The Double Hemisphere Star Atlas (1634): Empiricism, Technical Images, and Cross-Cultural Trust

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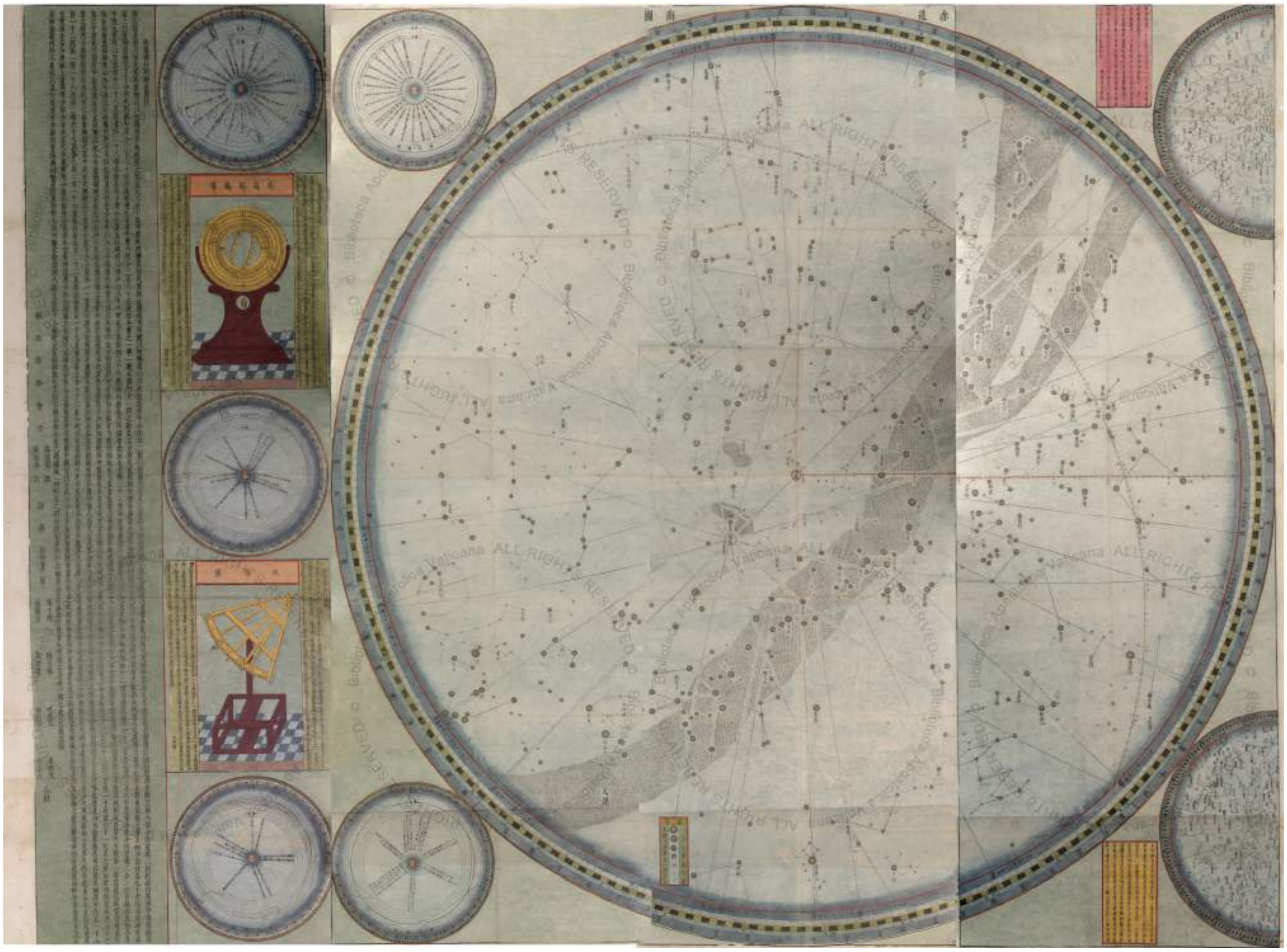
The *Double Hemisphere Star Atlas* 赤道南北両總星図 is a stunning eight-part woodblock print of enormous scale — nearly five meters long when fully assembled — issued in 1634 by the Imperial Grand Secretariat in the Chongzhen era of the Ming dynasty (fig. 1). The *Atlas* represents the culmination of collaborative research that Jesuit and Ming astronomers carried out between 1629-1634 in Beijing. As such, the story it recounts concerns the global history of art, religion, and science. Production was directed by the influential Chinese Christian scholar Xu Guagqi 徐光啓 (1562-1633) who died a year before the impressive *Atlas* was printed, and the German Jesuit astronomer Johann Adam Schall von Bell 湯若望 (1592-1666) who drafted the explanatory texts and coordinated the general design.[1] The postscript on the eighth and final sheet (far left) credits ten others who contributed to the *Atlas*' creation in various capacities, reiterating how the project was a joint effort by a Sino-European working group.[2]

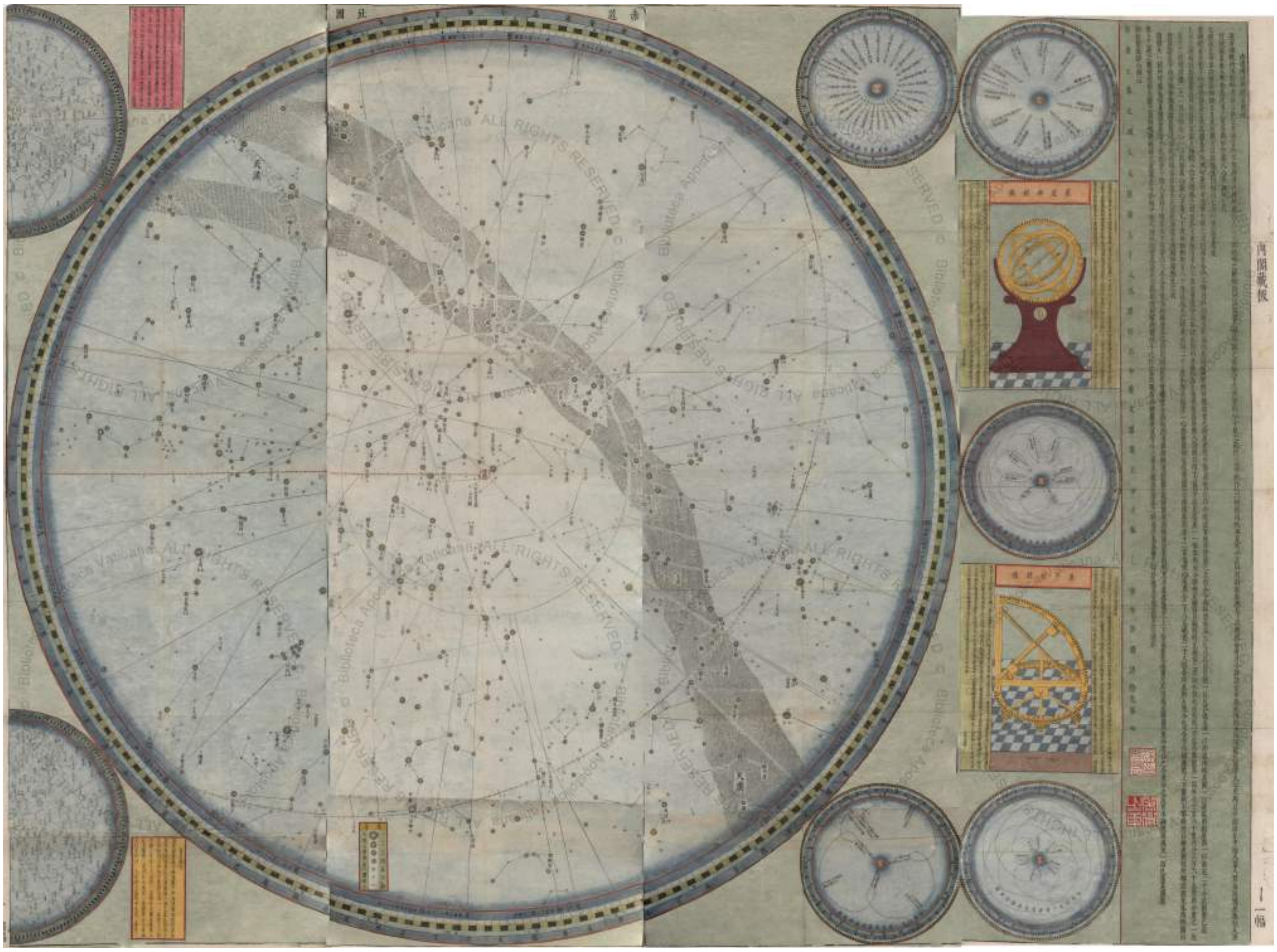
Technical images like charts, maps, diagrams, and tables that saturated early modern visual culture provided fertile opportunities for cross-cultural communication. Representations in this genre — sometimes called "epistemic images" — act as containers of information that could be shared easily across linguistic and cultural boundaries. At the same time, as many have argued over the past few decades, these types of images also perform a number of social functions that far exceed their characterization as dispassionate illustrations of factual findings.[3] Technical images do more than simply transmit data; they dispute and demonstrate ideas as they envision and produce knowledge about the world; they participate in the making of society as they make knowledge.[4] In the rapidly expanding early modern global knowledge economy, technical images negotiated complex sets of worldviews; sometimes affirming mutual



1. Xu Guangqi, Adam Schall et. al. *Double Hemisphere Star Atlas* (赤道南北両總星図), 1634. Eight-part wood block print, 67 1/3 x 175 1/2 in. (171 x 446 cm.). Vatican Apostolic Library, MS Barb. Or. 149. (Artwork in the public domain; photograph provided by (c) 2019 Biblioteca Apostolica Vaticana)

understanding while at other times iterating misunderstandings, confusion, obfuscation, or conflict. Such social practice that technical images visualize is the subject of this paper.

Schall and his team presented the multi-block print to the Chongzhen emperor in September 1634 as a crowning achievement of the Calendar Department (*Liju* 曆局), a bureaucratic office that the emperor had founded in 1629 just a year after taking the throne.[5] Adherence to European methods of astral science distinguished this new office from its rivals within the Ministry of Astronomy (*Qintianjian* 欽天監) — the *Datong ke* 大統科 run by Mandarin officials using traditional Chinese methods, and the *Huihui ke* 回回科*,* or the Muslim department that specialized in the calculation of eclipses.[6] To the consternation of these two competing groups, it was Xu Guangqi and the Jesuit consultants who won the imperial mandate to revise the state's outdated calendar



in 1629, on account of having predicted with greater precision a solar eclipse that took place that year on the 21st of June.[7]

Calendars tend to be inherently political documents no matter where they are made. They regulate the lives of people by institutionalizing chronological constructs and dictating when certain activities or rituals might take place. Their far-reaching effects make systematic revisions to established calendrical structures challenging to carry out. This is likely why the Ming government refrained from actually implementing the revised calendar, even after the Calendar Department had largely completed its work, which it had made available in print as an encyclopedic collection called the *Chongzhen Lishu* 崇禎曆書 (*Books on Calendrical Astronomy of the Chongzhen Reign*) containing twenty two treatises and two star catalogs.[8] The government's equivocation at this point in the project was a significant setback for the Jesuits.

In an important historiographic turn, scholars now broadly resist the often-repeated tale of Jesuit missionaries in early modern China overcoming adversity against non-believers to transmit scientific knowledge. To some extent this critique reflects a more general discomfort with writing about the history of global exchange exclusively from the perspective of a Western interlocutor. But as Florence Hsia and Roger Hart among others have demonstrated, these triumphant narratives are also suspect because they first originated in Jesuit publications that promoted their overseas missions, like Matteo Ricci's widely read *De Christiana expeditione apud Sinas suscepta ab Societate Jesu* (*The Christian expedition to China of the Society of Jesus,* 1615), Adam Schall's *Historica narratio, de initio et progressu missionis Societatis Jesu apud Chinenses* (*Historical Narrative About the Beginning an Progress of the Jesuit Mission Among the Chinese*, 1665), and Athanasius Kircher's *China illustrata* (*China Illustrated*, 1667).[9] Yet the suspicion of conflict at the Ming court was not entirely ungrounded. Opposition to the Jesuit-lead calendrical reform project — especially from the *Datong ke* who had proudly overseen the state's official calendar for centuries — is one instance where friction was more than just a figment of Jesuit imagination. It was this tension that motivated the Calendar Department to produce the visually impressive *Atlas* that distilled their research as a tribute to the throne. The multi-block print worked to defend the Department's scientific labor and to protect the group's political standing and influence in Beijing.

The Jesuits considered the Calendar Department's standing at court worthy of defense at all costs, especially in the precarious moment immediately following the death of their greatest advocate Xu Guangqi. For decades the China mission had invested heavily in astronomy as a diplomatic tool to approach the inner heart of the Middle Kingdom. Ever since the Jesuits were permitted to enter Mainland China in 1582, mission leaders pressed their directors in Rome repeatedly, demanding that they send astronomers who knew how to predict solar eclipses; particularly in demand were those who had the ability to compile calendars. "One of the most useful things that could come from [Europe] for this court," wrote Matteo Ricci for example in 1605, "would be a Father or a Brother who would be a good astronomer." The requests stressed the dire need for a professional mathematician with an ability "to determine the course and the true location of the planets, and the calculation of the eclipses; in short one who can make astronomical almanacs."[10] Ricci and his successors insisted that such an individual could give their mission "a great reputation, open more this entrance in China, and make our stay [here] more stable and free."[11] Mission leaders deemed astronomy a crucial component of apostolic labor in the Ming Empire, and hoped that the cultural authority that astronomical expertise could earn their organization would accordingly establish their spiritual authority in China. The order acquiesced, sending some of its brightest mathematicians and an entire library's worth of books over the years.[12] All of that was now at stake in 1634.

On a more personal level, the *Double Hemisphere Star Atlas* served as an eloquent defense of Adam Schall's own work as a missionary scientist up to that point. Recruited in Rome by the French Jesuit Nicolas Trigault (1577-1628) in 1616 who had briefly returned to Europe from China to secure personnel, supplies, and funding for the mission, the twenty-six-year-old Schall boarded a ship in Lisbon in 1618 and sailed to the Jesuit mission station in Macau together with a handful of other mathematicians and astronomers who had volunteered to fill the ambassadorial role; Wenzel Kirwitzer (1588-1626), Giacomo Rho (1592-1638), Francisco Furtado (1589-1653), and Johann Terrenz Schreck (1576-1630).[13]

Upon arrival, Schall had to establish his credentials as an expert on astronomy step by step.[14] Together with his scientifically inclined brothers, he transported from Macau to Beijing as early as 1623 a variety of European analytic devices, including the telescope and planetary tables, which he showcased broadly.[15] Schall gradually built a reputation as an authority on astronomy by conducting in Beijing demonstrations of the Galilean telescope and holding lessons on celestial events like lunar eclipses.[16] Learning the language, he also co-wrote and co-published with literati figures like Xu Guangqi treatises in Chinese on specialist subjects like the eclipse, the telescope, and trigonometry. His *Treatise on the Telescope* (遠鏡説) from 1626, for example, introduced Chinese readers for the first time to the structure, principles, manufacture, and use of that instrument, and the discoveries that European scientists like Galileo Galilei (1564-1642) had made with that tool.[17] Groundwork like this that he laid for over a decade eventually qualified Schall for a position in Xu Guangqi's Calendar Department in Beijing, to which he was summoned to contribute as one of the two European consultants the department was allowed in June 1630, when the more senior scholar Schreck passed away and vacated the post. By this point the calendrical reform project was generations in the making, and Schall considered its success a personal assignment.

At first the print medium seems to suggest that the *Atlas*' creators planned to circulate the work widely, and indeed two sets of copies were immediately sent to Rome so that the mission's fruitful labors in China could be showcased.[18] Its contents and mode of presentation make clear, however, that the *Atla*s was created primarily to satisfy an audience of one: the Chongzhen Emperor (1611-44). In what is described as an unusual move against protocol, the emperor kept in his private apartment the gilded presentation-copy impressions, which were affixed to eight wooden panels that formed a folding screen.[19] Flattery played at least some part here. The *Atlas* acknowledges the symbolically meaningful year 1628 — the date in which the emperor's reign began — by mapping the stars according to the coordinates that they occupied that particular year.[20] The preface to the *Atlas* that Xu wrote shortly before his death, however, also speaks of a didactic purpose. The *Atlas* was to assist in the emperor's personal celestial observations, so that he, in turn:

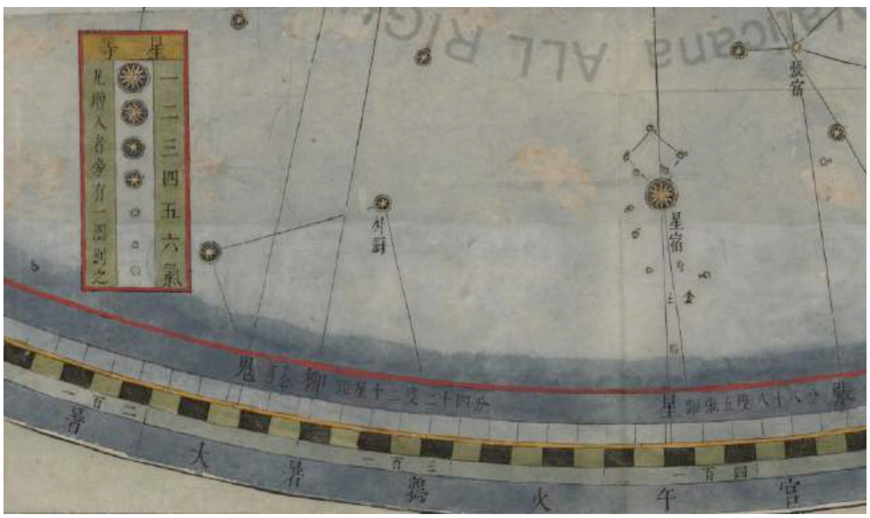
> (...) may become aware of the true state of the heavenly bodies, gains clear insight into the nature of the lines of longitude and latitude, and arranges the stars within his mind [so that] he will be able to announce the seasons to the people just as easily as if he pointed to the palm of his hand.[21]

To this effect Xu also claims that the *Atlas* was made large intentionally to facilitate the emperor's star gazing experience, because the four star maps that his team previously presented to the throne were too small and less comprehensive.[22] Ultimately the stunning display sought to lure its observer(s) to the *Chongzhen*

Lishu, the multi-volume compendium on calendrical astronomy whose data and celestial system the *Atlas* visually indexed. Its large dimensions, ambitious scope, and lavishness of production additionally indicate that the oversized multi-block print was a luxury item intended for the connoisseurs of astral science — a fact that may explain why so few full sets survive in archives across the globe today.[23]

A SHARED KNOWLEDGE SPACE

The *Star Atlas* participates in ongoing European debates about the nature of the cosmos, and demonstrates just how well the missionary scientists in Beijing were versed in current discussions in the field back home.[24] The two large projections in the center claim to be accurate visual records of the northern and southern celestial hemispheres. Sandwiched between them are two medium-sized maps — one of the celestial equator (top) and the other, of the celestial ecliptic (bottom). As far as we know, this is the first celestial map produced in China that utilized a classification system to denote a star's apparent brightness (fig. 2), and here the mapmakers referred closely to the system of star magnitudes that the German astronomer Johannes Bayer (1572-1625) had devised in his beautifully illustrated star atlas, *Uranometria* (1603).[25]



2. *Double Hemisphere Star Atlas,* detail showing the classification system for star magnitudes, and notation to distinguish newly observed stars.

The ten smaller circular diagrams in the *Atlas* that frame the two large projections on either end trace the orbit of the five known planets, Mercury, Venus, Jupiter, Mars, and Saturn, and their variations in latitude over time. These ten diagrams testify to the fact that the *Atlas* uses the Tychonic geo-heliocentric system of the universe — a system devised by the sixteenth-century Danish nobleman Tycho Brahe (1546-1601), where the Sun revolved around a stationary central Earth while all the other planets revolved around the Sun. The Tychonic model was an acceptable compromise between Ptolomy's geocentricism and the controversial heliocentrism of Nicolaus Copernicus (1473-1543), since it retained the centrality of earth on which European astronomy was based since antiquity.[26] After the Catholic Church had added Copernicus' *De Revolutionibus orbium coelestium* (*On the Revolutions of the Heavenly Spheres*, 1543) to the *Index librorum prohibitorum* (*Index of Forbidden Books*) in 1616 — more than seven decades after its publication — the Jesuit order followed suit by forbidding its members from presenting Copernicus' theories.[27] In choosing to share Tycho Brahe's geo-heliocentric model instead in China, astronomers like Schall and Rho divulge how the religious mission of the Jesuits intertwined with their scientific endeavors in complicated ways.

At the same time the *Atlas* also addressed Chinese astronomy carefully. The mapmakers used indigenous names and constellations to identify the stars rather than simply translating Latin designations into Mandarin. Schall, Xu and their team also ignored the twelve Western zodiac signs in favor of the twelve Chinese ones. The preface and postscript to the *Atlas* discuss the merits of various Chinese systems like the three groups of stars that traditionally ordered the Chinese celestial sphere, and the twenty eight lunar lodges (*xiu* 宿).[28] Throughout, Schall and Xu make respectful references to local sources on astronomy, some as old as Kan Te 甘德, a fourth century BCE figure whose star catalog was revised during the Tang dynasty (618-907).[29] Presenting their work in relation to the rich history of astronomical research in China in this way increased the probability that other Ming scholars would take the Calendar Department more seriously, but showcasing a similarly distinguished lineage also aligned Sino-European traditions as equals. In this, the astronomers may have been following the strategy of assimilation that Matteo Ricci employed when creating his wall-sized map of the world (*Kunyu wanguo quantu* 坤輿萬國全圖) in 1602, an ambitious initiative that notably culled geographic information from European cartographic sources and from Chinese and Korean ones.[30]

What we can glean from the *Atlas*' careful curation of ideas is how the production of knowledge was a process conducive to the formation of communities.[31] Schall and Xu's elaborate polar projection is not only a stunning monument to scientific learning, but also an ambitious cultural venture that required intense cooperation across religious, linguistic, political and ideological boundaries. Behind the endeavor lurks a certain innocent hope that sees contemplating the vast expanse of the cosmos together as an activity that may erase trivial terrestrial divisions like language, religion, and national boarders. The preface and postscript to the *Star Atlas* attest to this notion very clearly. The preface by Xu, while expressing profound respect for traditional Chinese sources on astral science, strongly advocates for European methods of study grounded in direct observation that relied on new instruments like the telescope. On Adam Schall's part, a deep familiarity with Chinese astronomy is evident in the postscript that he penned.[32] In this sense the *Atlas* was a product befitting the multicultural Ming court.

Some scholars have viewed Late Ming efforts to integrate Chinese and European calendrical astronomy with skepticism, and have portrayed the language of assimilation that Xu and Schall used as purely rhetorical, but we should not discredit entirely the sincere effort it took early modern individuals to find fluency with foreign cultures.[33] The process of producing technical images like the *Double Hemisphere Star Atlas* is community building, because it requires an interweaving of several intellectual strands. Both Xu and Schall demonstrate in their work itself an openness toward bodies of knowledge that were initially alien to them. They show command over diverse intellectual traditions and model a transnational academic partnership, making the *Atlas* a fruitful experiment in applied cross-cultural exchange. What we have in this elaborately produced celestial map then is not a simple vehicle for the "transmission" of scientific knowledge from one part of the globe to another, but rather a kind of shared knowledge space within which disparate thoughts and systems of knowledge are patiently negotiated.

At the same time, the community that proponents of this inter-cultural calendrical science envisioned was unquestionably a Christian one. Adam Schall expressed frustration, for example, with the fact that he was forbidden to use the term “Western” to describe either the administrative office to which he belonged or its astronomical methods. “The word *Xi* 西 (Western) is very unpopular (with the Chinese),” he wrote in 1640 in a report to the Vice-Provincial Francisco Furtado (1587-1653) who oversaw half of the China mission’s governance, “and the emperor in his edicts never uses any word other than *Xin* 新 (New); in fact, the former word is employed only by those who wish to depreciate us.”[34] The Chongzhen emperor prudently saw “new astronomy” as a concept that would enable his administration to adopt his calendrical reform project more easily. Schall however, to whom these terms were clearly not synonymous, wished to draw a stronger connection between Western identity and the work of his team. In this paradoxical exchange between multicultural inclusivity and identity politics, we glean the great distance between our inherited notions of modern science and the early modern conceptions of universal knowledge.

LANGUAGE OF EMPIRICISM

What Adam Schall hammered home through his early activities and publications in Beijing with the assistance of local authorities like Xu Guangqi was the highly marketable idea that empirical observation distinguished European astronomical methods from Chinese or Arabic ones. The Europeans of course had no monopoly over observational astronomy — in China for instance specialists had been using instruments like armillary spheres and celestial globes already for some time.[35] Yet developing the notion of empiricism into a full-blown marketing campaign for their organization gave the Jesuit scientists an edge as they vied for influence at court, and Schall easily took up this talking point in his written work.

For instance, Schall reiterates the importance of firsthand observation in the postscript to the *Star Atlas*, where he explains the fundamental rules that his team at the Calendar Department followed in the mapmaking process. While noting that they carefully consulted numerous Chinese star catalogs, the Jesuit insisted that, “on our map, *we have not dared to insert stars without a practical observation of each single one*,”[36] indicating that the *Atlas* intentionally excluded many stars that older astronomical texts discussed if direct observation could not confirm their presence and location. On the other hand, if previously unknown stars were discovered in the fieldwork process, Schall claims that his team assigned them new names and added them to the imperial *Catalog of Fixed Stars* 恒星経緯表 and *Atlas* without hesitation. The charting of stars by their longitudes and latitudes was in fact one important observational method the Calendar Department introduced to Chinese astronomers.[37] Overall, the aim here clearly was to create a definitive and precise record of stellar bodies and their locations.

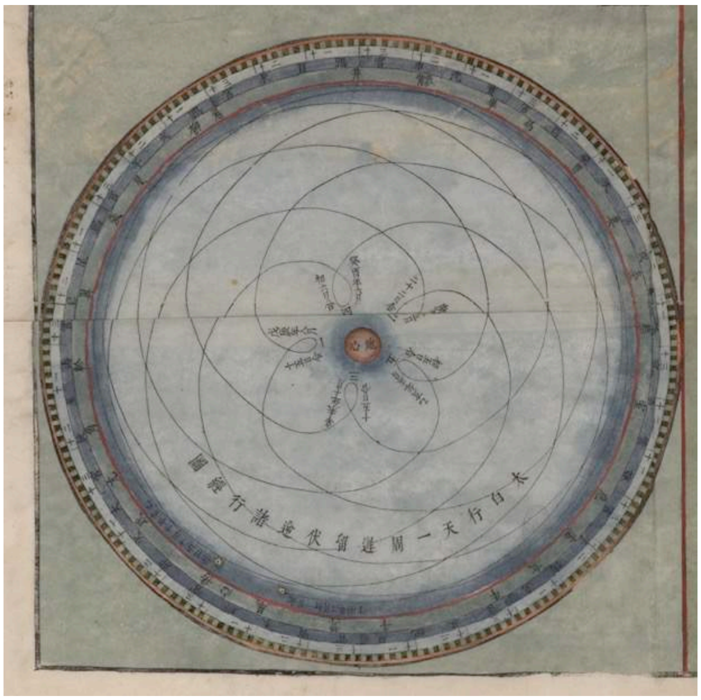
As if to buttress this claim, the postscript even lists eight officials by name who conducted the stellar observations: Chen Yujie 陳于階, Meng Lüji 孟履吉, Yang Zhihua 楊之華, Huang Hongxian 黄宏憲, Zhu Maoyuan 祝懋元, Cheng Tingrui 程廷端, Zhu Goushou 朱國壽, and Zhang Caichen 張寀臣. Such maneuvers allow the *Atlas* to put forward a case for a scientific study that is fundamentally a cumulative and social process. The Calendar Department's work should be trusted, not because it sets forth theoretical musings of a solitary sage, but because the organization gathers its findings meticulously through firsthand observations, carried out collectively by a community of qualified individuals.[38]

析木宮

星名	黃道經度	分	黃道緯度	分	向	赤道經度	分	赤道緯度	分	向	等
心宿一 火木	〇二	三十四	〇三	五十五	南	二百三十九	三十八	二十四	三十四	南	四
二 火木	〇四	三十六	〇四	二十七	南	二百四十二	四十三	二十五	三十	南	一
三 火木	〇六	〇六	〇五	五十	南	二百四十三	十八	二十七	二十	南	四
心宿南四 增 火木	〇一	二十	〇六	三十八	南	二百三十七	三十九	二十六	五十六	南	五
五	〇一	五十	〇六	四十	南	二百三十八	二十三	二十七	〇八	南	五
尾宿一	二十	〇七	十五	〇〇	南	二百四十五	四十七	三十六	五十二	南	四
二 火水	〇九	五十	十一	〇〇	南	二百四十六	二十	三十二	五十二	南	三

3. Xu Guangqi, Adam Schall et.al. *Catalog of Fixed Stars* (恒星経緯表), a volume in the *Chongzhen Lishu* 崇禎曆書 (*Books on Calendrical Astronomy of the Chongzhen Reign*), ca.1633. Roman Archive of the Society of Jesus (Jap. Sin. II 38.4)

That Schall and Xu framed astronomy to be an empirical discipline is reinforced by the *Star Atlas*' visual rhetoric. For example, some stars represented in the northern and southern hemisphere projections are accompanied by a curious black circle (see fig. 2), a subtle mark used to identify stellar bodies that the Calendar Department had newly observed since publishing their *Catalog of Fixed Stars* 恒星経緯表 — an important section within the *Chongzhen Lishu* 崇禎曆書 (*Books on Calendrical Astronomy of the Chongzhen Reign*) (fig. 3). While the *Catalog* listed the coordinates of a total of 1,365 stars, the *Atlas,* issued just a few years later, included 1,812 stars.[39] The *Atlas* therefore offers 447 additionally observed stars to present, as it claims, as comprehensive a view of the celestial sphere as possible.[40] What we have here is an example of what Lorraine Daston and Peter Galison have called "images of record."[41] The mapmakers made sure to visually alert their audience of the current status of their research, and to indicate where source material had yet to be made public. Such transparency of process with regard to both fieldwork and data processing is one of several means by which Schall and Xu's *Atlas* trains the eye of its observers.



4. *Double Hemisphere Star Atlas,* detail showing the diagram of Venus' planetary orbit.

The *Atlas* invokes firsthand observation further in the ten circular diagrams of planetary motions. These smaller figures illustrate the intricate geometric patterns that the five known planets make over time as they orbit both the earth and the sun according to the Tychonic geo-heliocentric model of the cosmos. For example, the diagram charting the movement of Venus that we see at the bottom right corner of the *Atlas* portrays the distinct pentagonal rose-petal pattern that Venus makes in its direct and retrograde motion around the earth (fig. 4). Venus is shown to orbit the sun five times per each of its rotation around the earth. The beautiful looped patterns that the planets seemingly make in their retrograde motions is understood today to be an optical illusion resulting from the elliptical orbits the planets make relative to the earth and the sun. By essentially retaining the geocentric system's epicycles however, these ten diagrams defend a theory of planetary motion that was becoming increasingly problematic to maintain in seventeenth-century European astronomy. What is significant here is the fact that the *Atlas* retained epicycles on account of the evidence that the geometric patterns of planetary motion were apparently true to those observers on earth who monitored the nights' sky first hand. The celestial map summons firsthand observation in order to validate a controversial cosmological system.

The incontrovertible power of the eyewitness is a theme that the *Chongzhen Lishu* consistently raised. For instance, in his *Wu-wei Li-chih 五緯曆指* (*Astronomical Handbook of the Five Planets*), Giacomo Rho, the Milanese Jesuit astronomer who worked alongside Schall and Xu at the Calendar Department and who edited Schall's postscript to the *Atlas*, advised readers to always side with observed facts whenever learned theories disagreed with perceived phenomena:

> If indeed a theory, which has been constructed, is without discrepancy with the gist of what is learned from detailed observation, then it is a true theory. If this is not the case, then how could we disregard the heavens by remaining wedded to antiquity?[42]

Keen observers were more reliable, in other words, than authors of sophisticated theories. Treatises like this that made up the *Chongzhen Lishu* framed empirically gathered data as foundational building blocks for a universal science.

Turning back to the *Atlas*, we again see a strategic deployment of empiricism in the illustrations of the distinct set of instruments that made the *Atlas'* imaging possible; the ecliptic armillary sphere 黄道経緯儀 (upper right), azimuthal quadrant 地平経緯儀 (lower right), equatorial armillary sphere 赤道経緯儀 (upper left), and the sextant 紀限儀 (lower left). Accompanying texts explain how the instruments are useful in measuring the altitudes and motions of the stars. Together these prominently exhibited devices make visible the technology that generated the *Atlas*, and characterize the project overall as one that involved the attentive watching of celestial events. Instruments such as these found their way to Beijing aboard Jesuit ships, but Schall and Rho also guided new local production under imperial patronage.[43] Jesuit astronomers active in China repeatedly asserted the usefulness of such devices in their publications. "Observational instruments are to the astronomer what the plumb line or square is to the engineer," wrote Schall in his *Xinfa Liyin* 新法暦引(*Introduction to the*

New Calendrical Methods), "that is, they are indispensable."[44] Featuring such observational instruments conspicuously, the *Atlas* contends that the information it shares is guaranteed by empirical evidence, the kind of evidence that was gathered using the latest of technologies. The *Atlas* trains the eye of its observers, not only by revealing its subject in a wondrous representation, but also by instructing us how to obtain such revelations on our own.[45] The *Atlas* highlights instrument-aided vision as a strong basis to portray European modes of knowledge-assembly as a universal and objective science, in a stunning anticipation of Western definitions of modernity.

Paying close attention to an idea like empirical observation divulges the many ways in which an early modern technical image such as the *Double Hemisphere Star Atlas* operated, not only as containers of knowledge, but also as sites for performance and persuasion in a cross-cultural context. Showcasing how European astronomy was grounded in observational methods, the *Atlas* gave Chinese audiences the impression that the body of knowledge it relayed was accessible to anyone. This, ironically, would also conveniently suggest that verification of fieldwork data was unnecessary because the trust in its findings that empirical observations generated strongly implied that the task of discerning what is true and what is false had already been handled. While a whole confluence of motives generated the rhetoric of empiricism in the mission fields, observational astronomy served as one crucial tool with which the Jesuits sought to build credibility and authority in China.

KNOWLEDGE AND EXPERIENCE: WITHIN AND BEYOND SCIENCE

The rhetoric of empiricism that Jesuit astronomers deployed so consistently in Late Ming China, echoed principles that leading scientists back home often articulated. Scholars like Galileo frequently drew stark contrasts between direct study of the natural world and the humanist model of inquiry that sought to understand the natural world by combing through written sources. The type of person who adheres to the latter method, wrote Galileo to Kepler mockingly in a letter in 1610:

> (...) thinks that philosophy is some kind of book—like the *Aeneid* or the *Odyssey*—and seeks truth not in the world or in nature, but (in their own words) in confrontation with texts! How I wish I could spend a good long time laughing with you.[46]

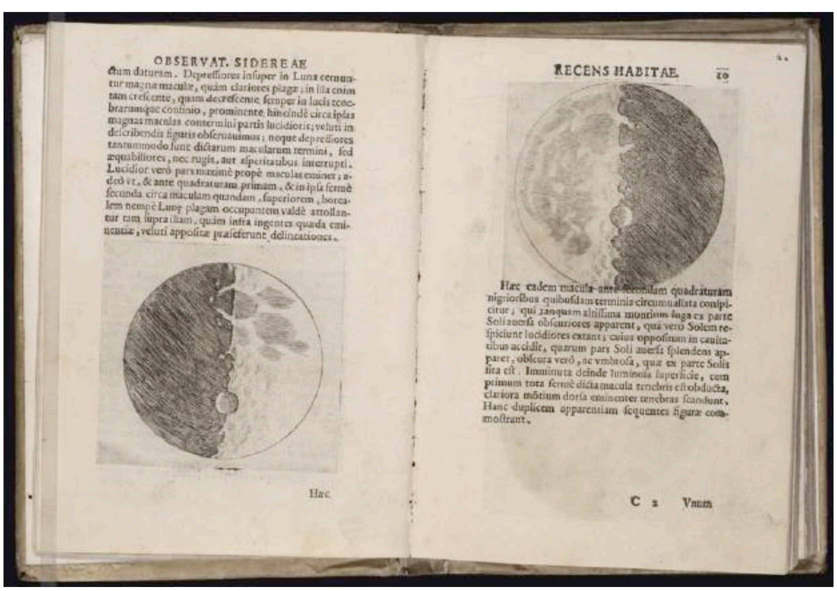
By the middle of the seventeenth-century in Europe, observational practices had become irreplaceable analytical tools in astronomy, botany, anatomy, and a number of other fields in natural philosophy.[47] This trend significantly reshaped how sensory experience, and testimony of the eye in particular, intervened in the production of knowledge, challenging the previously dominant tradition of classical philology that primarily relied on the authoritative opinions of past writers.[48]

In astronomy more specifically, between the late 1570s and 1590s, Tycho Brahe produced an impressive series of studies that transformed the discipline in Europe. In essence Tycho aimed to observe and measure the position of every visible star in the sky. His approach was innovative because he based his inquiries on nightly observations carried out for over a decade at his purpose-built observatory called Uraniborg on the island of Hven in Denmark (figs. 5, 6). With astonishing dedication, the eccentric Danish nobleman sought to produce a definitive study of the celestial sphere utilizing novel analytical instruments,

5, 6. Tycho Brahe, *Astronomiae Instauratae Mechanica* (Hamburg: Impressum Wandesburgi, 1602 [1598]). Title page, and illustration of the mural quadrant at Uraniborg. Library of Congress, Rare Book and Special Collections Division, QB85.B8.1602. (Artwork in the public domain; photography provided by (c) Library of Congress) many of which were of his own unique design.[49] Devotion to hands-on empirical methods of research is clear in Tycho's *Astronomiae instauratae mechanica* (*Instruments for the Restoration of Astronomy*, 1598), an influential treatise that any aspiring astronomer of Adam Schall's generation would have read carefully. Tycho's descriptions of the planets and stars were coupled with a thorough discussion of methodology.

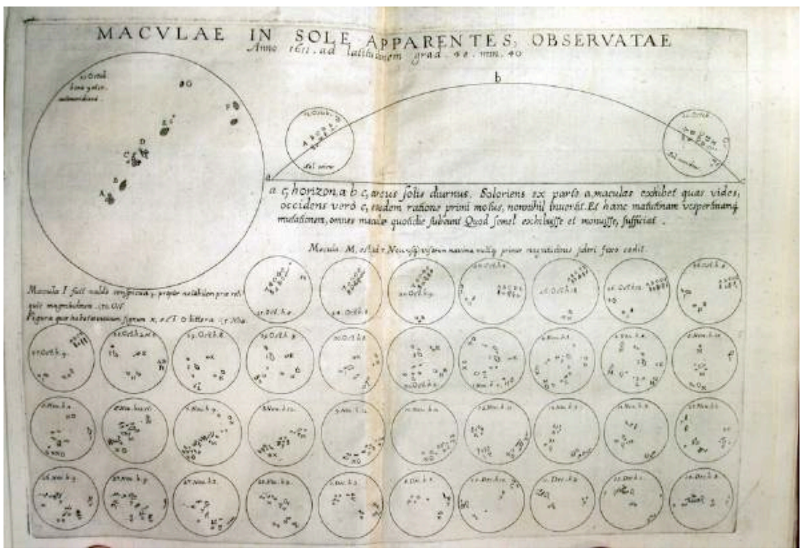
> First of all we determined the course of the sun by very careful observations during several years. We not only investigated with great care its entrance into the equinoctial points, but we also considered the position lying in between these and the solstitial points, particularly in the northern semicircle of the ecliptic since the sun there is not affected by refraction at noon. Observations were made in both cases and repeatedly confirmed, and from these I calculated mathematically both the apogee and the eccentricity corresponding to these times.[50]

Measuring precisely the coordinates of stars and movements of planets became so vital to Tycho and to the specialists across Europe with whom he exchanged opinions that, at Uraniborg, he even embedded large observational instruments directly into the bedrock to reduce the harmful impacts of wind. Tycho remained remarkably influential well after the relevance of the data he gathered began to fade with the advent of the telescope, in large part because his principles of empirical research continued to resonate with practitioners.



7. Galileo Galilei, *Sidereus Nuncius* (Venice: Baglioni, 1610), 9v-10r. Beinecke Rare Book & Manuscript Library, Yale University, QB41 G33 1610B OS. (Artwork in the public domain; photography provided by (c) Beinecke Rare Book and Manuscript Library)

The invention of the telescope in the early seventeenth century cemented observational practice as the ideal approach to track nature's true form and behavior. Particularly significant were Galileo's richly illustrated publications; *Sidereus Nuncius* (*Starry Message*) printed in Venice in 1610, and the so-called *Macchie* *solari* (*On Sunspots*) issued in Rome in 1613 (figs. 7, 8).[51] Both treatises reported groundbreaking discoveries that the author had made with the help of the telescope — the first volume on the physical features of the moon's surface as well as on the four stars orbiting Jupiter, and the second work on the progress of sunspots across the solar disk.[52] By attempting to relay exactly what the astronomer saw through the telescopic lens, these publications in turn created what Martin Kemp has called "surrogate eyewitnesses."[53] Readers are transformed to become firsthand observers of celestial phenomena, actively participating in the production of new astronomical knowledge.



8. Galileo Galilei, *Istoria e Dimostrazioni intorno alle Macchie Solari* (Rome: Giacomo Mascardi, 1613). History of Science Collections, University of Oklahoma Libraries (Artwork in the public domain; photography provided by (c) University of Oklahoma Libraries)

Such literature on astral science that reinforced the connections between knowledge and experience played a central part in Adam Schall's education. From 1608 for about a decade, Schall underwent in Rome his studies to become an ordained priest and a scholar of mathematics, the discipline under which astronomy was a subfield.[54] Schall studied, like Matteo Ricci had before him, at the Collegio Romano under the great mathematician Christoph Clavius (1537-1612) who had assisted Pope Gregory XIII's calendar reform project in the 1580s.[55] Another influential mentor was Christoph Grienberger (1561-1636), the chair of mathematics and the censor of Jesuit scientific publications who also compiled a star catalog of his own in 1612.[56] Through ten years of training under Clavius and Grienberger, Schall was groomed to become one of the Society's leading scholars. In Rome Schall also became privy to the latest discussions in the field of astronomy. For example, on April 14th 1611, he had occasion to attend in person Galileo's public demonstration of the telescope on the Janiculum Hill.[57] In the feast that followed that historic event, participants discussed the merits of observations mediated by instruments in the pursuit of knowledge. That these educational experiences had a profound effect on Schall is obvious in the work that he carried out in China over his nearly five-decades-long career as a missionary scientist, including his *Treatise on the Telescope* and the *Double Hemisphere Star Atlas*.[58]

The rhetoric of empiricism that Adam Schall and his colleagues at the Calendar Department employed was fashioned out of early modern European models of astronomical inquiry that Tycho, Galileo, Grienberger and others had set forth. Schall and his colleagues like Rho and Schreck framed their own celestial research in Beijing as empirical practices based on intimate, hands-on observations, because this was the methodological approach through which they themselves had learned to examine the heavens. But if empirical observation was a crucial common thread that ran through Schall's education as a scientist, the notion just as persistently informed his spiritual training as a Jesuit, where sensorial experience played an absolutely fundamental pedagogical role.

Since its papal confirmation as a religious order in 1540, the Society of Jesus utilized visual images strategically in its spiritual practice. Early fathers of the Company like Ignatius Loyola (1491-1556) and Jérôme Nadal (1507-80) understood images to be crucial instruments in activating devotional processes like meditation and prayer.[59] They developed a curriculum for the novitiate that identified organs of perception as basic tools for engaging their spiritual senses. Accordingly, spiritual training manuals that they wrote framed empirical observation as a reliable method to access specialized theological knowledge. In texts like Ignatius' *Spiritual Exercises* (1548) and Nadal's *Annotations and Meditations on the Gospels* (1595) that all novices read in the course of their training, images both tangible and intangible were strategically deployed to activate the reader's imagination and inspire in them a mystical sort of contemplation. Ignatius called this approach to prayer "the application of senses (*applicatio sensuum*)."[60]

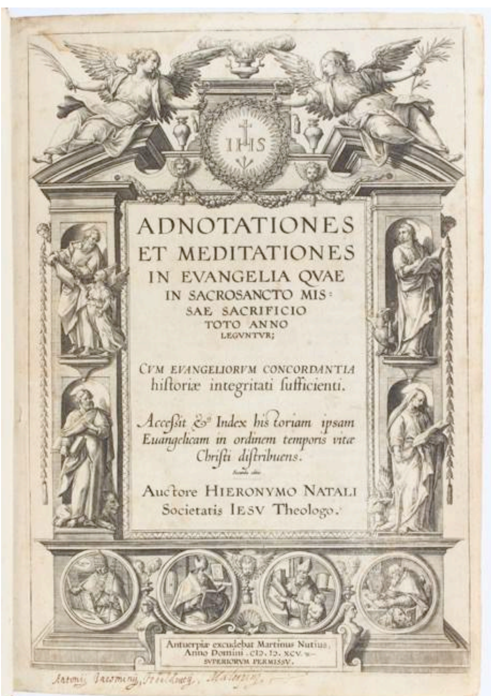
Pictorial works by artists like Giovanni Battista Moroni (1520-78) illustrate Jesuit models of contemplative prayer that Schall and his brethren would have practiced, and its rising popularity in the late sixteenth and early seventeenth centuries (fig. 9). Moroni's sacred portrait shows two unidentified contemporary

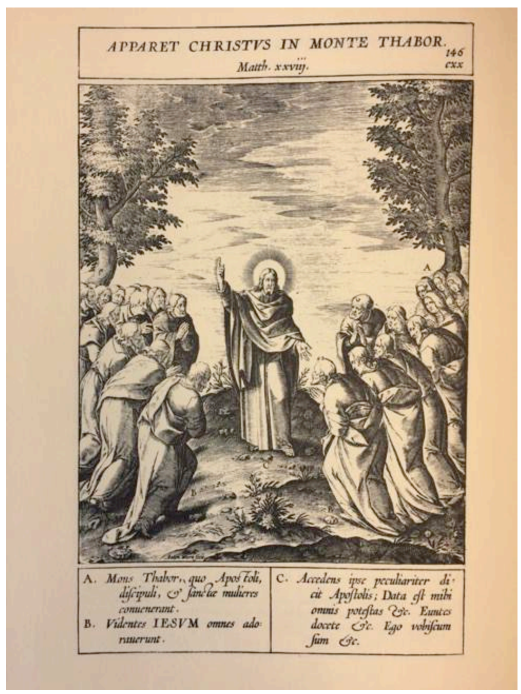
9. Giovanni Battista Moroni, *Two Donors in Adoration before the Madonna and Child and St. Michael*, ca. 1557–60. Oil on canvas, 35 1/4 x 38 1/2 in. (89.5 x 97.8 cm) Virginia Museum of Fine Arts, Richmond; Adolph D. and Wilkins C. Williams Fund (62.20) © Virginia Museum of Fine Arts, Richmond / Katherine Wetzel

devotees — a Northern Italian woman in private prayer with her copy of the *Spiritual Exercises* opened on the ledge, and a man to the left, perhaps her husband, inviting our participation in the scene taking place. Above them, as the clouds part in a heavenly revelation, Moroni presents the archangel Michael saluting the Madonna and Child, an apparition that the praying woman "sees" with her spiritual sense.[61] We witness in this painting both the act of devotional prayer and its desired effects, which thereby transform us into participants ourselves in a similar sort of meditational contemplation. The particular revelation that we see depicted here is the subject of a specific exercise that Ignatius prepared for day one on week two of his four-week training program. The meditational prompt for that day, written in the typical first-person voice, reads in part: "(...) I will see our Lady and the Angel saluting her. I will reflect upon this to draw profit from what I see."[62] Moroni's painting perfectly captures the process by which the *Spiritual Exercises* transforms readers into active beholders who could speak of sacred subjects authoritatively as if they had witnessed and experienced them firsthand.

What works of art like Moroni's sacred portraiture show is the degree to which the Jesuit order and its founders emphasized the senses as potential instruments of faith. The same idea of *applicatio sensuum* is put into practice even more rigorously in Jerome Nadal's *Annotations and Meditations on the Gospels,* a book that every Society member knew just as intimately as Ignatius' *Spiritual*

Exercises (fig. 10).[63] Nadal's popular book provides commentary and prayer-prompts on key events from the gospels, in order to help its readers gain a basic comprehension of scripture and to acquire the capacity to contemplate higher theological truths. As Walter Melion has persuasively explored, images played an absolutely central role in this scheme.[64] Nadal paired each scene from the gospels with a richly detailed folio engraving — 153 in total — all of which had caption keys that describe important features that make up the narrative moment. These annotated engravings invite readers/viewers to achieve full immersion in the sacred episodes by making visible the places, figures and events that they feature. Together, the book's visual imagery and meditation prompts facilitated readers to simulate empirical observation of sacred events as if they were present on the scene in person, unlocking a doorway to a spiritual vision.





10, 11. Jerome Nadal, *Adnotationes et meditationes in Evangelia* (Antwerp, 1595) Title page and plate 120, *Christ Appears on Mount Tabor*, engraving by Hieronymus Wiericx after Bernardino Passeri. (Artwork in the public domain)

An exemplary instance of this object-viewer dynamic in Nadal's book is chapter 120, the annotations and meditations on the Risen Christ's appearance to his apostles and worshippers at Mount Tabor (fig. 11).[65] The detailed burin engraving by Hieronymus Wiericx shows Christ's epiphany to a group of male and female followers who fall on their knees as Christ speaks. The semicircle composition in a naturalistic landscape with an opening in the foreground is designed to place the readers/viewers at the specific site of action as live witnesses to the miraculous event, an event that is vividly taking place in front of our very eyes. Above in the banner we read the title of the scene, and a citation of the gospels where this episode occurs, Matthew xxviii, in which Christ commands his apostles to "go and make disciples of all nations." Below the engraving, captions describe the basic protagonists and setting of the scene who are identified by alphabetical keys in the illustration.

Nadal annotates these captions more fully in the following pages so that his readers may understand the full context of the sacred event, and properly interpret Christ's command to evangelize. The implicit call for the readers to heed Christ's words and to follow in the footsteps of his apostles is made much more explicit in the longer Meditation section that finally concludes this chapter, where Nadal encourages his readers to dwell on the particular episode and its attendant details carefully, and incites direct participation in the mysteries through spiritual reflection.

> (...) we must then contemplate and study what Christ does and says as though we were present in spirit there, and as much as we can. This idea we ought to have ever in mind as we pray and do our spiritual exercises. We shouldn't pray or contemplate Christ's mysteries as though they're far removed from us, or as though they took place elsewhere. Rather, we should be there in mind and heart, where the events occurred. Then from all the circumstances of person, place, word, and work, we can energize spirit and devotion.[66]

The entire chapter is an exercise in simulation. In fact, the distinct appeal of Nadal's *Annotations and Meditations on the Gospels* lay not just in its rich illustrations, but rather in the pedagogical technique that it employs in order to impart complex theological ideas, a technique that relies on immersive experiences like simulated vision and empathetic emotional engagement.

Scholars who study early modern Jesuit visual culture often draw unhelpful separations between technical images (like maps, diagrams, charts, and scientific study-drawings) and artistic or spiritual ones. Nevertheless, significant parallels exist between these genres of images, including the object-viewer dynamic that they sometimes employed. The *Star Atlas*' self-professed empiricism resonates with the visual culture of Adam Schall's Roman educational environment. Contemporary European astronomy prepared Schall to embrace empiricism as an exemplary approach to the study of nature, while his theological training as a Jesuit shaped Schall's understanding of pedagogy, and the instrumental role that firsthand experience played in any didactic process. The *Double Hemisphere Star Atlas* is clearly indebted to both notions of empiricism in its claims to be an accurate visual simulation of the heavens composed of aggregate experiential data. In this sense, we might say that the circumstances of its production are embedded in the *Atlas*' very own visual agency.

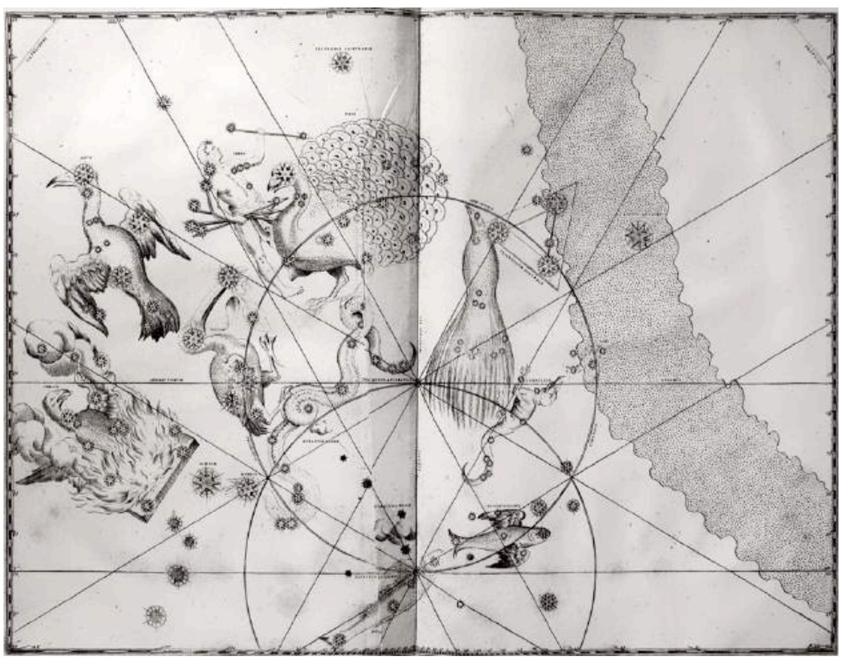
At the same time, Schall and his colleagues at the Calendar Department framed the notion of empiricism distinctly in their *Atlas* of 1634 as a tool to transcend cultural difference. The *Atlas* is not only shaped by its social context, but also actively attempts to shape society. While the *Atlas* clearly echoes ideas like sense application and empirical science that were current in Jesuit circles in Europe, its true ambitions lay beyond the mere transmission of specialized knowledge; its larger goal was to win absolute trust from an audience that had little reason to grant it. The *Atlas* reveals how Jesuit missionary scientists working in late Ming China framed observational astronomy as a neutral Middle Ground that provided opportunities to cultivate trust among strangers.[67] By insisting upon instrument-aided observational practices, Schall and his team hoped to prove that their worldviews — astronomical or otherwise — were objectively and verifiably correct. Technical images like the *Star Atlas* were produced in large part to reinforce this claim to transnational authority.

EMPIRICISM, PERFORMANCE, AND RECEIVED KNOWLEDGE

Inherent in the *Double Hemisphere Star Atlas* is a troubling contradiction; the multi-block print was actually a product of the library just as much as it claimed to be of the observatory. Despite its purported dismissal of textual learning in favor of knowledge discovered via field research, the *Atlas* visually presents astronomical datasets and ideas wholeheartedly transcribed from a wide array of European publications. The mapmakers took great advantage of existing source material, in much the same way a humanist might engage in philological study, and produced an *Atlas* whose content today seems deeply derivative in nature.

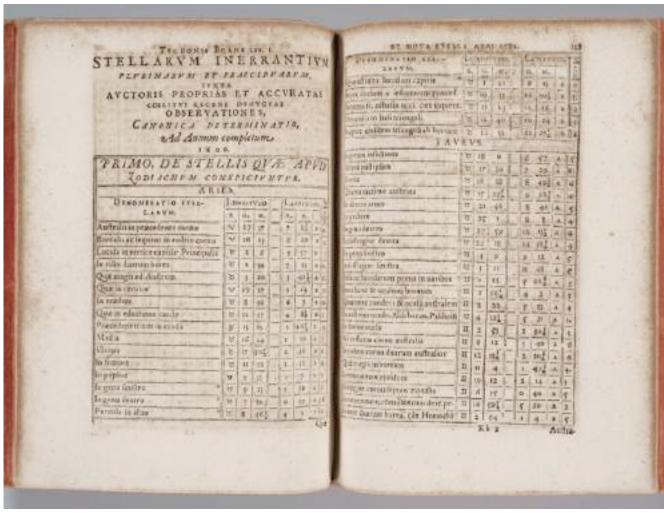
In fact, to contemplate the *Atlas* is to attempt to focus in and out of its source material. While Xu Guangqi and Adam Schall's calendrical reform team did use modern observational instruments when verifying the data that made up their star charts, the majority of the stars' coordinates included in the *Star Atlas* and in the *Chongzhen Lishu*'s *Catalog of Fixed Stars 恒星経緯表* actually originated in publications and not exclusively in newly observed or independently gathered findings (see fig. 3).[68]

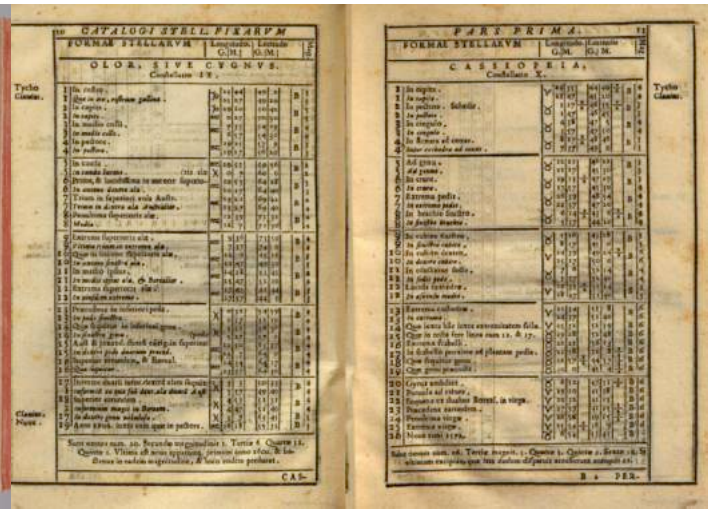
This strategy is most obvious in the stellar projection of the southern hemisphere. The celestial map of the southern hemisphere included twenty-three European constellations made up of stars that were previously unknown in China, breaking the cardinal rule followed elsewhere in the *Atlas* of abiding by Chinese constellation systems. These twenty-three new constellations were copied directly from Johannes Bayer's widely read *Uranometria*, whose stellar map famously included twelve constellations that were newly discovered in the southern hemisphere by Dutch navigators in the 1590s (fig. 12).[69] Adam Schall and Giacomo Rho could have observed these stars in the southern polar region themselves during their long voyage from Lisbon to Macau, but it is more likely that they transcribed the constellations directly from Bayer's book and visualized them in the *Atlas* when the need arose.



12. Johannes Bayer, *Uranometria* (Augsburg: Christoph Mang, 1603). New constellations of the southern hemisphere. Linda Hall Library (Artwork in the public domain; photography provided by (c) Linda Hall Library)

The duplication of content is even more egregious where the coordinates of stars is concerned. Contrary to repeated assertions of empiricism and originality of findings, the *Atlas* and its attendant *Catalog of Fixed Stars* copied the celestial coordinates of 767 stars directly from the huge pool of data Tycho Brahe included in his star chart in volume one of his two-volume *Astronomiae*





13 Tycho Brahe (Johannes Kepler ed.), *Astronomiae instauratae progymnasmata* (Prague, 1602). Detail showing the star catalog. Library of Congress, Rare Book and Special Collections Division, QB41.B73.1602. (Artwork in the public domain; photography provided by (c) Library of Congress)

14 Christoph Grienberger, *Catalogus veteres affixarum longitudines, ac latitudines conferens cum nouis, imaginum caelestium prospectiva duplex* (Rome: Bartolomeo Zannetti, 1612), ETH-Bibliothek, Zürich, Rar.4336 (Artwork in the public domain, photography provided by (c) ETH-Bibliothek, Zürich)

instauratae progymnasmata (*Introduction to a New Astronomy*), a book published posthumously in 1602 (fig. 13).[70] Moves like this by Schall and his colleagues suggest tensions in the ideological aim of the calendrical reform project, straddling the boundary between translation and shared research.

The most important source for Schall and his team was, without a doubt, Christoph Grienberger's *Catalogus veteres affixarum* (*Catalog of Affixed Stars*) from 1612 — a treatise that Schall knew intimately and likely carried with him personally to China (fig. 14). This *Catalog,* whose compilation Schall would have been apprised of in real time as a student at the Collegio Romano, gave additional measurements for 458 stars not found in Tycho's earlier chart.[71] Although Schall did modify his teacher's stellar coordinates so that they would accurately map the night's sky for the year 1628 instead of 1600, he essentially copied-and-pasted the entirety of Grienberger's datasets into his own star catalog in the *Chongzhen Lishu*, even arranging his data columns in the manner that Grienberger did in his *Catalogus* (see fig. 3).[72] The detailed if small double hemisphere star atlas that Grienberger included in his book as an appendix also may have inspired Schall to translate his star chart into a stunning visual display (figs. 15, 16). The pilfering of data was not only antithetical to the claims of empiricism; it also has the

15, 16 Christoph Grienberger, *Catalogus veteres affixarum,* celestial maps of the northern and southern hemispheres appended to the volume. ETH-Bibliothek, Zürich, Rar.4336 (Artwork in the public domain, photography provided by (c) ETH-Bibliothek, Zürich)

unfortunate effect of reducing the Chinese collaborators at the Department who Schall listed on the Atlas as "observers" essentially to the status of fact-checkers.

Contrary to its rhetoric then, neither the reformed calendar of the Chongzhen reign nor the *Star Atlas* was actually a product of observational astronomy in the strictest sense. Rather, recent European specialist publications disingenuously served as immediate precedents, while field research only worked to validate that existing expert knowledge, so much so that it is difficult to imagine the celestial map without the precedents set by Tycho, Bayer, and Grienberger. Although the fact that Adam Schall drew on the humanist tradition of scholarship is not problematic in it of itself, his substitution of bookish study for eyewitness accounts is misleading. There is a glaring disconnect between the presentation of Schall's methods at the Ming court, and how the *Atlas* and *Star Catalog* were actually compiled. Schall and his team presented secondhand knowledge of empirically gathered data as if those firsthand experiences were their own; as if anyone anywhere could acquire that specialized knowledge, so long as they too followed the authoritative methods of an objective science. If nothing else, this episode offers a cautionary tale against those of us who might anachronistically idealize early modern Sino-European exchange as a historical model for multi-cultural pluralism.

The *Star Atlas* employed instrument-aided vision and the rhetoric of empiricism performatively as modes of marketing and of othering, selling the idea of objective knowledge as a way to distinguish and promote European identity and the Jesuit world-view. A project that advertises itself to be an exemplar of technologically cutting-edge science and transparent cross-cultural exchange therefore is also a site for cultural imperialism and obfuscation of methods. This slippage between rhetoric and reality presents a fascinating metaphor for the limitations of vision. If graphic representations of the celestial sphere like the *Double Hemisphere Star Atlas* challenge the limits of visibility in the optical sense, they also test the limits of mutual understanding across cultural divides. The *Atlas* demonstrates the many ways in which early modern technical images acted not only as containers for knowledge but also as sites for performance and persuasion that intervened in society. What makes these technical images fascinating to study is how they create a shared knowledge space within which disparate thoughts and cultural systems are negotiated.

The present study is an attempt to engage in a global art history that is not just about greater inclusion of previously marginalized works, or the documentation of intercultural contact as a byproduct of travel and trade, but about probing the manners in which visual artifacts themselves negotiated cultural distances and reshaped society.[73] Here Adam Schall's *Double Hemisphere Star Atlas* served as a vehicle to examine the inherently contradictory ways in which early modernity grappled with global consciousness; expressing on the one hand the struggle to foster common ground inclusively, while on the other hand engaging in a form of cultural imperialism.

[1] Pasquale D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," *Monumenta Serica* 18 (1959): 328-59, esp. pp. 340-1; Keizo Hashimoto, "Jesuit Observations and Star-Mappings in Beijing as the Transmission of Scientific Knowledge," in Luís Saraiva ed., *History of Mathematical Sciences: Portugal and East Asia II* (London: World Scientific Publishing, 2004), 129-46. See also Anthony Grafton ed., *Rome Reborn: The Vatican Library and Renaissance Culture* exh. cat. (Washington, DC: Library of Congress, 1993), 270-3. Xu Guangqi died on 8 Nov. 1633. On Star charts more broadly, see: Deborah Jean Warner, *The Sky Explored: Celestial Cartography 1500-1800* (New York: A. R. Liss, 1979); Anna Friedman Herlihy, "Renaissance Star Charts," in David Woodward ed., *The History of Cartography Volume Three: Cartography in the European Renaissance Part 1* (Chicago: University of Chicago Press, 2007), 99-122.

[2] Listed as an editor is Giacomo Rho 羅雅谷, the Milanese Jesuit missionary who arrived in China aboard the same ship as Schall. Wu Mingchu 鄔明著 produced the drawings and diagrams. Celestial observations were conducted by Chen Yujie 陳于階, Meng Lüji 孟履吉, Yang Zhihua 楊之華, Huang Hongxian 黄宏憲, Zhu Maoyuan 祝懋元, Cheng Tingrui 程廷端, Zhu Goushou 朱國壽, and Zhang Caichen 張宷臣.

[3] On the epistemic image, from a vast literature, see: Alexander Marr, "Knowing Images," *Renaissance Quarterly* 69 (2016): 1000-13; Horst Bredekamp, Vera Dünkel, Birgit Schneider, *The Technical Image: A History of Styles in Scientific Imagery* (Chicago: University of Chicago Press, 2015), 1-5; Catelijne Coopmans, Janet Vertesi, Michael Lynch, and Steve Woolgar "Introduction: Representation in Scientific Practice Revisited," in Coopmans et. al eds., *Representation in Scientific Practice Revisited* (Cambridge, MA: MIT Press, 2014): 13-22; Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007), 17-51; James Elkins, "Art History and Images That Are Not Art," *The Art Bulletin* 77, no. 4 (1995): 553-71.

[4] David Hess, *Science and Technology in a Multicultural World: Cultural Politics of Facts and Artifacts* (New York: Columbia University Press, 1995), 54-86.

[5] D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 341.

[6] Chu Pingyi, "Scientific Texts in Contest, 1600-1800," in Florence Bretelle-Establet ed., *Looking at it from Asia: The Processes that Shaped the Sources of History of Science* (Heidelberg, London, and New York: Springer, 2010), 141-66.

[7] Lü Lingfeng, "Eclipses and the Victory of European Astronomy in China," *East Asian Science, Technology, and Medicine* 27 (2007): 127-45; Chu, "Archiving Knowledge," 160-3; Catherine Jami, *The Emperor's New Mathematics: Western Learning and Imperial Authority During the Kangzi Reign 1662-1722* (London and New York: Oxford University Press, 2012), 38-41.

[8] The Calendar Department published the *Chongzhen Lishu* gradually in five installments. Original copies are rare. Pingyi Chu "Archiving Knowledge: A Life History of the Calendrical Treatises of the Chongzhen Reign (*Chongzhen lishu*)," in Florence Bretelle-Establet and Karine Chemla eds., *What did it Mean to Write an Encyclopedia in China?*[special issue of *Extrême-Orient Extrême-Occident*] (2007): 159-84; Henri Bernard, "L'encyclopédie astronomique du P. Schall: La réforme du calendrier chinois sous l'influence de Clavius, de Galilée et de Kepler," *Monumenta Serica* 3 (1938), 63; Sun Xiaochun, "On the Star Catalogue and Atlas of Chongzhen Lishu," in Catherine Jami, Peter Engelfriet and Gregory Blue eds., *Statecraft and Intellectual Renewal in Late Ming China: The Cross-Cultural Synthesis of Xu Guangqi 1562-1633* (Leiden and Boston: Brill, 2001), 311-21; 徐光啓 (Xu Guangqi) and 潘鼐 (Pan Nai) eds., *崇禎曆書: 附西洋新法曆書增刊十種* (*Chongzhen li shu: fu xi yang xin fa li shu zeng kan shi zhong*) 2 vols. (Shanghai: 上海古籍出版社 [Shanghai gu ji chu ban she], 2009). On scholarly printing in the Late Ming period, see: Benjamin Elman, Collecting and Classifying: Ming Dynasty Compendia and Encyclopedias (Leishu)," *Extrême-Orient Extrême-Occident* 29 (2007): 131-57.

[9] Florence Hsia, *Sojourns in a Strange Land: Jesuits and Their Scientific Missions in Late Imperial China* (Chicago: University of Chicago Press, 2009), 30-50; Roger Hart, *Imagined Civilizations: China, the West, and Their First Encounter* (Baltimore: Johns Hopkins University Press, 2013); Keizo Hashimoto and Catherine Jami, "From the Elements to Calendar Reform: Xu Guangqi's Shaping of Mathematics and Astronomy," in *Statecraft and Intellectual Renewal in Late Ming*

China, 263-78. On the historiography of this issue, see: Catherine Jami, "'European Science in China' or 'Western Learning?' Representations of Cross-Cultural Transmission, 1600-1800," *Science in Context* 12, no. 3 (1999): 413-34.

[10] Matteo Ricci to Joao Alvarez, Beijing, 12 May 1605. Matteo Ricci, *Lettere (1580–1609)*, Francesco D'Arelli ed. (Macerata: Quodlibet, 2001), 406. Translation is D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 329-30.

[11] D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 329-30.

[12] By most counts, the Jesuit library's collection included over 7,000 books by 1620, a substantial portion of which covered mathematical subjects including astronomy.

[13] Pasquale d'Elia, *Galileo in China: Relations through the Roman College between Galileo and the Jesuit Scientist Missionaries 1610-1640*, Rufus Suter and Matthew Sciascia trans. (Cambridge, MA: Harvard University Press, 1960). Schall volunteered for the China mission soon after meeting Nicholas Trigcault in January 1616. He arrived in Macau from Portugal in July 1619, with a team that Trigault had recruited. Schreck was a most senior scholar among them, who not only was a member of the Academia dei Lincei but also a friend of Galileo Galilei and Johannes Kepler.

[14] On the use of scientific instruments in these efforts, see: Pingyi Chu, "Trust, Instruments, and Cross-Cultural Scientific Exchanges: Chinese Debate over the Shape of the Earth, 1600-1800*," Science in Context* 12 no. 3 (1999): 385-412; Keizo Hashimoto, "Johann Adam Schall and Astronomical Works on Star Mappings," in Malek ed., *Western Learning and Christianity in China*, vol. 1, pp. 517-32.

[15] Baichun, "The Introduction of European Astronomical Instruments," 99-131; Yi Shitong, "Several Newly-Found Astronomical Instruments Related to Johann Adam Schall von Bell," in Malek ed., *Western Learning and Christianity in China,* vol. 1, pp. 555-67.

[16] The Jesuits in Beijing made a conscious decision to learn *guanhua*, the language of the erudite literati. On the language training of Jesuit missionaries in Late Ming China, see Liam Brockey, *Journey to the East: The Jesuit Mission to China 1579-1724* (Cambridge, MA: Harvard University Press, 2007), 243-86.

[17] Zhang Zhishan, "Johann Adam Schall von Bell and his Book on the Telescopes," in Malek ed. *Western Learning and Christianity in China,* vol. 2, pp. 681-90. The treatise was later included in the *Chongzhen Lishu*.

[18] D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 341.

[19] "Ante mensem plus minus una cum aliquot libris quae [sic] Regi obtulimus praesentavi duo planisphaeria stellata ingentis magnitudinis, quae in serico impressa deauratis stellis, curavi agglutinali cratibus e levi ligno fabrefactis, plicatilibus more sinensi, ita ut facile hinc inde transferri et exponi possint, relictis superne ac infra marginibus, qui pulchre exornati gratissime totam machinam (ipsi *gwey pim* vocant) conspectui inge. Haec Rex diutius quam solet alia detinuit in conclavi, certo argumento ea sibi placuisse, quare nunc aggredior alia duo geographica eadem magnitudine et forma, quae prioribus associanda intromitterentur." Adam Schall to Father Theodore de Buzu, Assistant to the General of German Affairs, 1 Sept. 1634. Roman Archives of the Society of Jesus (Jap. Sin. 142.2). The letter is fully transcribed in Bernard, "L'Encyclopédie astronomique du Père Schall," Appendix I, pp. 483-93. The edition of the *Atlas* presented to the emperor, printed on silk, hand-colored and mounted onto a folding screen, was known as *Hengxing bingzhang* 恒星屏障 (Screen of Fixed Stars).

[20] Xiaochun, "On the Star Catalogue and Atlas of *Chongzhen Lishu*," 314.

[21] The preface and postscript to the *Atlas* are fully transcribed and Translated by Pasquale d'Elia. For this particular passage, see D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 349.

[22] D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 347; Xiaochun, "On the Star Catalogue and Atlas of *Chongzhen Lishu*," 313-4. The four maps were produced in the process of compiling the Chongzhen Lishu, and include: the General Atlas of Visible Stars 見界總星図, the *Double Atlas of Stars at the Equator* 赤道両總星図, the *Double Atlas of Stars at the Ecliptic* 黄道両總星図, and the *Ecliptical Star Atlas in Twenty Divisions* 黄道二十分星図.

[23] There is a fine example in the Toyo Bunko library in Tokyo, a deluxe imperial edition in Beijing's First Historical Archives colored in blue and gold and mounted on silk, and an exceptionally well-preserved, hand-colored set housed in the Vatican Library. The Bibliothèque National de France, Paris and the Staatsbibliothek zu Berlin have partial copies.

[24] Missionary scientists in Beijing like Schall could also rely on the 7,000-volume library of European books that they had amassed. Nicholas Standaert, "The Transmission of Renaissance Culture in Seventeenth Century China," *Renaissance Studies* 17, no. 3 (2003): 367-91, esp. pp. 378-82.

[25] Nick Kanas, *Star Maps: History, Artistry, and Cartography* (New York and London: Springer, 2012), 153-6; Johannes Bayer, *Uranometria: Omnium asterismorum continens schemata, nova metodo delineata, aereis laminis expressa* (Augsburg, 1603).

[26] Nathan Sivin, "Copernicus in China," in Idem., *Science in Ancient China: Research and Reflections* (Aldershot, Hampshire: Variorum, 1990 [1973]), 1-53.

[27] Astronomers like Schall and Rho, however, were free to share Tycho Brahe's geo-heliocentric model, as well as Johannes Kepler's defense of Copernicus (*Epitome of the Copernican System*, 1627) in China. Michael Mendillo, Patricia Burnham, Deborah Warner, and Samuel Edgerton, *Celestial Images: Antiquarian Astronomical Charts and Maps from the Mendillo Collection* (Seattle: University of Washington Press, 2005), 77; Sivin, "Copernicus in China," 1-53; 橋本敬造 (Keizo Hashimoto),「アダム・シャール・フォン・ベルとティコ・ブラーへの世界体系の中国への導入」 *関西大学社会学部紀要* 24, no. 2 (1993): 75-82.

[28] D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 354.

[29] Ibid, 346.

[30] Pasquale D'Elia, "Recent Discoveries and New Studies (1938-60) on the World Map in Chinese of Father Matteo Ricci S.J.," *Monumenta Serica* 20 (1961): 108-16; Boleslaw Szczesniak, "Matteo Ricci's Maps of China," *Imago Mundi* 11 (1954): 127-36; Theodore Foss, "Ricci's World Map: The 1602 *Kunyu Wanguo Quantu*," in Natasha Reichle ed., *China at the Center: Ricci and Verbiest - World Maps* (San Francisco: Asian Art Museum, 2016), 17-28.

[31] Benjamin Anderson, *Cosmos and Community in Early Medieval Art* (New Haven: Yale University Press, 2017); David Turnbull, *Masons, Tricksters, and Cartographers*: *Comparative Studies in the Sociology of Scientific Knowledge* (London: Routledge, 2000).

[32] Xiaochun, "On the Star Catalogue and Atlas of *Chongzhen Lishu*," 315.

[33] Chu, "Scientific Texts in Contest 1600-1800," 141-66; Hart, *Imagined Civilizations,* 195-256.

[34] "Acrecentó que a palavra *sy* [西], está totalménte desterrada, com el Rey no seu despácho chamar a regra de *sin fã* [新法], pretendendo de a honrar e alevantar com isso, e assi se alguém a chama *sý fã* [西法], he por desprezo, e pouco caso que faz." Adam Schall to Francisco Furtado, November 1640. Roman Archive of the Society of Jesus (Jap. Sin. 142. 5). The letter is fully transcribed in its original Portuguese in Alfons Väth, *Johann Adam Schall von Bell S.J.: Missionar in China, kaiserlicher Astronom und Ratgeber am Hofe von Peking, 1592-1666: ein Lebens- und Zeitbild*, (Nettetal: Steyler Verlag, 1991 [1933]), 356; Bernard, "L'Encyclopédie astronomique du Père Schall," Appendix III. The English translation is from Joseph Needham, *Science and Civilization in China, volume 3: Mathematics and the Sciences of the Heavens and the Earth* (Cambridge: Cambridge University Press, 1959), 449.

[35] Needham, *Science and Civilization in China, volume 3*, 169-458. See also: Zhang Baichun, "The Introduction of European Astronomical Instruments and the Related Technology into China during the Seventeenth Century," *East Asian Science, Technology, and Medicine* 20 (2003): 99-131.

[36] D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J.," 355-6.

[37] Xiaochun, "On the Star Catalogue and Atlas of *Chongzhen Lishu*," 315; Kanas, *Star Maps,* pp. 20-3.

[38] On the community-building role of scientific observation, see: Lorraine Daston, "The Empire of Observation: 1600-1800," in *Histories of Scientific Observation,* eds. Lorraine Daston and Elizabeth Lunbeck (Chicago: University of Chicago Press, 2011), 81-113.

[39] Xiaochun, "On the Star Catalogue and Atlas of *Chongzhen Lishu*," 314. The *Catalog of Fixed Stars* listed a total of 1765 stars by their Chinese names, of which only 1365 were given coordinates.

[40] Ibid. 314 and 316. These 447 "additional" stars were stellar bodies included in Chinese sources without coordinates because they were too faint to locate properly in the sky. The Calendar Department first published their *Catalog* with the names of these stars but without their coordinates, and used the production of the *Atlas* as an occasion to amend that data deficiency.

[41] Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007), 22.

[42] Giacomo Rho, *Wu-wei Li-chih 五緯曆指* (*Astronomical Handbook of the Five Planets*) in 徐光啓 (Xu Guangqi) and 潘鼐 (Pan Nai) eds. *崇禎曆書* (*Chongzhen lishu*), 347-490. English translations can be found in: Pasquale D'Elia, *Galileo in China: Relations through the Roman College between Galileo and the Jesuit Scientist-Missionaries 1610-1640*, trans. by Rufus Suter and Matthew Sciascia (Cambridge, Mass., Harvard University Press, 1960); 55; Willard Peterson, "Western Natural Philosophy Published in Late Ming China," *Proceedings of the American Philosophical Society* 117 no. 4 (1973): 295-322, esp. pp. 313-5.

[43] Zhang Baichun, "The Introduction of European Astronomical Instruments and the Related Technology into China during the Seventeenth Century," *East Asian Science, Technology, and Medicine* 20 (2003): 99-131; Yi Shitong, "Several Newly-Found Astronomical Instruments Related to Johann Adam Schall von Bell," in Malek ed., *Western Learning and Christianity in China,* vol. 1, pp. 555-67.

[44] D'Elia, *Galileo in China*, 45.

[45] On such agencies of atlases, see Daston and Galison, *Objectivity*, pp. 19-27.

[46] "Putat enim hoc hominum genus, philosophiam esse librum quendam velut Eneida et Odissea; vera autem non in mundo aut in natura, sed in confrontatione textuum (utor illorum verbum), esse quaerenda. Cur tecum diu ridere non possum?" Galileo to Johannes Kepler, 19 Aug. 1610, Vienna, Österreichische Nationalbibliothek, Prints and Manuscripts Collection, Cod. 10702, fol. 65-66. The letter is transcribed in Antonio Favaro ed., *Le Opere di Galileo Galilei*, vol. 10 (Florence: G. Barbèra, 1900), 423. On Galileo's reputation as an empiricist, see: Michael Segre, *In the Wake of Galileo* (New Brunswick, NJ: Rutgers University Press, 1991), 33-41; Mary Winkler and Albert van Helden, "Representing the Heavens: Galileo and Visual Astronomy," *Isis* 83, no. 2 (1992): 195-217. On the inter-relationship of science and humanism for Kepler, see Anthony Grafton, *Defenders of the Text: The Traditions of Scholarship in the Age of Science 1450-1800* (Cambridge MA: Harvard University Press, 1994), 178-203.

[47] On empiricism in early modern European science, see, Peter Dear, "Jesuit Mathematical Science and the Reconstitution of Experience in the Early Seventeenth Century," *Studies in History and Philosophy of Science* 18 (1987): 133-75; Pamela Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004); Gianna Pomata ed., *Historia: Empiricism and Erudition in Early Modern Europe* (Cambridge, MA: MIT Press, 2005), 1-40; Cynthia Klestinec, *Theaters of Anatomy: Students, Teachers, and Traditions of Dissection in Renaissance Venice* (Baltimore: Johns Hopkins University Press, 2011).

[48] Grafton, *Defenders of the Text,* Introduction; Brian Ogilvie, *The Science of Describing: Natural History in Renaissance Europe* (Chicago: University of Chicago Press, 2008).

[49] John R. Christianson, *On Tycho's Island: Tycho Brahe and his Assistants 1570-1601* (London: Cambridge University Press, 1999); Gurdrum Wolfschmidt, "The Observatories and Instruments of Tycho Brahe," *Acta Historica Astronomiae* 16 (2002): 203-16; Anna Friedman Herlihy, "Renaissance Star Charts," in David Woodward ed., *The History of Cartography, vol. 3.1: Cartography in the European Renaissance* (Chicago: University of Chicago Press, 2007), 99-122.

[50] Tycho Brahe, *Tycho Brahe's Description of his Instruments and Scientific Work* [*Astronomiae instauratae mechanica*, 1598], ed. and trans. by Hans Raeder, Elis Strömgren, and Bengt Strömgren (Copenhagen: I Kommission Hos Ejnar Munksgaard, 1946), 110-11.

[51] Galileo Galilei, *Sidereus Nuncius* (Venice: Baglioni, 1610); Idem. *Istoria e dimostrazioni intorno alle macchie solari e loro accidenti* (Rome: Mascardi, 1613).

[52] Winkler and Helden, "Representing the Heavens," 205-11; Ruth Noyes, "Mattheus Greuter's Sunspot Etchings for Galileo Galilei's *Macchie Solari* (1613)," *The Art Bulletin* 98, no. 4 (2016): 466-87.

[53] Martin Kemp, "A Question of Trust: Old Issues and New Technologies," in Coopmans et.al. eds., *Representation in Scientific Practice Revisited,* 343-46.

[54] Born in Cologne, Schall moves to Rome in 1608 and initially attends the Germanicum, the German-speaking pontifical seminary founded by Ignatius Loyola. He joins the Society of Jesus in October 1611, and is ordained in early 1618 before leaving for Macau in April that year. For Schall's biography, see Väth, *Johann Adam Schall von Bell S.J.*

[55] James Lattis, *Between Copernicus and Galileo: Christoph Clavius and the Collapse of Ptolomaic Cosmology* (Chicago: University of Chicago Press, 2010); Ugo Baldini ed., *Christoph Clavius e l'attività scientifica dei Gesuiti nell'età di Galileo* (Rome: Bulzoni, 1995); 466-87.

[56] On Grienberger, see: Michael John Gorman, "Mathematics and Modesty in the Society of Jesus: The Problems of Christoph Grienberger," in *The New Science and Jesuit Science: Seventeenth Century Perspectives*, Mordechai Feingold ed. (Dordrecht: Kluwer, 2003), 1-120.

[57] D'Elia, *Galileo in China*, 8-15; David Freedberg, *The Eye of the Lynx: Galileo, His Friends, and the Beginnings of Modern Natural History* (Chicago: University of Chicago Press, 2002), 108-15. Johann Schreck was also in attendance as a member of the Academia dei Lincei.

[58] Schall lived and worked in the Middle Kingdom, tenaciously surviving accusations of political conspiracies launched by court officials, and of heresy from his fellow brethren. On accusations of heresy brought against Schall in 1649 by the Jesuit Gabriel de Magalhães, see: Claudia von Collani, "Two Astronomers: Martino Martini and Johann Adam Schall von Bell," in Luisa Paternicò, Claudia von Collani, and Riccardo Scartezzini eds., *Martino Martini: Man of Dialogue* (Trento: Università degli Studi di Trento, 2016), 65-93; Väth, *Johann Adam Schall von Bell S.J.,* 253-9. On the charges of treason against Qing rule, see: Huang Yilong 黃一農, "Zeri zhi zheng yu Kangxi liyu 擇日之爭與康熙曆獄 (Disputes over the Selection of Dates and the Calendar Case during the Reign of Kangxi)," in *Qinghua xuebao 清華學報* (*Tsing Hua Journal of Chinese Studies*), 21, no. 1 (1991): 247-80; Shu-Jyuan Deiwiks, "The Secret Manchu Documents on the Trial of Jesuit Missionary Johann Adam Schall (1592-1666) before the Supreme Court of Peking," *Monumenta Serica* 51 (2003): 641-8; Eugenio Menegon, "Yang Guangxian's Opposition to Johann Adam Schall: Christianity and Western Science in His Work *Budeyi,*" in Roman Malek ed., *Western Learning and Christianity in China*: *The Contribution and Impact of Johann Adam Schall von Bell, S.J. 1592-1666,* 2 vols. Monumenta Serica Monograph Series 35 (Sankt Augustin, Germany: China-Zentrum and the Monumenta Serica Institute, 1998), vol. 1, pp. 311-37; Qiong Zhang, *Making the New World Their Own: Chinese Encounters with Jesuit Science in the Age of Discovery* (Leiden: Brill, 2015).

[59] From a vast literature on this subject, see: Walter Melion, "Introduction: The Jesuit Engagement with the Status and Functions of the Visual Image," in Walter Melion et al. eds., *Jesuit Image Theory* (Leiden and Boston: Brill, 2016), 1-53; Fréderic Cousinié, "The Mental Image in Representation," in Ralph De Koninck, Agnes Guiderdoni-Bruslé, and Walter Melion eds. *Ut Pictura Meditatio: The Meditative Image in Northern Art 1500-1700* (Turnhout: Brepols, 2011), 203-46. See also Evonne Levy, "Early Modern Jesuit Arts and Jesuit Visual Culture: A View form the Twenty-First Century," *Journal of Jesuit Studies* 1 (2014): 66-87.

[60] Jeffrey Chipps Smith, *Sensuous Worship: Jesuits and the Art of the Early Catholic Reformation in Germany* (Princeton, NJ: Princeton University Press, 2002), 29-40; Wietse de Boer, "Invisible Contemplation: A Paradox in the Spiritual Exercises," in Karl Enenkel and Walter Melion eds. *Meditatio - Refashioning the Self: Theory and Practice in Late Medieval and Early Modern Intellectual Culture* (Brill, 2010), 235-56; Dario Velandia Onofre, "Word and Image in Saint

Ignatius of Loyola: the Shaping of Visual Culture in Spain after the Council of Trent," *Word & Image* 34 no. 4 (2018): 332-48.

[61] On the sacred portraiture genre whose invention is attributed to Moroni, see: Aimee Ng, Simone Facchinetti, and Arturo Galansino, *Moroni: The Riches of Renaissance Portraiture,* exh.cat. (New York: The Frick Collection and Scala Art Publishers, 2019).

[62] Ignatius Loyola, *Exercitia Spiritualia* (Rome, 1548).

[63] On this topic, see Walter Melion's essay in this volume. See also Idem. "Artifice, Memory, and *Reformatio* in Hieronymus Natalis's *Adonationes et meditationes in Evangelia*," *Renaissance and Reformation* 22 no. 3 (1998): 5-34; Thomas Buser, "Jerome Nadal and Early Jesuit Art in Rome," *The Art Bulletin* 58 no. 3 (1976): 424-33. Ignatius is thought to have commissioned the volume initially. The illustrations were designed by Bernardino Passeri and engraved by the Wiericx brothers in Antwerp.

[64] Walter Melion, "The Art of Vision in Jerome Nadal's *Adnotationes et meditatones in Evangelia*," in Jerome Nadal, *Annotations and Meditations on the Gospels 3 vols*., ed. and trans. Frederick Homann S.J. (Philadelphia: Saint Joseph's University Press, 2003), vol. 1, pp. 1-96, especially pp. 9-32.

[65] Ibid. 9-14.

[66] Jerome Nadal, *Annotations and Meditations on the Gospels*, 3 vols. Frederick Homann trans. (Philadelphia: Saint Joseph University Press, 2005), vol. 3, p. 137.

[67] On the concept of the Middle Ground, see: Richard White, *The Middle Ground: Indians, Empires, and Republics in the Great Lakes Region, 1650-1815* (Cambridge: Cambridge University Press, 1991); Nicholas Thomas, *Entangled Objects: Exchange, Material Culture, and Colonialism in the Pacific* (Cambridge, MA: Harvard University Press, 1991). See also Francesca Trivellato, Leor Halevi, and Catia Antunes eds., *Religion and Trade: Cross-Cultural Exchanges in World History, 1000-1900* (New York: Oxford University Press, 2014).

[68] Hashimoto, "Jesuit Observations and Star-Mappings in Beijing," 129-46.

[69] Johannes Bayer, *Uranometria: Omnium asterismorum continens schemata, nova metodo delineata, aereis laminis expressa* (Augsburg, 1603). In the southern polar region, Bayer charted stars observed by the Dutch navigator Pietr Dirkz Keyser. On the role of European explorers in charting the stars in the southern hemisphere, see: Kanas, *Star Maps*, 117-26.

[70] Tycho Brahe, *Astronomiae instauratae progymnasmata,* Johannes Kepler ed. (Prague, Godfrey Tampach, 1602). The second volume in this two-volume book was published earlier at Uraniborg in 1588, and was titled *De Mundi Aetherei Recentioribus Phaenomenis Liber Secundus* (*Second Book About Recent Phenomena in the Celestial World*).

[71] To Tycho's list, Grienberger added the coordinates of 458 more stars. See Giancarlo Truffa, "The First Printed Edition of Tycho's 1004 Star Catalogue," *Acta Historica Astronomiae* 16 (2002): 310-22, esp. pp. 317-9.

[72] Hashimoto, "Jesuit Observations and Star-Mappings in Beijing as the Transmission of Scientific Knowledge," 134-9; D'Elia, "The Double Stellar Hemisphere of Johann Schall von Bell S.J." 336; Xiaochun, "On the Star Catalogue and Atlas of *Chongzhen Lishu*," 317-8.

[73] From a rapidly growing literature on this theme, see; Claire Farago, 'The Global Turn' in Art History: When and How Does it Matter?" in Daniel Savoy ed. *The Globalization of Renaissance Art: A Critical Review* (Leiden and Boston: Brill, 2017), 299-313; David Carrier, *A World Art History and its Objects* (University Park, PA: Pennsylvania State University Press, 2008).