the two. Both are north of the twenty-third and are the closer of the four to *al-Thurayyā*. The distance between *al-Thurayyā* and every one of them is around one third of a *dhirā'* . The distance between these two stars is around one *dhirā'*.

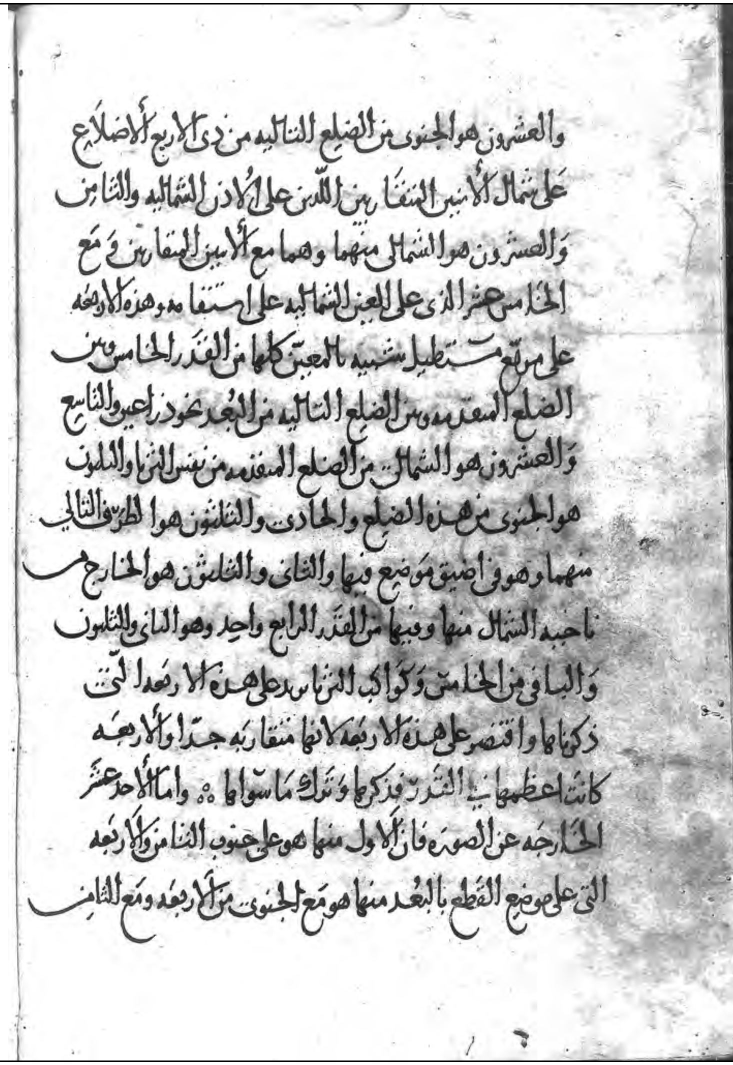
They are located south of the two stars that are close to *al-Thurayyā* and the leg of *Mumsek Ra's al-Ghūl* (the Man holding the head of the monster which is the Constellation Perseus).

Between these two stars is a star less than the 5^{th} magnitude which was not mentioned by Ptolemy.


188
والعشرون من القدر الخامس وهو مع الاثنين المتقاربين اللذين على
الاذن الشمالية ومع العشرين الذي على منشأ القرن الشمالي على استقامة
والخط المستقيم الذي يصل بينه وبين العشرين يمر فيما بين الاثنين
المتقاربين والرابع والعشرون بين الثالث والعشرين وبين الخامس
عشر على المنتصف من القدر السادس وفي طوله او عرضه في كتاب
بطلميوس خطا لانه في الكرة يقع بين الاثنين المتقاربين اللذين على
الاذن الشمالية وبين الثالث والعشرين على الاستقامة وهو في
السماء بين الثالث والعشرين وبين الخامس عشر على استقامة معهما
والخامس والعشرون هو الجنوبي من الاثنين اللذين على الضلع المقدم
من ذي الاربع الاضلاع الذي في العنق خلف الثريا والسادس والعشرون
هو الشمالي منهما وهما على شمال الثالث والعشرين وهذان
الاثنان يليان الثريا من الاربعة بين الثريا وبين كل واحد منهما نحو
ثلث ذراع وبين الكوكبين نحو ذراع وهما على جنوب الاثنين اللذين
على عاتق الثريا وعلى رجل ممسك راس الغول وبين الاثنين كوكب
من القدر الخامس او اصغر لم يذكره بطلميوس والسابع

Folio 189

The twenty-seventh is the southernmost star of the other side of the four sided (quadrilateral), and is north of the two close stars which are located on the northern ear.
The twenty-eighth is the northernmost of the two. Together with the two close stars and with the fifteenth which is on the northern eye it forms a straight line. These four (stars) form a quadrilateral which resembles a *Mu'en* (rhombus) and they are all of the 5th magnitude. The distance between the front side and the other side is around two *dhirā'*.
The twenty-ninth is the northern (star) of the sides of *al-Thurayyā* (the Pleiades) and the thirtieth is the southern of these sides. The thirty-first is on the other side and is located in the narrowest position in it. The thirty-second is the (star) outside (of the main image of *al-Thurayyā*) towards the north.
Al-Thurayyā has one star of the 4th magnitude which is the thirty-second and the rest are of the 5th magnitude.
The stars of *al-Thurayyā* are more (in number) than these four which we mentioned; (however) I will only mention these four because they are very close together. These four were the brightest in magnitude therefore (Ptolemy) (only) mentioned them and left the others.
As for the eleven (stars) which are outside the constellation, the first of these is the (star) located south of the eighth (star) and (south) of the four (stars) on the cut-off position.


والعشرون هو الجنوبي من الضلع التالية من ذي الاربع الاضلاع
على شمال الاثنين المتقاربين اللذين على الاذن الشمالية والثامن
والعشرون هو الشمالي منهما وهما مع الاثنين المتقاربين ومع
الخامس عشر الذي على العين الشمالية على استقامة وهذه الاربعة
على مربع مستطيل شبيه بالمعين كلها من القدر الخامس وبين
الضلع المتقدمة من الضلع التالية من البعد نحو ذراعين والتاسع
والعشرون هو الشمالي من الضلع المتقدمة من نفس الثريا والثلثون
هو الجنوبي من هذه الضلع والحادي والثلثون هو الطرف التالي
منهما وهو في اضيق موضع فيها والثاني والثلثون هو الخارج
ناحية الشمال منها وفيها من القدر الرابع واحد وهو الثاني والثلثون
والباقي من الخامس وكواكب الثريا تزيد على هذه الاربعة التي
ذكرناها واقتصر على هذه الاربعة لانها متقاربة جدا والاربعة
كانت اعظمها في القدر فذكرها وترك ما سواها . واما الاحد عشر
الخارجة عن الصورة فان الاول منها هو على جنوب الثامن والاربعة
التي على موضع القطع بالبعد منها وهو مع الجنوبي من الاربعة ومع الثامن

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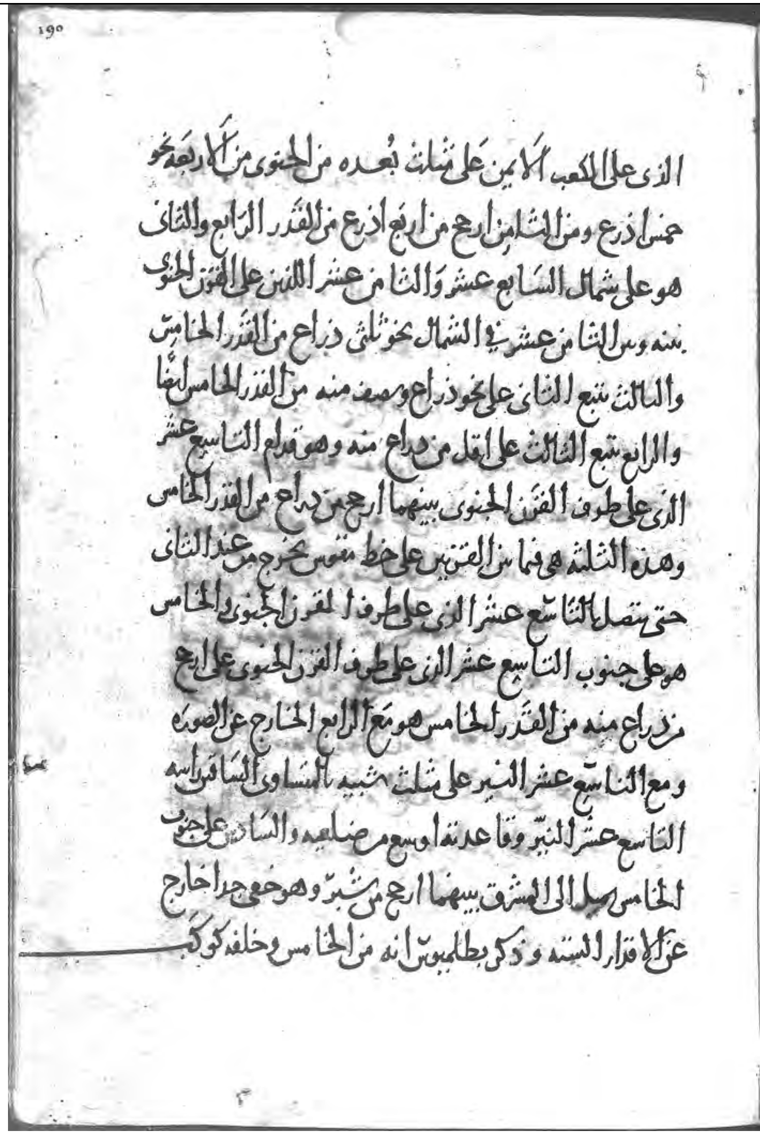
It forms a triangle together with the southern (star) of the four and with the eighth (star) on the right hock.
The distance between it (the first star) and the southern (star) of the four is around five *dhirā’*, and between it and the eighth is a little more than four *dhirā’*. It is of the 4th magnitude.
The second (star) is located north of the seventeenth and the eighteenth which are on the southern horn.
The distance between it and the eighteenth (star) towards the north is close to two third of *dhirā’*, and it is of the 5th magnitude.
The third is close to the second by around one and a half *dhirā’*, and is also of the 5th magnitude.
The fourth is close to the third by less than one *dhirā’*, and it is in-front of the nineteenth (star) which is on the southern horn. The distance between them is a little more than one *dhirā’*. It is of the 5th magnitude.
These three (stars) are located between the two horns and form a curved line which starts from the second (star) and reaches the nineteenth (star) which is on the southern horn.
The fifth (star) is south of the nineteenth (star) which is on the southern horn. It is more than one *dhirā’ away* from it and is of the 5th magnitude. It forms together with the fourth (star) that is outside the constellation and the bright nineteenth (star) a *Muthallath* (triangle) similar to a *Mutasawi al-Saqain* (Isosceles triangle) whereby its head is the bright nineteenth (star) and its base is wider than its sides.
The sixth (star) is south of the fifth, towards the east. The distance between them is slightly more than one *Shibr* (1 *Shibr* = 1/3 dhirā’). It is very dim; outside of the sixth magnitude, (however) Ptolemy mentioned that it is of the 5th magnitude.



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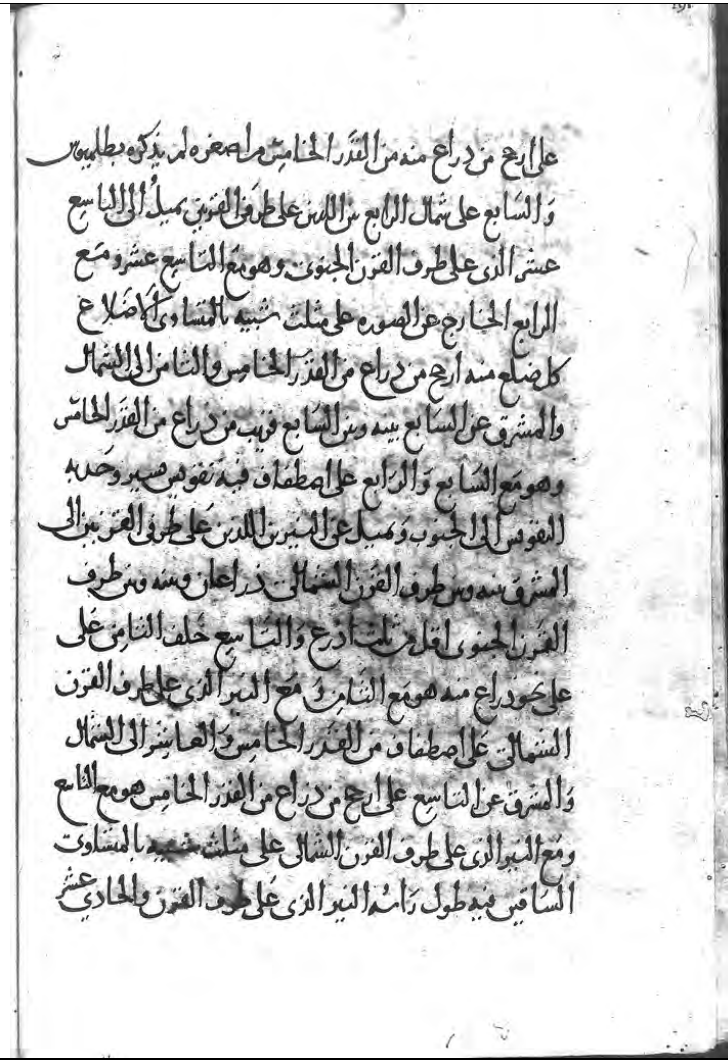
Behind it is a star that is slightly more than one *dhirā’* away which is less than 5th magnitude (and) which was not mentioned by Ptolemy. The seventh (star) is north of the fourth between the two sides of the horns towards the nineteenth (star) which is on the southern horn. It forms an equilateral triangle together with the nineteenth and the fourth (star) that is outside the constellation where every side is slightly more than one *dhirā’ in* length. It is of the 5th magnitude. The eighth (star) is north east of the seventh. The distance between it and the seventh is close to (one) *dhirā’*. It is of the 5th magnitude. (The eighth) together with the seventh and the fourth form a line with a slight curve with its curve facing towards the south.
It is located towards the east between the two bright stars on the horn. The distance between it and the tip of the northern horn is two *dhirā’* and between it and the southern horn less than a third of a *dhirā’*.
The ninth (star) is behind the eight (star) close to one *dhirā’ in* distance away from it. It forms a straight line together with the eight (star) and the bright (star) on northern horn. It is of the 5th magnitude.
The tenth (star) is north east of the ninth more than one *dhirā’* away and is of the 5th magnitude.
It forms together with the ninth (star) and the bright (star) on the northern horn a *Muthallath* (triangle) similar to a *Mutasawi al-Saqain* (Isosceles triangle), whereby its head is the bright (star) on the tip of the horn.



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The eleventh (star) is close to the ninth and the tenth. The distance between it and the ninth is more than one *dhirā’* and between it and the tenth less one *dhirā’*. It is of the 5^{th} magnitude. The latitudes and longitudes of these five (stars) from the seventh up to the eleventh is wrong. For if they are to be drawn on a globe they will be different from how they would appear in the sky.

South of the four stars on the cut off position and the eight star of the constellation are two aligned stars of the 6^{th} magnitude which have not been mentioned by Ptolemy. South of the eighth star and on the same line there is a star of the 6^{th} magnitude which has not been mentioned also.

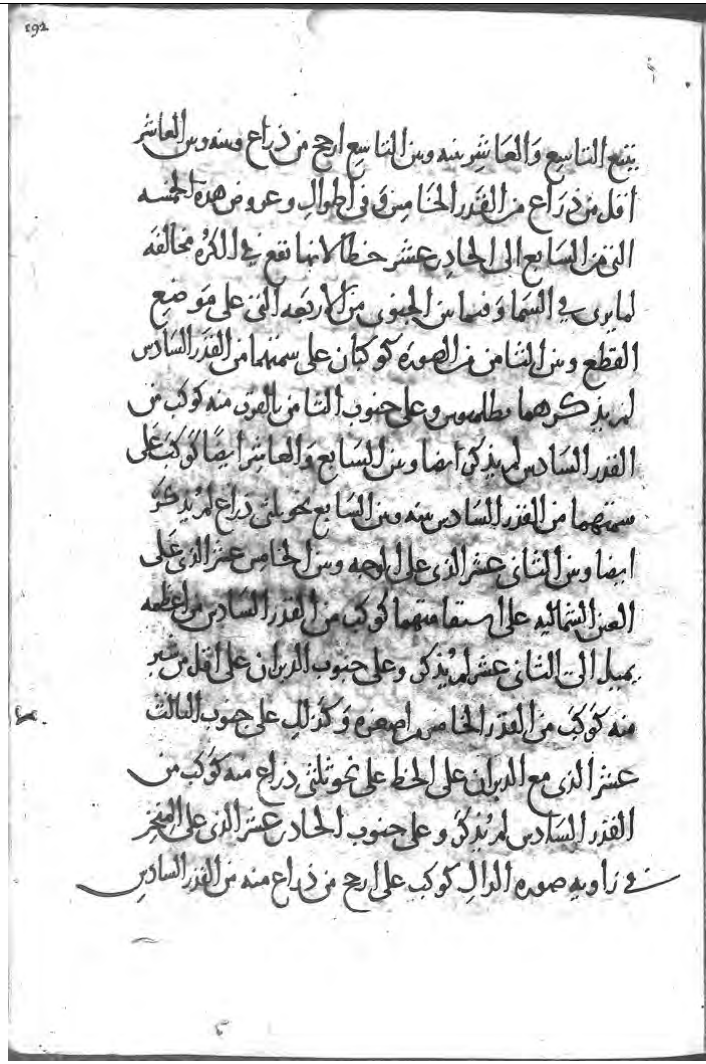
Between the seventh and the tenth (stars) there is also a star on the same line which is of the 6^{th} magnitude. It is two thirds of a *dhirā’* away from the seventh star and was also not mentioned (by Ptolemy).

Between the twelfth, which is on the face, and the fifteenth which is on the northern eye, is a star on the same line. It is much greater than a 6^{th} magnitude but closer to the twelfth star and was (also) not mentioned.

South of Aldebaran and a little less than one *Shibr* away from it, is a star that is less than a 5^{th} magnitude.

Also south of the thirteenth star which forms a line with Aldebaran and is two-thirds of a *dhirā’* away from it, is a star of the 6^{th} magnitude that was not mentioned.

South of the eleventh star which is on the nose and on the corner of the (stars) that resemble *al-Dāl* (the Greek letter Δ), is a star that is more than one *dhirā’* away. It is of the 6^{th} magnitude and was not mentioned (by Ptolemy).



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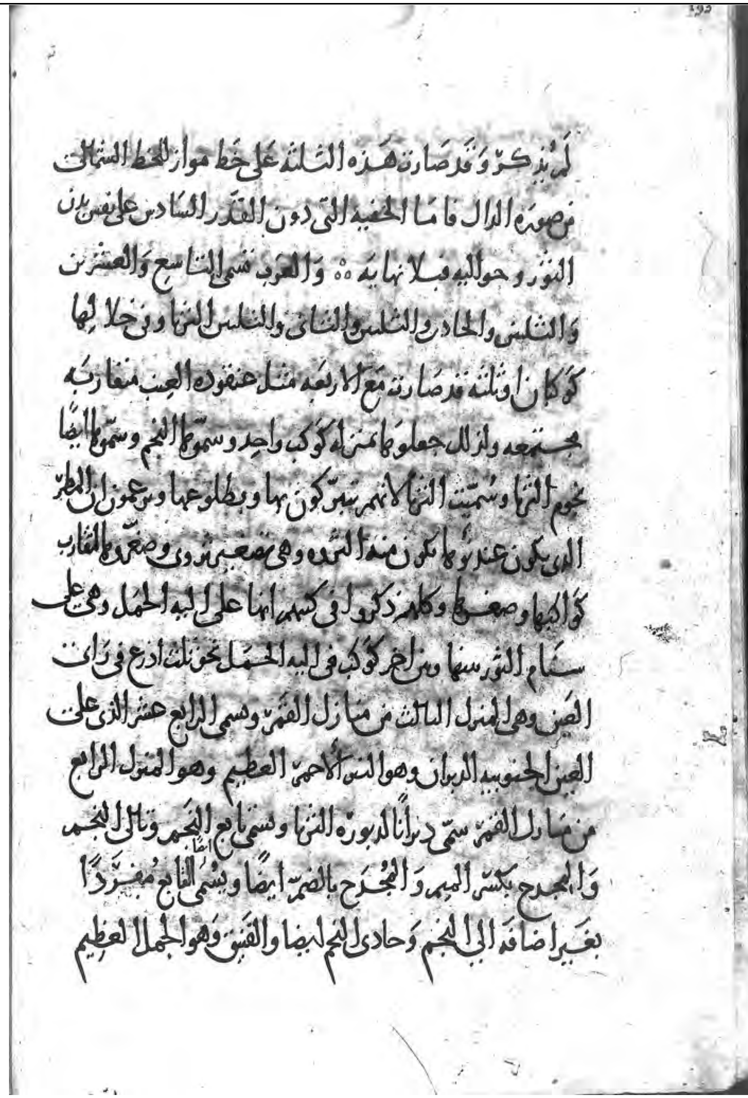
All these three stars form a parallel line to the northern line of (stars) that resemble *al-Dāl* (the Greek letter Δ).
As for the dim stars on the body and around Taurus which are fainter than the 6th magnitude, they are endless.
The Arabs called the twenty-ninth, the thirtieth, the thirty-first and the thirty-second, *al-Thurayyā* (the Pleiades). Inside (the Pleiades) are two stars or three together with the other four looking like a bunch of grapes that are close together. Therefore they considered them as one star and named it *al-Najm* (The Star) par excellence. They also named it *Nujūm al-Thurayyā* (the stars of the Pleiades). It was called *al-Thurayyā* because they were blessed by it and by its rising, and they claimed that the rain which falls when it *Naw'* (sets) brings fortune. (*al-Thurayyā)* means a small fortune (the diminutive noun for fortune). They (the Arabs) diminutised it because its stars are close and small. They mentioned in their books that it is located on the *Aliyet* (the buttocks or the fat tail of a sheep) of (the constellation) Aries, (however) it is located on the *Sinām* (hump) of Taurus.
The distance between it and the last star on the buttocks of Aries is three *dhirā'* as is seen by the eye. It is the third of *Manāzil al-Qamar* (the lunar mansions).
The fourteenth star which is on the southern eye is called *Al-Dabarān*. It is a great bright red star. It is the fourth of the lunar mansions. It was called *Al-Dabarān* because it follows *al-Thurayyā*. It is (also) called *Tab' al-Najm* (the follower star) and *Tālī al-Najm* (the rear star) and *al-Mijdaḥ* where the letter M is accented, as well as *al-Mujdaḥ*. It is just called *al-Tab'* (follower) by itself without adding the word *al-Najm* (star). It is also called *Ḥadī al-Najm* (star follower – follower of the Pleiades) and *al-Fanīq*, which means the great Camel.



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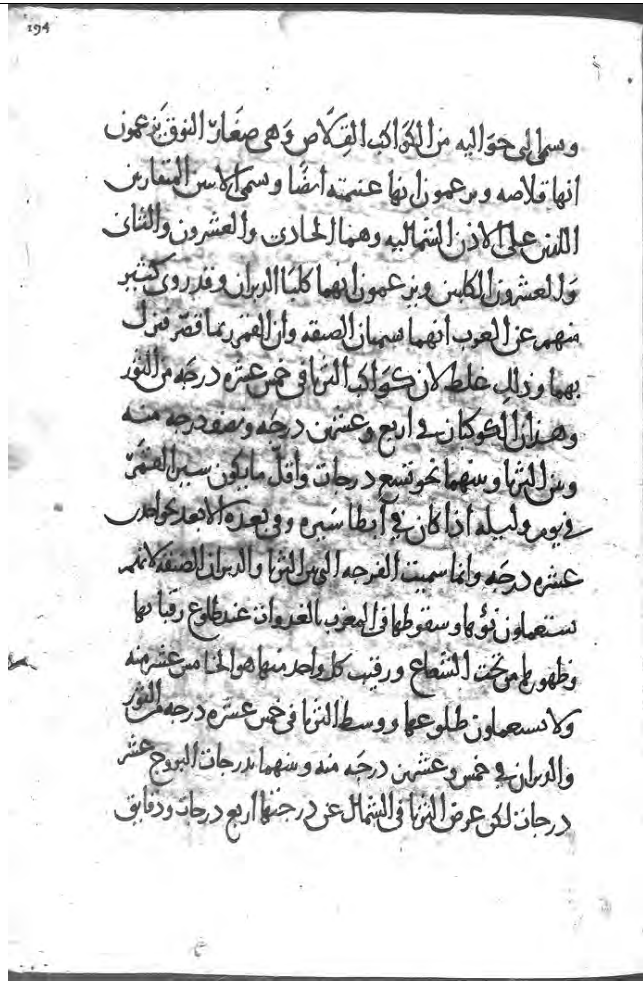
The stars around (*Aldebaran)* are called *al-Qilāṣ* which are the small Camels. (The Arabs) claim that (these stars) are named *Qilāṣa* and also (named) *Ghunaīma*.
The two close stars on the northern ear, which are the twenty-first and the twenty-second are called *al-Kalbain* (the two dogs). (The Arabs) claim they are the dogs of Aldebaran.
Many (scholars) narrate from the Arabs that (these two stars) are called *al-Ḍayīqa* (the small gap) and that the Moon perhaps slowed down and stopped there. This is wrong because the stars of al-*Thurayyā* are fifteen degrees in (the sign of) Taurus and these two stars are twenty-four and a half degrees in it. The distance between them and al-*Thurayyā* is nine degrees and the least amount the Moon travels in one day and one night when it is (moving) slowest and at its greatest distance (from the Earth), is eleven degrees.
The gap between the *al-Thurayyā* and *Aldebaran* was called *al-Ḍayīqa* because they (the Arabs) use its *Naw'* (setting) and its setting in the west at dawn when its *Raqīb* (companion star) rises from under the light (of the Sun). The *Raqīb* (companion star) of each one is the fifteenth star (of the lunar mansions). They (the Arabs) do not use its rising.
The middle of *al-Thurayyā* is on the fifteenth degrees of Taurus and Aldebaran is at twenty five degree in it. The distance on the degrees of the zodiac between them is ten degrees. However the latitude of *al-Thurayyā* in the north from its (zodiac) degree is four degrees and a few minutes.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وسمي ما حواليه من الكواكب القلاص وهي صغار النوق يزعمون
انها قلاصه ويزعمون انها غنيمة ايضا وسمي الاثنين المتقاربين
اللذين على الاذن الشماليه وهما الحادي والعشرون والثاني
والعشرون الكلبين ويزعمون انهما كلبا الدبران وقد روى كثير
منهم عن العرب انهما يسميان الضيقة وان القمر ربما قصر فنزل
بهما وذلك غلط لان كواكب الثريا في خمس عشرة درجة من الثور
وهذان الكوكبان في اربع وعشرين درجة ونصف درجة منه
وبين الثريا وبينهما نحو تسع درجات واقل ما يكون سير القمر
في يوم وليلة اذا كان في ابطا سيره وفي بعده الابعد نحو احدى
عشرة درجة وانما سميت الفرجة التي بين الثريا والدبران الضيقة لانهم
يستعملون نوءها وسقوطها في المغرب بالغدوات عند طلوع رقيبها
وظهوره من تحت الشعاع ورقيب كل واحد منها هو الخامس عشر منه
ولا يستعملون طلوعها ووسط الثريا في خمس عشرة درجة من الثور
والدبران في خمس وعشرين درجة منه وبينهما بدرجات البروج عشر
درجات لكن عرض الثريا في الشمال عن درجتها اربع درجات ودقايق

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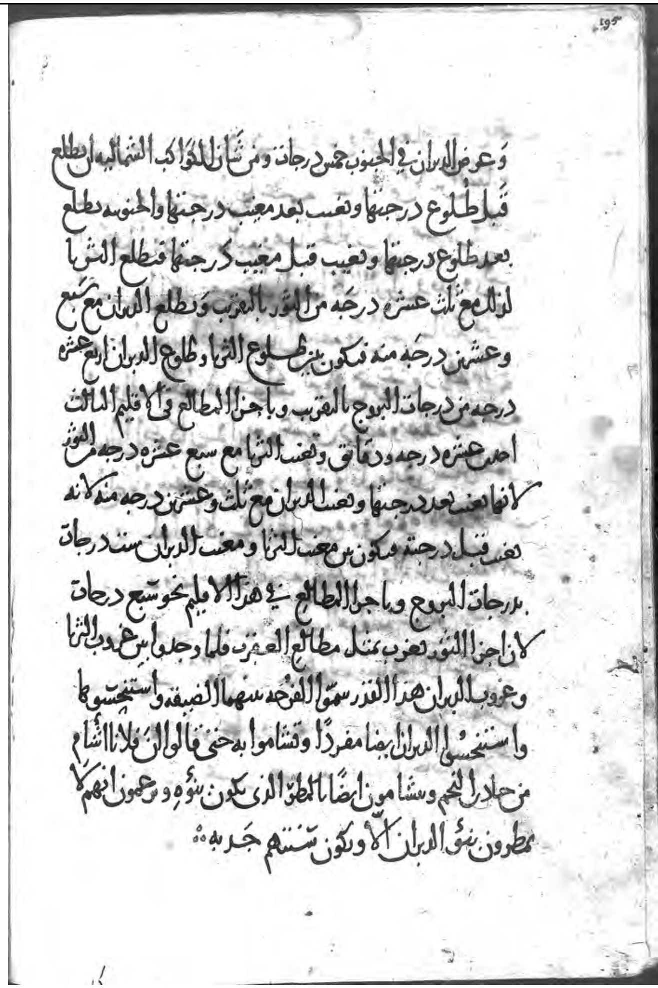
And the latitude of Aldebaran in the south is five degrees. And it is in the nature of the northern stars to rise before their (zodiac) degree rises and to set after their (zodiac) degree sets, and the southern (stars) rise after their (zodiac) degree rises and to set before their (zodiac) degrees sets.
Therefore *al-Thurayyā* rises approximately at thirteen degrees of Taurus and Aldebaran rises at twenty seven of it. Thereby the degrees between the rise of *al-Thurayyā* and Aldebaran are approximately fourteen degrees of the degrees of the zodiac and eleven degrees and a few minutes from the horizon in the third *Iqlīm* zone (one of the seven climatic zones which the Earth is divided into).
And *al-Thurayyā* sets at seventeen degrees of Taurus because it sets after its zodiac degree. And Aldebaran sets at twenty three degrees of it because it sets before its zodiac degrees. Thereby the degrees between the setting of *al-Thurayyā* and Aldebaran are six degrees of the degrees of the zodiac and seven degrees from the horizon in this zone. The degrees of Taurus sets at the same time as the degrees of Scorpio rise. When they found this difference between the setting of *al-Thurayyā* and Aldebaran they called this gap between them *al-Ḍayīqa* (the small gap). They considered it (*al-Ḍayīqa)* to be unlucky, as well as Aldebaran by itself, and they (believed) it to be a bad omen. They say that someone is more unlucky than (the star) *Ḥadī al-Najm*. They are also ill-omened from the rain that falls when it *Naw’* (sets) and they claim that whenever rain falls when Aldebaran *Naw’* (sets) then that year will be dry.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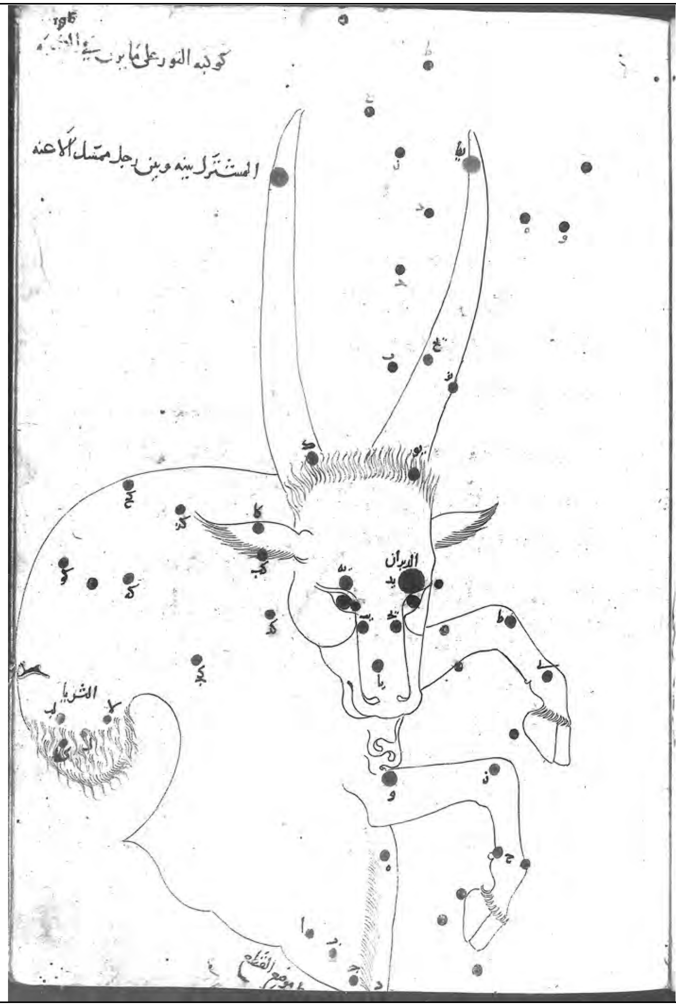
وعرض الدبران في الجنوب خمس درجات ومن شأن الكواكب الشمالية ان تطلع
قبل طلوع درجتها وتغيب بعد مغيب درجتها والجنوبية تطلع
بعد طلوع درجتها وتغيب قبل مغيب درجتها فتطلع الثريا
لذلك مع ثلث عشرة درجة من الثور بالتقريب وتطلع الدبران مع سبع
وعشرين درجة منه فتكون بين طلوع الثريا وطلوع الدبران اربع عشرة
درجة من درجات البروج بالتقريب وباجزاء المطالع في الاقليم الثالث
احدى عشرة درجة ودقائق وتغيب الثريا مع سبع عشرة درجة من الثور
لانها تغيب بعد درجتها وتغيب الدبران مع ثلث وعشرين درجة منه لانه
تغيب قبل درجته فيكون بين مغيب الثريا ومغيب الدبران ستة درجات
بدرجات البروج وباجزاء المطالع في هذا الاقليم نحو سبع درجات
لان اجزاء الثور تغرب بمثل مطالع العقرب فلما وجدوا بين غروب الثريا
وغروب الدبران هذا القدر سموا الفرجة سهما الضيقة واستنحسوها
واستنحسوا الدبران ايضا مفردا وتشاءموا به حتى قالوا انا اشأم
من حادي النجم ويتشاءمون ايضا بالمطر الذي يكون بنوءه ويزعمون انهم
لا يمطرون بنوء الدبران الا ويكون سنتهم جدبة

Folio 196 The constellation Taurus as seen on the globe.	

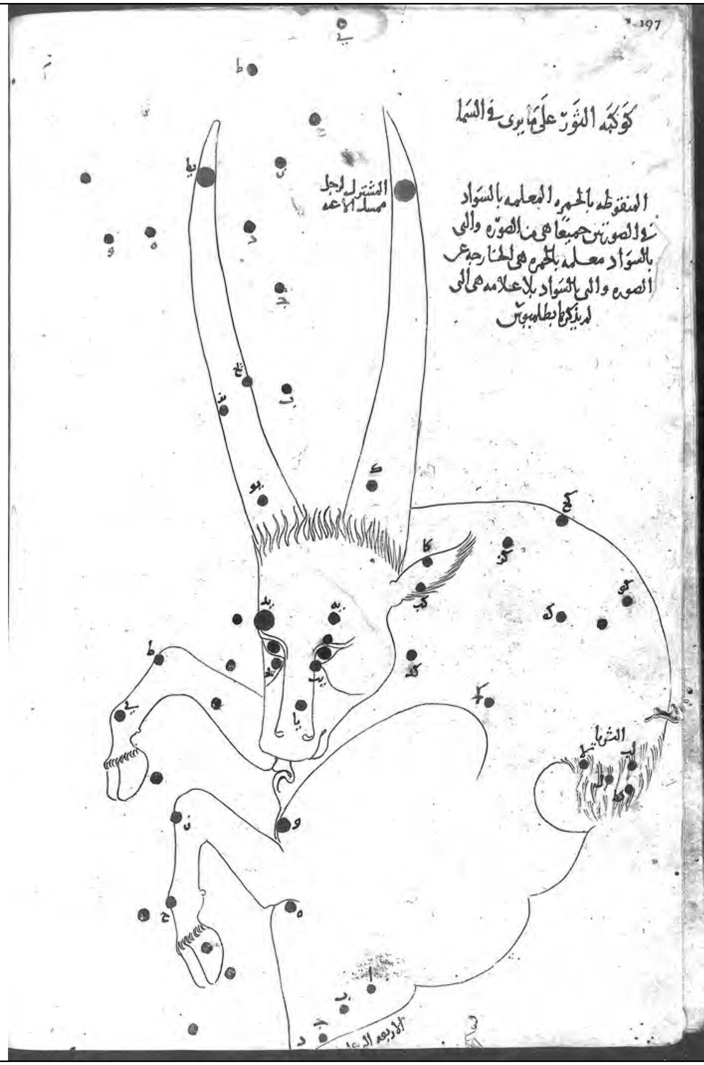
Folio 197 The constellation Taurus as seen in the sky. The stars drawn in red and labeled in black, in both images, are part of the constellation. The stars drawn in black and labeled in red are outside the constellation. The stars drawn in black and not labeled are those not mentioned by Ptolemy.	

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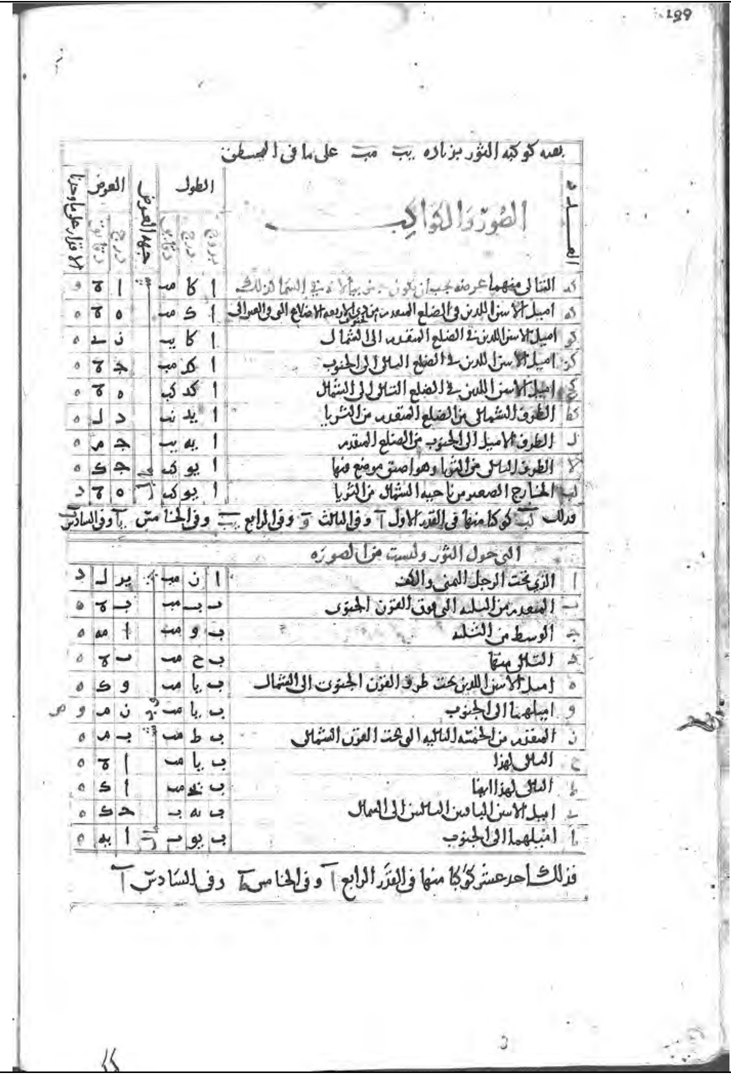
Table of the constellation Taurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Asterism and stars	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The northernmost of the 4 stars in the cut-off position.	1(30)	09	02	S	06	00	4
2	The one after.	1(30)	08	42	S	07	15	4
3	The one after this also.	1(30)	07	22	S	08	30	4(m)
4	The southernmost of the 4.	1(30)	07	02	S	09	15	4(m)
5	The one on the rear of these, on the right shoulder blade.	1(30)	12	22	S	09	30	6
6	The star in the chest.	1(30)	16	22	S	03	00	3
7	The star in the right knee.	1(30)	59	22	S	12	40	4
8	The star on the right hock.	1(30)	15	42	S	14	50	4(m)
9	The star on the left knee.	1(30)	24	52	S	10	00	4
10	The star on the left lower leg.	1(30)	15	42	S	13	00	4
11	The star on the nostrils in the face looks like the letter (Δ) al-*Dāl* from the books of the Greeks.	1(30)	21	42	S	05	45	3(s)
12	The one between this and the northern eye.	1(30)	23	02	S	04	15	3(s)
13	The one between it and the southern eye.	1(30)	23	32	S	05	50	3(s)
14	The bright star the reddish one of the letter (Δ) al-*Dāl* on the southern eye and it is al-Dabarān	1(30)	25	22	S	05	10	1
15	The remaining one on the northern eye	1(30)	24	32	S	03	00	3(s)
16	The star on the place where the southern horn and the ear join the head	1(30)	29	52	S	04	00	5
17	The southernmost of the 2 stars in the southern horn	2(60)	03	02	S	05	00	5
18	The northernmost of these	2(60)	02	42	S	03	30	5
19	The star on the tip of the southern horn	2(60)	10	22	S	04	30	3
20	The star on the northern horn triangle. "The star on the tip of the northern horn is the same star as the one on right leg of the constellation Auriga"	1(30)	28	22	S	04	00	4
21	The northernmost of the 2 stars close together in the northern ear	1(30)	24	42	N	00	30	4
22	The southern of them. The latitude as seen in the sky should be 00 00.	1(30)	24	22	N	04	00	4
23	The more advanced of the 2 small stars in the neck	1(30)	19	42	N	00	40	5

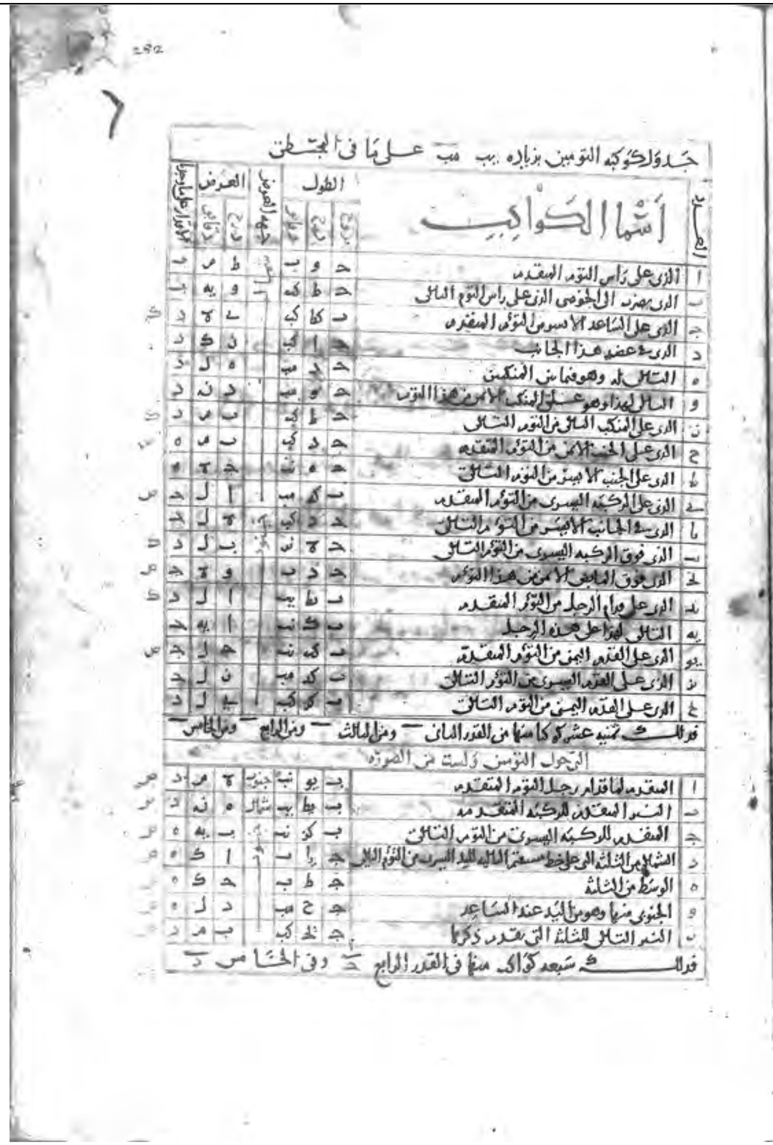
Folio 199

number	Asterism and stars	longitude			Lat direction	Latitude		Magnitude as we found it
Remaining of the constellation Taurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
24	The rearmost of them. Its latitude should be southerly because in the sky it is so.	1(30)	21	42	N	01	00	6
25	The quadrilateral in the neck, the southernmost star on the advanced side	1(30)	20	42	N	05	00	5
26	The northernmost star on the advanced side	1(30)	21	12	N	50	10	5
27	The southernmost star on the rear side	1(30)	24	42	N	03	00	5
28	The northernmost one on the rear side	1(30)	24	24	N	05	00	5
29	The Pleiades the northern end of the advanced side	1(30)	14	52	N	04	30	5
30	the southern end of the advanced side	1(30)	15	12	N	03	40	5
31	The rearmost and narrowest end of the Pleiades	1(30)	16	22	N	03	20	5
32	The small star outside the Pleiades towards the north	1(30)	16	22	N	05	00	4
32 stars, 1 of the 1st magnitude, 6 of the 3rd, 12 of the 4th, 11of the 5th, 2 of the 6th								
The stars around the constellation and not part of the constellation								
1	The star under the right foot and the shoulder blade	1(30)	50	42	S	14	30	4
2	The most advanced of the 3 stars over the southern horn	2(60)	02	42	S	02	00	5
3	The middle one of the three	2(60)	06	42	S	01	45	5
4	The rearmost of them	2(60)	08	42	S	02	00	5
5	The northernmost of the 2 stars under the southern tip of the southern horn	2(60)	11	42	S	06	20	5
6	The southernmost of them	2(60)	11	42	S	50	40	6(s)
7	The most advanced of the 5 stars under the northern horn.	2(60)	09	42	N	02	40	5
8	The one to the rear of this	2(60)	11	42	N	01	00	5
9	The one to the rear again of the latter	2(60)	13	42	N	01	20	5
10	The northernmost of the remaining rearmost 2	2(60)	15	02	N	03	20	5
11	The southernmost of these two	2(60)	16	02	N	01	15	5
11 stars, 1 of the 4th magnitude, 10 of the 5th, 1 of the 6th magnitude								



Folio 152

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Table for the Constellation Gemini (*al-Tawāmān*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
1	The star on the head of the forward twin	3(90)	6	2	N	9	40	2
2	The reddish star on the head of the rear twin	3(90)	9	22	N	6	15	2
3	The star in the left forearm of the forward twin	2(60)	29	22	N	10	0	4(m)
4	The star in the same [left] upper arm	3(90)	1	22	N	50	20	4
5	The one to the rear of that, just over the place between the shoulders	3(90)	4	42	N	5	30	4
6	The one to the rear of this, on the right shoulder of the same [forward] twin	3(90)	6	42	N	4	50	4
7	The star on the rear shoulder of the rear twin	3(90)	9	22	N	2	40	4(k)
8	The star on the right side of the forward twin	3(90)	4	22	N	2	40	5(s)
9	The star on the left side of the rear twin	3(90)	5	52	N	3	0	5
10	The star on the left knee of the forward twin	2(60)	25	42	N	1	30	3(s)
11	The star under the left knee of the rear twin	3(90)	4	22	S	0	30	3
12	The star in the left groin of the rear twin	3(90)	0	57	S	2	30	4(m)
13	The star over the bend in the right knee of the same [rear] twin	3(90)	4	2	S	6	0	3(s)
14	The star on the forward foot of the forward twin	2(60)	19	12	S	1	30	4(k)
15	The one to the rear of this on the same foot	2(60)	20	52	S	1	15	4(k)
16	The star on the right foot of the forward twin	2(60)	22	52	S	3	30	3(s)
17	The star on the left foot of the rear twin	2(60)	24	42	S	50	30	3
18	The star on the right foot of the rear twin	2(60)	27	22	S	10	30	4
18 stars, 2 is of the 2nd magnitude, 5 of the 3rd magnitude, 9 of the 4th magnitude, 2 of the 5th magnitude								



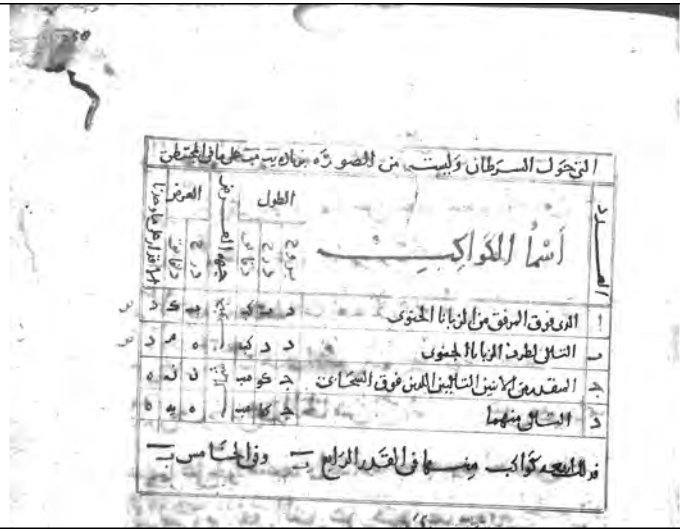
The ones surrounding the constellation Gemini but not in it.								
1	The star in advance of the forward foot of the forward twin	2(60)	16	52	S	0	40	4(s)
2	The bright star in advance of the forward knee	2(60)	19	12	N	5	50	4(s)
3	The star in advance of the left knee of the rear twin	2(60)	17	52	S	2	15	5(s)
4	The northernmost of the three stars in a straight line to the rear of the right arm of the rear twin	3(90)	11	2	S	1	20	5(s)
5	The middle one of the three	3(90)	9	2	S	3	20	5(s)
6	The southernmost of them, near the forearm of the [right] arm	3(90)	8	42	S	4	30	5(s)
7	The bright star to the rear of the above-mentioned 3	3(90)	13	22	S	2	40	4(s)
7 stars, 3 of the 4th magnitude, 4 of the 5th magnitude.								

Folio 257

Table for the constellation Cancer (*al-Saraṭān*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The middle of the nebulous mass in the chest, called *al-Mi'laf* (Praesepe)	3(90)	23	12	N	0	40	nebula
2	The quadrilateral containing the nebula [no. 1]: the northernmost of the two foremost stars	3(90)	20	22	N	1	15	4(s)
3	The southernmost of the two foremost stars	3(90)	20	42	S	1	10	4(s)
4	The northernmost of the rear 2 stars on the quadrilateral, which are called *al-Ḥimārain* (Aselli)	3(90)	23	2	N	2	40	4
5	The southernmost of these two	3(90)	24	2	S	0	10	4
6	The star on the southern claw	3(90)	29	12	S	5	30	4
7	The star on the northern claw	3(90)	21	2	N	11	50	4
8	The star on the northern rear leg	3(90)	14	22	N	1	0	5(s)
9	The star on the southern rear leg	3(90)	20	12	S	7	30	4
9 stars, 7 of the 4th magnitude, 1 of the 5th magnitude and 1 nebula.								

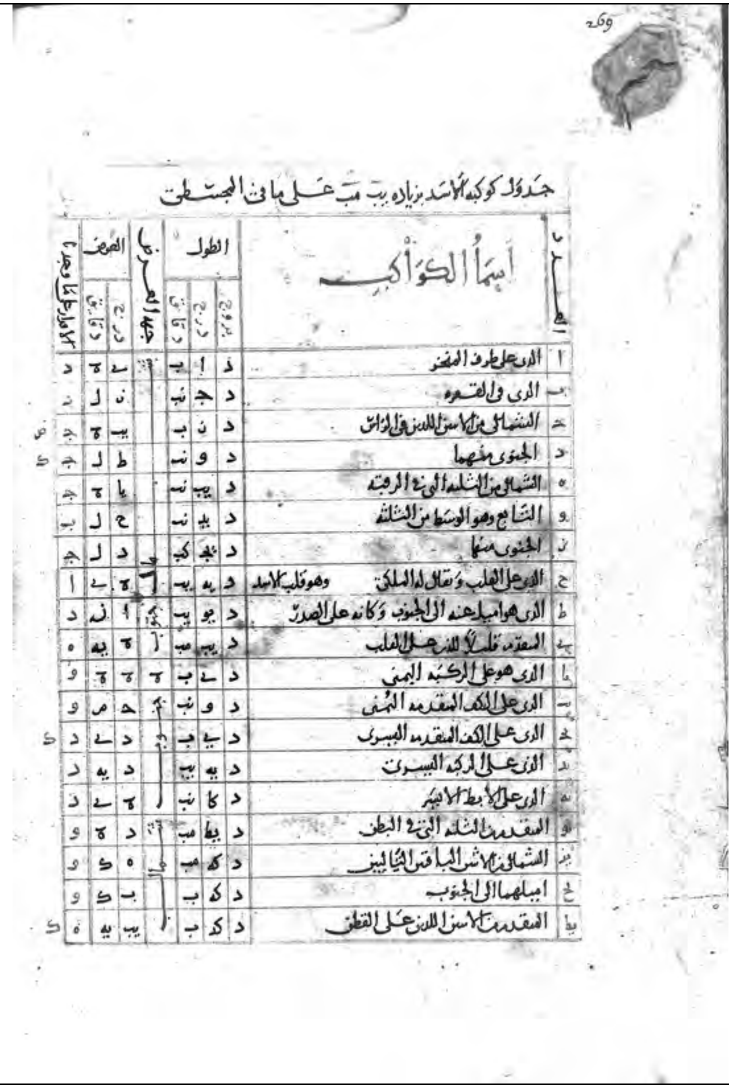
Folio 258

The ones surrounding the constellation Cancer but not in it with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star over the joint in the southern claw	4(120)	2	22	S	2	20	4(s)
2	The star to the rear of the tip of the southern claw	4(120)	4	22	S	5	40	4(s)
3	The more advanced of the two stars over the nebula and to the rear of it	3(90)	26	42	N	7	50	5
4	The rearmost of these [two]	3(90)	29	42	N	5	15	5
4 stars, 2 of the 4th magnitude, 2 of the 5th magnitude								



Folio 269

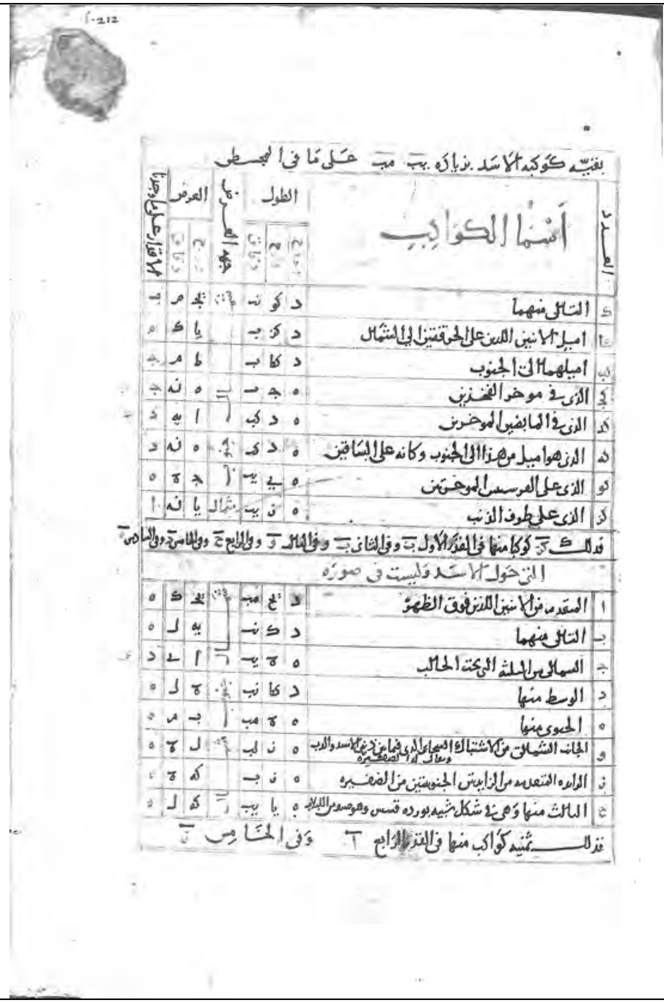
Table of the constellation Leo (*al-Asad*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tip of the nostrils	4(120)	1	2	N	10	0	4
2	The star in the gaping jaws	4(120)	3	52	N	7	30	4
3	The northernmost of the two stars in the head	4(120)	7	2	N	12	0	3(s)
4	The southernmost of these	4(120)	6	52	N	9	30	3(k)
5	The northernmost of the 3 stars in the neck	4(120)	12	52	N	11	0	3
6	The one close to this, the middle one of the three	4(120)	14	52	N	8	30	2
7	The southernmost of them	4(120)	13	22	N	4	30	3
8	The star on the heart, called *al-Malikī* and *Qalb al-Asad* (Regulus)	4(120)	15	12	N	0	10	1
9	The one south of this, approximately on the chest	4(120)	16	12	S	1	50	4
10	The star a little in advance of the star on the heart [no. 8]	4(120)	12	42	S	0	15	5
11	The star on the right knee	4(120)	10	2	0	0	0	6
12	The star on the right front paw	4(120)	6	52	S	3	40	6
13	The star on the left front paw	4(120)	10	2	S	4	10	4(k)
14	The star on the left [front] knee	4(120)	15	12	S	4	15	4
15	The star on the left armpit	4(120)	21	52	S	0	10	4
16	The most advanced of the three stars in the belly	4(120)	19	42	N	4	0	6
17	The northernmost of the other, rearmost 2	4(120)	25	42	N	5	20	6
18	The southernmost of these [two]	4(120)	25	2	N	2	20	6
19	The foremost of the two stars on the rump	4(120)	24	2	N	12	15	5(m)



Folio 212

Remaining stars of the constellation Leo with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
20	The rearmost of them	4(120)	26	52	N	13	40	2
21	The northernmost of the 2 stars in the buttocks	4(120)	27	2	N	11	20	5
22	The southernmost of them	4(120)	29	2	N	9	40	3
23	The star in the hind thighs	5(150)	3	2	N	5	50	3(s)
24	The star in the hind leg-bends	5(150)	4	22	N	1	15	4(k)
25	The one south of this, approximately in the lower legs	5(150)	4	22	S	5	50	4
26	The star on the hind paws	5(150)	10	12	S	3	0	5
27	The star on the end of the tail	5(150)	7	12	N	11	50	1
27 stars, 2 of the 1st magnitude, 2 of the 2nd magnitude, 6 of the 3rd magnitude, 8 of the 4th magnitude, 4 of the 5th magnitude, 5 of the 6th magnitude.								
The ones surrounding the constellation but not in it.								
1	The foremost of the two above the back	4(120)	18	42	N	13	20	5
2	The rearmost of them	4(120)	20	52	N	15	30	5
3	The northernmost of the 3 under the flank	5(150)	0	12	N	1	10	4(s)
4	The middle one of these	4(120)	29	52	S	0	30	5
5	The southernmost of them	5(150)	0	42	S	2	40	5
6	The northernmost part of the nebulous mass between the edges of Leo and Ursa [Major], called *al-Ḍafira* (Coma Berenices)	5(150)	7	32	N	30	0	5
7	The foremost of those on the southern edge of Coma	5(150)	7	2	N	25	0	5
8	The rearmost of them. They (three stars) are shaped like an ivy leaf	5(150)	11	12	N	25	30	5
8 stars, 1 of the 4th magnitude, 7 of the 5th magnitude.								



Folio 225

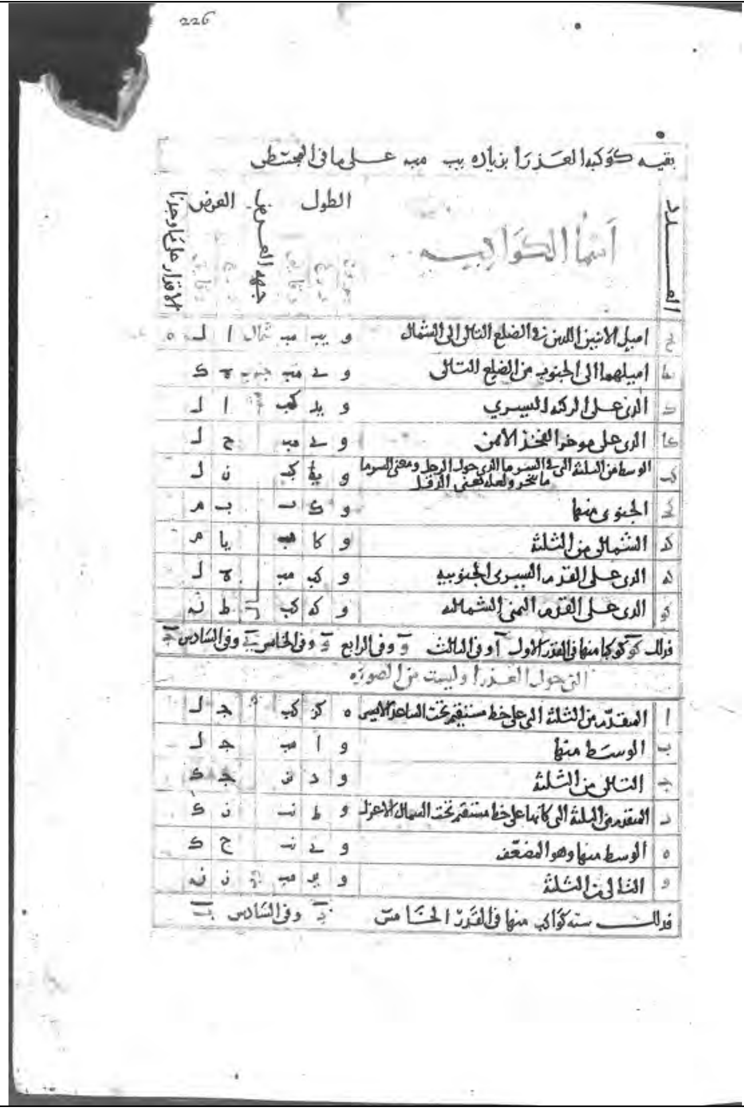
Table of the constellation Virgo (*al-'Adhrā'*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The southernmost of the 2 stars in the top of the skull	5(150)	9	2	N	4	15	5
2	The northernmost of them	5(150)	9	42	N	5	40	5
3	The northernmost of the 2 stars to the rear of these, in the face	5(150)	13	22	N	8	0	5
4	The southernmost of them	5(150)	12	52	N	5	30	5
5	The star on the tip of the southern left wing	5(150)	11	42	N	0	10	3
6	The foremost of the 4 stars in the left wing	5(150)	20	57	N	1	10	3
7	The one to the rear of this	5(150)	25	52	N	2	50	3
8	the one farther to the rear of this	5(150)	29	52	N	2	50	6
9	The last and rearmost of the 4	6(180)	3	42	N	1	40	4
10	The star in the right side under the girdle	5(150)	27	2	N	8	30	3
11	the foremost of the 3 stars on the right northern wing	5(150)	20	52	N	13	50	5(s)
12	The southernmost of the other 2	5(150)	22	52	N	11	40	6
13	The northernmost of these, called *al-'Iṭāf*	5(150)	24	52	N	15	10	3
14	The star on the left hand, called *al-Sunbula* and *al-Simāk al-A'zal.*	6(180)	9	22	S	2	0	1(s)
15	The star under the apron just about over the right buttock	6(180)	7	32	N	8	40	3(s)
16	The quadrilateral in the left thigh: the northern star on the foremost side	6(180)	9	2	N	3	20	5(s)
17	The southern star on the foremost side	6(180)	9	42	N	0	10	6

Folio 226

Remaining stars of the constellation Virgo with the addition of 12 (degrees) 42 (minutes) to what is found in the Almagest

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
18	The northernmost of the 2 stars on the rear side	6(180)	12	42	N	1	30	5(s)
19	The southernmost star on the rear side	6(180)	10	42	S	0	20	5(s)
20	The star on the left knee	6(180)	14	22	N	1	30	5(s)
21	The star in the back of the right thigh	6(180)	10	42	N	8	30	5
22	The middle star of the 3 in the garment-hem round the feet	6(180)	19	22	N	7	30	4
23	The southernmost of them	6(180)	20	2	N	2	40	4
24	The northernmost of the three	6(180)	21	2	N	11	40	4(s)
25	The star on the left, southern foot	6(180)	22	42	N	0	30	4
26	The star on the right, northern foot	6(180)	25	22	N	9	50	4(m)
26 stars, 1 of the 1st magnitude, 6 of the 3rd magnitude, 6 of the 4th magnitude, 10 of the 5th magnitude, 3 of the 6th magnitude.								
The ones surrounding the constellation but not in it.								
1	The foremost of the three in a straight line under the left forearm	5(150)	27	22	S	3	30	5
2	The middle one of these	6(180)	1	42	S	3	30	5
3	The rearmost of the 3	6(180)	4	57	S	3	20	5
4	The foremost of the 3 stars almost on a straight line under *al-Simāk al-A'zal*	6(180)	9	52	S	7	20	6
5	The middle one of these, which is a double star	6(180)	10	52	S	8	20	5
6	The rearmost of the three	6(180)	17	52	S	7	50	6
6 stars, 4 of the 5th magnitude, 2 of the 6th magnitude.								



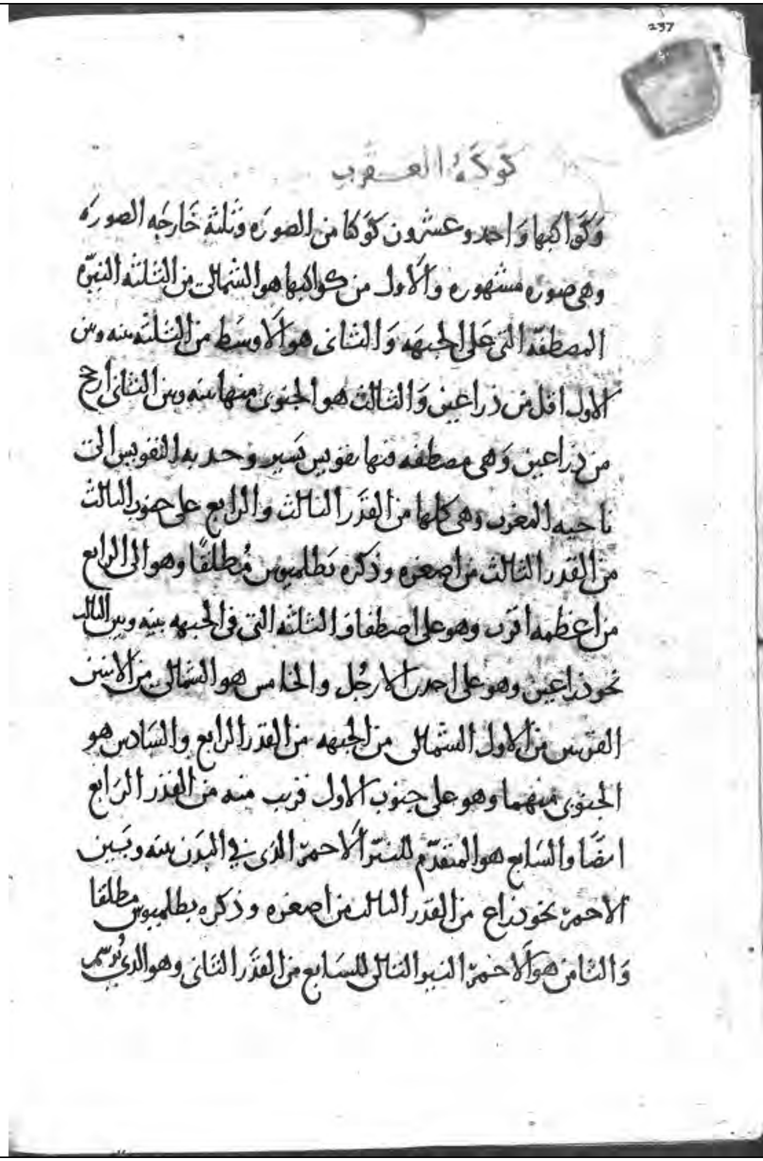
Folio 236

Constellation Libra (*al-Zubānayn* and also *al-Mīzān*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tip of *al-Zubānā al-Janūbī* (the southern claw): the bright one	7(210)	0	42	N	0	40	3(k)
2	The star to the north of this and fainter than it	6(180)	29	42	N	2	30	5(s)
3	The star on the tip of *al-Zubānā al-Shamālī* (the northern claw): the bright one	7(210)	4	52	N	8	50	3(m)
4	The faint star in advance of this	7(210)	0	22	N	8	30	5(s)
5	The star in the middle of the southern claw	7(210)	6	42	S	1	40	4
6	The one in advance of this on the same claw	7(210)	4	2	N	1	15	5(s)
7	The star in the middle of the northern claw	7(210)	10	32	N	4	45	4
8	The one to the rear of this on the same claw	7(210)	15	42	N	3	30	4
8 stars, 2 are of the 3rd magnitude, 3 of the 4th magnitude, 3 of the 5th magnitude.								
The ones surrounding the constellation Libra but not in it.								
1	The most advanced of the 3 stars north of the northern claw	7(210)	8	52	N	9	0	5
2	The southernmost of the rearmost 2 [of these]	7(210)	16	22	N	6	40	4(s)
3	The northernmost of them	7(210)	17	2	N	9	15	4(s)
4	The rearmost of the 3 stars between the claws	7(210)	16	12	N	0	30	6
5	The northernmost of the other 2 in advance [of the latter]	7(210)	13	2	N	3	0	6
6	The southernmost of them	7(210)	13	52	S	1	30	4
7	The most advanced of the 3 stars south of the southern claw	7(210)	5	42	S	7	30	3(s)
8	The northernmost of the other 2 towards the rear	7(210)	13	52	S	8	10	4
9	The southernmost of them	7(210)	14	42	S	9	40	4
9 stars, 1 is of the 3rd magnitude, 5 of the 4th magnitude, 1 of the 5th magnitude, 2 of the 6th magnitude.								

Folio 237 (Manuscript Marsh144)

The constellation Scorpio (*al-'Aqrab)*

Its stars are twenty-one stars in the constellation and three outside the constellation. It is a well known constellation.
The first of its stars is the northern of the three aligned bright (stars) on the forehead. The second is the middle of the three. The distance between it and the first is less than two *dhirā'*. The third is the southern of them. The distance between it and the second is a little more than two *dhirā'*. They all form a slightly curved line with its curve pointed towards the west. They are all of the 3rd magnitude.
The fourth is south of the third. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. However its magnitude can be considered as much greater than 4th magnitude. It is aligned with the three (stars) on the forehead. The distance between it and the third is close to two *dhirā'*. It is located on one of the legs (of the constellation).
The fifth is the northern of the two stars which are close to the first northern (star) on the forehead. It is of the 4th magnitude.
The sixth is the southern of these (two). It is south of the first (star) and close by it. It is also of the 4th magnitude.
The seventh is closer to the bright red (star) on the body. The distance between it and the red (star) is close to one *dhirā'*. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude.
The eighth is the bright red (star) that is close to the seventh. It is of the 2nd magnitude. It is (one of the stars that are) drawn on an astrolabe.

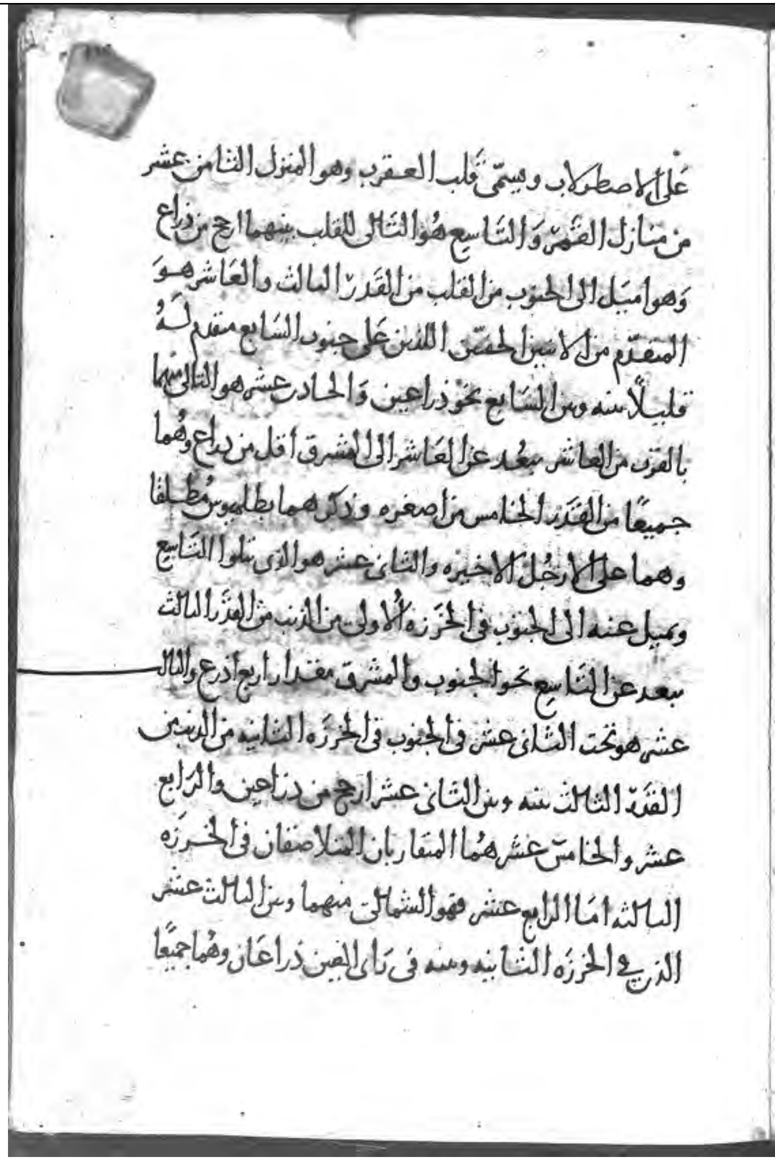

237

كوكبة العقرب

وكواكبها واحد وعشرون كوكبا من الصورة وثلثة خارجة الصورة
وهي صورة مشهورة والاول من كواكبها هو الشمالي من الثلثة النيرة
المصطفة التي على الجبهة والثاني هو الاوسط من الثلثة بينه وبين
الاول اقل من ذراعين والثالث هو الجنوبي منها بينه وبين الثاني ازيد
من ذراعين وهي مصطفة فيها تقويس يسير وحدبة التقويس الى
ناحية المغرب وهي كلها من القدر الثالث والرابع على جنوب الثالث
من القدر الثالث من اصغره وذكره بطلميوس مطلقا وهو الى الرابع
من اعظمه اقرب وهو على اصطفاف الثلثة التي في الجبهة بينه وبين الثالث
نحو ذراعين وهو على احدى الارجل والخامس هو الشمالي من الاثنين
القريبين من الاول الشمالي من الجبهة من القدر الرابع والسادس هو
الجنوبي منهما وهو على جنوب الاول قريب منه من القدر الرابع
ايضا والسابع هو المتقدم للنير الاحمر الذي في البدن بينه وبين
الاحمر نحو ذراع من القدر الثالث من اصغره وذكره بطلميوس مطلقا
والثامن هو الاحمر النير التالي للسابع من القدر الثاني وهو الذي يرسم

Folio 238

It is called *Qalb al-‘Aqrab* (the heart of Scorpio). It is the eighteenth of the lunar mansions.
The ninth is to the rear of *al-Qalb* (the heart). The distance between them is a little more then one *dhirā’*. It is closer to the south than *al-Qalb* (the heart). It is of the 3rd magnitude.
The tenth is the more advanced of the two dim stars which are south of the seventh (but) is a little in front of it. The distance between it and the seventh is close to two *dhirā’*.
The eleventh is the rearmost of the two close to the tenth. The distance between it and the tenth towards the south is less than one *dhirā’*.
They are all less than 5th magnitude. Ptolemy mentioned that they are exactly 5th magnitude. They are on the last leg (of the constellation).
The twelfth is to the rear of the ninth towards the south. It is located on the first *Kharaza* (joint) of the tail. It is of the 3rd magnitude. The distance between it and ninth towards the south-east is about four *dhirā’*.
The thirteenth is under the twelfth, towards the south in the second *Kharaza* (joint) of the tail. It is of the 3rd magnitude. The distance between it and the twelfth is close to two *dhirā’*.
The fourteenth and the fifteenth are two close and nearby (stars) located on the third *Kharaza* (joint). As for the fourteenth it is north of the two. The distance between it and the thirteenth (star) which is located on the second *Kharaza* (joint) is a distance of two *dhirā’*, as can be seen by the eye.
They are all of the 4th magnitude.


على الاصطرلاب ويسمى قلب العقرب وهو المنزل الثامن عشر
من منازل القمر والتاسع هو التالي للقلب بينهما ارجح من ذراع
وهو اميل الى الجنوب من القلب من القدر الثالث والعاشر هو
المتقدم من الاثنين الخفيين اللذين على جنوب السابع متقدم له
قليلا بينه وبين السابع نحو ذراعين والحادي عشر هو التالي منهما
بالقرب من العاشر يبعد عن العاشر الى المشرق اقل من ذراع وهما
جميعا من القدر الخامس من اصغره وذكرهما بطلميوس مطلقا
وهما على الارجل الاخيرة والثاني عشر هو الذي يتلو التاسع
ويميل عنه الى الجنوب في الخرزة الاولى من الذنب من القدر الثالث
يبعد عن التاسع نحو الجنوب والمشرق مقدار اربع اذرع والثالث
عشر هو تحت الثاني عشر في الجنوب في الخرزة الثانية من الذنب من
القدر الثالث بينه وبين الثاني عشر ارجح من ذراعين والرابع
عشر والخامس عشر هما المتقاربان المتلاصقان في الخرزة
الثالثة اما الرابع عشر فهو الشمالي منهما وبين الثالث عشر
الذي في الخرزة الثانية وبينه في راي العين ذراعان وهما جميعا

Folio 239

The sixteenth follows the fifteenth and is located on the fourth *Kharaza* (joint) of the tail. It is less than 3rd magnitude. However its magnitude can be considered as much greater than 4th magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. The distance between it and the fifteenth towards the east is a distance of one and a half *dhirā'* as can be seen by the eye.
The seventeenth follows the sixteenth but is a little further from it towards the north. It is located on the fifth *Kharaza* (joint) of the tail. It is of the 3rd magnitude. The distance between it and the sixteenth towards the east is close to two and a half *dhirā'*.
The eighteenth follows the seventeenth but is a little further from it towards the north. It is located on the sixth *Kharaza* (joint). It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. The distance between it and the seventeenth towards the north east is close to two *dhirā'*.
The nineteenth is north of the eighteenth but is a little further from it towards the west. It is located on the seventh *Kharaza* (joint). The distance between it and the eighteenth which is in the sixth *Kharaza* (joint) towards the north-west is distance of one *dhirā'*. It is of the 3rd magnitude.
The twentieth is to the rear of the two bright stars which are located on *al-Ḥumma* (the sting). It is also of the 3rd magnitude. It is closer to the nineteenth (star) towards the north. The distance between it and the nineteenth is close to one and a half *dhirā'*.
The twenty-first is the more advanced of the two (stars) which are close together.


من القدر الرابع والسادس عشر يتلو الخامس عشر وفي الخرزة الرابعة
من الذنب من القدر الثالث من أصغره وهو أولى بالرابع من أعظمه
أو من وذكره بطلميوس مطلقا بينه وبين الخامس عشر إلى المشرق
ذراع ونصف في رأي العين والسابع عشر يتلو السادس عشر
ويميل عنه إلى الشمال ميلا يسيرا وهو في الخرزة الخامسة
من الذنب من القدر الثالث بينه وبين السادس عشر إلى المشرق نحو
ذراعين ونصف والثامن عشر يتلو السابع عشر ويميل إلى الشمال
ميلا يسيرا في الخرزة السادسة من القدر الثالث من أصغره وذكره
بطلميوس مطلقا بينه وبين السابع عشر إلى المشرق والشمال مقدار
ذراعين والتاسع عشر على شمال الثامن عشر متقدما عنه قليلا إلى المغرب
في الخرزة السابعة بينه وبين الثامن عشر الذي في الخرزة السادسة
نحو الشمال والمغرب مقدار ذراع من القدر الثالث والعشرون هو
التالي من الاثنين النيرين اللذين في الحمة من القدر الثالث
أيضا متقدما للتاسع عشر وما يلي عنه إلى الشمال بينه وبين التاسع
عشر نحو ذراع ونصف والحادي والعشرون هو المتقدم منهما بالقرب

Folio 240

It is less than 3rd magnitude. Ptolemy mentioned that it is of the 4th magnitude. (However) its (magnitude) is not less then (the star located) on the fourth joint, for (Ptolemy) mentioned that that was of the 3rd (magnitude). The distance between it and the twentieth (star) that is located in the sting is a distance of about one *Shibr*.

The Arabs call the three (stars) on the forehead *al-Iklīl* (crown). We explained about this when we mentioned the constellation Libra and that the story from the Arabs about this is wrong.

The bright red eighth star on the body is called *al-Qalb* (the heart).

The seventh star in front of *al-Qalb* and the ninth star behind it are called *al-Nīyāṭ*.

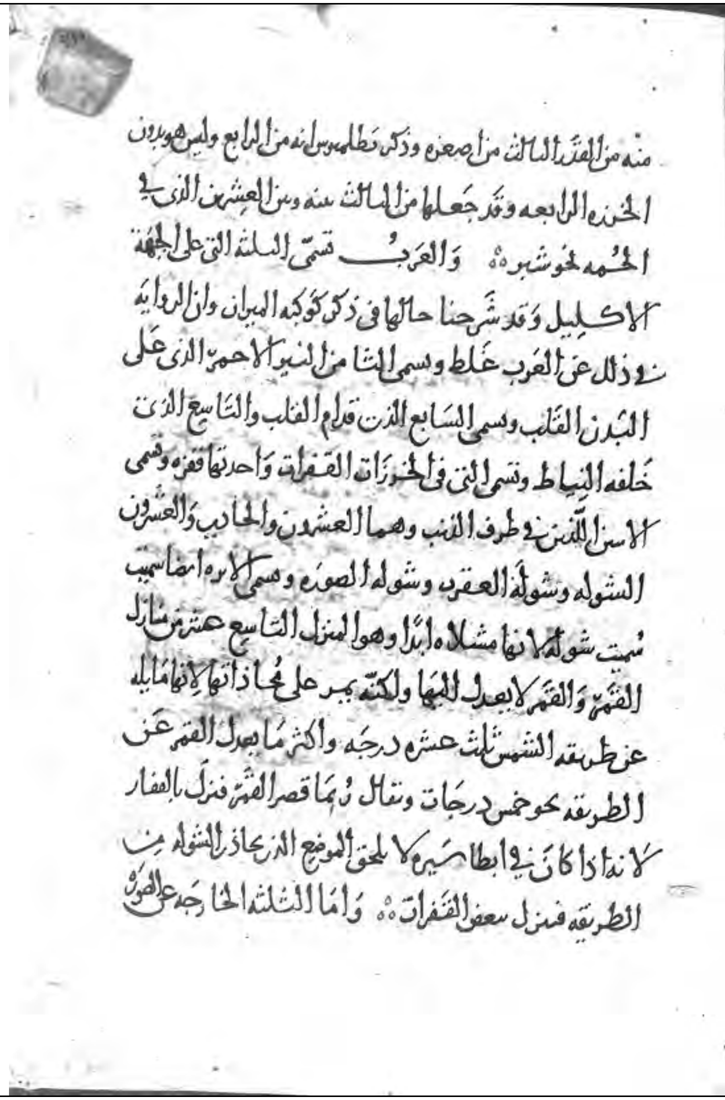
The stars on the *Kharazāt* (plural of joint) are called *al-Fiqarāt* (spinal vertebrae) and singularly *Fiqra*.

The two stars, on the tip of the tail, which are the twentieth and the twenty-first are called *al-Shawla* (the sting) or *Shawlat al-ʻAqrab* (the sting of Scorpio) or *Shawlat al-Sura* (the sting of the constellation) and are also called *al-Ibra* (the needle). They were called *al-Shawla* because they always rise vertically. They are the nineteenth of the lunar mansions.

(However the Moon) does not approach them but passes close by because they are thirteen degrees further away than the orbit of the Sun.

The furthest distance the Moon drifts from its orbit is five degrees.

They (the Arabs) say that when the Moon slows down it might stay in the joints. Because if the Moon is in its slowest pace it does not reach the location of *al-Shawla* but stays in some of the joints.



منه من القدر الثالث من اصغره وذكر بطلميوس انه من الرابع وليس هو بدون
الخرز الرابعه وقد جعلها من الثالث منه وبين العشرين الذي في
الحمه نحو شبر [illegible] والعرب تسمي الثلثة التي على الجبهة
الاكليل وقد شرحنا حالها في ذكر كوكبة الميزان وان الروايه
في ذلك عن العرب غلط وسموا الثامن النير الاحمر الذي على
البدن القلب وسموا السابع الذي قدام القلب والتاسع الذي
خلفه النياط وتسمى التي في الخرزات الفقرات واحدتها فقرة وتسمى
الاثنين اللذين في طرف الذنب وهما العشرون والحادي والعشرون
الشوله وشولة العقرب وشولة الصورة وتسمى الابرة انما سميت
شولة لانها مشالة ابدا وهو المنزل التاسع عشر من منازل
القمر والقمر لا يصل اليها ولكنه يمر على محاذاتها لانها مايله
عن طريقة الشمس ثلث عشرة درجه واكثر ما يصل القمر عن
الطريقه نحو خمس درجات ويقال ربما قصر القمر فنزل بالفقار
لانه اذا كان في ابطا سيره لا يلحق الموضع الذي يحاذي الشولة من
الطريقة فنزل بعض الفقرات وأما الثلثة الخارجة على الصورة

Folio 241

As for the three stars outside the constellation, the first is a star to the rear of *al-Shawla* and behind the nineteenth star which is on the seventh joint. It is less than 4th magnitude. Ptolemy mentioned that it is a nebulous object. The distance between it and the nineteenth star which is on the seventh *Kharaza* (joint) is a distance that is a little more than one *dhirā'*. And the distance between it and *al-Shawla* is close to one and a half *dhirā'*.

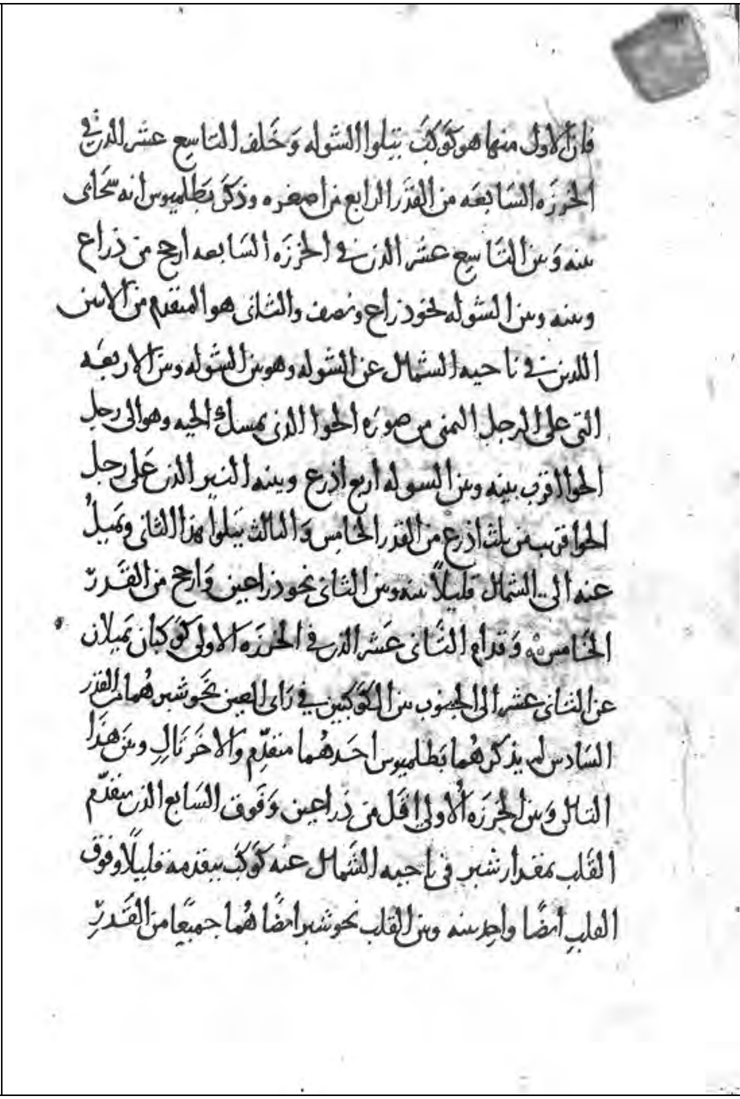
The second star is the most advanced of the two stars towards the north from *al-Shawla*. It is located between *al-Shawla* and the four stars which are on the right leg of the constellation *al-Ḥawwā* (Ophiuchus) holding *al-Ḥayya* (the constellation Serpens or the snake). It is closer to the leg of the constellation *al-Ḥawwā*. The distance between it and *al-Shawla* is four *dhirā'* while the distance between it and the bright star on the leg of *al-Ḥawwā* is less than three *dhirā'*. It is of the 5th magnitude.

The third is to the rear of the second and a little towards the north. The distance between it and the second is close to two *dhirā'*. It is of the 5th magnitude.

In front of the twelfth star which is on the first joint are two stars towards the south. The distance between these two stars as can be seen by the eye is a distance of one *Shibr*. They are of the 6th magnitude. They were not mentioned by Ptolemy. One is in front and the second is to the rear. The distance between the one to the rear and between the first joint is a distance that is less than two *dhirā'*.

Above the seventh star that is in advance to *al-Qalb* by one *Shibr* towards the north is a star that is a little further away.

Above *al-Qalb* also is another star that is one *Shibr* away.



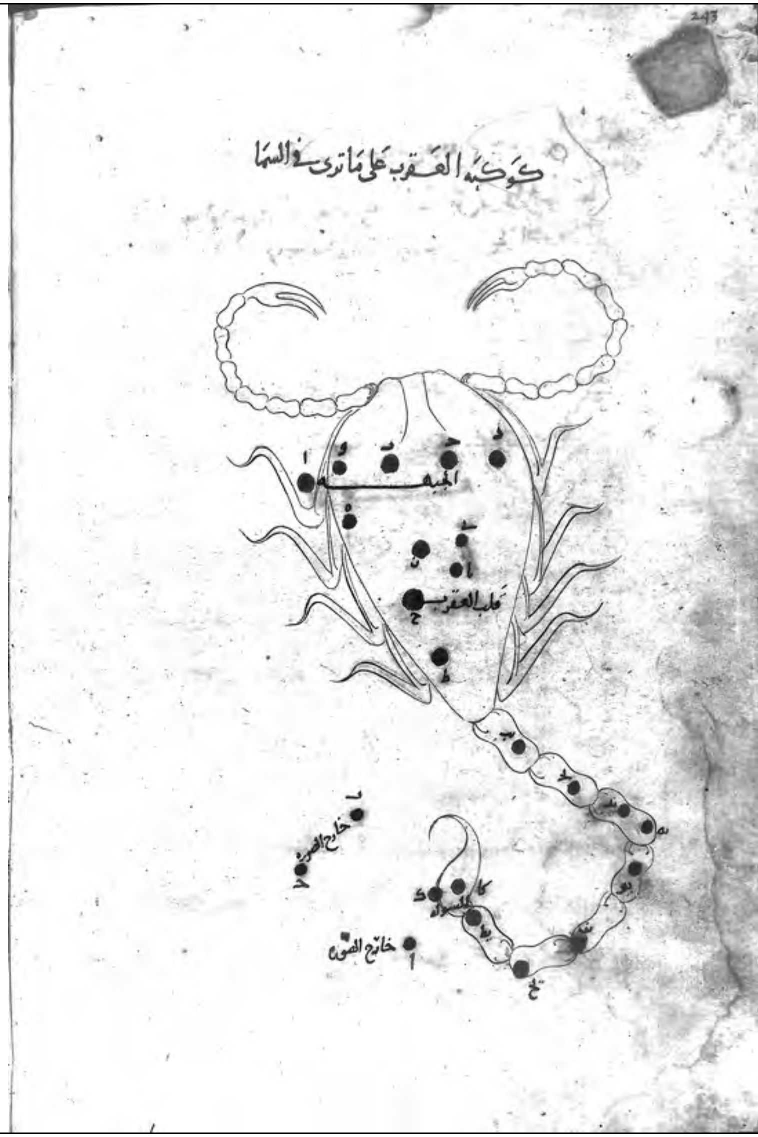
Folio 242

These are all less than 5th magnitude and were not mentioned by Ptolemy. In front of the southernmost of the three stars on the forehead are two nearby stars which are of the 6th magnitude and which were also not mentioned by Ptolemy.

The constellation Scorpio as seen on the globe.

Folio 243

The constellation Scorpio as seen in the sky.

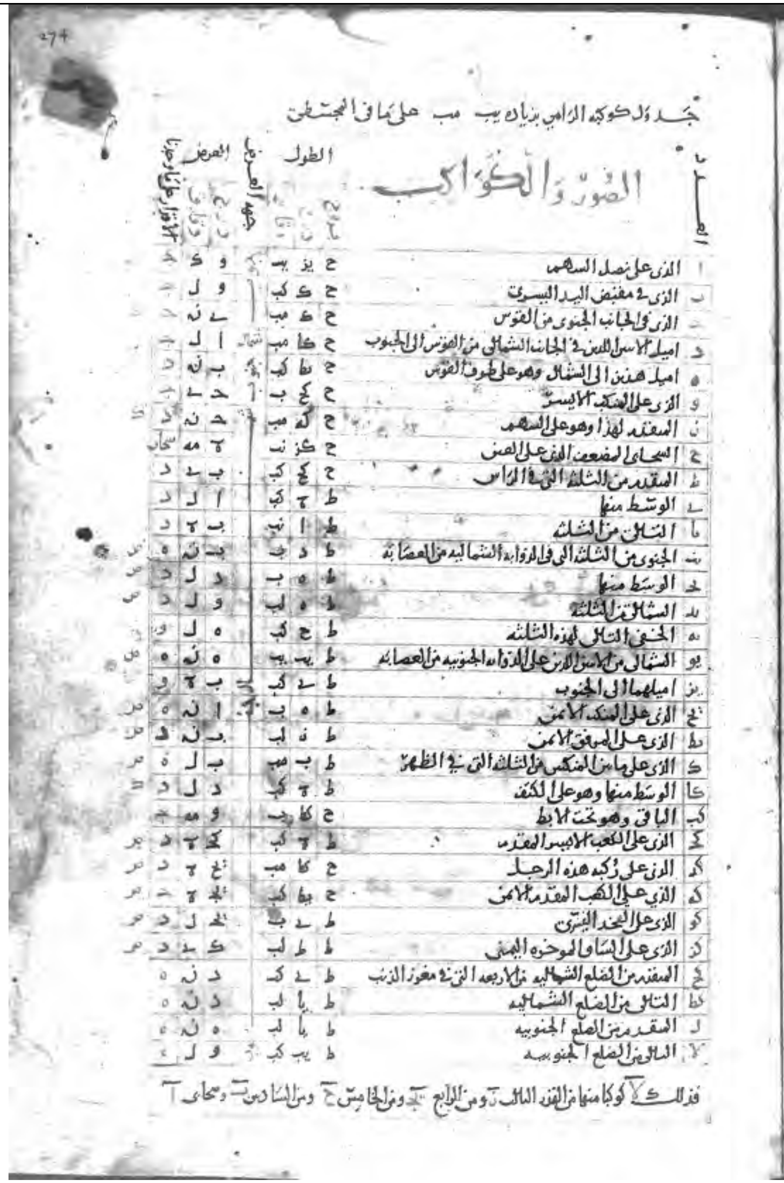


Folio 244

Table of the constellation Scorpio with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Names of the stars	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The northernmost of the 3 bright stars on the forehead.	7(210)	19	02	N	01	20	3
2	The middle one of these.	7(210)	18	22	S	01	40	3
3	The southernmost of the three	7(210)	18	22	S	05	00	3
4	The star south again of this on one of the legs	7(210)	18	42	S	50	50	3(s)
5	The southernmost of the 2 stars adjacent to the northernmost of the three bright ones	7(210)	19	42	N	01	40	4
6	The southernmost of these	7(210)	19	02	N	00	30	4
7	The most advanced of the 3 bright stars in the body	7(210)	23	22	S	03	45	3(s)
8	The middle one of these which is reddish and called *Qalb al-'Aqrab* (Antares)	7(210)	25	22	S	04	00	2
9	The rearmost of the 3	7(210)	17	12	S	05	30	3
10	The advanced star of the 2 under these approximately on the last leg	7(210)	22	10	S	06	10	5(s)
11	The rearmost of these	7(210)	23	22	S	06	40	5(s)
12	The star in the first tail joint from the body	8(240)	01	12	S	11	00	3
13	The one after this in the 2nd joint	8(240)	01	32	S	15	00	3
14	The northern star of *al-Muḍ'af* (the double star) in the 3rd joint	8(240)	02	42	S	18	40	4
15	The southern star of the double star	8(240)	02	52	S	19	30	4
16	The one following in the 4th joint	8(240)	05	52	S	19	30	3(s)
17	The one after that in the 5th joint	8(240)	10	52	S	18	50	3
18	The next one again in the 6th joint	8(240)	12	12	S	16	40	3(s)
19	The star in the 7th joint the joint next to the sting	8(240)	11	42	S	15	20	3
20	The rearmost of the 2 stars in the sting	8(240)	10	12	S	13	20	3
21	The more advanced of these	8(240)	09	42	S	13	30	3
21 stars, 1 of the 2nd magnitude, 14 of the 3rd, 4 of the 4th, 2 of the 5th								
The stars around the constellation Scorpio and not part of the constellation								
1	The nebulous star to the rear of the sting	8(240)	13	52	S	13	15	4(s)
2	The most advanced of the 2 stars to the north of the sting.	8(240)	08	12	S	06	10	5
3	The rearmost of them.	8(240)	12	12	S	04	10	5
3 stars, 1 of the 4th magnitude, 2 of the 5th magnitude								

Folio 274

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Table of the constellation Sagittarius (*al-Rāmi*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
1	The star on the point of the arrow	8(240)	17	12	S	6	20	3(s)
2	The star in the [bow-] grip held by the left hand	8(240)	20	22	S	6	30	3
3	The star in the southern portion of the bow	8(240)	20	42	S	10	50	3(m)
4	The southernmost of the [2] stars in the northern portion of the bow	8(240)	21	42	N	1	30	3
5	The northernmost of these, on the tip of the bow	8(240)	19	2	S	2	50	4
6	The star on the left shoulder	8(240)	28	2	S	3	10	3
7	The one in advance of this, just over the arrow	8(240)	25	42	N	3	50	4(k)
8	The star on the eye, which is nebulous and double	8(240)	27	52	N	0	45	nebula
9	The most advanced of the 3 stars in the head	8(240)	28	22	N	2	10	4
10	The middle one of these	9(270)	0	22	N	1	30	4
11	The rearmost of the three	9(270)	1	52	N	2	0	4
12	The southernmost of the 3 stars in the northern cloak-attachment	9(270)	4	2	N	2	50	5(s)
13	The middle one of these	9(270)	5	2	N	4	30	4(s)
14	The northernmost of the three	9(270)	5	32	N	6	30	4(s)
15	The faint star to the rear of these three	9(270)	8	22	N	5	30	6
16	The northernmost of the 2 stars on the southern cloak-attachment	9(270)	12	12	N	5	50	5(s)
17	The southernmost of them	9(270)	10	22	N	2	0	6
18	The star on the right shoulder	9(270)	5	2	S	1	50	5(s)
19	The star on the right elbow	9(270)	7	32	S	2	50	4(s)
20	The three stars in the back: the one just above the place between the shoulders	9(270)	2	42	S	2	30	5(s)
21	The middle one, just above the shoulder-blade	9(270)	0	22	S	4	30	4(k)
22	The other one, under the armpit	8(240)	29	2	S	6	45	3
23	The star on the front left hock	9(270)	0	22	S	23	0	4(s)
24	The one on the knee of the same leg	8(240)	29	42	S	18	0	4(s)



25	The star on the front right hock	8(240)	19	22	S	13	0	3(s)
26	The star on the left thigh	9(270)	10	2	S	13	30	4(s)
27	The star on the right hind lower leg	9(270)	9	32	S	20	10	4(s)
28	The four stars [forming a quadrilateral] in the place where the tail joins [the body]: the advance star on the northern side	9(270)	10	22	S	4	50	5
29	The rear star on the northern side	9(270)	11	32	S	4	50	5
30	The advance star on the southern side	9(270)	11	32	S	5	50	5
31	The rear star on the southern side	9(270)	12	22	S	6	30	5
31stars, 7 is of the 3rd magnitude, 13 the 4th magnitude, 8 of the 5th magnitude, 2 of the 6th magnitude and 1 nebula.								

Folio 281

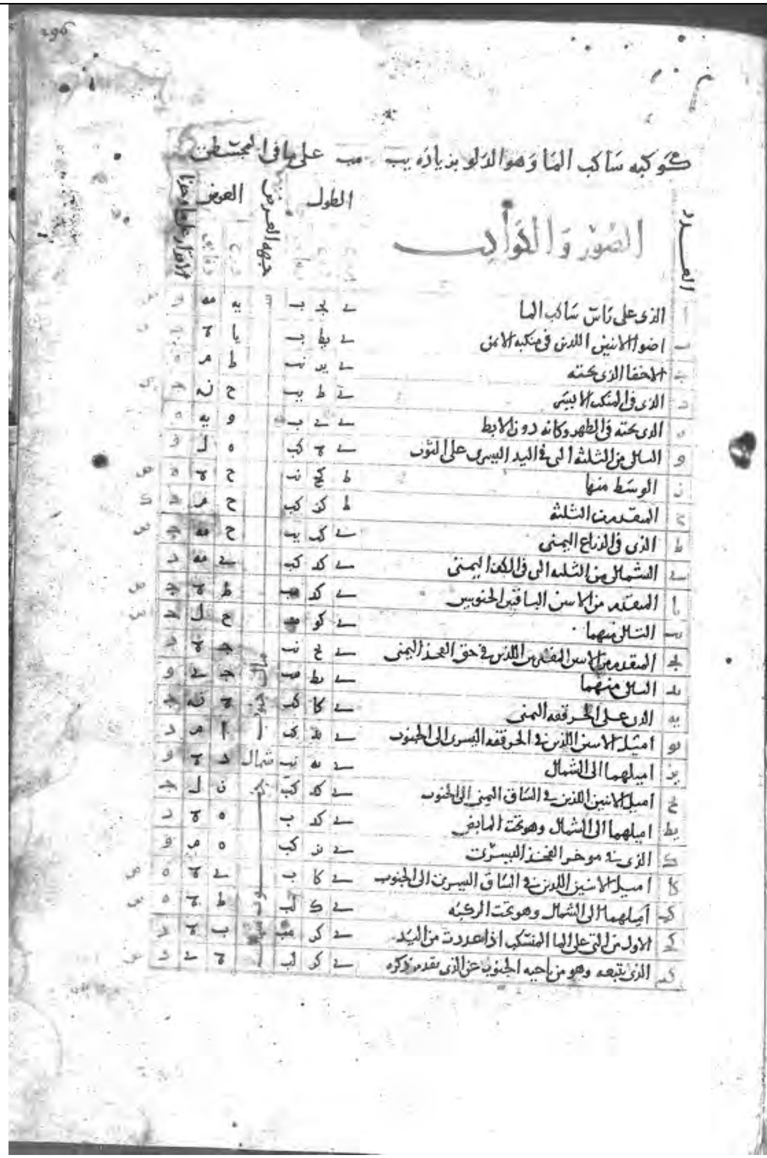
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
Constellation Capricorns (*al-Jadī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
1	The northernmost of the 3 stars in the rear horn	9(270)	20	2	N	7	20	3(s)
2	The middle one of these	9(270)	20	22	N	6	40	5(s)
3	The southernmost of the three	9(270)	20	2	N	5	0	3(s)
4	The star on the tip of the advanced horn	9(270)	17	42	N	8	0	6(s)
5	The southernmost of the 3 stars in the muzzle	9(270)	21	42	N	0	45	6
6	The more advanced of the other two	9(270)	21	22	N	1	45	6
7	The rearmost of these	9(270)	21	32	N	1	30	6
8	The star in advance of the [above] 3, under the right eye	9(270)	18	52	N	0	40	6
9	The northernmost of the 2 stars in the neck	9(270)	24	22	N	3	50	6
10	The southernmost of them	9(270)	24	32	N	0	50	6
11	The star on the left, doubled-up knee	9(270)	23	32	S	6	30	4
12	The star under the right knee	9(270)	24	22	S	8	40	4
13	The star on the left shoulder	9(270)	29	22	S	7	40	4(s)
14	The more advanced of the 2 stars close together under the belly	10(300)	2	52	S	6	50	4(s)
15	The rearmost of these	10(300)	3	2	S	6	0	5(m)
16	The rearmost of the 3 stars in the middle of the body	10(300)	1	22	S	4	15	6
17	The southernmost of the other, advanced 2	9(270)	29	22	S	4	0	6
18	The northernmost of them	9(270)	29	22	S	2	50	5(s)
19	The more advanced of the 2 stars in the back	9(270)	29	22	0	0	0	4
20	The rearmost of them	10(300)	3	42	S	0	50	4
21	The more advanced of the 2 stars in the southern spine	10(300)	6	2	S	4	45	4
22	The rearmost of them	10(300)	7	42	S	4	30	4(s)
23	The more advanced of the 2 stars in the section [of the body] next to the tail	10(300)	7	32	S	2	10	3(s)
24	The rearmost of them	10(300)	9	2	S	2	0	3


كوكبة الجدي بزيادة يب مب على ما في المجسطي

25	The most advanced of the 4 stars on the northern portion of the tail	10(300)	9	32	N	0	20	5(s)
26	The southernmost of the other 3	10(300)	11	22	0	0	0	5
27	The middle one of these	10(300)	10	22	N	2	50	5
28	The northernmost of them, on the end of the tail-fin	10(300)	11	22	N	4	20	5
28stars, 4 is of the 3rd magnitude, 8 the 4th magnitude, 7 of the 5th magnitude, 9 of the 6th magnitude.								

Folio 296

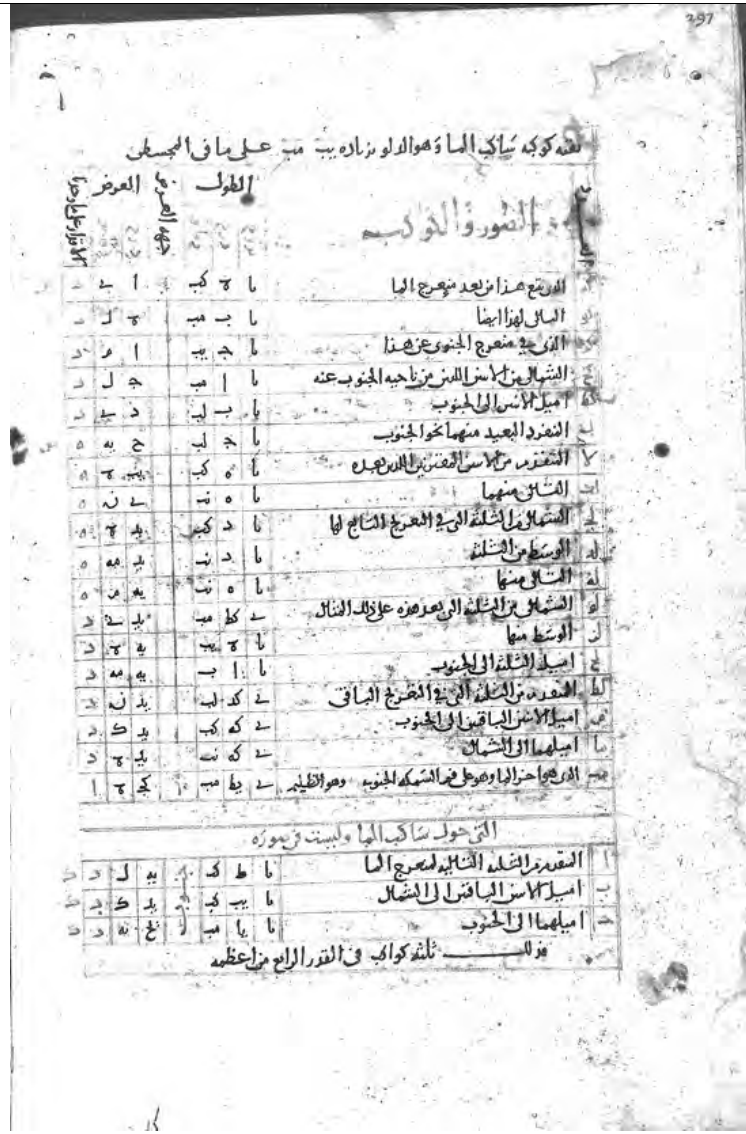
Constellation Aquarius (*Sākib al-Mā’*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the head of Aquarius	10(300)	13	2	N	15	45	6(s)
2	The brighter of the 2 stars in the right shoulder	10(300)	19	2	N	11	0	3(s)
3	The fainter one, under it	10(300)	17	52	N	9	40	5
4	The star in the left shoulder	10(300)	9	12	N	8	50	3(s)
5	The one under that, in the back, approximately under the armpit	10(300)	10	2	N	6	15	5
6	The rearmost of the three stars in the left arm, on the coat	10(300)	0	22	N	5	30	6
7	The middle one of these	9(270)	28	52	N	8	0	5(s)
8	The most advanced of the three	9(270)	27	22	N	8	40	4(m)
9	The star in the right forearm	10(300)	22	12	N	8	45	3(s)
10	The northernmost of the 3 stars on the right hand	10(300)	24	22	N	10	45	4(k)
11	The more advanced of the other 2 to the south	10(300)	24	42	N	9	0	3(s)
12	The rearmost of them	10(300)	26	42	N	8	30	3(s)
13	The more advanced of the 2 stars close together in the hollow of the right [hip]	10(300)	18	52	N	3	0	4
14	The rearmost of them	10(300)	19	42	N	3	10	5(s)
15	The star on the right buttock	10(300)	21	22	S	0	50	4(s)
16	The southernmost of the 2 stars in the left buttock	10(300)	14	22	S	1	40	4(s)
17	The northernmost of them	10(300)	15	52	N	4	0	6
18	The southernmost of the 2 stars in the right lower leg	10(300)	24	22	S	7	30	3
19	The northernmost of them, under the knee-bend	10(300)	24	2	S	5	0	4
20	The star in the back of the left thigh	10(300)	17	22	S	5	40	6
21	The southernmost of the 2 stars in the left lower leg	10(300)	21	2	S	10	0	5(s)
22	The northernmost of these, under the knee	10(300)	20	32	S	9	0	5(s)
23	The stars on the flow of water: the most advanced [in the section] beginning at the hand	10(300)	27	42	N	2	0	4
24	The one next to the latter towards the south	10(300)	27	32	N	0	10	4(s)



Folio 297

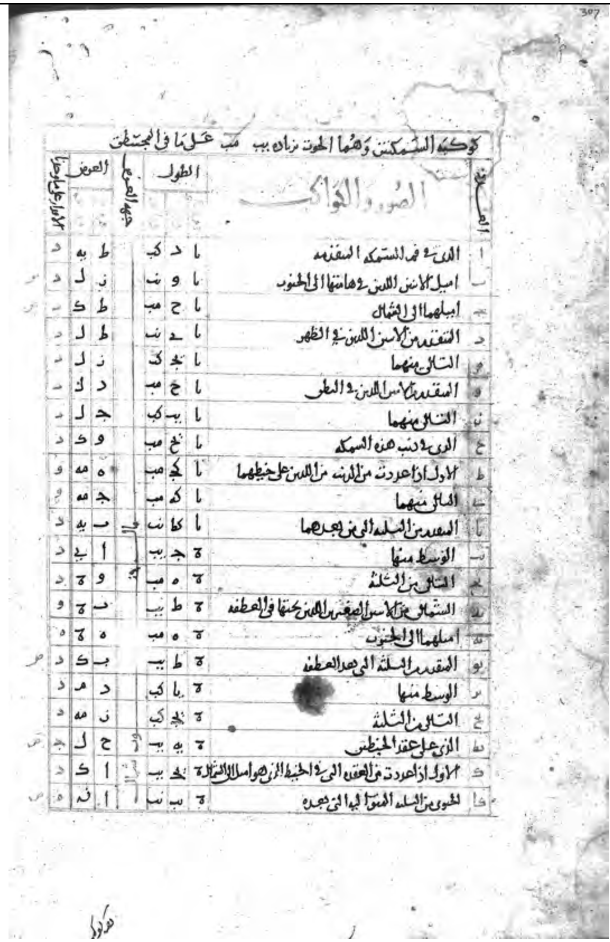
Remaining stars of the constellation Aquarius with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
25	The one next to this, after [the beginning of] the bend	11(330)	0	22	S	1	10	4(s)
26	The one to the rear again of this	11(330)	2	42	S	0	30	4(s)
27	The one in the bend to the south of this	11(330)	3	12	S	1	40	4
28	The northernmost of the 2 stars to the south of this	11(330)	1	42	S	3	30	4
29	The southernmost of the two	11(330)	2	32	S	4	10	4
30	The lone star at some distance from these [two] towards the south	11(330)	3	32	S	8	15	5(s)
31	The more advanced of the 2 stars close together after the latter	11(330)	5	22	S	12	0	5
32	The rearmost of them	11(330)	5	52	S	10	50	5
33	The northernmost of the 3 stars in the next group	11(330)	4	22	S	14	0	5
34	The middle one of the three	11(330)	4	52	S	14	45	5
35	The rearmost of them	11(330)	5	52	S	15	40	5
36	The northernmost of the next 3 [arranged] likewise	10(300)	29	42	S	14	10	4
37	The southernmost of the three	11(330)	0	12	S	15	0	4
38	The middle one of the three	11(330)	1	2	S	15	45	4
39	The most advanced of the 3 stars in the remaining group	10(300)	24	32	S	14	50	4
40	The southernmost of the other 2	10(300)	25	22	S	14	20	4
41	The northernmost of them	10(300)	25	52	S	14	0	4
42	The star at the end of the water and on the mouth of Piscis Austrinus called *al-Dhulaīm*	10(300)	19	42	S	23	0	1
42 stars, 1 of the 1st magnitude, 6 is of the 3rd magnitude, 19 the 4th magnitude, 12 of the 5th magnitude, 4 of the 6th magnitude.								
The ones surrounding the constellation Aquarius but not in it.								
1	The most advanced of the 3 stars to the rear of the bend in the water	11(330)	9	22	S	15	30	4(m)
2	The northernmost of the other 2	11(330)	12	22	S	14	20	4(m)
3	The southernmost of them	11(330)	11	42	S	18	15	4(m)
3 stars much more than the 4th magnitude.								



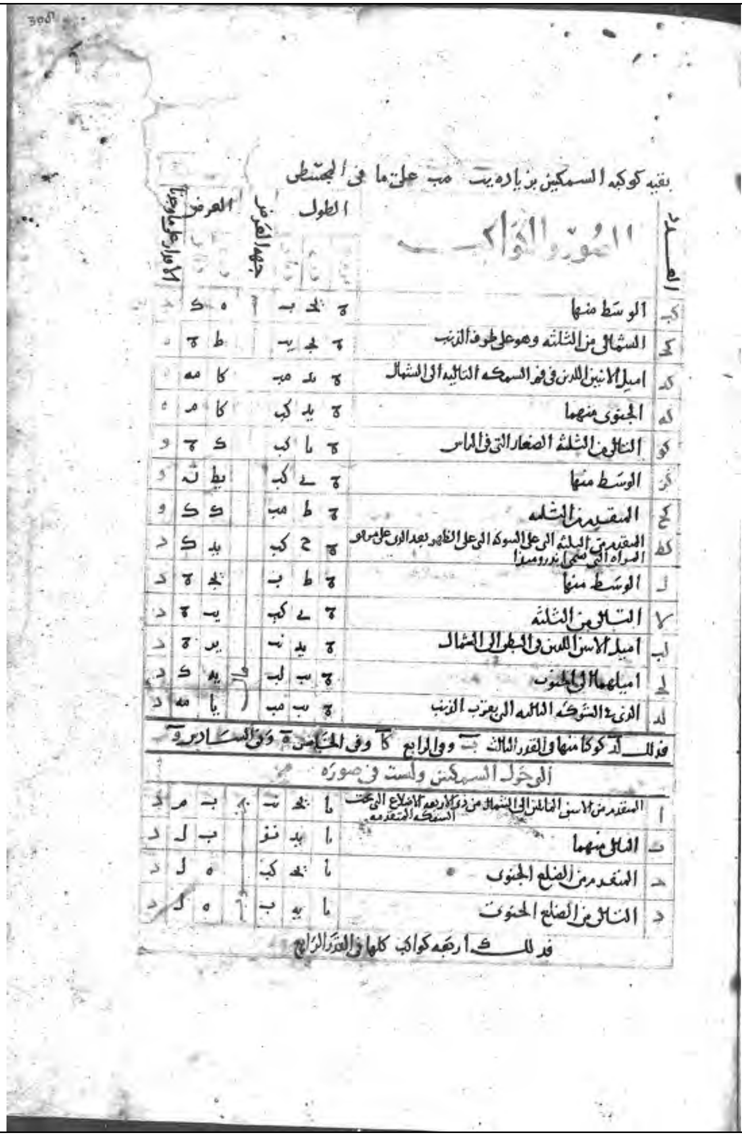
Folio 307

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
Constellation Pisces (al-*Samakatān and al-Ḥūt*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
		zodiac	deg	min		deg	min	
1	The star in the mouth of the advanced fish	11(330)	4	22	N	9	15	4
2	The southernmost of the 2 stars in the top of its head	11(330)	6	52	N	7	30	4(s)
3	The northernmost of them	11(330)	8	42	N	9	20	4(s)
4	The more advanced of the 2 stars in the back	11(330)	10	52	N	9	30	4
5	The rearmost of them	11(330)	13	22	N	7	30	4
6	The more advanced of the 2 stars in the belly	11(330)	8	42	N	4	30	4
7	The rearmost of them	11(330)	12	22	N	3	30	4
8	The star in the tail of the same [advanced] fish	11(330)	18	42	N	6	20	4
9	The stars forming its fishing-line: the first after the tail	11(330)	23	42	N	5	45	6
10	The one to the rear	11(330)	25	42	N	3	45	6
11	The most advanced of the 3 following bright stars	11(330)	29	52	N	2	15	4
12	The middle one of these	0	3	12	N	1	10	4
13	The rearmost of the three	0	5	42	S	6	0	4
14	The northernmost of the 2 small stars under these, in the bend	0	9	12	S	2	0	6
15	The southernmost of them	0	5	42	S	5	0	5
16	The most advanced of the 3 stars after the bend	0	9	12	S	2	20	4(s)
17	The middle one of these	0	11	22	S	4	40	4
18	The rearmost of the three	0	13	22	S	7	45	4
19	The star on the knot joining the 2 fishing-lines	0	15	12	S	8	30	4(m)
20	The first of the stars in the northerly fishing line, beginning at the knot	0	13	12	N	1	20	4
21	The southernmost of the 3 stars following this	0	12	52	N	1	50	5(s)



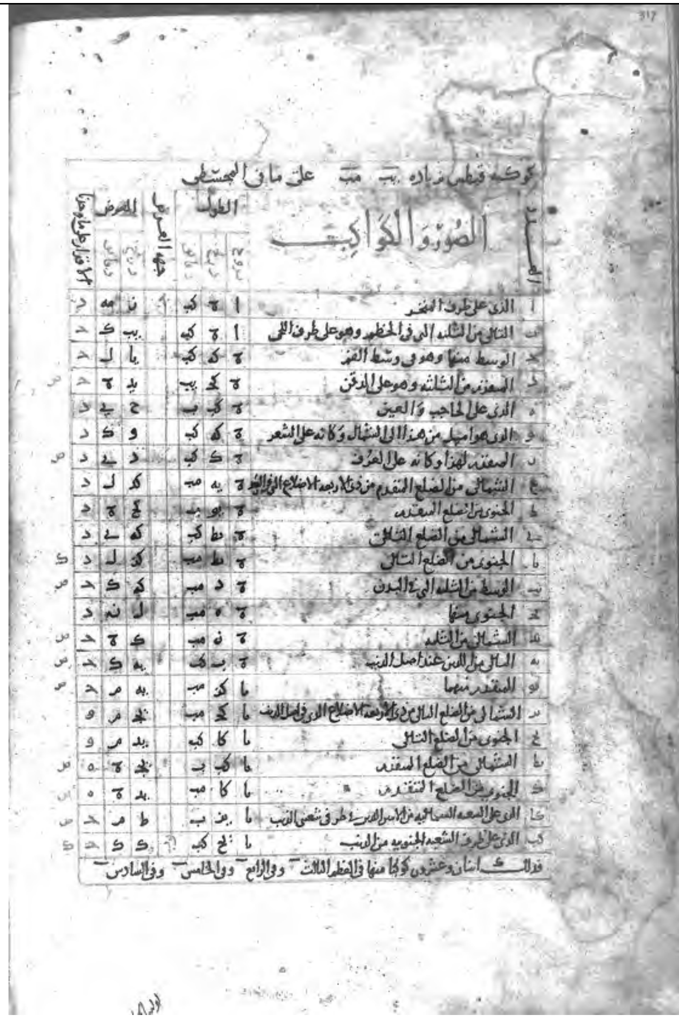
Folio 308

Remaining stars of the constellation Pisces with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
22	The middle one of these	0	13	2	N	5	20	4(m)
23	The northernmost of the 3, which is also on the end of the tail	0	13	12	N	9	0	5
24	The northernmost of the 2 stars in the mouth of the rear fish	0	13	42	N	21	45	5
25	The southernmost of them	0	13	22	N	21	40	5
26	The rearmost of the 3 small stars in the head	0	11	22	N	20	0	6(s)
27	The middle one of these	0	10	22	N	19	50	6(s)
28	The most advanced of the three	0	9	42	N	20	20	6(s)
29	The most advanced of the 3 stars on the spine in the back, following [i.e. to the rear of] the star on the elbow of Andromeda [345 And 11]	0	8	22	N	14	20	4
30	The middle one of the three	0	9	2	N	13	0	4
31	The rearmost of the three	0	10	22	N	12	0	4
32	The northernmost of the 2 stars in the belly	0	14	52	N	17	0	4
33	The southernmost of them	0	12	32	N	15	20	4
34	The star in the rear spine, near the tail	0	12	42	N	11	45	4
34 stars, 2 are of the 3rd magnitude, 21 the 4th magnitude, 5 of the 5th magnitude, 6 of the 6th magnitude.								
The ones surrounding the constellation Aquarius but not in it.								
1	The quadrilateral under the advance fish: the more advanced of the 2 northern stars	11(330)	13	52	S	2	40	4
2	The rearmost of them	11(330)	14	57	S	2	30	4
3	The more advanced star on the southern side	11(330)	13	22	S	5	30	4
4	The rearmost one on the southern side	11(330)	15	2	S	5	30	4
4 stars, all of the 4th magnitude.								



Folio 317

Constellation Cetus (*Qīṭus*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star on the tip of the nostrils	1(30)	0	22	S	7	45	4
2	The three stars in the snout: the rearmost, on the end of the jaw"	1(30)	0	22	S	12	20	3
3	The middle one, in the middle of the mouth"	0	25	22	S	11	30	3
4	The most advanced of the 3, on the cheek"	0	23	12	S	14	0	3(s)
5	The star on the eyebrow and the eye	0	22	2	S	8	10	4
6	The one to the north of this, approximately on the hair"	0	25	22	S	6	20	4
7	The one in advance of these, approximately on the mane"	0	20	22	S	4	10	4(s)
8	The quadrilateral in the chest: the northernmost star on the forward side	0	15	42	S	24	30	4
9	The one on the end of the southern tail-fin	0	16	2	S	28	0	4
10	The northernmost one on the rear side	0	19	22	S	25	10	4
11	The southernmost one on the rear side	0	19	42	S	27	30	4(k)
12	The middle one of the 3 stars in the body	0	4	42	S	25	20	3(s)
13	The southernmost of them	0	5	42	S	30	50	4
14	The northernmost of the three	0	7	42	S	20	0	3(s)
15	The rearmost of the 2 stars by the section next to the tail	0	2	22	S	15	20	3(s)
16	The more advanced of them	11(330)	27	42	S	15	40	3(s)
17	The quadrilateral in the section next to the tail: the northernmost star on the rear side	11(330)	23	42	S	13	40	6
18	The southernmost one on the rear side	11(330)	21	22	S	14	40	6
19	The northernmost one on the forward side	11(330)	22	2	S	13	0	5(s)
20	The southernmost one on the forward side	11(330)	21	42	S	14	0	5(s)
21	The 2 stars at the ends of the	11(330)	17	2	S	9	40	3(s)



	tail-fins: the one on the northern [tail-fin]							
22	The one on the end of the southern tail-fin	11(330)	18	22	S	20	20	3(m)
22 stars, 9 of the 3rd magnitude, 9 of the 4th magnitude, 2 of the 5th magnitude. and 2 of the 6th magnitude								

Folio 318 (Manuscript Marsh144)
The constellation Orion (*Jabbār)* or *(al-Jauzā')*

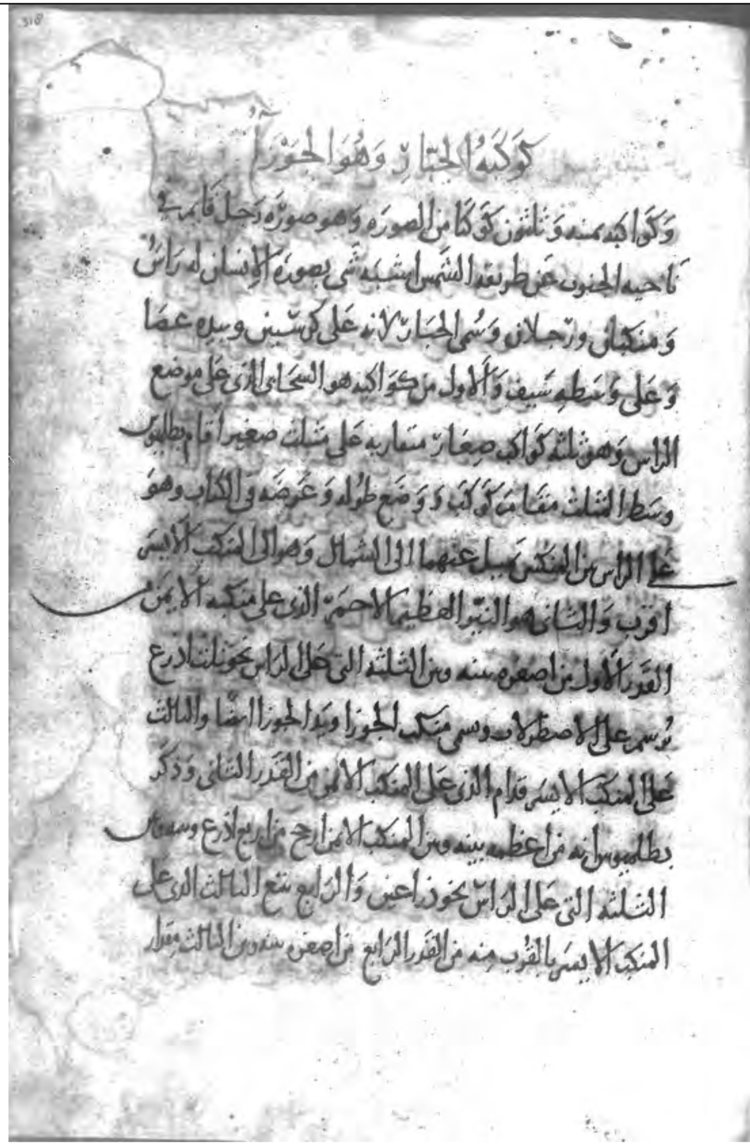
Its stars are thirty-eight stars in the constellation. It is the image of a man standing south of the path of the Sun. It most resembles an image of a human with a head, two shoulders and two legs. It was called *al-Jabbār* because it is (standing) on two legs with a stick in his hands and a sword on his middle.

The first of its stars is the *Saḥābi* (nebula) on the head. This nebula is made up of three small stars close together forming a small *Muthallath* (triangle). Ptolemy mentioned it to be one star located in the middle of the triangle and he indicated its longitude and latitude in his book. It is located on the head between the two shoulders and further away towards the north but closer to the left shoulder.

The second is the great bright red star located on the right *Mankib* (shoulder). It is less than the 1st magnitude. The distance between it and the three stars on the head is three *dhirā'*. It is (one of the stars that are) drawn on an astrolabe. It is called *Mankib al-Jauzā'* (the shoulder of Orion) and also *Yad al-Jauzā'* (the hand of Orion).

The third is located on the left shoulder next to the star on the right shoulder. It is of the 2nd magnitude. Ptolemy mentioned that it is much more (than the 2nd magnitude). The distance between it and the star on the right shoulder is a little more than four *dhirā'*. The distance between it and the three stars on the head is two *dhirā'*.

The fourth (star) is next to the third (star) which is on the left shoulder and is close to it. It is less than the 4th magnitude. The distance between it and the third star is two-thirds of a *dhirā'*.



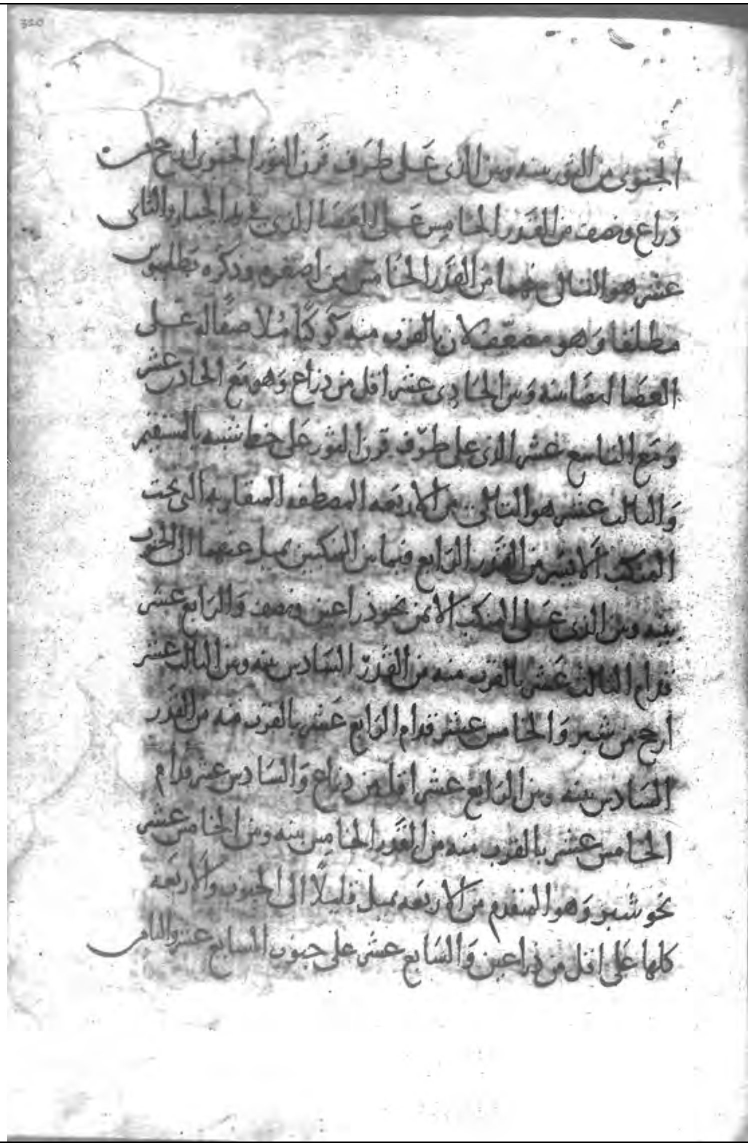
Folio 319

The fifth is north of the second star and is inclined a little towards the east. It is located on the right elbow. It is of the 4th magnitude. The distance between it and the second star in the north-east is a little more than one *dhirā‘*.
The sixth is north of the fifth, located on the right *sa’ed* (forearm). It is of the 6th magnitude. The distance between it and the fifth star is close to two *dhirā‘*. It forms together with the fifth and the second (stars) a line with a slight curve with its curve pointed towards the north.
The seventh is the *tālī* (rearmost) of the two close stars north of the sixth star. The distance between it and the sixth star is less than one *dhirā‘*. It is of the 5th magnitude. Ptolemy mentioned that it of the 4th magnitude. It is located on the right hand.
The eighth is close to the seventh star. It is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. It is also located on the right hand. The distance between it and the seventh towards the north-west is one *dhirā‘*.
The ninth is to the rear of the two close-by stars. It is north of the seventh and eighth stars. The distance between it and seventh star in the north is a little less then one *dhirā‘*. It is of the 6th magnitude. It is also located on the right hand.
The tenth is *al-mutaqadem* (in-advance) of the ninth star and close to it. It is also of the 6th magnitude. It is also located on the right hand.
The eleventh is the more advanced of the two stars that are north of the four stars on the right hand. They are inclined towards the west. It (the eleventh star) is to the rear of the nineteenth star which is on the eastern horn of (the constellation) Taurus.

Folio 320

The distance between it and the star which is on the eastern horn of (the constellation) Taurus is more than one and a half *dhirā‘*. It is of the 5th magnitude. It is located on *al-‘Sā* (the staff) held by Orion.
The twelfth is to the rear of the two. It is less than the 5th magnitude. Ptolemy mentioned that it is exactly 5th magnitude. It is a *Muḍ'af* (double star) because there is a star next to it. It is also located on the staff. The distance between it and eleventh is less than one *dhirā‘*. It forms together with the eleventh (of Orion) and the nineteenth which is on the tip of the horn of (the constellation) Taurus a slightly straight line.
The thirteenth is the rearmost of the four stars that form a straight line under the left shoulder. It is of the 4th magnitude. It is located between the two shoulders towards the south. The distance between it and the star on the right shoulder is a distance of two and half *dhirā‘*.
The fourteenth is in advance of the thirteenth and close by it. It is of the 6th magnitude. The distance between it and thirteenth is more than one *dhirā‘*.
The fifteenth is in advance of the fourteenth and close by it. It is of the 6th magnitude. The distance between it and fourteenth is less than one *dhirā‘*.
The sixteenth is in advance of the fifteenth and close by it. It is of the 5th magnitude. The distance between it and fifteenth is about one *Shibr*.
It is the one in advance of the four stars towards the south. All the four (stars) are less than two *dhirā‘* in distance.

The seventeenth is south of the seventeenth and eighteenth stars that are on the middle of the southern horn of the (constellation) Taurus.



Folio 321

The distance between it and the seventeenth (star) that is on the middle of the southern horn of the (constellation) Taurus is more than one *dhirā'*. It is the northernmost star of the nine curved stars that are on the left *Kum* (pelt). It is of the 4th magnitude.

The eighteenth is in advance of the seventeenth and close by it. It is the second of the nine stars. It is south-east of the seventeenth by a distance of more than one *Shibr*. It is also of the 4th magnitude.

The nineteenth is south of the eighteenth and close by it. It is of the 4th magnitude. It is south of the eighteenth by a distance of more than one *dhirā'*. It is the third of the nine stars.

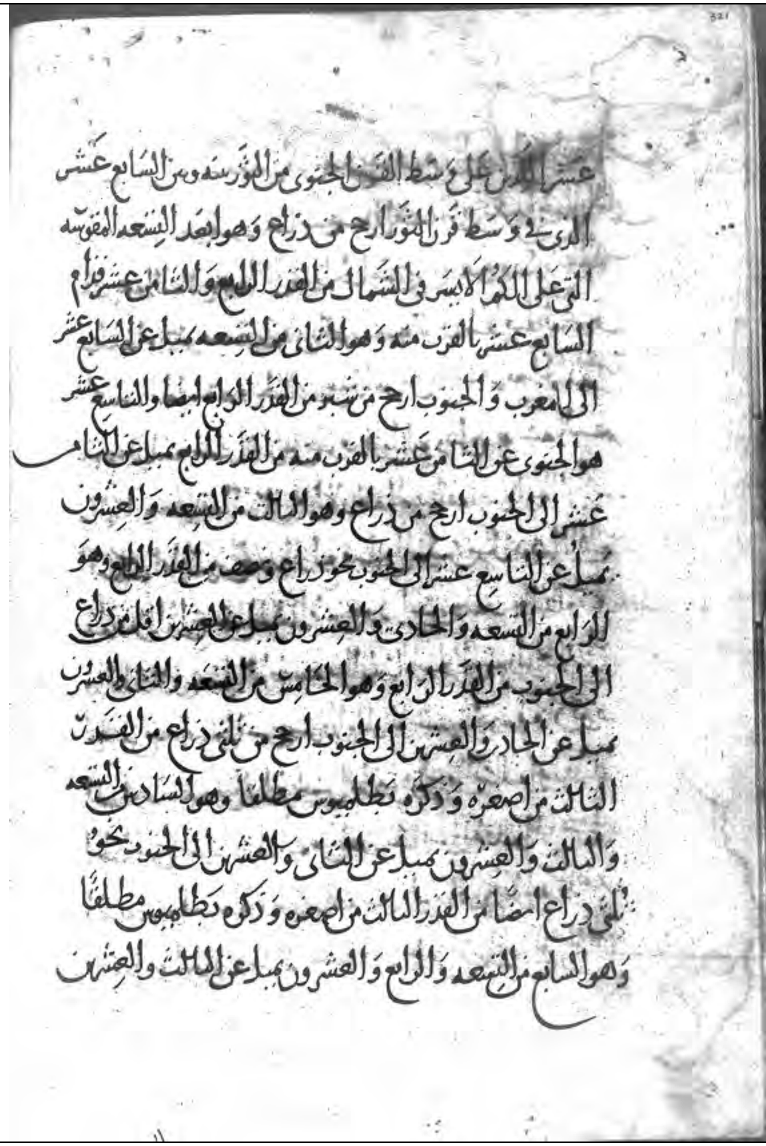
The twentieth is south of the nineteenth by a distance of one and a half *dhirā'*. It is of the 4th magnitude. It is the fourth of the nine stars.

The twenty-first is south of the twentieth by a distance of less than one *dhirā'*. It is of the 4th magnitude. It is the fifth of the nine stars.

The twenty-second is south of the twenty-first by a distance of more than two-third a *dhirā'*. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. It is the sixth of the nine stars.

The twenty-third is south of the twenty-second by a distance of two-third a *dhirā'*. It is also less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. It is the seventh of the nine stars.

The twenty-fourth is south of the twenty-third by a distance of one and a third *dhirā'*.


عشر الذي على وسط القرن الجنوبي من الثور سته ومن السابع عشر
الذي في وسط قرن الثور ارجح من ذراع وهو ابعد التسعه المقوسه
التي على الكم الايسر في الشمال من القدر الرابع والثامن عشر وام
السابع عشر بالقرب منه وهو الثاني من التسعه يبعد عن السابع عشر
الى المغرب والجنوب ارجح من شبر من القدر الرابع ايضا والتاسع عشر
هو الجنوبي عن الثامن عشر بالقرب منه من القدر الرابع يبعد عن الثامن
عشر الى الجنوب ارجح من ذراع وهو الثالث من التسعه والعشرون
يبعد عن التاسع عشر الى الجنوب نحو ذراع ونصف من القدر الرابع وهو
الرابع من التسعه والحادي والعشرون يبعد عن العشرين اقل من ذراع
الى الجنوب من القدر الرابع وهو الخامس من التسعه والثاني والعشرون
يبعد عن الحادي والعشرين الى الجنوب ارجح من ثلثي ذراع من القدر
الثالث من اصغره وذكره بطلميوس مطلقا وهو السادس من التسعه
والثالث والعشرون يبعد عن الثاني والعشرين الى الجنوب نحو
ثلثي ذراع ايضا من القدر الثالث من اصغره وذكره بطلميوس مطلقا
وهو السابع من التسعه والرابع والعشرون يبعد عن الثالث والعشرين

Folio 322

It is also less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude. It is the eighth of the nine stars.

The twenty-fifth is south-east of the twenty-fourth by a distance of half a *dhirā‘*. It is of the 4th magnitude. Ptolemy mentioned that it is of the 3rd magnitude. It is the southernmost star of the nine curved stars.

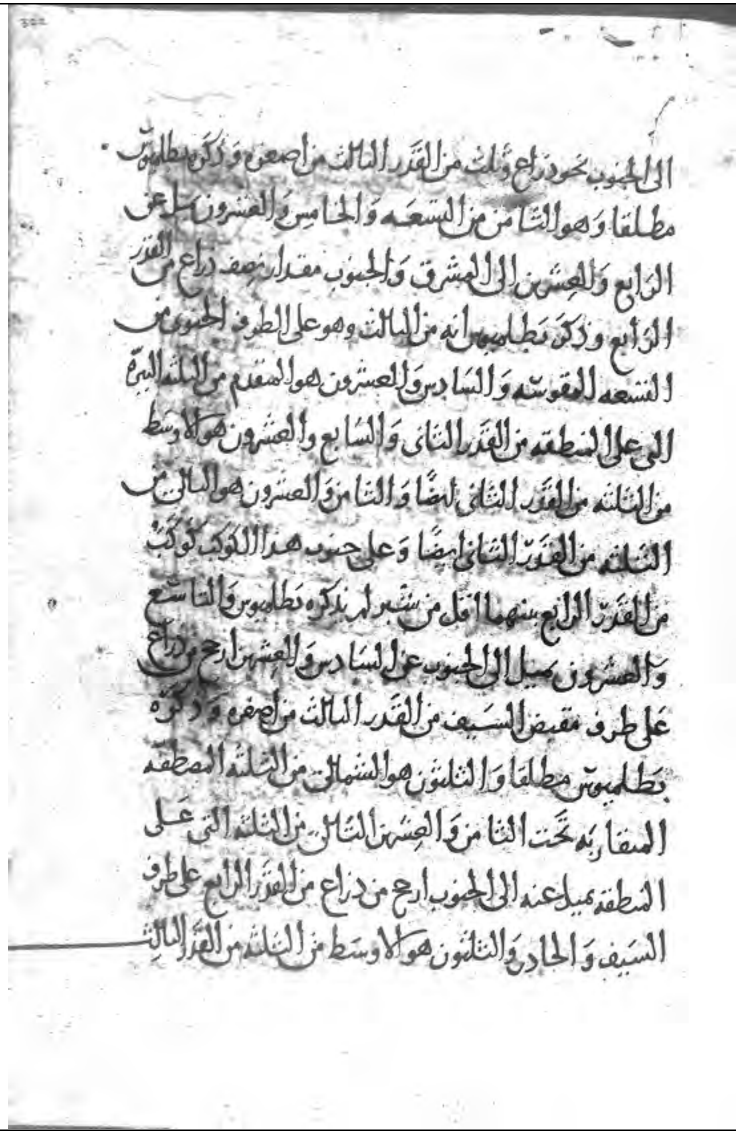
The twenty-sixth is the most advanced of the three bright stars on the belt. It is of the 2nd magnitude.

The twenty-seventh is the middle of the three stars. It is also of the 2nd magnitude.

The twenty-eighth is the rearmost of the three stars. It is also of the 2nd magnitude. South of this star is a star of the 4th magnitude. The distance between them is less than one *Shibr*. It was not mentioned by Ptolemy.

The twenty-ninth is south of the twenty-sixth by a distance of more than one *dhirā‘*. It is located on the tip of the handle of the sword. It is less than 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude.

The thirtieth is the northernmost of the three aligned stars under the twenty-eighth star which is the rearmost of the three stars on the *Minṭaqa* (belt).
It is south of it by a distance of more than one *dhirā‘*. It is of the 4th magnitude. It is located on the tip of the sword.
The thirty-first is the middle of the three. It is less than 3rd magnitude.


الى الجنوب نحو ذراع وثلث من القدر الثالث من اصغر وذكر بطلميوس
مطلقا وهو الثامن من التسعة والخامس والعشرون يلي عن
الرابع والعشرين الى المشرق والجنوب مقدار نصف ذراع من القدر
الرابع وذكر بطلميوس انه من الثالث وهو على الطرف الجنوبي من
التسعة المقوسة والسادس والعشرون هو المتقدم من الثلاثة النيرة
التي على المنطقة من القدر الثاني والسابع والعشرون هو الاوسط
من الثلاثة من القدر الثاني ايضا والثامن والعشرون هو التالي من
الثلاثة من القدر الثاني ايضا وعلى جنوب هذا الكوكب كوكب
من القدر الرابع بينهما اقل من شبر لم يذكره بطلميوس والتاسع
والعشرون يميل الى الجنوب عن السادس والعشرين ارجح من ذراع
على طرف مقبض السيف من القدر الثالث من اصغر وذكره
بطلميوس مطلقا والثلاثون هو الشمالي من الثلاثة المصطفة
المتقاربة تحت الثامن والعشرين التالي من الثلاثة التي على
المنطقة يبعد عنه الى الجنوب ارجح من ذراع من القدر الرابع على طرف
السيف والحادي والثلاثون هو الاوسط من الثلاثة من القدر الثالث

Folio 323
The distance between it and the thirtieth is less than one *Shibr*

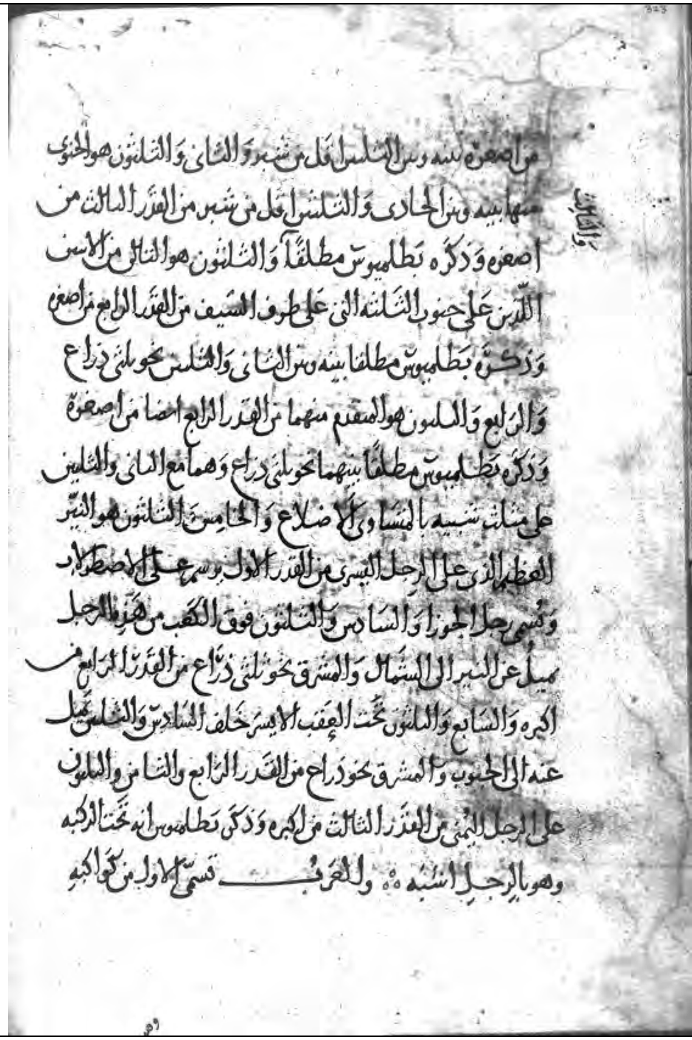
The thirty-second is the southernmost of them. The distance between it and the thirty-first is less than one *Shibr*. It is less than the 3rd magnitude. Ptolemy mentioned that it is exactly 3rd magnitude.

The thirty-third is the rearmost of the two stars that are south of the three which are on the tip of *al-Saif* (the sword). It is less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between it and the thirty-second is about two-thirds of a *dhirāʻ*.

The thirty-fourth is the more advanced of them. It is also less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between them is about two-thirds of a *dhirāʻ*. They form together with the thirty-second an almost *Muthallath Mutasāwi al-Aḍla'* (equilateral triangle).

The thirty-fifth is the large bright star on the left leg. It is of the 1st magnitude. It is (one of the stars that are) drawn on an astrolabe. It is called *Rijl al-Jauzā'* (the leg of Orion).

The thirty-sixth is above the *K'eb* (ankle-joint) of this leg. It is south-east of the bright star by two-third a *dhirāʻ*. It is greater than the 4th magnitude.
The thirty-seventh is under the left *'Akeb* (heel) and behind the thirty-sixth. It is south-east of it by one *dhirāʻ*. It is of the 4th magnitude.
The thirty-eighth is on the right *Rijl* (leg). It is greater than the 3rd magnitude. Ptolemy mentioned that it is under the *Rukba* (knee), but it is more likely on the leg.



Folio 324

The Arabs call the first of its stars which are the three small close-by stars which resemble the points of the letter *Tha* (ث) and which are located on the head, *al-Haq'a* and also *Haq'at al-Jauzā*. It was also mentioned as *al-Taḥātī*, *al-Taḥiyat* , *al-Taḥia* and also *al-Athāfī* because it resembles it. It is the fifth of the lunar mansions.

The great bright star (the second star) is called *Mankib al-Jauzā'* and also *Yad al-Jauzā'*. It was mentioned as *Mirzam al-Jauzā'* and this is wrong, because it was their practice to begin the name of any bright star by *Mirzam* like the two (stars) *Mirzam al-Shi'rayan*.

They called the third star which is on left shoulder *al-Nājid* and it was also called by *al-Mirzam.*

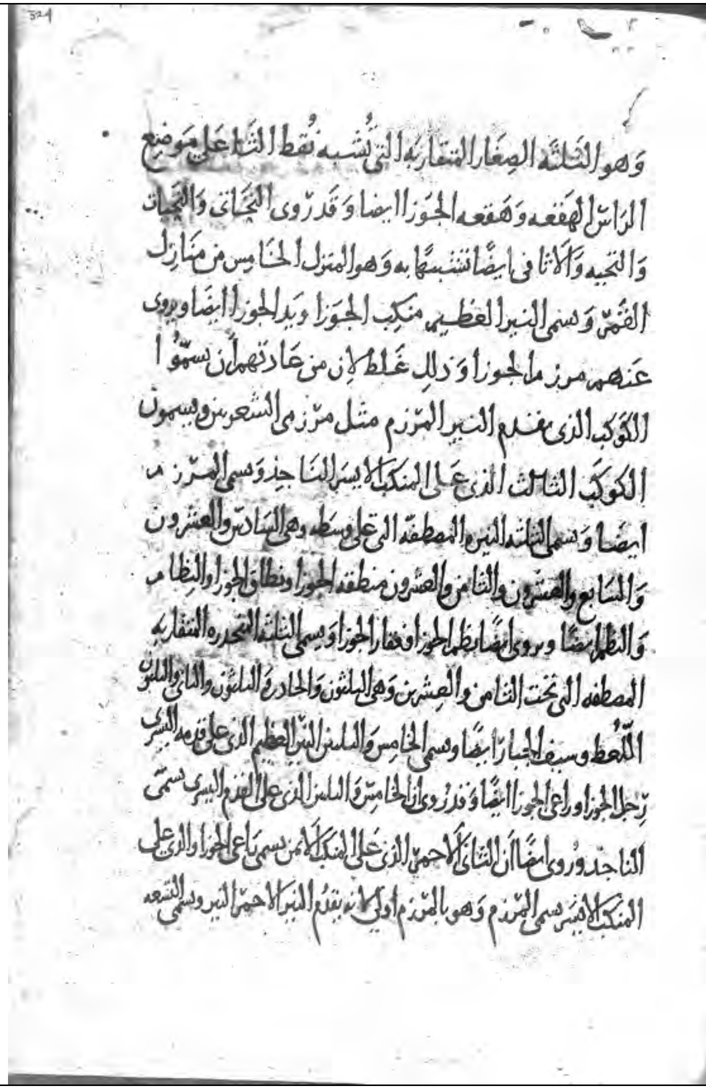
The three bright stars that are aligned on its middle and which are the twenty-sixth, the twenty-seventh and the twenty-eighth were called *Minṭaqat al-Jauzā'*, *Niṭāq al-Jauzā'* and *al-Niẓām* and also *al-Naẓm*. They were also mentioned as *Naẓm al-Jauzā'* and *Faqār al-Jauzā'*.

The three stars that are close-by and vertically aligned, located under the twenty-eighth, which are the thirtieth, the thirty-first and the thirty-second, were called *al-Laqaṭ* and also *Saif al-Jabbār*.

The thirty-fifth which is the great bright star on the left leg was called *Rijl al-Jauzā'* and *Rā'ī al-Jauzā'*. It was also mentioned that the thirty-fifth which is on the left leg was called *al-Nājid*.

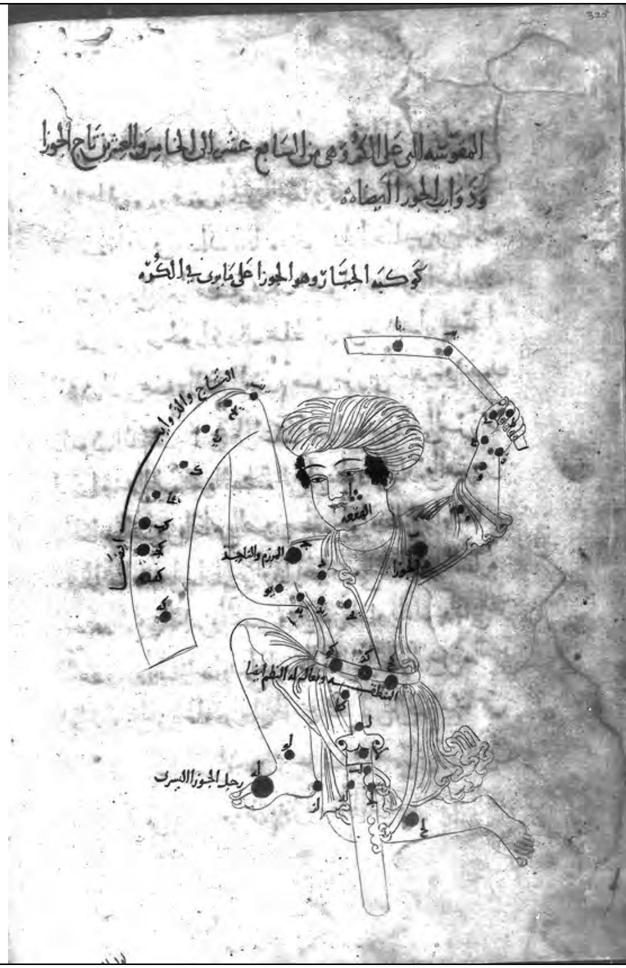
It was also mentioned that the second star that is the red star on the right shoulder was called *Rā'ī al-Jauzā'* and the one on the left shoulder was called *al-Mirzam* which is the first *Mirzam* because it proceeds the bright red star.

The nine curved stars that are on the pelt, which start from the seventeenth until the twenty-fifth, were called *Tāj al-Jauzā'* and also *Dhawā'īb al-Jauzā'*.



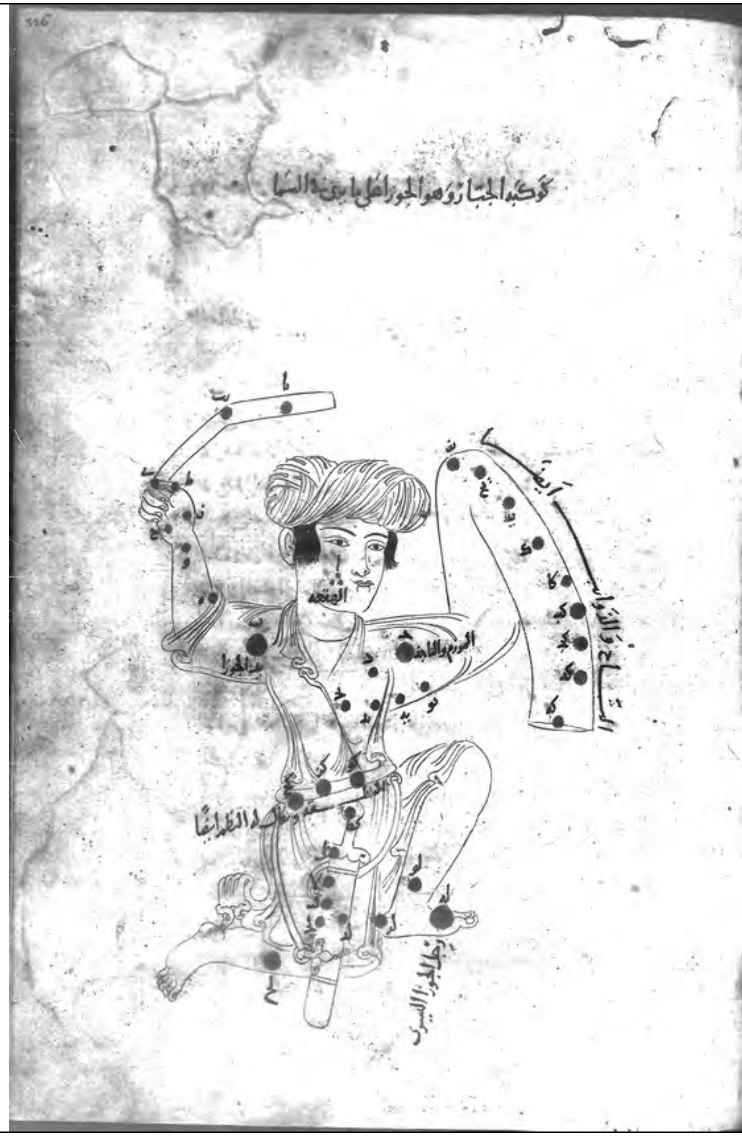
Folio 325

The constellation Orion (*al-Jabbār)* or *(al-Jauzā')* as seen on the globe.



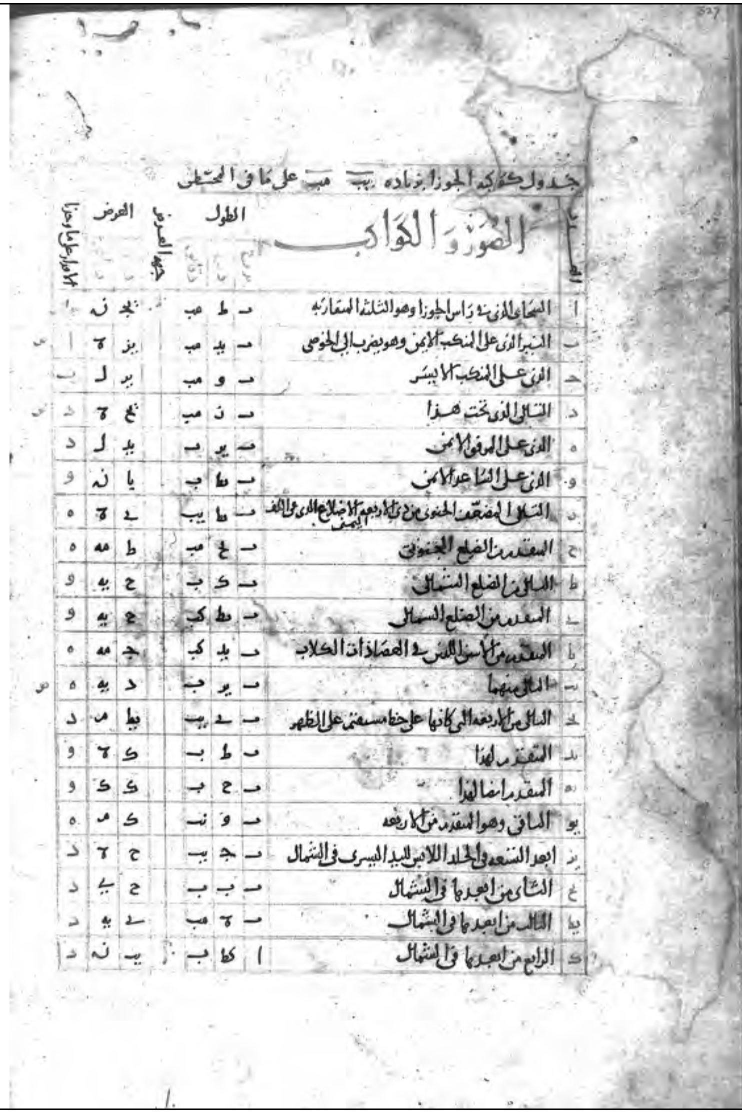
Folio 326

The constellation Orion (*al-Jabbār)* or *(al-Jauzā')* as seen in the sky.



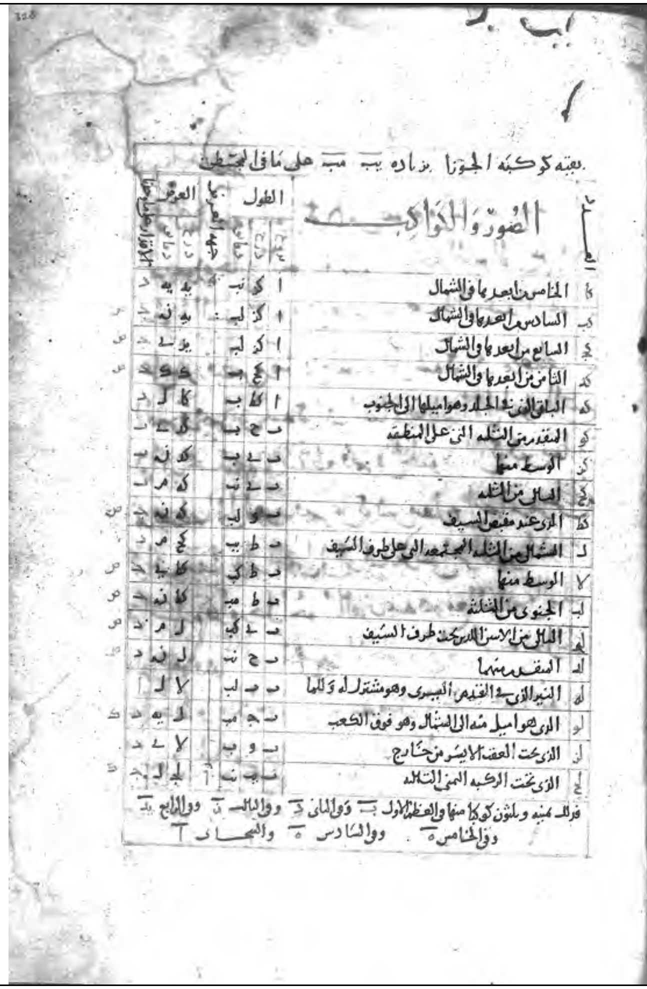
Folio 327

Table of the constellation Orion with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The nebulous star in the head of Orion, which are the three close stars	2(60)	09	42	S	13	50	nebula
2	The bright reddish star on the right shoulder	2(60)	14	42	S	17	00	1(s)
3	The star on the left shoulder	2(60)	06	42	S	17	30	2
4	The one under this to the rear	2(60)	50	42	S	18	00	4(s)
5	The star on the right elbow	2(60)	06	02	S	14	30	4
6	The star on the right forearm	2(60)	19	02	S	11	50	6
7	The quadrilateral in the right hand: The rear , double star on the southern side	2(60)	19	12	S	10	00	5
8	The advanced star on the southern side	2(60)	38	42	S	09	45	5
9	The rear one on the northern side	2(60)	20	02	S	08	15	6
10	The advanced one on the northern side	2(60)	19	22	S	08	15	6
11	The more advanced of the 2 stars in the staff	2(60)	14	22	S	03	45	5
12	The rearmost of them	2(60)	17	02	S	04	15	5(s)
13	The rearmost of the 4 stars almost on a straight line just over the back	2(60)	10	12	S	19	40	4
14	The one in advance of this	2(60)	09	02	S	20	00	6
15	The one in advance again of this	2(60)	08	02	S	20	20	6
16	The last and most advanced of the 4	2(60)	06	52	S	20	40	5
17	The stars in the pelt on the left arm: The northernmost	2(60)	03	12	S	08	00	4
18	The 2nd from the northernmost	2(60)	02	02	S	08	10	4
19	The 3rd from the northernmost	2(60)	00	42	S	10	15	4
20	The 4th from the northernmost	1(30)	29	02	S	12	50	4



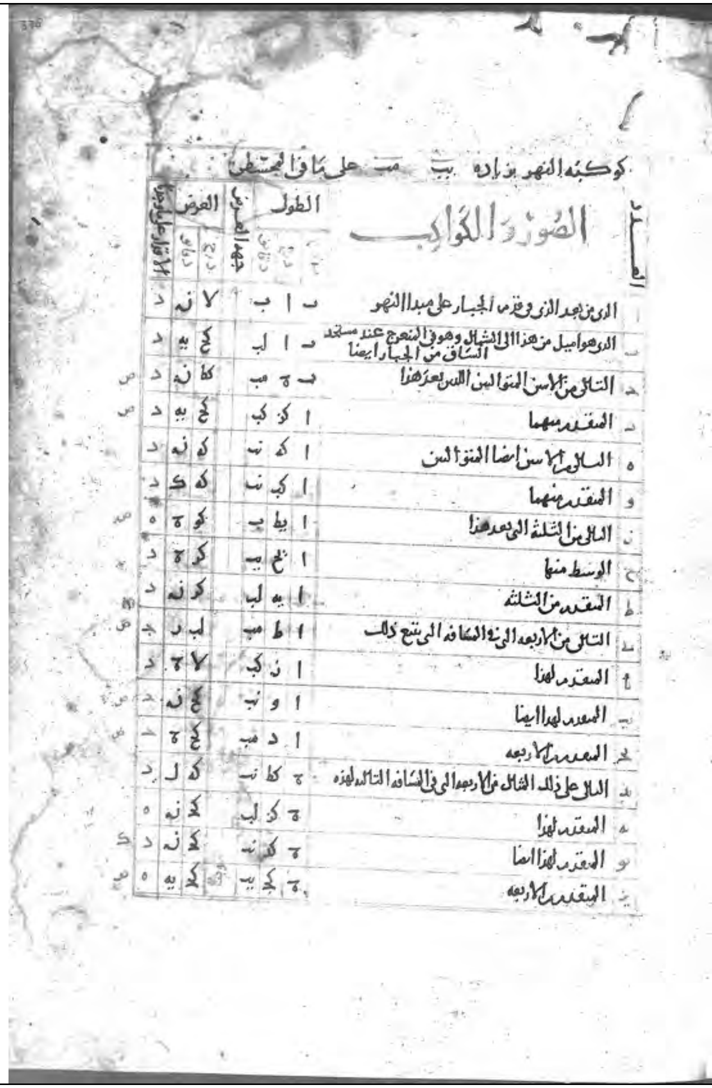
Folio 328

Table of the constellation Orion with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
21	The 5th from the northernmost	1(30)	27	52	S	14	15	4
22	The 6th from the northernmost	1(30)	27	32	S	15	50	3(s)
23	The 7th from the northernmost	1(30)	27	32	S	17	10	3(s)
24	The 8th from the northernmost	1(30)	18	02	S	20	20	3(s)
25	The last and the southernmost of those in the pelt	1(30)	29	02	S	21	30	4
26	The most advanced of the 3 stars on the belt	2(60)	08	02	S	24	10	2
27	The middle one	2(60)	10	02	S	24	50	2
28	The rearmost of the three	2(60)	10	52	S	25	40	2
29	The star near the handle of the sward	2(60)	06	32	S	25	50	3(s)
30	The northernmost of the 3 stars joined together at the tip of the dagger	2(60)	09	12	S	28	40	4
31	The middle one	2(60)	09	22	S	29	10	3(s)
32	The southernmost of the three	2(60)	09	42	S	29	50	3(s)
33	The rearmost of the 2 stars under the tip of the sword	2(60)	10	22	S	30	40	4(s)
34	The more advanced of them	2(60)	08	52	S	30	50	4(s)
35	The bright star in the left foot, which is (applied in) common to the water (of Eridanus)	2(60)	02	32	S	31	30	1
36	The star to the north of it in the lower leg over the ankle-joint	2(60)	03	42	S	30	15	4(k)
37	The star under the left heel to the outside	2(60)	06	02	S	31	10	4
38	The star under the right rear knee	2(60)	12	52	S	33	30	3(k)
38 stars, 2 of the 1st magnitude, 4 of the 2nd , 7 of the 3rd, 14 of the 4th , 5 of the 5th , 5 of the 6th and 1 nebula.								



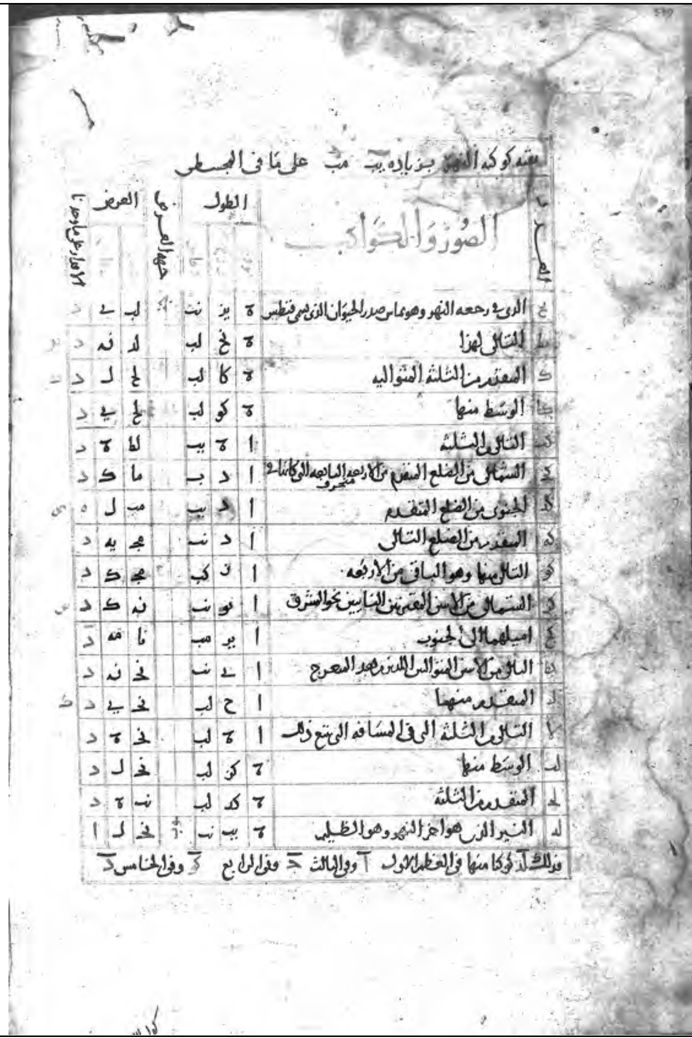
Folio 338

Constellation Eridanus (*al-Nahr*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star after the one in the foot of Orion [HR1713], at the beginning of the river"	2(60)	1	2	S	31	50	4
2	The one north of this, in the curve near the shin of Orion"	2(60)	1	32	S	28	15	4
3	The rearmost of the 2 stars next in order after this	2(60)	0	42	S	29	50	5
4	The more advanced of them	1(30)	27	22	S	28	15	4(s)
5	The rearmost of the next 2 in order again	1(30)	25	52	S	25	50	4
6	The more advanced of them	1(30)	22	52	S	25	20	4
7	The rearmost of the 3 stars after this	1(30)	19	2	S	26	0	5(s)
8	The middle one of these	1(30)	18	12	S	27	0	4
9	The most advanced of the three	1(30)	15	32	S	27	50	4
10	The rearmost of the four stars in the next interval	1(30)	9	42	S	32	7	3(s)
11	The one in advance of this	1(30)	7	22	S	31	0	4
12	The one in advance again of this	1(30)	6	52	S	28	50	4(m)
13	The most advanced of the 4	1(30)	4	42	S	28	0	3(s)
14	The rearmost of the 4 stars in the next interval again	0	29	52	S	25	30	4
15	The one in advance of this	0	27	32	S	23	50	5
16	The one in advance again of this	0	24	52	S	23	50	4(m)
17	The most advanced of the 4	0	23	12	S	23	15	6



Folio 339

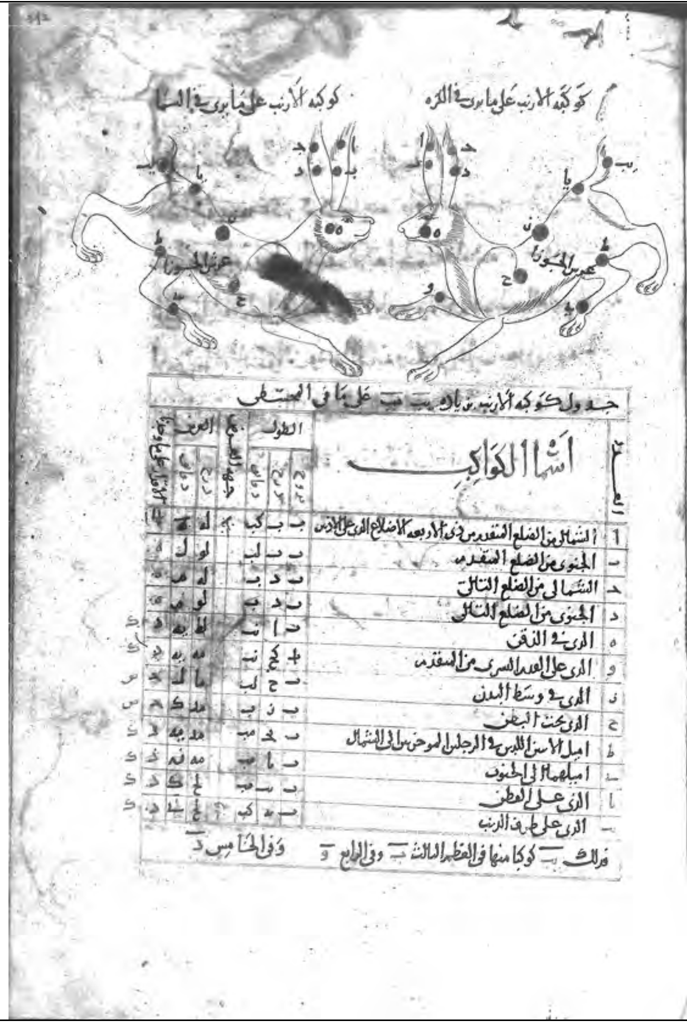
Remaining stars in the constellation Eridanus (*al-Nahr*) with with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
18	The first star in the bend of the river, which [star] touches the chest of Cetus"	0	17	52	S	32	10	4
19	The one to the rear of this	0	18	32	S	34	50	4(s)
20	The most advanced of the next [group of] three	0	21	32	S	38	30	4(m)
21	The middle one of these	0	26	32	S	38	10	4
22	The rearmost of the three	1(30)	0	12	S	39	0	4
23	The next four stars, nearly forming a trapezium: the northern one on the forward side"	1(30)	4	2	S	41	20	4
24	The southernmost on the forward side	1(30)	4	12	S	42	30	5(s)
25	The more advanced one on the rear side	1(30)	4	52	S	43	15	4
26	The last of the 4, the rear one on that side"	1(30)	7	22	S	43	20	4
27	The northernmost of the 2 stars close together at some distance to the east	1(30)	16	52	S	50	20	4(s)
28	The southernmost of them	1(30)	17	42	S	51	45	4
29	The rearmost of the next 2 stars after the bend	1(30)	10	52	S	53	50	4
30	The more advanced of them	1(30)	8	32	S	53	10	4(m)
31	The rearmost of the 3 stars in the next interval	1(30)	0	32	S	53	0	4
32	The middle one	0	27	32	S	53	30	4
33	The most advanced of the three	0	24	32	S	52	0	4
34	The last star of the river, the bright one	0	12	52	S	53	30	1
34 stars, 1 of the 1st magnitude, 3 of the 3rd magnitude, 26 of the 4th magnitude, 4 of the 5th magnitude.								



Folio 342

Table for the Constellation Lepus (*al-Arnab*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The quadrilateral just over the ears: the northern star on the forward side	2(60)	2	22	S	35	0	5
2	The southern star on the forward side	2(60)	2	32	S	36	30	5
3	The northern star on the rear side	2(60)	4	2	S	35	40	5
4	The southern star on the rear side	2(60)	4	2	S	36	40	5
5	The star in the cheek	2(60)	1	52	S	39	15	4(k)
6	The star on the left front foot	2(60)	28	52	S	45	15	4(m)
7	The star in the middle of the body	2(60)	8	32	S	41	30	3(s)
8	The star under the belly	2(60)	7	2	S	44	20	3(s)
9	The northernmost of the 2 stars in the hind legs	2(60)	18	42	S	44	15	4(k)
10	The southernmost of them	2(60)	11	42	S	45	50	4(k)
11	The star on the rump	2(60)	12	42	S	38	20	4(k)
12	The star on the tip of the tail	2(60)	15	22	S	38	10	4(k)
12 stars, 2 of the 3rd magnitude, 6 of the 4th magnitude, 4 of the 5th magnitude								

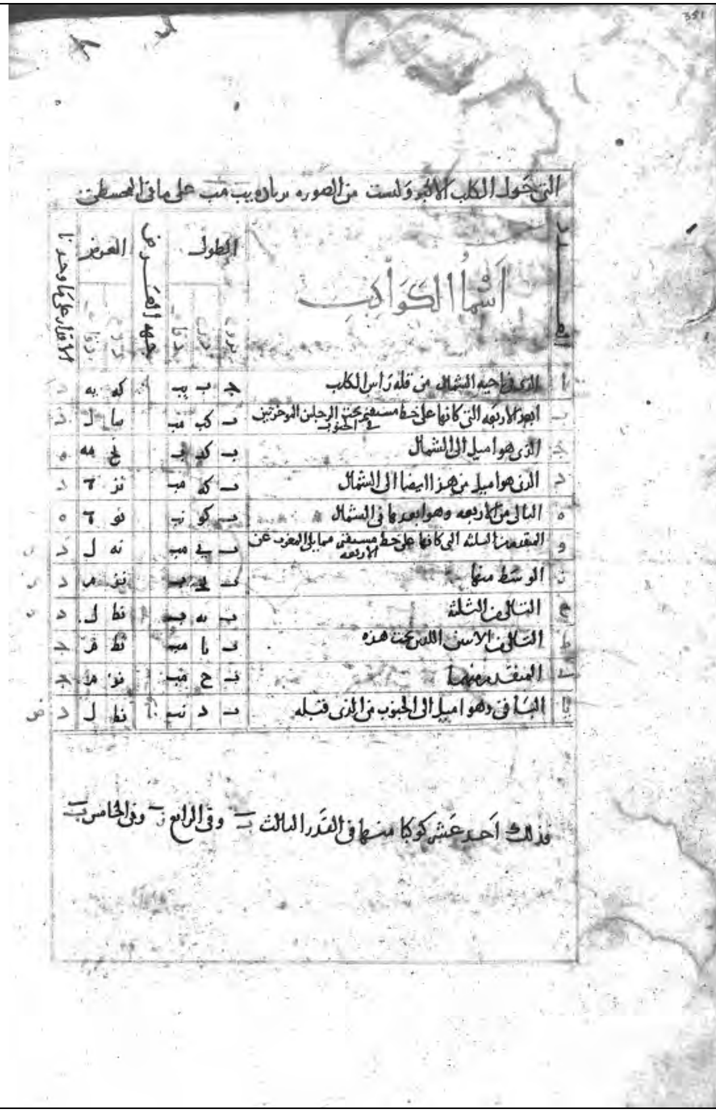


Folio 350

Constellation Canis Major (*al-Kalb al-Akbar*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the mouth, the brightest, which is called *al-Kalb* (Dog) and *al-Shi'ra al-Yamāniya* and *al-'Ayyūq*	3(90)	0	22	S	39	10	1
2	The star on the ears	3(90)	2	22	S	35	0	4(s)
3	The star on the head	3(90)	4	2	S	36	30	5
4	The northernmost of the 2 stars in the neck	3(90)	6	2	S	37	45	4
5	The southernmost of them	3(90)	8	2	S	40	0	4
6	The star on the chest	3(90)	3	12	S	42	40	5
7	The northernmost of the 2 stars on the right knee	2(60)	28	52	S	41	15	5
8	The southernmost of them	2(60)	28	42	S	42	30	5
9	The star on the end of the front leg *al-Mirzam*	2(60)	23	42	S	41	20	3
10	The more advanced of the 2 stars in the left knee	2(60)	27	22	S	46	30	5
11	The rearmost of them	2(60)	28	52	S	45	50	5
12	The rearmost of the 2 stars in the left shoulder	3(90)	7	22	S	46	10	4
13	The more advanced of them	3(90)	4	22	S	47	0	5
14	The star in the place where the left thigh joins [the body]	3(90)	9	22	S	48	45	3
15	The star below the belly, in the middle of the thighs	3(90)	6	22	S	51	30	3
16	The star on the joint of the right leg	3(90)	5	42	S	54	10	4
17	The star on the end of the right leg	2(60)	22	22	S	53	45	3
18	The star on the tail	3(90)	14	52	S	50	40	3(s)
18 stars, 1 of the 1st magnitude, 5 of the 3rd magnitude, 5 of the 4th, 7 of the 5th magnitude.								

Folio 351

The ones surrounding the constellation Canis Major but not in it with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star to the north of the top of Canis Major	3(90)	2	12	S	25	15	4
2	The southernmost of the 4 stars almost on a straight line under the hind legs	2(60)	22	42	S	61	30	4
3	The one north of this	2(60)	24	2	S	58	45	5
4	The one north again of this	2(60)	25	42	S	57	0	4
5	The last and northernmost of the 4	2(60)	26	52	S	56	0	5
6	The most advanced of the 3 stars almost on a straight line to the west of the [above] four	2(60)	10	42	S	55	30	4(s)
7	The middle one	2(60)	13	2	S	57	40	5
8	The rearmost of the three	2(60)	15	2	S	59	30	4(s)
9	The rearmost of the 2 bright stars under these	2(60)	11	42	S	59	40	3
10	The more advanced of them	2(60)	8	42	S	57	40	3
11	The last star, to the south of the above	2(60)	4	52	S	59	30	4(s)
11 stars, 2 of the 3rd magnitude, 7 of the 4th magnitude, 2 of the 5th magnitude.								

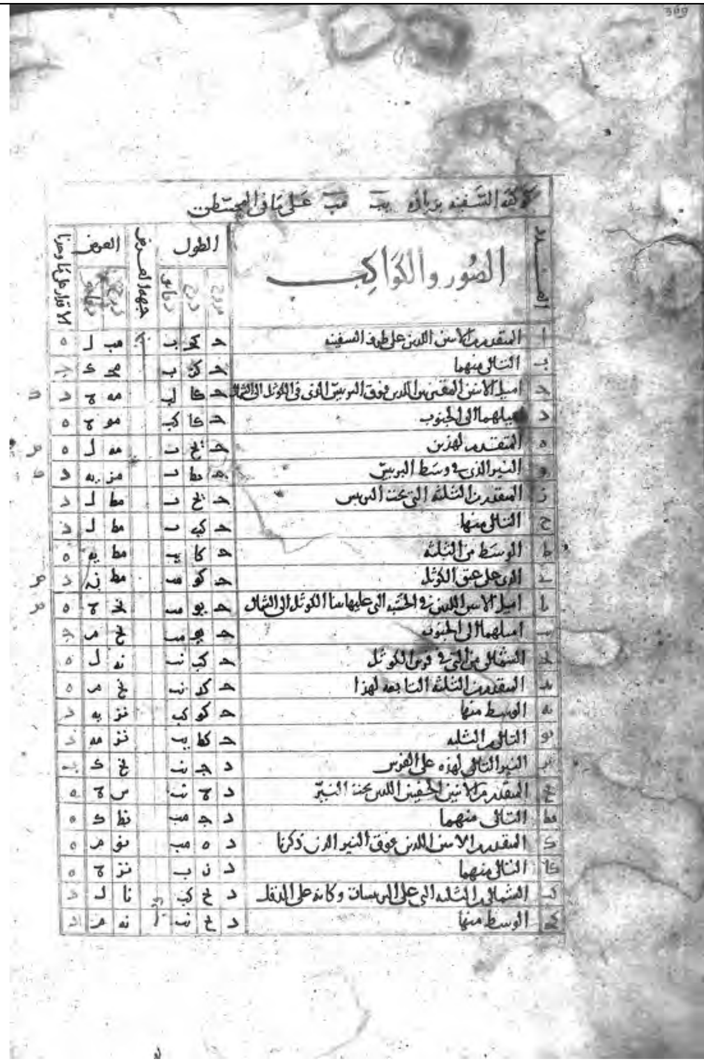


Folio 353

Constellation Canis Minor (*al-Kalb al-Mutaqadem) (al-Kalb al-Aṣghar)* with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the neck called *al-Mirzam*	3(90)	7	42	S	14	0	4
2	The bright star just over the hindquarters, called *al-Shi'ra al-Shāmīya* and *al-Ghumaiṣa* (Procyon)	3(90)	11	52	S	16	10	1
2 stars, 1 of the 1st magnitude, 1 of the 4th magnitude								

Folio 369

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
Constellation Argo Navis (*al-Safina*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
1	The more advanced of the 2 stars in the stern-ornament	3(90)	23	2	S	42	30	5
2	The rearmost of them	3(90)	27	2	S	43	20	3
3	The northernmost of the 2 stars close together over the little shield in the poop	3(90)	21	31	S	45	0	4(m)
4	The southernmost of them	3(90)	21	22	S	46	0	5
5	The star in advance of these	3(90)	18	2	S	45	30	5(s)
6	The bright star in the middle of the little shield	3(90)	19	2	S	47	15	4(m)
7	The most advanced of the 3 stars under the little shield	3(90)	18	2	S	49	30	4
8	The rearmost of them	3(90)	22	2	S	49	30	4
9	The middle one of the three	3(90)	21	12	S	49	15	5
10	The star on the goose [-neck]	3(90)	26	42	S	49	50	4(s)
11	The northernmost of the 2 stars in the stern-keel	3(90)	16	42	S	53	0	5(s)
12	The southernmost of them	3(90)	16	42	S	58	40	3
13	The northernmost of the stars in the poop-deck:	3(90)	22	52	S	55	30	5
14	The most advanced of the next 3	3(90)	24	52	S	58	40	5
15	The middle one	3(90)	26	22	S	57	15	4
16	The rearmost of the three	3(90)	29	12	S	57	45	4
17	The bright star on the deck to the rear of these	4(120)	3	52	S	58	20	2
18	The more advanced of the 2 faint stars under the bright one	4(120)	0	52	S	60	0	5
19	The rearmost of them	4(120)	3	42	S	59	20	5
20	The more advanced of the 2 stars over the above-mentioned bright one	4(120)	5	42	S	56	40	5
21	The rearmost of them	4(120)	7	2	S	57	0	5
22	The northernmost of the 3 stars on the little shields, approximately on the mast-holder"	4(120)	18	22	S	51	30	4
23	The middle one	4(120)	18	52	S	55	40	4

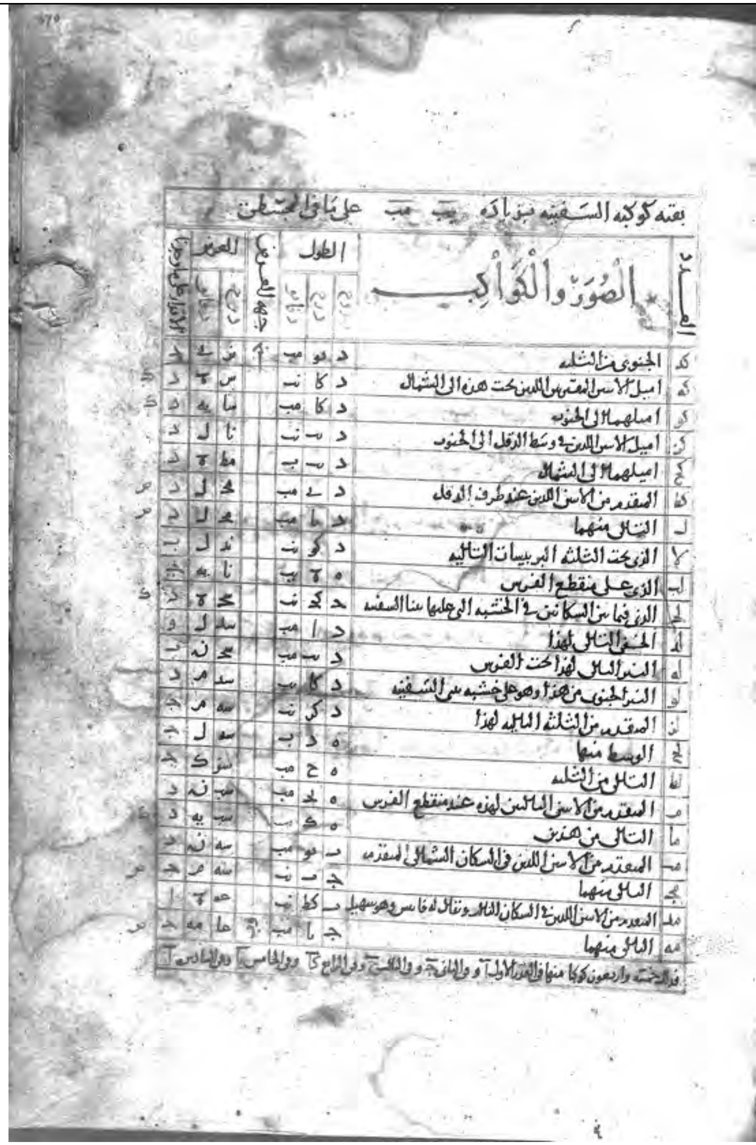


Folio 370

Remaining stars of the constellation Argo Navis with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
24	The southernmost of the three	4(120)	16	42	S	57	10	4
25	The northernmost of the 2 stars close together under these	4(120)	21	52	S	60	0	4(k)
26	The southernmost of them	4(120)	21	42	S	61	15	4(k)
27	The southernmost of the 2 stars in the middle of the mast	4(120)	12	52	S	51	30	4
28	The northernmost of them	4(120)	12	2	S	49	0	4
29	The more advanced of the 2 stars by the tip of the mast	4(120)	10	42	S	43	30	4(s)
30	The rearmost of them	4(120)	11	42	S	43	30	4(s)
31	The star below the 3rd and rearmost little shield	4(120)	26	52	S	54	30	2
32	The star on the cut-off of the deck	5(150)	0	12	S	51	15	3
33	The star between the steering-oars in the keel	3(90)	23	52	S	63	0	4(m)
34	The faint star to the rear of this	4(120)	1	42	S	64	30	6
35	The bright star to the rear of this, under the deck	4(120)	12	42	S	63	50	2
36	The bright star to the south of this, on the lower [part of the] keel	4(120)	21	12	S	64	40	4
37	The most advanced of the 3 stars to the rear of this	4(120)	27	52	S	65	40	3
38	The middle one	5(150)	4	2	S	65	30	3
39	The rearmost of the three	5(150)	8	42	S	66	20	3
40	The more advanced of the 2 stars to the rear of these, near the cut-off	5(150)	13	42	S	62	50	4
41	The rearmost of them	5(150)	20	42	S	62	15	4(m)
42	The more advanced of the 2 stars in the northern, forward steering-oar	2(60)	16	42	S	65	50	4
43	The rearmost of them	3(90)	2	52	S	65	40	3(s)
44	The more advanced of the 2 stars in the other steering-oar, called *Suhail* (Canopus)	2(60)	29	52	S	75	0	1
45	The other, rearmost star	3(90)	11	42	S	71	45	3(s)

45 stars, 1 of the 1st magnitude, 3 of the 2nd, 8 of the 3rd, 21 of the 4th, 11 of the 5th, 1 of the 6th.



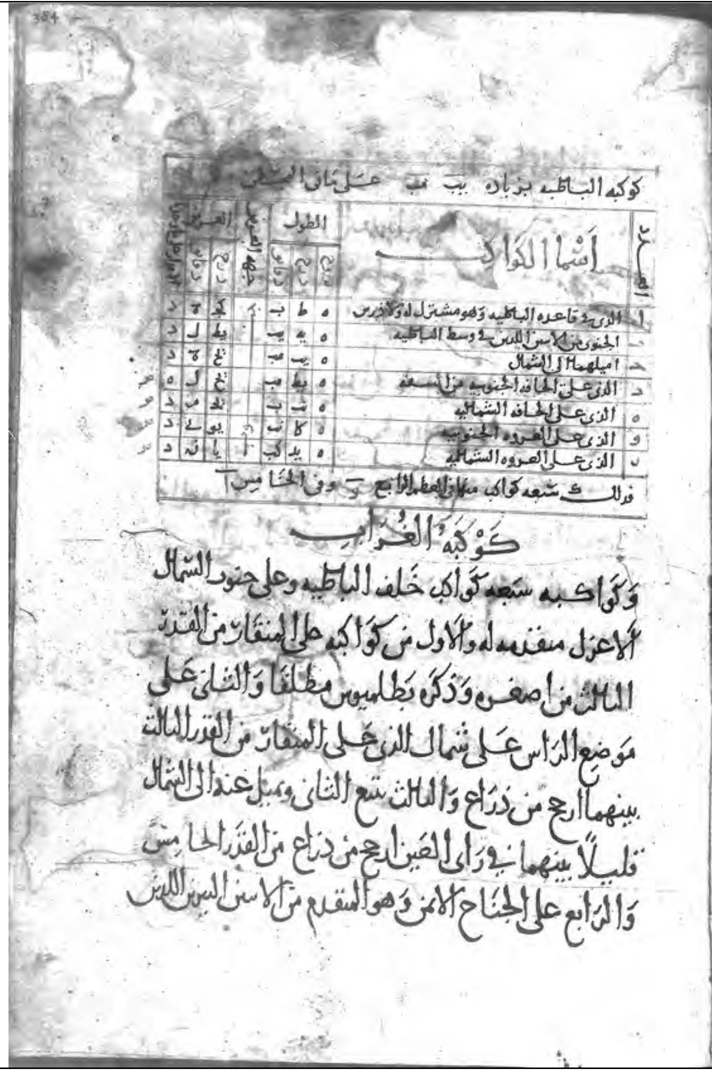
Folio 381

Constellation Hydra (*al-Shujā'*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The 5 stars in the head: the southernmost of the 2 advance ones, which is on the nostrils	3(90)	26	42	S	15	0	4(s)
2	The northernmost of these [2], which is above the eye	3(90)	26	2	S	13	10	4
3	The northernmost of the 2 to the rear of these, which is approximately on the skull	3(90)	28	2	S	11	30	4
4	The southernmost of them, on the gaping jaws	3(90)	28	12	S	14	45	5
5	The rearmost of all, approximately on the cheek	4(120)	0	32	S	12	0	4(m)
6	The more advanced of the 2 stars in the place where the neck joins [the head]	4(120)	3	2	S	14	40	6
7	The rearmost of them	4(120)	6	2	S	19	20	4
8	The middle star of the following three in the bend of the neck	4(120)	11	32	S	15	20	4(s)
9	The rearmost of the 3	4(120)	13	22	S	14	50	4(s)
10	The southernmost of them	4(120)	11	12	S	17	10	4(s)
11	The faint, northernmost star of the 2 close together to the south	4(120)	11	52	S	19	45	6(s)
12	The bright one of these two close stars called *al-Fard*	4(120)	12	42	S	20	30	2
13	The most advanced of the 3 stars to the rear, after the bend [in the neck]	4(120)	18	42	S	26	30	4
14	The middle one	4(120)	21	22	S	26	0	4
15	The rearmost of the three	4(120)	23	52	S	23	15	4(k)
16	The most advanced of the next 3 stars almost on a straight line	5(150)	0	42	S	24	40	3(s)
17	The middle one	5(150)	2	42	S	23	0	4(s)
18	The rearmost of the three	5(150)	5	42	S	22	10	3
19	The northernmost of the 2 stars after [i.e. to the rear of] the base of Crater	5(150)	14	12	S	25	45	4
20	The southernmost of them	5(150)	15	2	S	30	10	4

21	The most advanced of the 3 stars after these, as it were in a triangle	5(150)	24	52	S	31	20	4(k)
22	The middle and southernmost one	5(150)	27	12	S	33	10	4
23	The rearmost of the three	5(150)	28	52	S	31	20	3
24	The star after Corvus, in the section by the tail	6(180)	12	42	S	13	40	3(s)
25	The star on the tip of the tail	6(180)	26	12	S	17	40	3(s)
25 stars, 1 is of the 2nd magnitude, 5 of the 3rd magnitude, 16 of the 4th magnitude, 1of the 5th magnitude. and 2 of the 6th magnitude								
The ones surrounding the constellation Hydra but not in it.								
1	The star to the south of the head	3(90)	25	12	S	23	15	3
2	The star some distance to the rear of those in the neck [nos. 6-15]	4(120)	23	42	S	16	0	4
2 stars 1 of the 3rd magnitude and 1 of the 4th magnitude.								

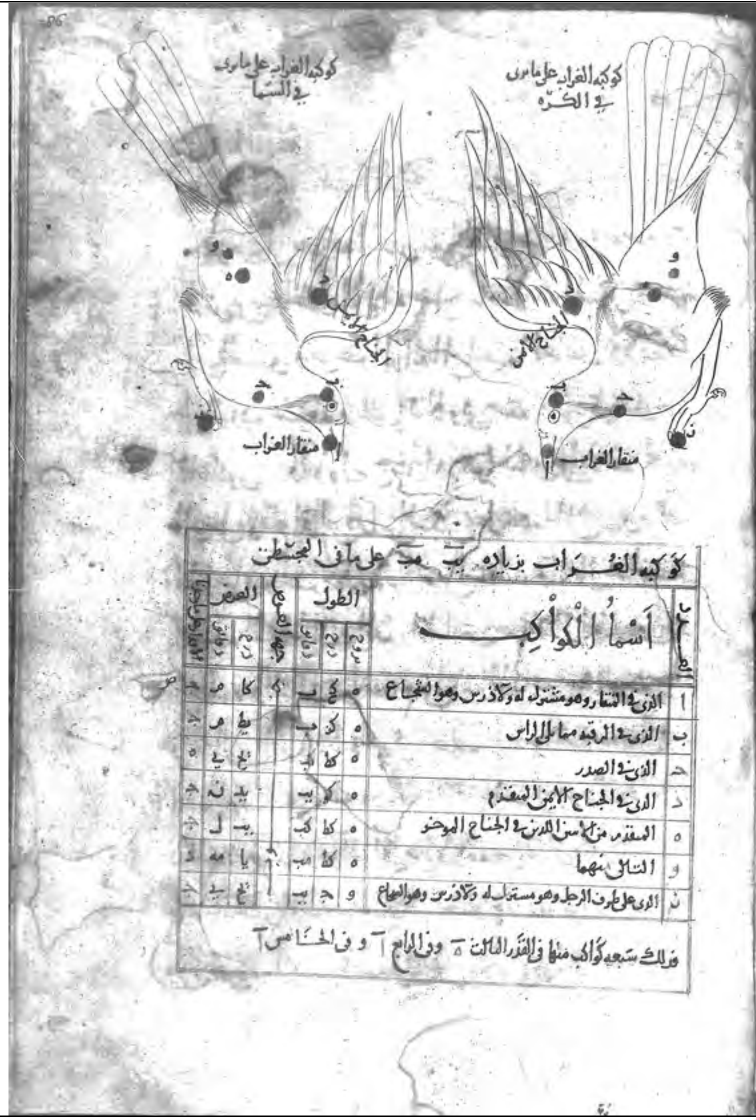
Folio 384

Constellation Crater (*al-Bāṭīya*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the base of bowl, which is common to Hydra	5(150)	9	2	S	23	0	4
2	The southernmost of the 2 stars in the middle of the bowl	5(150)	15	12	S	19	30	4
3	The northernmost of them	5(150)	12	42	S	18	0	4
4	The star on the southern rim of the mouth (of the bowl)	5(150)	19	42	S	18	30	5(s)
5	The star on the northern rim	5(150)	52	2	S	13	40	4(s)
6	The star on the southern handle	5(150)	21	52	S	16	10	4(s)
7	The star on the northern handle	5(150)	14	22	S	11	50	4(s)
7 stars, 6 of the 4th magnitude, 1of the 5th magnitude								



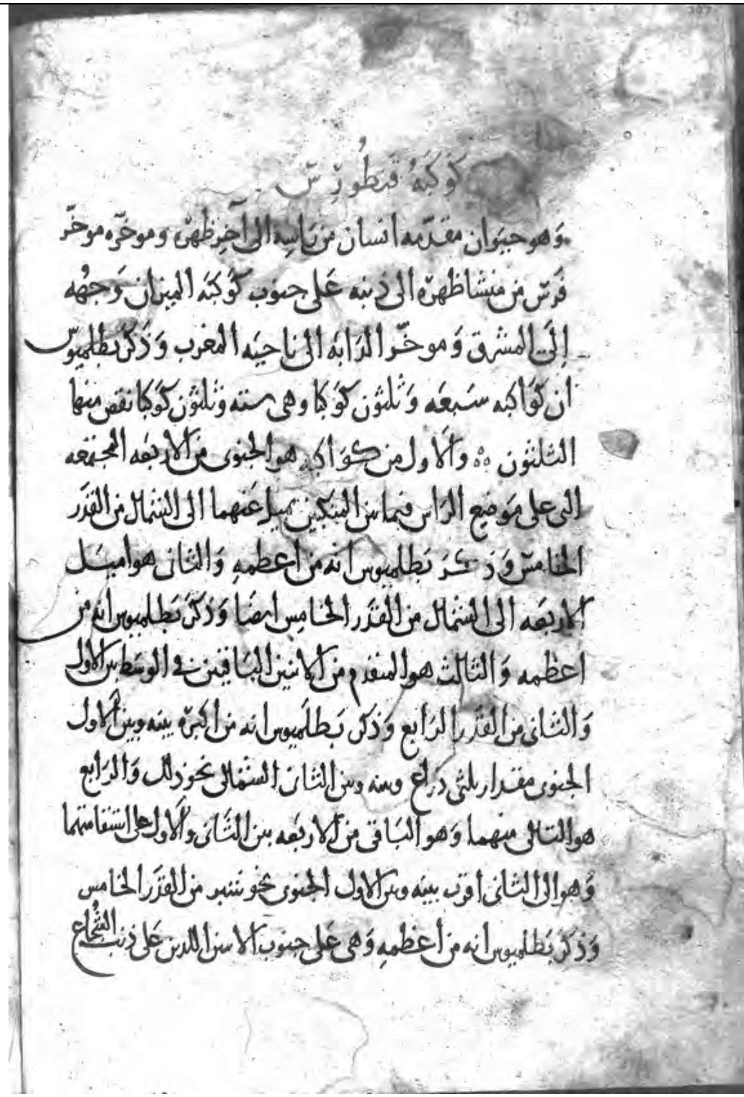
Folio 386

Constellation Corvus (*al-Ghurāb*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the beak, which is common to Hydra	5(150)	28	2	S	21	40	3(s)
2	The star in the neck, by the head	5(150)	27	2	S	19	40	3
3	The star in the breast	5(150)	29	22	S	18	10	5
4	The star in the forward right wing	5(150)	26	12	S	14	50	3
5	The more advanced of the 2 stars in the rear wing	5(150)	29	22	S	12	30	3
6	The rearmost of them	5(150)	29	42	S	11	45	4
7	The star on the end of the leg, which is common to Hydra	6(180)	3	12	S	18	10	3
7 stars, 5 of the 3rd magnitude, 1 of the 4th magnitude and 1 of the 5th magnitude								



Folio 387 (Manuscript Marsh144)
The constellation Centaurus (*Qanṭūris*)

It is (the image of) an animal, with its forward part resembling a human being from its head until the end of its back. Its rearward part resembles a horse from the start of its back until its tail. It is south of the constellation *al-Mīzān* (Libra). Its head is pointing towards the east and the rear of the animal is pointing towards the west. Ptolemy mentioned that its stars are thirty-seven stars; however there are thirty-six stars with the thirtieth (star) missing.
The first of its stars is the southernmost of the four that are clustered on the head, which is located between the two shoulder-blades and inclined towards the north of the two (shoulder-blades). It is of the 5th magnitude. Ptolemy mentioned that it is much greater than the 5th magnitude.
The second is the northernmost of the four. It is also of the 5th magnitude. Ptolemy mentioned that it is much greater than the 5th magnitude.
The third is the more advanced of the remaining two (stars) located in the middle between the first and the second. It is of the 4th magnitude. Ptolemy mentioned that it is greater than the 4th magnitude.
The distance between it and the first southerly star is a distance of two-third of a *dhirā'*. The distance between it and the second northerly star is the same distance.
The fourth (star) is the rearmost of these. It is the last of the four stars. It is located on a straight line between the first and the second. It is closer to the second star. The distance between it and the first southerly star is one *Shibr*. It is of the 5th magnitude. Ptolemy mentioned that it is much greater than the 5th magnitude. It is located south of the two stars on the tail of *al-Shujā'* (the constellation Hydra).


كوكبة قنطورس
وهو حيوان مقدمه انسان من راسه الى آخر ظهره ومؤخره مؤخر
فرس من منشأ ظهره الى ذنبه على جنوب كوكبة الميزان وجهه
الى المشرق ومؤخر الدابة الى ناحية المغرب وذكر بطلميوس
ان كواكبه سبعة وثلثون كوكبا وهي ستة وثلثون كوكبا نقص منها
الثلثون والاول من كواكبه هو الجنوبي من الاربعة المجتمعة
التي على موضع الراس فيما بين الكتفين مايل عنهما الى الشمال من القدر
الخامس وذكر بطلميوس انه من اعظمه والثاني هو اميل
الاربعة الى الشمال من القدر الخامس ايضا وذكر بطلميوس انه من
اعظمه والثالث هو المتقدم من الاثنين الباقيين في الوسط بين الاول
والثاني من القدر الرابع وذكر بطلميوس انه من اكبره بينه وبين الاول
الجنوبي مقدار ثلثي ذراع وبينه وبين الثاني الشمالي نحو ذلك والرابع
هو التالي منهما وهو الباقي من الاربعة بين الثاني والاول على استقامتهما
وهو الى الثاني اقرب بينه وبين الاول الجنوبي نحو شبر من القدر الخامس
وذكر بطلميوس انه من اعظمه وهي على جنوب الاثنين اللذين على ذنب الشجاع

Folio 388

It is closer to the twenty-fifth star which is on the tip of the tail (of the constellation Hydra).

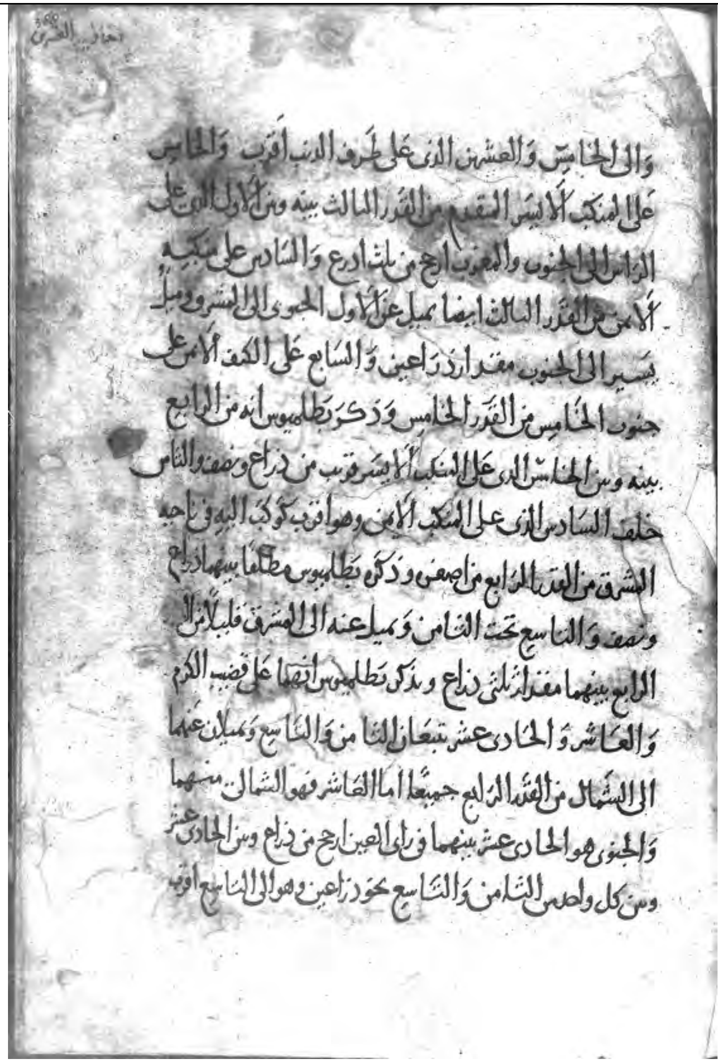
The fifth is on the left advanced shoulder. It is of the 3rd magnitude. The distance between it and the first star on the head towards the south-west is a distance of one third of a *dhirā‘*.

The sixth star is on the right shoulder. It is also of the 3rd magnitude. It is located east of the southerly first star and slightly towards the south by a distance of two *dhirā‘*.

The seventh is on the right shoulder-blade south of the fifth star. It is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. The distance between it and the fifth star which is on the left shoulder is close to one and a half *dhirā‘*.

The eighth star is behind the sixth star that is on the right shoulder. It is the closest star to it from the east. It is less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between them is one and half *dhirā‘*.

The ninth is under the eighth star and slightly towards the east from it. It is of the 4th magnitude. The distance between them is two-thirds of a *dhirā‘*. Ptolemy mentioned that they are located on the *Kaḍīb al-Karm* (thyrsus or vine leaves). The tenth and the eleventh follow the eighth and the ninth towards the north. Both are of the 4th magnitude. As for the tenth it is the northerly of the two, and the southerly is the eleventh. The distance between them as the eye can see is a distance of one *dhirā‘*. The distance between the eleventh star and both the eighth and the ninth stars is a distance of two *dhirā‘*. It is closer to the ninth.


والى الخامس والعشرين الذي على طرف الذنب اقرب والخامس
على المنكب الايسر المتقدم من القدر الثالث بينه وبين الاول الذي على
الراس الى الجنوب والمغرب ارجح من ثلث ذراع والسادس على منكبه
الايمن من القدر الثالث ايضا يميل عن الاول الجنوبي الى المشرق وميلا
يسيرا الى الجنوب مقدار ذراعين والسابع على الكتف الايمن على
جنوب الخامس من القدر الخامس وذكر بطلميوس انه من الرابع
بينه وبين الخامس الذي على المنكب الايسر قريب من ذراع ونصف والثامن
خلف السادس الذي على المنكب الايمن وهو اقرب كوكب اليه في ناحية
المشرق من القدر الرابع من اصغره وذكر بطلميوس مطلقا بينهما ذراع
ونصف والتاسع تحت الثامن ويميل عنه الى المشرق قليلا من
الرابع بينهما مقدار ثلثي ذراع وذكر بطلميوس انهما على قضيب الكرم
والعاشر والحادي عشر يتبعان الثامن والتاسع ويميلان عنهما
الى الشمال من القدر الرابع جميعا اما العاشر فهو الشمالي منهما
والجنوبي هو الحادي عشر بينهما في رأي العين ارجح من ذراع وبين الحادي عشر
وبين كل واحد من الثامن والتاسع نحو ذراعين وهو الى التاسع اقرب

Folio 389

Ptolemy mentioned that they are on the tip of the thyrsus (vine leaves).

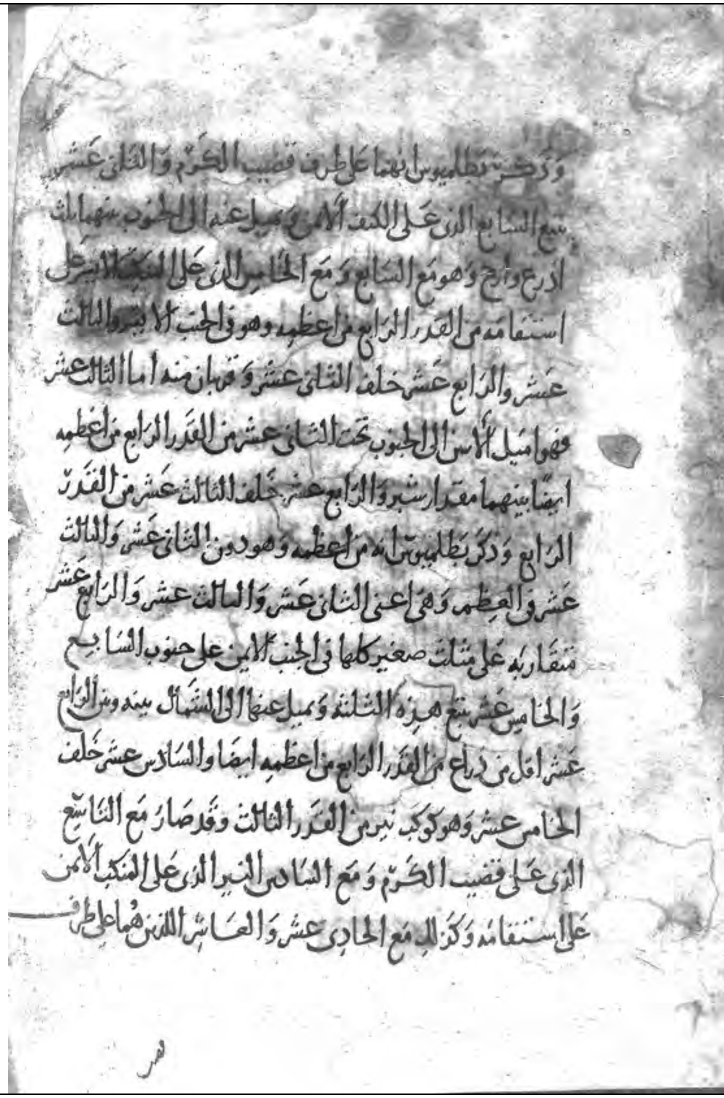
The twelfth is below the seventh star which is on the right shoulder. It is to the south of it and the distance between them is one-third of a *dhirā‘* and slightly more. It forms a straight line together with the seventh and the fifth star which is on the left shoulder. It is much greater than the 4th magnitude. It is on the left hand side.

The thirteenth and fourteenth stars are next to and close to it (twelfth). As for the thirteenth it is the southernmost of the two below the twelfth. It is also much greater than the 4th magnitude. The distance between them is one *Shibr.*

The fourteenth is next to the thirteenth. It is of the 4th magnitude. Ptolemy mentioned that it is much greater (than 4th magnitude); however it is less than the twelfth and the thirteenth in magnitude. The twelfth, thirteenth and the fourteenth are close together and they form a small triangle. They are all on the right side and south of the seventh star.

The fifteenth star follows these three stars towards the south. The distance between it and the fourteenth is less than one *dhirā‘*. It is also much greater than the 4th magnitude.

The sixteenth is behind the fifteenth and it is a bright star of the 3rd magnitude. It forms a straight line together with the ninth star which is on the thyrsus and with the bright sixth star which is on the right shoulder. It also forms a straight line together with the eleventh star and with the tenth star which are on the tip of the thyrsus



Folio 390

It is as if it forms an equilateral triangle together with tenth star and the sixth star which is on the right shoulder, with this bright sixteenth star on the its head. It is located on the right arm.

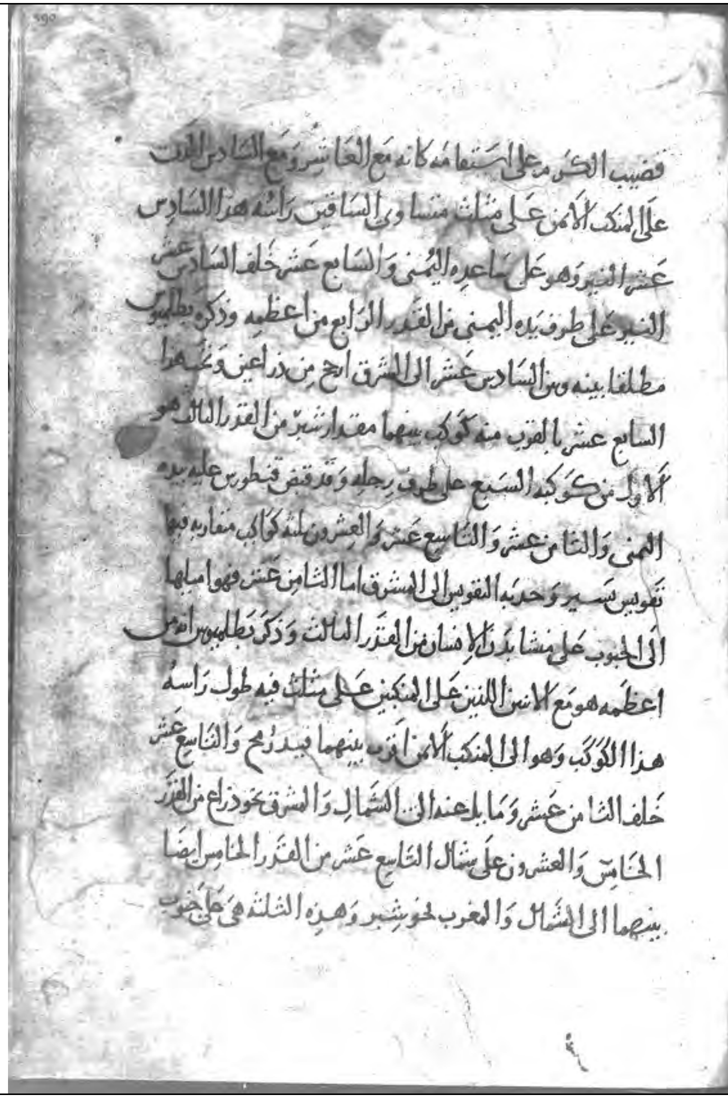
The seventeenth (star) is behind the bright sixteenth (star). It is located on the tip of its hand. It is much greater than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude. The distance between it and the sixteenth (star) towards the east is more than two *dhirāʻ*. Under this seventeenth star and close by is a star with a distance between them of one *Shibr*. It is of the 3rd magnitude. It is the first star on the leg of the constellation al-Sab’ (constellation Lupus), with Centaurus grabbing it with his right hand.

The eighteenth, nineteenth and the twentieth (stars) are three close-by stars forming a line with a slight curve with its curve pointed towards the east.

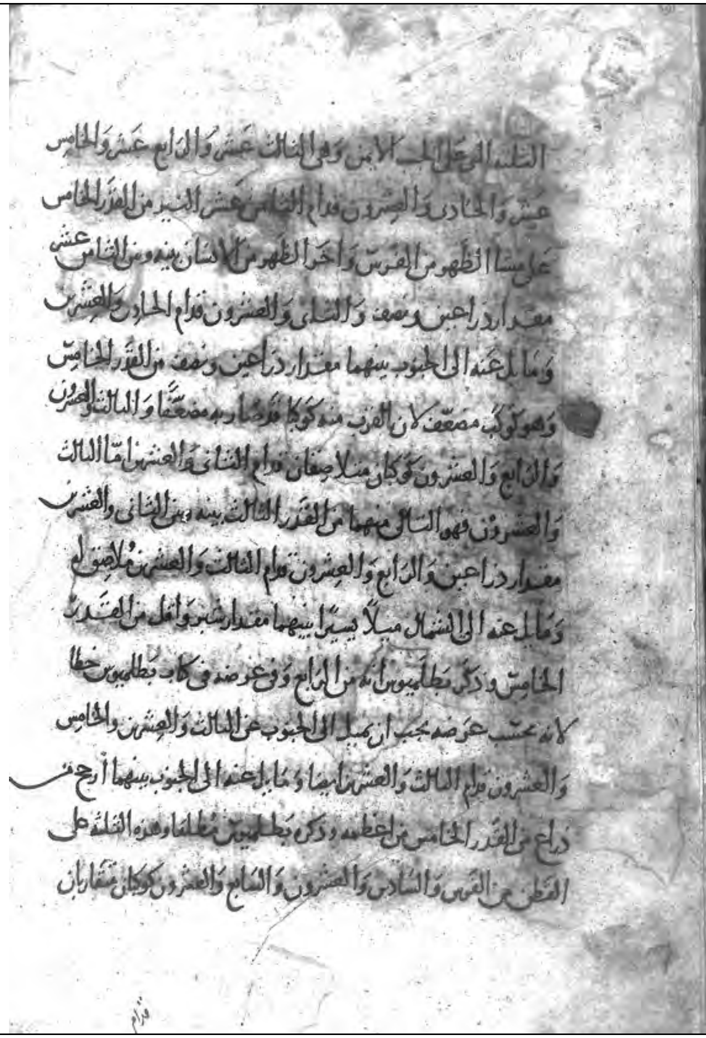
As for the eighteenth (star) it is the southernmost of the three located on place where the human body joins the horse. It is of the 3rd magnitude. Ptolemy mentioned that it is much greater than the 3rd magnitude. It forms a large triangle together with the two stars on the shoulders with this star on its head. It is closer to the right shoulder. The distance between them is one *Rumḥ*.

The nineteenth is behind the eighteenth star and is located towards the north-east by one *dhirāʻ*. It is of the 5th magnitude.

The twentieth is north of the nineteenth. It is also of the 5th magnitude. The distance between them towards the north-west is one *Shibr*.



Folio 391



All these three stars are south of the three stars which are located on the left hand side and which are the thirteenth, fourteenth and the fifteenth.
The twenty-first is in front of the bright eighteenth (star). It of the 5th magnitude. It is located where the back joins the body of the horse and at the end of the human form. The distance between it and the eighteenth (star) is two and half *dhirā‘*.
The twenty-second is in front of the twenty-first and oriented towards the south. The distance between them is two and half *dhirā‘*. It is of the 5th magnitude. It is a double star because next to it is star which makes it a double star.
The twenty-third and the twenty-fourth are two close stars in front of the twenty-second (star). As for the twenty-third it is the rearmost of the two. It is of the 3rd magnitude. The distance between it and the twenty-second is two *dhirā‘*.
The twenty-fourth is in front of the twenty-third and close to it and is located towards the north a little. The distance between them is less than one *Shibr*. It is of the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude. Its latitude in the book of Ptolemy is wrong because according to that latitude it should be located south of the twenty-third (star).
The twenty-fifth is also in front of the twenty-third and is located south of it. The distance between them is a little more than *dhirā‘*. It is much greater than the 5th magnitude. Ptolemy mentioned that it is exactly 5th magnitude.
All these three stars are on the *Qaṭen* (rump) of the horse.
The twenty-sixth and the twenty-seventh are two close stars.

Folio 392

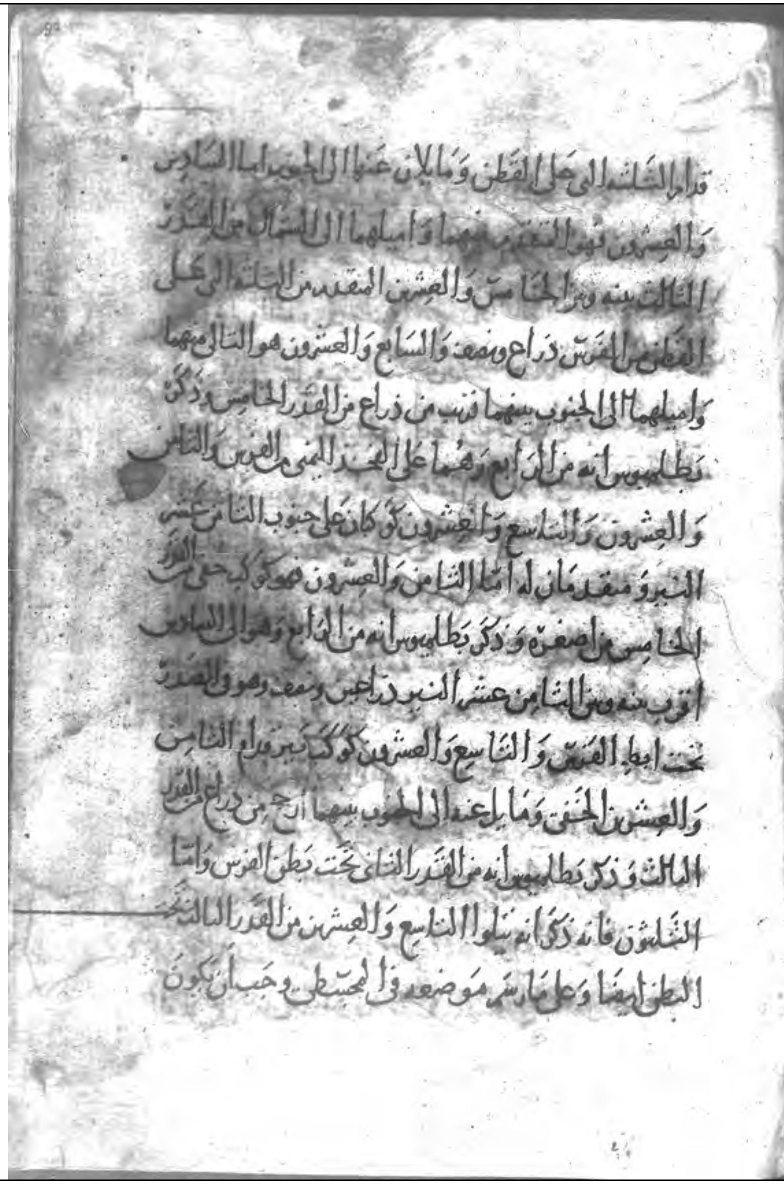
They are located next to the three stars on the rump towards the south.
As for the twenty-sixth it is the more advanced and northernmost of the two. It is of the 3rd magnitude. The distance between it and the twenty-fifth which is the most advanced of the three on the rump is a distance of one and a half *dhirā'*.

The twenty-seventh is the rearmost and the southernmost of the two. The distance between them is close to one *dhirā'*. It is of the 5th magnitude. Ptolemy mentioned that it is the 4th magnitude. They are located on the right *Fakhed* (thigh) of the horse.

The twenty-eighth and the twenty-ninth are two stars that are located south of the bright eighteenth star and are in advance of it.
As for the twenty-eighth it is a dim star. It is less than the 5th magnitude. Ptolemy mentioned that it is of the 4th magnitude; however it is closer to the 6th magnitude. The distance between it and the bright eighteenth star is two and half *dhirā'*. It is located on the chest under the armpit of the horse.

The twenty-ninth is a bright star in front of the dim twenty-eighth star and south of it. The distance between them is a little more than one *dhirā'*. It is of the 3rd magnitude. Ptolemy mentioned that it is of the 2nd magnitude and under the horse's belly.

As for the thirtieth (Ptolemy) mentioned that it is to the rear of the twenty-ninth and that it is of the 3rd magnitude and that it is also located under the belly. However when its location according the *Almagest* is drawn on the globe the distance between them would be less than one *dhirā'*.



Folio 393

However there is no star that can be seen at that location, nor is there any star around it which can be considered to be it except those well known stars.

The thirty-first, thirty-second, thirty-third and the thirty-fourth are four stars south of the twenty-sixth and the twenty-seventh stars.
As for the thirty-first it is the northernmost of them. It is of the 2nd magnitude. It forms an elongated triangle together with the twenty-third and the bright twenty-sixth with this star on its head. The distance between it and the twenty-sixth is five *dhirā‘*. The distance between it and the twenty-third is six *dhirā‘*. It is located on the knee-bend of the right hind leg.

The thirty-second is the rearmost of the four. The distance between it and the thirty-first towards the south-west is a distance of two *dhirā‘*. It is of the 2nd magnitude. It is located on the hock of the right leg.

The thirty-third is the most advanced of the four. The distance between it and the thirty-first towards the south-west is a distance of one and a half *dhirā‘*. It is less than 3rd magnitude. Ptolemy mentioned that it is of the 4th magnitude. It is located on the knee-bend of the left hind leg.

As for the thirty-fourth it is the southernmost of the four. It is of the 2nd magnitude. It forms together with the thirty-second and the thirty-third an Isosceles triangle.

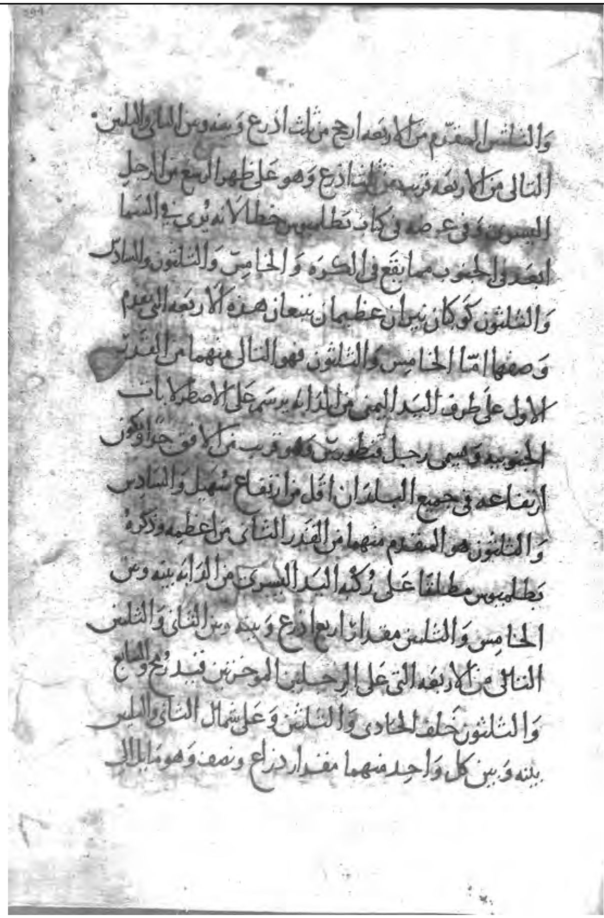
Folio 394/395

The distance between it (thirty-fourth) and the thirty-third which is the most advanced of the four is a distance of one-third of a *dhirāʻ*. The distance between it and the thirty-second which is the rearmost of the four is a distance of one-third of a *dhirāʻ*. It is located on the frog of the hoof on the left leg. Its latitude in the book of Ptolemy is wrong because in the sky it is seen further to the south than its location (if it was drawn from Ptolemy's data) on the globe.

The thirty-fifth and the thirty-sixth are two bright and great stars which are in front of these four stars that were mentioned before.
As for the thirty-fifth it is the rearmost of the two. It is of the 1st magnitude. It is located on the tip of the right hand of the animal. It is drawn on the southern Astrolabes. It is called *Rijl Qanṭūris* (leg of Centaurus). It is very close to the horizon. Its height in all localities is less then (the star) *Suhail*.

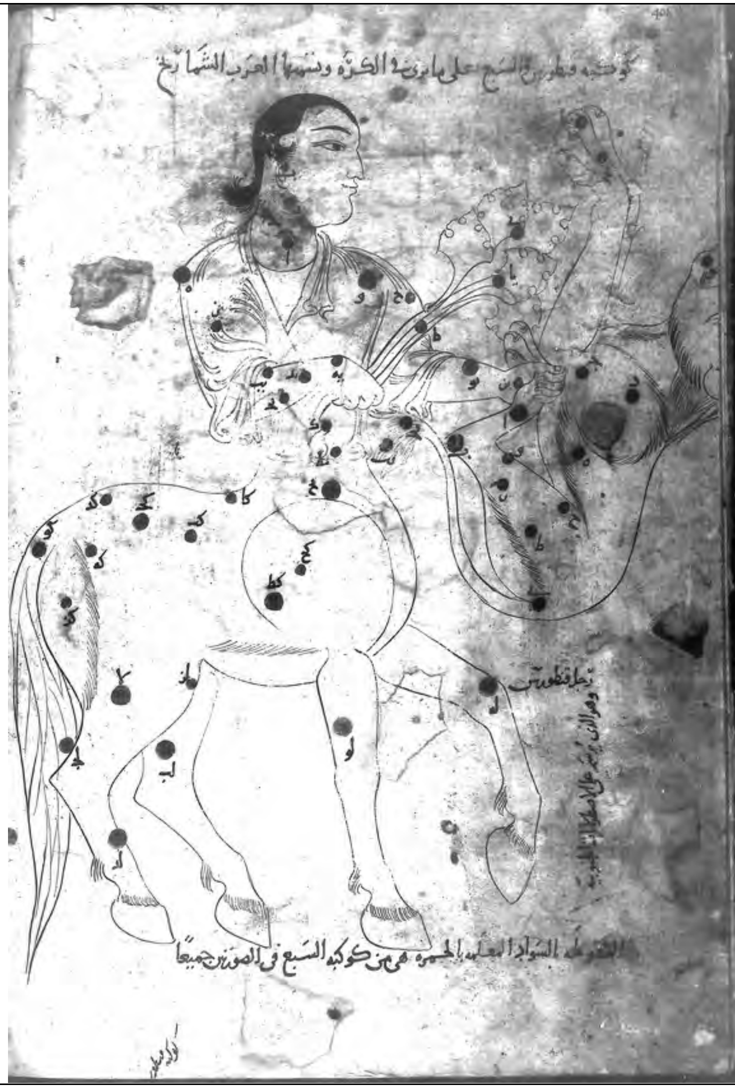
The thirty-sixth is the most advanced of the two. It is much greater than the 2nd magnitude. Ptolemy mentioned that it is exactly 2nd magnitude. It is located on the knee of the left front leg of the animal. The distance between it and the thirty-fifth is four *dhirāʻ*. The distance between it and the thirty-second which is the rearmost of the four and on the two legs is a distance of one *Rumḥ*.

The thirty-seventh is behind the thirty-first and south of the thirty-second. The distance from each one of them is one and a half *dhirāʻ*. It is also north of the thirty-first. It is less than the 4th magnitude. Ptolemy mentioned that it is exactly 4th magnitude.



Folio 401

The constellation Centaurus (*Qanṭūris)* and (constellation) Lepus as seen on the globe. The Arabs called them *al-Shamārīkh.*



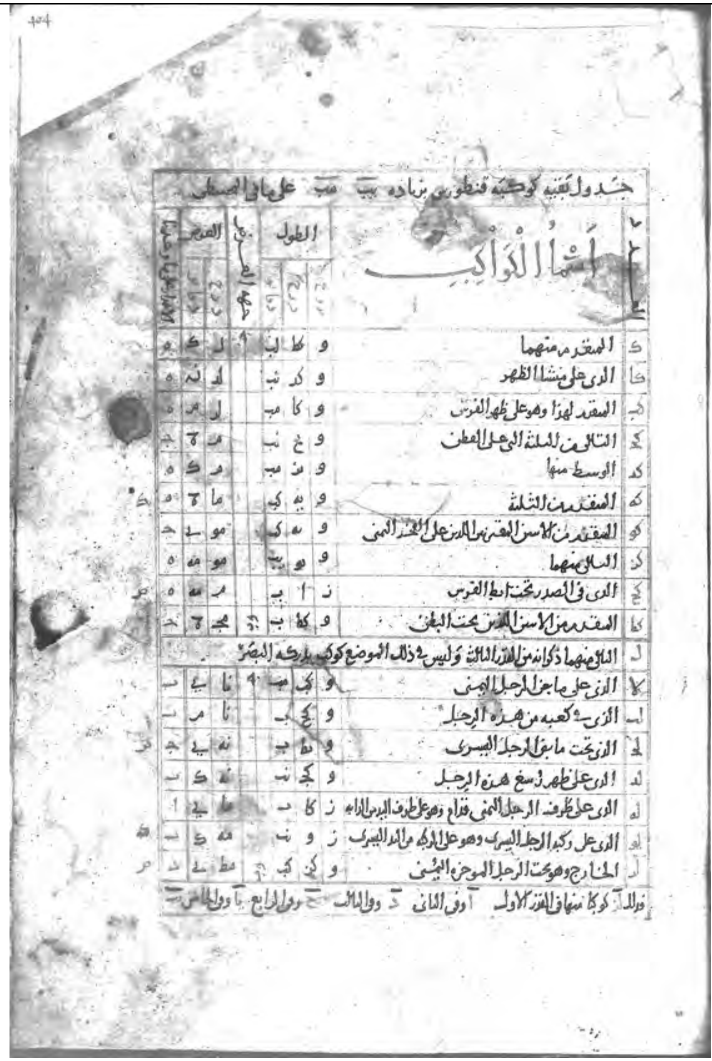
Folio 402 The constellation Centaurus (*Qanṭūris)* and (constellation) Lepus as seen in the sky. The Arabs called them *al-Shamārīkh.*	

Folio 403

Table of the constellation Centaurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The southernmost of the 4 stars in the head	6(180)	23	12	S	21	40	5
2	The northernmost of them	6(180)	22	42	S	18	50	5
3	The more advanced of the other, middle 2	6(180)	21	52	S	20	30	4
4	The rearmost of the these, the last of the 4	6(180)	22	42	S	20	00	5
5	The star on the left advanced shoulder	6(180)	18	52	S	25	40	3
6	The star on the right shoulder	6(180)	28	22	S	22	30	3
7	The star on the left shoulder-blade	6(180)	21	52	S	27	30	5
8	The northernmost of the advanced two of the four stars in the thyrsus.	7(210)	00	52	S	22	20	4(s)
9	The southernmost of these	7(210)	01	52	S	23	45	4
10	The one of the other two which is at the tip of the thyrsus	7(210)	04	42	S	18	15	4
11	The last one south of the latter	7(210)	05	12	S	20	50	4
12	The most advanced of the 3 stars in the right side	6(180)	26	02	S	28	20	4(m)
13	The middle one	6(180)	26	42	S	29	20	4(m)
14	The rearmost of the three	6(180)	27	52	S	28	00	4
15	The star on the right upper arm	6(180)	29	02	S	26	30	4(m)
16	The star on the right forearm	7(210)	05	32	S	25	15	3
17	The star on the right hand	7(210)	10	12	S	24	00	4(m)
18	The bright star in the place where the human body joins the horse	7(210)	00	42	S	33	30	3
19	The rearmost of the 2 faint stars to the north of this	7(210)	00	22	S	31	00	5

Folio 404

Table of the constellation Centaurus with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
number	Names of the stars	longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
20	The more advanced of them	6(180)	29	32	S	30	20	5
21	The star on the place where the back joins the horse body	6(180)	24	52	S	34	50	5
22	The star in advanced of this on the horse back	6(180)	21	42	S	37	40	5
23	The rearmost of the stars on the rump	6(180)	18	52	S	40	00	3
24	The middle one	6(180)	17	42	S	40	20	5
25	The most advanced of the three	6(180)	15	22	S	41	00	5(m)
26	The more advanced of the 2 stars close together on the right thigh	6(180)	15	22	S	46	10	3
27	The rearmost of them	6(180)	16	12	S	46	45	5
28	The star in the chest under the horse armpit	7(210)	01	02	S	40	45	5(s)
29	The more advanced of the 2 stars under the belly	6(180)	29	02	S	43	00	3
30	The rearmost of them (Ptolemy) mentioned that it is of the 3rd magnitude however there is no star in this are which can be seen.							
31	The star on the knee-bend of the right hind leg	6(180)	22	42	S	51	10	2
32	The star in the hock of the same leg	6(180)	28	02	S	51	40	2
33	The star under the knee-bend of the left hind leg	6(180)	59	02	S	55	10	3(s)
34	The star on the frog of the hoof on the same leg	6(180)	23	52	S	55	20	2
35	The star on the end of the right front leg	7(210)	21	02	S	41	10	1
36	The star on the knee of the left front leg	7(210)	06	52	S	45	20	2(m)
37	The star outside under the right hind leg	6(180)	27	22	S	49	10	4(s)
36 stars, 1 of the 1st magnitude, 4 of the 2nd, 8 of the 3rd, 11 of the 4th, 12 of the 5th.								



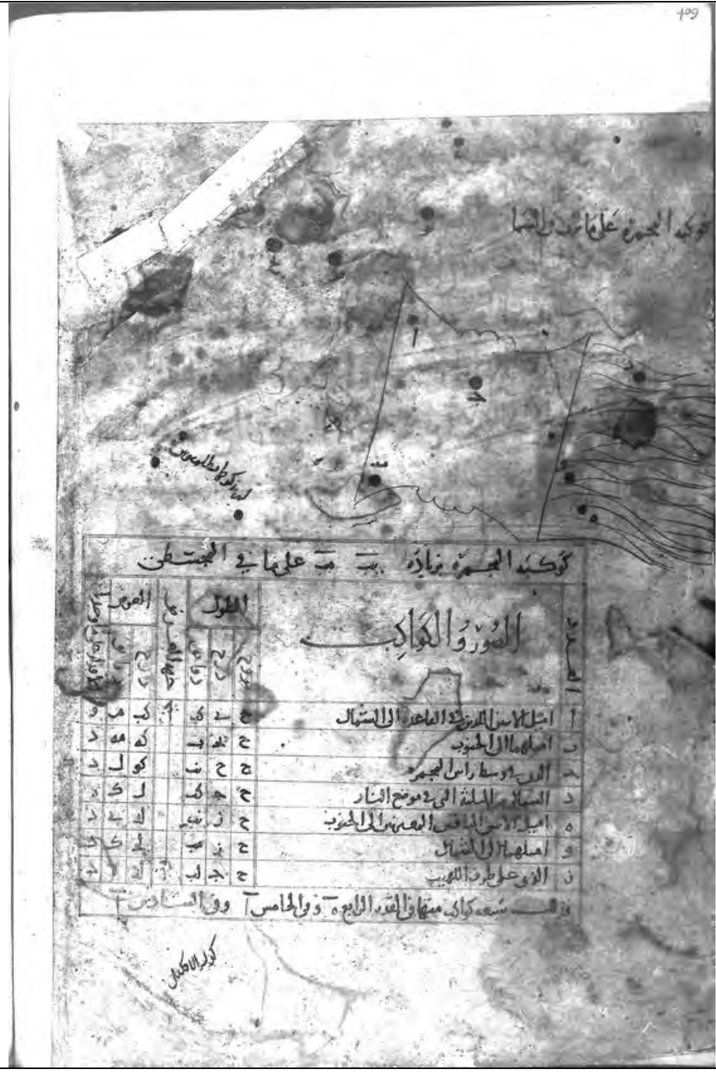
Folio 405

Table of the constellation Lupus (*al-Sab'*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star at the end of the hind leg, by the [right] hand of Centaurus	7(210)	10	42	S	24	50	3
2	The star on the bend in the same leg	7(210)	8	32	S	29	10	3
3	The more advanced of the 2 stars just over the shoulder-blade	7(210)	13	42	S	21	15	4(m)
4	The rearmost of them	7(210)	16	52	S	21	0	3(s)
5	The star in the middle of the body of Lupus	7(210)	15	42	S	25	10	4(m)
6	The star in the belly, under the flank	7(210)	12	52	S	27	0	5
7	The star on the thigh	7(210)	13	12	S	29	0	5
8	The northernmost of the 2 stars near the place where the thigh joins [the body]	7(210)	17	22	S	28	30	5
9	The southernmost of them	7(210)	16	22	S	30	10	5
10	The star on the end of the rump	7(210)	18	22	S	33	10	4(s)
11	(Ptolemy) mentioned that this is the southernmost of the 3 stars in the end of the tail; however there is no star that can be seen in this place.							
12	The middle one of the three	7(210)	4	32	S	30	30	4(s)
13	The northernmost of them	7(210)	5	42	S	29	20	5
14	The southernmost of the 2 stars in the neck	7(210)	21	32	S	17	0	4
15	The northernmost of them	7(210)	22	2	S	15	20	5
16	The more advanced of the 2 stars in the snout	7(210)	18	22	S	13	20	5(m)
17	The rearmost of them	7(210)	19	22	S	11	50	5(s)
18	The southernmost of the 2 stars in the front leg	7(210)	10	2	S	11	30	6
19	The northernmost of them	7(210)	12	12	S	10	0	5(s)
18 stars, 3 of the 3rd magnitude, 5 of the 4th magnitude, 9 of the 5th magnitude and 1 of the 6th magnitude.								

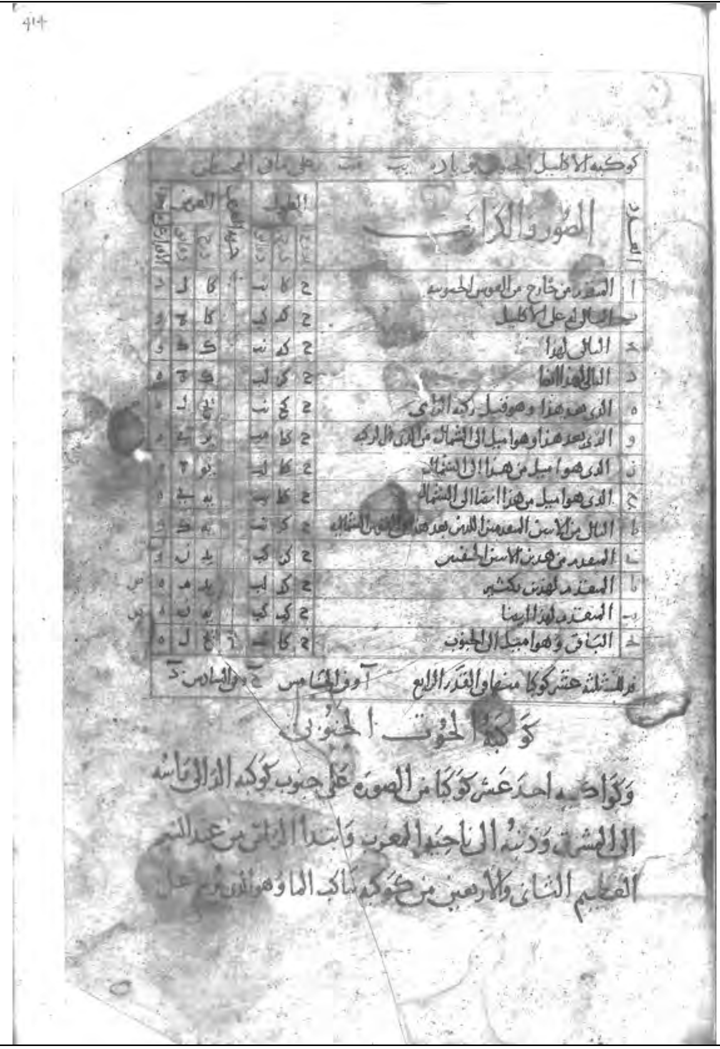
Folio 409

Constellation Ara (*al-Jamra*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The northernmost of the 2 stars in the base	8(240)	10	22	S	22	40	6
2	The southernmost of them	8(240)	13	2	S	25	45	4
3	The star in the middle of the little altar	8(240)	8	52	S	26	30	4(k)
4	The northernmost of the 3 stars in the brazier	8(240)	3	22	S	30	20	5(s)
5	The southernmost of the other 2 which are close together	8(240)	7	52	S	34	10	4(s)
6	The northernmost of these [2]	8(240)	7	42	S	33	20	4
7	The star on the end of the flame	8(240)	3	32	S	34	0	4
7 stars, 5 of the 4th magnitude, 1 of the 5th magnitude and 1 of the 6th magnitude.								



Folio 414

Constellation Corona Australis (*al-Iklīl al-Janūbī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*								
Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The most advanced of the stars on the southern rim, outside [the crown]"	8(240)	21	52	S	21	30	4
2	The star to the rear of this on the crown	8(240)	24	22	S	21	0	6
3	The one to the rear of this	8(240)	25	52	S	20	20	6
4	The one to the rear again of this	8(240)	27	32	S	20	0	5
5	The one after this, in front of the knee of Sagittarius	8(240)	28	52	S	18	30	5(s)
6	The one after this, which is north of the bright star in the knee [of Sagittarius, Sgr 24]	8(240)	29	42	S	17	10	5
7	The star to the north of this	8(240)	29	32	S	16	0	5
8	The one to the north again of this	8(240)	29	12	S	15	10	5
9	The rearmost of the 2 stars after this, in advance, in the northern rim	8(240)	27	52	S	15	20	6
10	The more advanced of these 2 faint stars	8(240)	27	22	S	14	50	6
11	The star quite some distance in advance of this	8(240)	24	32	S	14	40	5(s)
12	The one in advance again of this	8(240)	22	22	S	15	50	5(s)
13	The last one, which is south of the aforementioned star	8(240)	21	52	S	18	30	5
13 stars, 1 of the 4th magnitude, 8 of the 5th magnitude and 4 of the 6th magnitude.								



Folio 419

Table for the Constellation Piscis Austrinus (*al-Ḥūt al-Janūbī*) with the addition of 12 (degrees) 42 (minutes) to what is found in the *Almagest*

Number	Star Name	Longitude			Lat direction	Latitude		Magnitude as we found it
		zodiac	deg	min		deg	min	
1	The star in the mouth, which is the same as the beginning of the water [Aqr 42]	10(300)	18	22	S	20	20	4
2	The most advanced of the 3 stars on the southern rim of the head	10(300)	16	52	S	22	15	4
3	The middle one	10(300)	18	12	S	22	30	4
4	The rearmost of the three	10(300)	17	2	S	16	15	4
5	The star on the belly	10(300)	7	52	S	19	30	5
6	The star on the southernmost spine on the back	10(300)	13	52	S	15	10	6(s)
7	The rearmost of the 2 stars in the belly	10(300)	11	32	S	14	40	5
8	The more advanced of them	10(300)	7	52	S	15	5	5
9	The rearmost of the 3 stars on the northern spine	10(300)	4	32	S	16	30	5(k)
10	The middle one	10(300)	3	42	S	18	10	4
11	The most advanced of the three on the tip of the tail	10(300)	8	42	S	22	15	3(s)
11 stars, 1 of the 3rd magnitude, 5 of the 4th magnitude, 4 of the 5th magnitude and 1 of the 6th magnitude.								

Note: the last table in manuscript Marsh144 is not complete. I used the data in the Paris manuscript Arab5036.