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The Astronomical Images in the First Chinese Treatise on the Telescope by Johann Adam Schall von Bell Revisited

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A reanalysis of the eight astronomical images that Johann Adam Schall von Bell incorporated in the first Chinese treatise on the telescope to illustrate the telescopic discoveries made by Galileo Galilei shows that they were borrowed from the works on telescopic astronomy by Galileo Galilei and Johann Georg Locher, a student of Christopher Scheiner. Except minor changes to both Galileo's illustrations of the telescopic view of the moon and nebulae and Locher's illustration of sunspots, Locher's images about the phases of Venus and Jovian satellites were redrawn presumably to convey a clearer commitment to Tycho Brahe's system of the world and most of the contents in Locher's image of Saturn was replaced by Schall's own observation. These changes seem to be the result of two important factors that confined the transcultural transmission of astronomical knowledge from Europe to China through the Jesuits in the seventeenth century, namely the official standpoint of the Catholic Church on the ongoing cosmological issues and the cultural tradition of Chinese astronomy.

Keywords: Astronomical image, Jesuit astronomy, Johann Adam Schall von Bell, Telescopic discoveries, Transculturalism

Neubetrachtung der astronomischen Abbildungen in der ersten chinesischen Abhandlung über das Teleskop von Johann Adam Schall von Bell

Eine neue Betrachtung der acht astronomischen Abbildungen, die Johann Adam Schall von Bell zur Illustration der teleskopischen Entdeckungen von Galileo Galilei in die erste chinesische Abhandlung über das Teleskop aufgenommen hatte, zeigt dass sie den Arbeiten Galileo Galileis und Johann Georg Lochers, einem Studenten von Christoph Scheiner, über teleskopische Astronomie entlehnt worden sind. Während nur kleinere Veränderungen an zwei von Galileis Illustrationen der teleskopischen Ansichten des Mondes und von Nebeln sowie Lochers Darstellungen von Sonnenflecken vorgenommen worden sind, sind Lochers Abbildungen der Venusphasen und Jupitersatelliten neu gezeichnet worden, vermutlich um ein klareres Bekenntnis zu Tycho Brahes Weltsystem auszudrücken. Lochers Saturnabbildung ist mit Inhalten aus Schalls eigenen Beobachtungen ersetzt worden. Diese Veränderungen dürften das Ergebnis zweier Faktoren gewesen sein, die die transkulturelle Überlieferung astronomischem Wissens von Europa nach China durch die Jesuiten im 17. Jahrhundert beschränkt haben: der offizielle Standpunkt der Katholischen Kirche zu offenen kosmologischen Fragen und die kulturelle Tradition der chinesischen Astronomie.

Schlüsselwörter: Astronomische Abbildung, Jesuitische Astronomie, Johann Adam Schall von Bell, Teleskopische Entdeckungen, Transkulturalismus

In 1626, with the help of his Chinese disciple Li Zubai (李祖白, ?–1665), the German Jesuit on a mission to China, Johann Adam Schall von Bell (Chinese name 湯如望 Tang Ruwang or 湯若望 Tang Ruowang in its later form, 1591–1666) completed his second work in Chinese,[1] *An Explanation of the Far-seeing Glasses* (遠鏡説 *Yuanjing shuo, YJS*).[2] Historians have suggested that this widely disseminated first Chinese treatise on the telescope (D'Elia 1960: 33–41) corroborated the enormous influence of Jesuit sciences on China's scholarly approaches to the heavens before the mid-nineteenth century. Core evidence was provided by eight of its sixteen illustrations that delineate telescopic discoveries of Galileo Galilei (1564–1642). From the outset, there has been disagreement about the nature of this work. For the historian Fang Hao (方豪, 1910–1980), it was a translation of the *Telescopium, sive ars perficiendi novum illud Galilaei visorium instrumentum ad sidera* (*Telescope, or the Skill of Making Galilei's New Instrument for Observing Stars*), "the first book on the telescope," (Helden et al. 2010: 3) published in 1618 by the Italian mathematician Girolamo Sirtori (1580–?) (Fang 1948). A decade later, Pasquale d'Elia (1890–1963) while venturing that "Schall must have taken his clue precisely from this [book]," discounted that the *YJS* could be a translation, as it was apparently much shorter and not faithful to the *Telescopium*. My own comparison has verified D'Elia's rebuttal of the *YSL* as a translation of the *Telescopium*, but it also casts doubt on D'Elia's conclusion about Schall's source of inspiration, because not only are the content and focus of the two works very different, none of the eight astronomical images can really be connected to the *Telescopium*. Where then, did these images come from?

Among the early sixteenth-century European literature on telescopes and telescopic astronomy, there are two obvious candidates: (1) Galileo Galilei's *Sidereus nuncius* (*Sidereal Messenger*, 1610) and (2) *Disquisitiones mathematicae, de controversiis et novitatibus astronomicis* (*Mathematical Disquisitions, concerning the Astronomical Controversies and Novelties*, 1614) by the German astronomer Johann Georg Locher written under the supervision of his teacher, the famous Jesuit astronomer Christopher Scheiner (1573/75–1650) at the University of Ingolstadt (Graney 2019). A comparison of the eight astronomical images in the *YJS* to images found in these texts indicates that while some show resemblance to images in both works, others seem entirely new. For instance, interesting changes were made to more clearly express the astronomical thought that Schall hoped to convey. Some of the changes seem to be concessions made to the Chinese readership. In the following I first compare the contents and illustrative means of the *Telescopium* and the *YJS*, and then discuss the relation between the eight images of the *YJS* and their originals in the works of Galilei and Locher. Analyzing the purpose, content and use of texts and images in the *YJS* and its European sources, I ask how the Jesuit astronomer Schall in China reformulated European astronomical knowledge. Furthermore, I inquire into Schall's astronomical knowledge, his approach to his Chinese audience, and show how he not only reformulated the text but made changes to the images too.

The *Telescopium*

The Milanese scholar Girolamo Sirtori compiled the *Telescopium* in 1612, but it was first published in 1618 (Sirtori 1618). The work consists of thirty-one chapters and is grouped into three parts (Table 1). The five chapters in Part I provide basic knowledge about eye-glasses, telescopes, lenses and a chart specifying the so-called 'proportions' of the lens and the telescope which the author claimed to be a key to the construction of the telescope; the twenty-two chapters in Part II provide the reader with step by step instructions to construct a Galilean refracting telescope, especially the skills and tools required for grinding and polishing the objective and the eyepiece lens of a telescope; and the four chapters in Part III report on the author's own achievements in telescope construction (Molesini 2010).

The *YJS*

The main body of the *YJS* consists of four chapters entitled "On uses (利用 Liyong)," "An appendix on the benefits of separated uses (附分用之利 Fu fengyong zhi li)," "On causes (原繇 Yuanyou)," and "Rules of production, rules of use (造法用法 Zaofa yongfa)." Much shorter than the *Telescopium*, the YJS has similarly explicit and self-explanatory chapter titles. They are here translated and reviewed in detail to provide a basis of comparison.

As the table of contents (Table 2) illustrates, the chapter "On uses" includes two sections. The first section "Use for upward sighting (利用於仰觀 Liyong yu yangguan)" introduces the application of the telescope on astronomical observations, where Galileo's telescopic discoveries are listed as examples, including the mountains and valleys on the moon, the phase of Venus, sunspots, the satellites of Jupiter, the two 'little stars' on both sides of Saturn (formed by the rings of Saturn), as well as nebulae and the milky way; while the second section "Use for level sighting (利用於直視 Liyong yu zhishi)" introduces the application of the telescope for observing objects on both sea and land (including the military use of the telescope), as well as on image projection and drawing (camera obscura).

Table 1 The Contents of Sirtori's *Telescopium*

Parts	Chapters	Pages
I	Ch. 1. *De Perspicillis praecognoscenda quaedam*	15.5
	Some preliminary remarks about dioptric vision aids	
	Ch. 2. *Quis & quotuplex perspicillorum usus*	
	Some and multiple uses of the dioptric vision aids	
	Ch. 3. *De hodierna huius artis corruptela*	
	On the present corruption of this art	
	Ch. 4. *Diuisio & circumscriptio spicillorum ex eorum proprietate*	
	The classification and forms (contours) of vision-aiding glasses according to their properties	
	De Planis; de conuexus, de cauis	
	Ibid. On the plane, the convex, the concave (lenses)	
	Ch 5. *Declaratio Tabulae ut attinet ad Telescopium*	
	The explanation of the drawing as it pertains to the telescope	
II	Ch. 1. *De Constructione Telescopij*	50.5
	On the construction of the telescope	
	Ch. 2. *De Ratione parandae siue elaborandae Laminae planae*	
	On the art to prepare or to work out the plane lamina	
	Ch. 3. *De praeparatione formae quae perficit conuexum lentis*	
	On the preparation of the form which completes the convex (kind) of lens	
	Ch. 4. *De globulo ferro ad peripheriam Galilaei comparando cauum spicillum Telescopii perficiente*	
	Applying the surface of Galilei's iron ball completes the concave (kind) of the lens of the telescope	
	Ch. 5. *De Vitro & Christallo dignoscendo, & deligendo*	
	On distinguishing and selecting glass and crystal	
	Ch. 6. *De Christallo naturali, vulgo Montano*	
	On natural crystal, normally called mountainous	
	Ch. 7. *De lente ex rude officina deligenda*	
	On selecting a raw lens from a workshop	
	Ch. 8. *De Latitudine, & craßitie lentis*	
	On breadth, and thickness of a lens	
	Ch. 9. *De capulo, & de bitumine quo lens affigitur*	
	On a bowl, and on pitch with which lens is attached	
	Ch. 10. *Qua arte & quibus cautelis lens perficiatur*	
	By which technique and precautions the lens is accomplished	
	Ch. 11. *Smiris tenuissimus puluisculus poliendo christallo ut praeparetur*	
	The crystal must be polished with the finest dust of corundum in order to be finished	

Table 1 (Continued)

Parts	Chapters	Pages
	Ch. 12. *Lens & spicilla qua arte expoliantur & illustrentur*	
	By which technique are lenses and eye-glasses polished and cleared	
	Ch. 13. *De Smethicis, Stanno combusto, Aqua forti, Aceto*	
	On detergents, tin sulphide, aqua fortis, vinegar	
	Ch. 14. *Tripolis laudatur, deligitur & praeparatur*	
	Tripolis (alumina) is named, selected and prepared.	
	Ch. 15. *Globulus ferreus quomodo aptandus operi*	
	How the application of the iron ball works	
	Ch. 16. *Cauum spicillum Telescopii ut perficiatur*	
	How the concave eye-glass of a telescope is accomplished	
	Ch. 17. *De Spicillo ex una parte tantum cauo*	
	On the eye-glass that is concave on one side only	
	Ch. 18. *Summatim de perspicillis communibus*	
	Summary of the ordinary telescope	
	Ch. 19. *De praeparatione tubi in quo lens cum spicillo componitur*	
	On the preparation of the tube, into which the lens is put with the eye-glass	
	Ch. 20. *De Tubis cartaceis componendis ad experimenta capienda tam lentis quam aliorum spicillorum*	
	On the fabrication of paper tubes, for testing lenses as well as other eye-glasses	
	Ch. 21. *De Circino secante huic arti pernecessario*	
	On the dividing circle, which is needed in this art	
	Ch. 22. *Summatim recensentur accidentia que interuertant Telescopii opus*	
	The events are briefly reviewed that may overturn the work of the telescope	
III	Ch. 1. *Facilior alterius Telescopii fabrica monstratur*	8
	Demonstration of how to produce a telescope easily	
	It is revealed how to make easily another (kind) of telescope	
	Ch. 2. *De Admirando meo Telescopio triplici*	
	On my remarkable telescope in three ways	
	Ch. 3. *Ordo parandi mei Telescopii*	
	The order of preparing my telescope	
	Ch. 4. *De Tubo*	
	On the tube	

Table 2 The Contents of *YJS*

Parts	Chapters	Pages
YJS	Ch. 1. On uses (利用 Liyong)	12.5
	1.1 Use for upward sighting (利用於仰觀 Liyong yu yangguan)	
	1.2 Use for level sighting (利用於直視 Liyong yu zhishi)	
	Ch. 2. An appendix on the benefits of separated uses (附分用之利Fufenyong zhili)	
	2.1 Use for those suffering from myopia (利用於苦近視者用之Liyu kujinshi zhe yongzhi)	
	2.2 Use for those suffering from hyperopia (利用于苦遠視者用之Liyu ku yuanzhi zhe yongzhi)	9.5
	2.3 On the inferior benefits of itemized use and the invariable benefits of a combined use (分用不如合用之無不利 Fenyong buru heyong zhi wubuli)	
	Ch. 3. On causes (原繇Yuanyao)	
	3.1 Causes for the use of the telescope in producing diverse imagining effects through its unique capacity of refraction (易象不同而遠鏡獨妙於斜透以為利用之原Yixiang butonger yuanjing du miaoyu xietou yiwei liyong zhiyuan)	9.5
	3.2 Reasons for capacity of the telescope to catch and bend diverse rays of light (射線不一而遠鏡攝乎屈曲以為透射之繇Shexian buyi er yuanjingjia shehu ququ yi wei xietou zhi you)	
	3.3 The causes for the magnification and clarification of imagery through a combined use of the two types of lenses (視象明而大者繇乎二鏡之合用Shixiang mingerda zhe youhu erjing zhi heyong)	
	Ch. 4. On the process of making and using (造法用法Zaofa yongfa)	
	4.1 On lenses (鏡Jing)	
	4.2 On the tube (筒Tong)	
	4.3 On fitting to the distance (遠近各得其宜Yuanjing gede qiyi)	
	4.4 On protection from dazzling for an easy observation (避眩便觀 Bixuan bianguan)	
	4.5 On setting and adjustment (安放調停 Anfang tiaoting)	
	4.6 Tips for users with weak and shortsighted eyes (衰目短視用訣 Shuaimuduanshiyongjue)	
	4.7 On projecting images for drawing (借照作畫Jiezhaozuohua)	
	4.8 Tips for practical/habitual use (習用訣 Xiyongjue)	
	4.9 Tips for getting rid of dirt (去垢訣 Qugoujue)	

The three sections in the chapter "An appendix on the additional benefits of separated uses" deal with an itemized application of both convex and concave lenses.

The sections "Use for those suffering from myopia (利於苦近視者用之 Liyu ku jinshi zhe yongzhi)" and "Use for those suffering from hyperopia (利於苦遠視者用之 Liyu ku yuanzhi zhe yongzhi)" describe the effects and causes of the convex and concave lenses in the correction of myopia and hyperopia, while the section "On the inferior benefits of the itemized use and the invariable benefits of a combined use (分用不如合用之無不利 Fenyong buru heyong zhi wubuli)" explains how appropriate combinations of convex and concave lenses can improve the eyesight of people with different visual acuity.

The chapter "On causes" treats the optical principles of the lens and the telescope, and is divided into three sections. The first section "Causes for the use of the telescope in producing diverse imagining effects through its unique capacity of refraction (易象不同而遠鏡獨妙於斜透以為利用之原 Yixiang butong er yuanjing du miaoyu xietou yiwei liyong zhiyuan)" explains the rule of refraction, the second section "Reasons for the capacity of the telescope to catch and bend diverse rays of light (射線不一而遠鏡兼攝乎屈曲以為斜透之繇 Xieshe buyi er yuanjing jiashe hu ququ yiwei xietou zhiyou)" talks about cause of refraction in the telescope, and the third section "The cause for the magnification and clarification of imagery through the combined use of the two types of lenses (視象明而大者繇乎二鏡之合用 Shixiang mingerda zhe youhu erjing zhi heyong)" explains why a combination of two types of lenses can magnify targets at a far distance.

The chapter "On the processes of making and using" contains nine sections about the making and use of the telescope. The first section "On lenses (鏡 Jing)" describes both the convex and concave lenses and their proper combination in a telescope. The second section "On the tube (筒 Tong)" deals with the foldability of the tube on a telescope. The third section "On fitting to the distance (遠近各得其宜 Yuanjing gede qiyi)" treats the adjustment of the tube to an appropriate length according to the distance to observe. The fourth section "On protection from dazzling for an easy observation (避眩便觀 Bixuan bianguan)" introduces the measures taken to protect the eye from direct sunlight. The following three sections are called (5) "On setting and adjustment (安放調停 Anfang tiaoting)," (6) "Tips for users with weak and shortsighted eyes (衰目短視用訣 Shuaimu duanshi yongjue)," and (7) "On projecting images for drawing (借照作畫 Jiezhao zuohua)." They describe how to (5) set up and adjust the telescope for observation, (6) achieve a better view in the telescope if the user has weak eyesight or is shortsighted, and (7) project an outdoor image traced (with a telescope) through a dark room onto a paper to be traced. The eighth and ninth sections are “Tips for practical use (習用訣 Xiyong jue)” and “Tips for getting rid of dirt (去垢訣 Qugou jue).” They describe how to become more experienced and skillful in the use of a telescope, and how to clean the telescope.

As this juxtaposition reveals at a glance, the *YJS* and *Telescopium* are different in purpose, focus, structure and content, even though both deal with the telescope. The *Telescopium* consists of three parts almost exclusively devoted to the technical details of how to construct a high-quality refracting telescope. Schall’s focus, however, is on the usefulness of the lens and the telescope, confirming the *YJS*’s purpose as a promotional handbook, meant to introduce the telescope to Chinese literati elites in a general, intelligible and attractive way. That is the reason why “at the beginning [of the book] one sees a picture of a magnificent telescope pointed at the sky” (D’Elia 1960: 37), namely “A Picture of the Telescope (遠鏡圖 Yuanjing tu)” (Fig. 1) (Tang & Li 1626: front matter 2b). The first two chapters of explicit promotion take up twelve and a half double-sided pages, including the eight astronomical images illustrating Galillei’s telescopic discoveries, which are discussed further on later, and three other images illustrating the use of convex and concave lenses to correct eyesight (Fig. 2) (Tang & Li 1626: 5b–6b), whereas only two pages without illustration in the *Telescopium* are devoted to a brief introduction of the uses of eye-glasses and the causes why they are needed, where no mention is made about any astronomical application of the telescope. The elaboration of scientific principles that follow in the third chapter emphasizes concerns of Schall that are not touched upon at all in the *Telescopium*. These take up nine and a half double-sided pages, including two illustrations demonstrating the refraction effect of water in a bowl (Fig. 3) (Tang & Li 1626: 8a, 9a) and two illustrations showing the optical effect of a pair of lenses with respect to the eye (Fig. 4) (Tang & Li 1626: 11a–11b). The second section of the fourth chapter, which takes up another nine and a half double-sided pages, again highlights practical applications of the telescope. Only one double-sided page in this final chapter is devoted to the so-called “construction”, where one can read a very brief description of the object lens, the eyepiece lens and the tube. The actual process of production is not tackled.

Indeed, with all these differences in mind, we cannot agree that the *YJS* is a translation of the *Telescopium;* neither do we believe that “Schall must have taken his clue precisely from this [book]”, as D’Elia claimed (1960: 34). Further evidence is provided by the images used in the two books. The *YJS* contains sixteen illustrations, fifteen of them come with textual explanations and thus constitute the major part and main body of the *YJS.* In the *Telescopium*, we also find eighteen illustrations about procedures and tools used in the production of the telescope, but none of them have

Fig. 1 Picture of the telescope

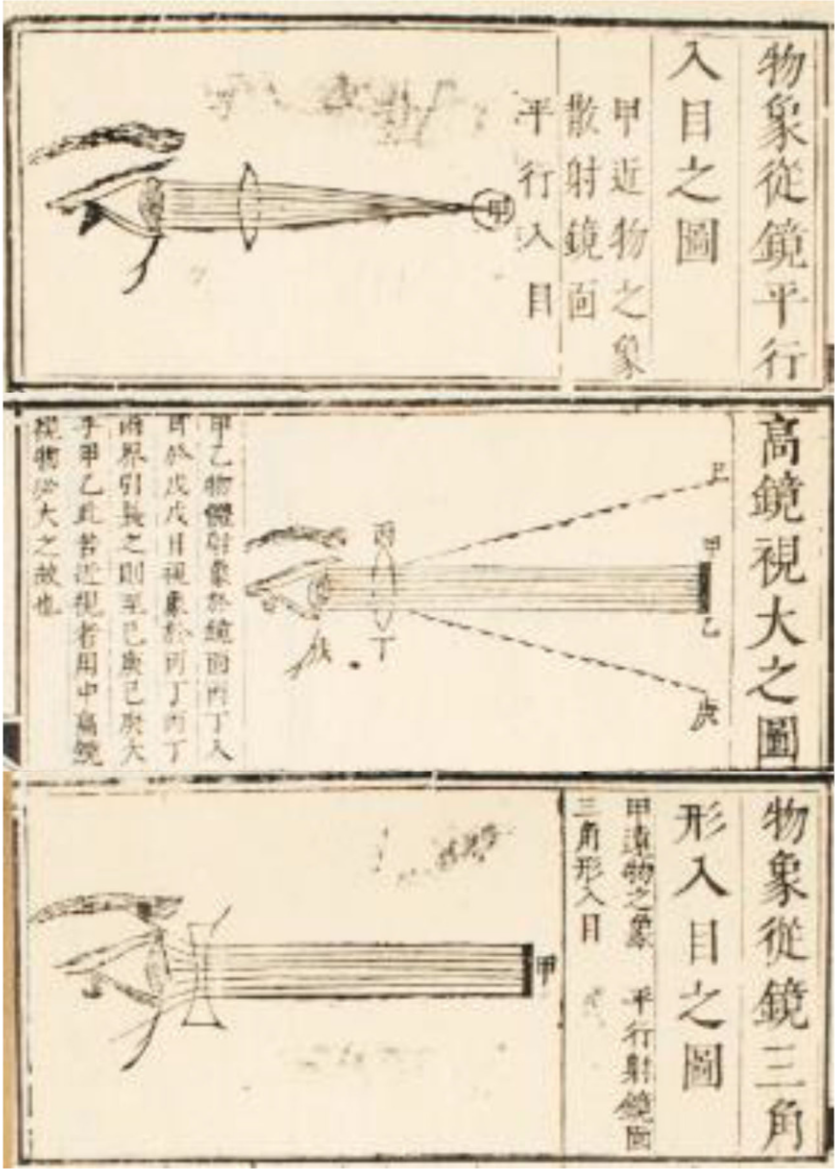

Fig. 2 Effects of individual lenses

any connection with the images in the *YJS*. A close look at the illustrations in the *YJS* suggests that they are borrowed from works by Galilei and Locher, and are adjusted to Schall own agenda and even mixed with his own experience when it is possible. This approach seems quite distant to that of a translation of selected sources. Identifying the prototypes of

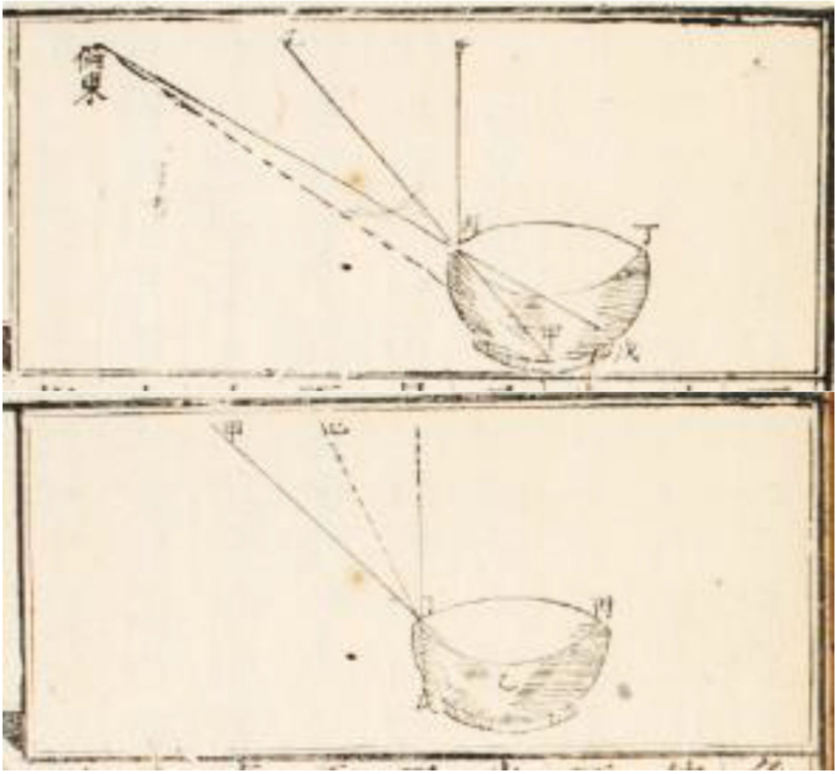

Fig. 3 Refraction of water in a bowl

these illustrations unfolds the nature of adaptations, helps us consider the motivations of the author of *YJS* as well as elucidate his practices and ideas of observing the heavens.

The Sources of the Astronomical Images in the *YJS*

The images in the *YJS* are, as far as we know, the very first depictions of the telescope to ever appear in a Chinese book, except for *Tianwen lüe* 天問略 by the Portuguese Jesuit Emmanuel Diaz (Chinese name 陽瑪諾 Yang Manuo, 1574–1659). In this book, Diaz included an image of the strange appearance of Saturn as seen in a telescope (D'Elia 1960: 18; Leitão 2008: 115). As mentioned above, the *YJS* includes a set of sixteen illustrations. The second to the ninth of them are astronomical images about the new telescopic discoveries made by Galileo.

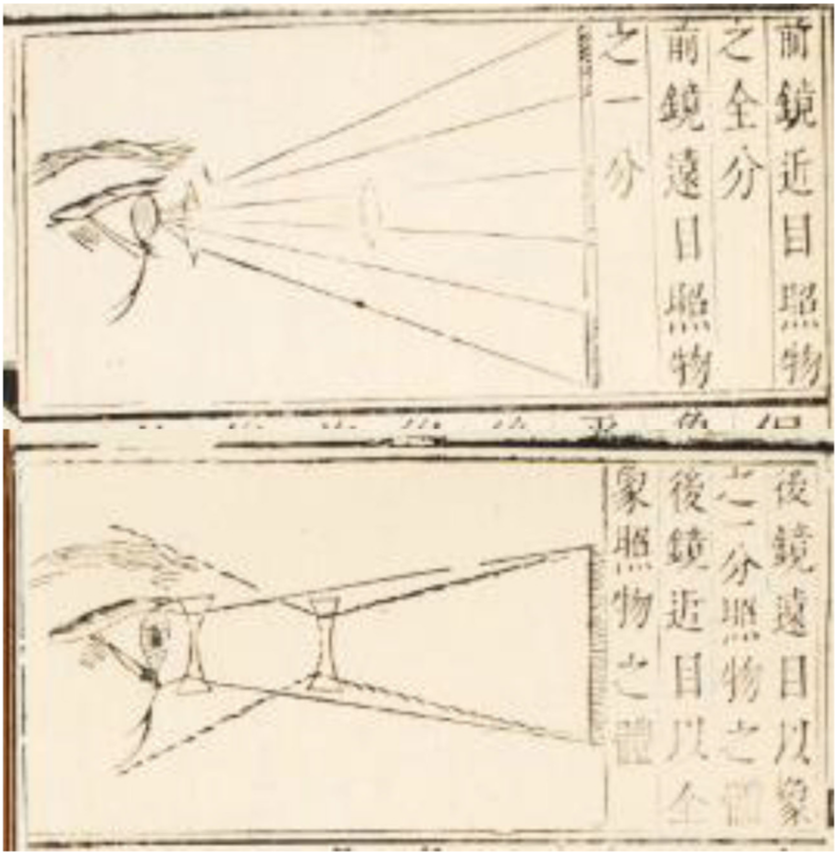

Fig. 4 Effects of a pair of lenses

While the *YSL* does not specify the sources of the illustrations in Fig. 1 to Fig. 4 above, some features and methods used for the eight astronomical images clearly resonate with other literature in Europe. Seven of them are discussed in the following showing how Schall borrowed them selectively from the works of Galileo and Locher, and thus adapted Galileo's arguments to a Jesuit view of the world.

The first two astronomical images are about the telescopic observation of the moon on the fourth day and the first quarter of a lunar month (Fig. 5) (Tang & Li 1626: 1b). The textual explanation on the same page is a very brief summary of Galileo's discovery and discussion regarding the surface topography of the moon:

> When observing the moon with a telescope, some places on its surface emerge as bulged and bright, and others as hollow and dim. Perhaps

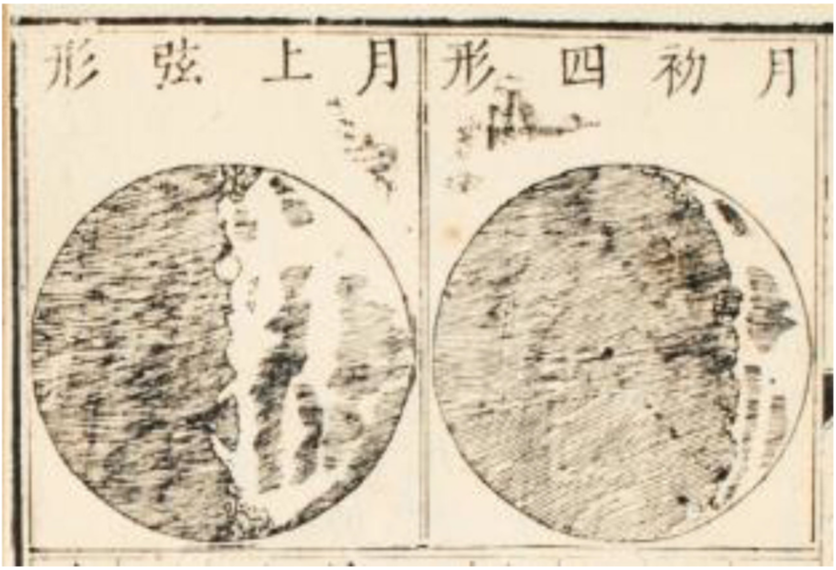

Fig. 5 Telescopic images of the moon

> this can be likened to how the first morning sunshine is reflected or caught on mountain tops that thus become bright. When observing the moon, try to put the telescope on one eye but put nothing on the other. Sizes will be remarkably different [to those observed when looking with both eyes]. (Tang & Li 1626: 1b)

As a comparison reveals, the image on the right of Fig. 5, "The Moon's Shape on the Fourth Day [of a Lunar Month] (月初四形 Yue chusi xing)," is related to Galileo's first image of the moon in the *Sidereus nuncius* (Fig. 6b) (Galilei 1610 [1989]: 41), while "The Moon's Shape in First Quarter (月上弦形 Yue shangxian xing)" (Fig. 5b) is related to Galileo's third or fifth image of the moon in the same book (Fig. 6a) (Galilei 1610 [1989]: 45–46) after being rotated 180 degrees clockwise as compared with Galilei's images in the Venice version of the *Sidereus nuncius* (Fig. 6a) (Galilei 1610 [1989]: 45–46). The two images seem to be based directly on the corresponding images in the Frankfurt pirate version of the same work, wherein the image for the first quarter is already rotated 180 degrees clockwise (Galilei 1610: 13, 16–18).

The third astronomical image in the *YJS*, "Picture of the Waning and Waxing plus First and Last Quarters of Venus (金星消長上下弦之圖Jinxing xiaozhang shangxiaxian zhitu)" (Fig. 7a) (Tang & Li 1626: 2a), is about the phases of Venus as seen in a telescope. The text explains the image as follows:

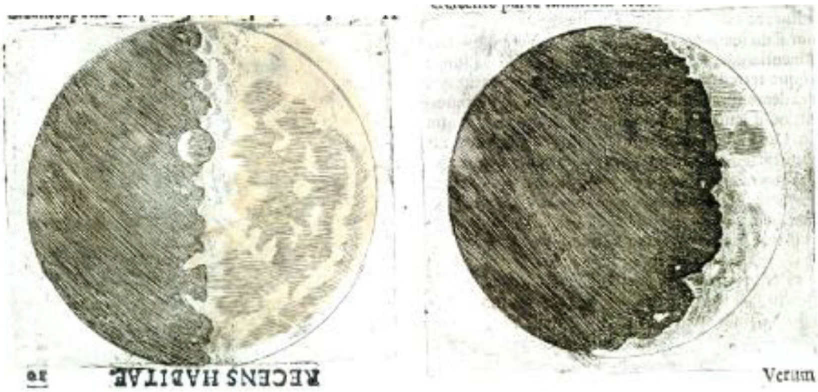

Fig. 6 Galileo's Images of the Moon from the Venetian version of the Sidereus Nuncius

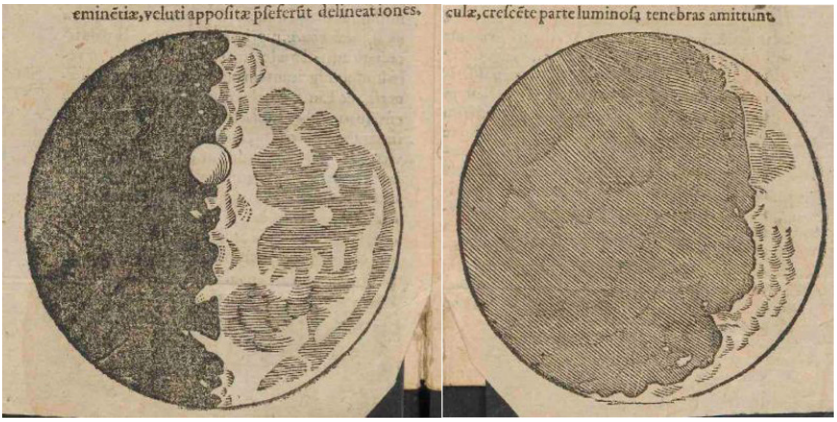

Fig. 7 Galilei's Images of the Moon from the Frankfurt version of the Sidereus Nuncius

> When observing Venus with a telescope, one can see it waning and waxing, showing phases from the first to the fourth quarters, just like the moon. The waning and waxing within the first to the last quarter takes place in a period of a year, which resembles the changing phases of the moon in a month. One can also see that the body of Venus changes its size through time. These changes indicate its movement around the sun. When it is above the sun, it will be in full brightness. When below the sun, its brightness will be weak. The size of its body looks different, depending on whether it is above or below, to the left or the right of the sun (Tang & Li 1626: 1b–2a).

Although Galileo was the first astronomer who observed and explained the phases of Venus, the picture here is not taken from his *Istoria e di-*

mostrazioni intorno alle macchie solari e loro accidenti (*The History and Demonstration Concerning Sunspots and Their Properties*, 1613) wherein he first announced his discovery and explained the phenomenon in favor of heliocentrism (Drake 1957: 93–94). Instead, Schall seems to have adapted a similar picture from Locher's *Disquisitiones* (Fig. 7b) (Locher 1614: 76; Graney 2017: 122). Compared with Locher's illustration that is centered on the eye of an observer, the picture in the *YJS* gives the reader a much clearer idea about the scheme of the world adopted by Schall, where the circle of the sun is centered on the earth while Venus revolves around the sun. This is a clear expression of the Tychonic system of the world that both the Catholic Church and the Society of Jesus supported. Moreover, Schall's explanation above is obviously based on Locher's discussion of the phenomenon in the same book, especially the following paragraphs which I cite for comparison:[3]

> Disquisition 38
> Concerning Venus.
> Venus is revolved around the sun, according to the teaching of ancients and according to phenomena now recently discovered. Through the course of a year Venus displays the monthly phases of the moon—a most delightful spectacle. Indeed, when most distant from Earth, Venus displays full phase, followed by gibbous, then then half-full phase when at its middle distance from Earth, then crescent a little later, and finally, when closest to Earth, it is dark and cannot be seen. Such illuminations necessitate that Venus circles around the sun.
> [...]
> This variety of appearances proves Venus passes on both the far side and the near side of the sun. <A whole Venus is on the far side of the sun.> That it appears whole and very small proves it to pass on the far side. <A half Venus is on the near side of the sun.> That Venus is seen to be a dark body, half illuminated, half in shadow demonstrates that it passes on the near side. (Graney 2017:120–121)

The fourth astronomical image in the *YJS*, "Picture of the Sun (太陽之圖 Taiyang zhitu)" (Fig. 8a) (Tang & Li 1626: 2b) delineates a telescopic observation of the sun. The text corresponding to the picture reads:

> When observing the rise and set of the sun with a telescope, the body is not perfectly round, but resembles a hen's egg. Perhaps this is due to the dusty vapor (塵氣 Chenqi) that, when rising into the sky, blurs sights. When observations are done at the hours of dawn *mao* 卯 and dusk *you* 酉, the rim of the sun's disk appears uneven with a jagged

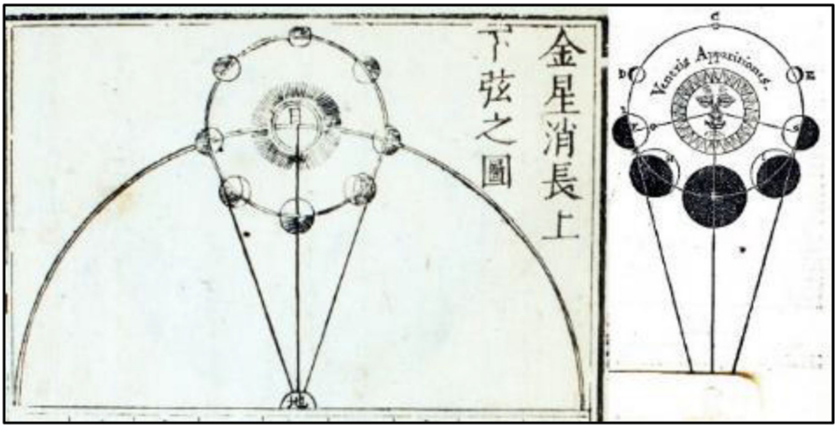

Fig. 8 Picture of the phases of Venus in YJS (**a**) and Disquisitiones mathematicae (**b**)

> edges. Dark spots are floating on the sun's surface which can differ in size and amount. They come out and disappear in groups, wandering across the surface of the sun and returning regularly in a cycle of fourteen days. While the front spots re-appear [from the west rim of the sun], the rear spots disappear [into the east rim]. The time [for the occurrence of the spots] is not regular at all. Nobody understands its causes. (Tang & Li 1626: 2b–3a)

Once again, this picture is not taken from Galileo's published work on sunspots, the *Istoria*, but adapted with little change from Locher's *Disquisitiones* (Fig. 8b) (Locher 1614: 65; Graney 2017: 102), while the explanation is evidently a digest of the relevant texts in the same book which I quote as follows:

> Disquisition 29
> Concerning the sun
> [...]
> An eye located at A on Earth sees daily wonders when observing the sun, especially when aided by the keen vision of the optic tube. It beholds the sun to be elliptical in shape when it is rising B and setting C. And regularly during rising, occasionally during setting, the eye finds that the sun, when on the horizon, will be mangled and have jagged edges and at the same time be trembling energetically. The eye will always find the sun to be sprinkled everywhere as if by dark spots and bright blazes. [...].
> Disquisition 30
> The spots on the sun

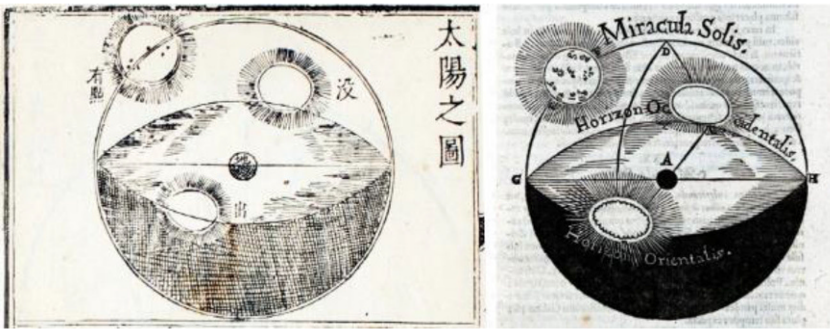

Fig. 9 Picture of the sun in YJS (**a**) and Disquisitiones (**b**)

> The spots are blackish bodies, roving around the sun by various motions. Thus far neither their number nor their nature has been determined. They are so close to the sun that they seem to be attached to it. […]
> Disquisition 32
> The elliptical sun.
> […] The elliptical sun is spawned by a perpendicular refraction that also explains many other things: why the sun appears higher than it should be; […].
> Disquisition 33
> The unevenness of the sun
> […] The one and only cause of this is the vapors present between us and the sun. These lie quite still over the lands throughout the night, but in the morning, they are aroused by the warming rays of the sun. When heated, they rise. And, because they fluctuate and change in shape, because they are not perfectly diaphanous, because they carry water vapor in varying amounts, they agitate, cleave, mangle, and despoil amazingly the solar light that is passing through them toward our eyes. […]. (Graney 2017: 101–105)

Apparently, Locher's understanding of sunspots is more like that of Galillei, who believed that the spots were located on the surface of the sun, rather than small bodies orbiting the sun as Scheiner suggested (Taton & Wilson 1989: 93; Drake 1957: 83, 106).

The fifth astronomical image in the *YJS*, "Picture of Four Stars Following Jupiter (四星隨木之圖Sixing suimu zhitu)" (Fig. 9a) (Tang & Li 1626: 3a), illustrates the four satellites that revolve around Jupiter. The explanation of the picture is quite brief as well:

> When observing Jupiter with a telescope, we can see four little stars accompanying it nearby and guarding the King of Wood. The motions of the four company stars of Jupiter are regularly patterned in fixed periods. From time to time, the eclipse can happen. Therefore it is clear that they are not stars on the Heaven of the Lodges (宿天 Xiutian). In order to learn their distances from Jupiter, you have to first study the positions of their circular orbits, and then [the distances] can be calculated. (Tang & Li 1626: 3a)

Adapted from Locher's *Disquisitiones* (Fig. 9b) is a picture of the Jovian satellites (Locher 1614: 81; Graney 2017: 129), the picture is redrawn again for a clearer expression of the cosmological commitment. What Schall added are two circles of the sun and Jupiter, as well as a circle representing the heaven of the fixed stars, which the *YJS* titles as "The Heaven of the Lodges" (宿天 Xiutian). All of them are centered on the earth (地 Di), rather than on the eye as in Locher's original picture. The image assumes a pure geocentric system, rather than the geo-heliocentric system proposed by Tycho Brahe. As far as the explanation in the *YJS* is concerned, clear connection can be found again with Locher's very long discussion of the motions of Jovian satellites, particularly the following texts:

> Disquisition 39
> Concerning the Satellites of Jupiter
> The remarkable company of Jupiter, first detected a few years ago by the outstanding, skilled, and learned Italian mathematician Galileo [...] has seized the admiration of the whole school of astronomers, for four attendants or satellites, each different in motion, size, and distance, circle around Jupiter as though it were their lord.
> [...]
> They are eclipsed by Jupiter when moving toward the east, on the far side, never when moving toward the west. Therefore, sometimes they are closer than Jupiter and sometimes farther.
> [...]
> Disquisition 40
> [Detailed discussion of the determination of the periods and distances of the four Jovian satellites.]. (Graney 2017: 124–131)

The seventh and eighth astronomical images in the *YJS,* entitled "Diagram of the *Qi* of Piled Corpses (積尸氣圖 Jishiqi tu)" (Fig. 10b) and "Diagram of the Lodge of the Mouth (觜宿之圖 Zixiu zhitu)" (Fig. 10a) (Tang & Li 1626: 4a) show the increased number of stars that can be observed with a telescope in the two Chinese constellations, the *Qi* of Piled

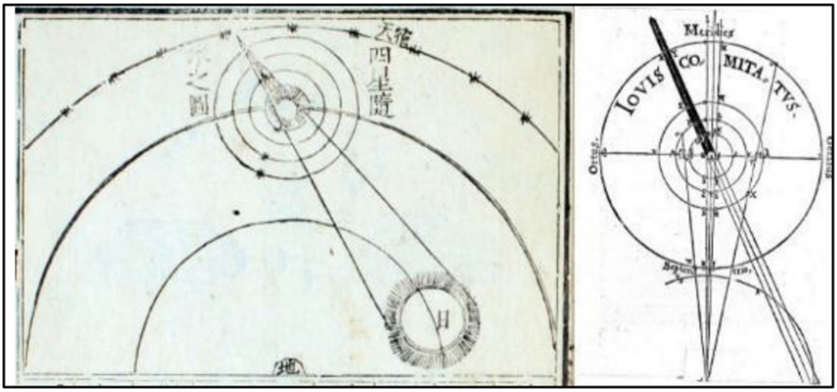

Fig. 10 Picture of the Jovian satellites in YJS (**a**) and Disquisitiones (**b**)

Corpses (積尸氣 Jishiqi) and the Lodge of the Mouth (觜宿 Zixiu). The text comments on these two images as follows:

> Observing the stars on the Heaven of the Lodges with a telescope, the number [of visible stars] is at least several tens more than [that seen] by ordinary plain-eye observation. The *Qi* of Piled Corpses in the Lodge of Ghost (鬼宿 Guixiu), the north star in the Lodge of the Mouth and the various small stars in the Silver River (銀河 Yinhe) are all difficult to see. In a telescope, however, they become very clear. (Tang & Li 1626: 3b–4b)

Both of these two pictures can be determined as copies of Galileo's illustrations of the telescopic view of the Nebulae of Orion (corresponding to the Lodge of the Mouth) and Praesepe (corresponding to the *Qi* of Piled Corpses) in the *Sidereus nuncius* (Fig. 11b), more exactly, mirror images of the corresponding images in both the Venetian and Frankfurt versions of the book (Galilei 1610 [1989]: 63; Galilei 1610: 32). In addition, Schall exchanged the European names of constellations with the Chinese names, just as he uses Silver River instead of Milky Way.

Compared with the lengthy descriptions and discussions in Galileo and Locher's original works, the *YJS*'s explanations of the seven astronomical images are extremely short and succinct. They are very brief summaries, rather than translations, of the reports and discussions of Galileo and Locher. As shown above, comparison of the texts in the *YJS* and *Disquisitiones* on sunspots, the phases of Venus, and the Jovian satellites reveals that basic ideas are abstracted, long descriptions skipped, and technical details omitted.

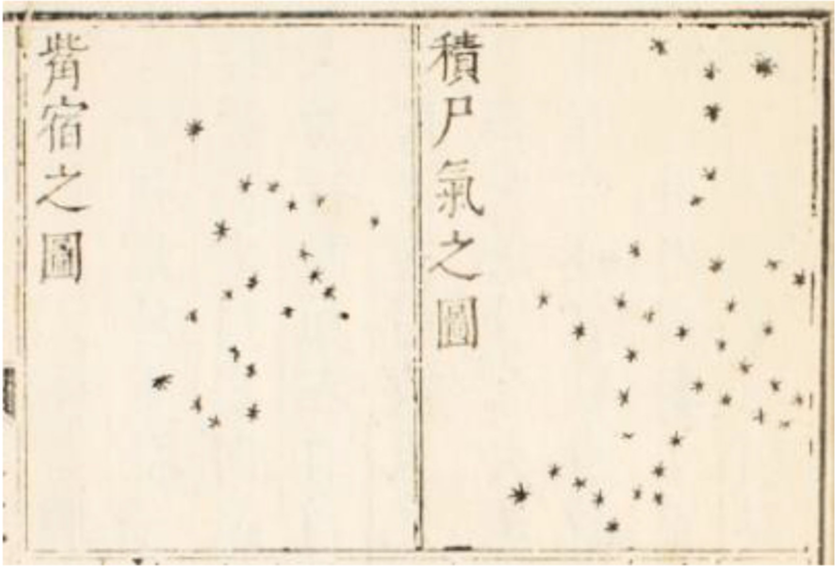

Fig. 11 More stars seen in the Vapor of Piled Corpses (**b**) and the Lodge Mouth (**a**)

The Source of the Sixth Astronomical Image in the *YJS*

While the close analysis of the previous seven images reveals their European literary sources, the sixth astronomical image in the *YJS*, "Picture of Saturn (土星之圖 Tuxing zhitu)" (Fig. 12) (Tang & Li 1626: 3b) invites questions about Schall's approach to astronomy and how he used the telescope. Common software was used to compare the imagery with historical astronomical situations. The caption of the picture, which is the briefest of all of the eight images, explains that: "Observing Saturn with a telescope, you can see two little stars on both of its sides. After a while, they will come gradually closer to Saturn and finally combine into one body, like an egg having two ears at its two bulgy ends." (Tang & Li 1626: 3b)

A more or less similar picture (Fig. 13) can be found in Locher's *Disquisitiones* as a part of "Disquisition 44 Concerning Saturn," reporting a telescopic observation of Saturn made at Ingolstadt in February 1614 (Locher 1614: 88–90; Graney 2017: 139–140 and 143). According to the report, when Saturn was located at F on the night of February 12^{th}, while Venus was located at K and the moon located at I, the two "starlets" G and H were seen on the two sides of Saturn ("threefold"); when Saturn moved to D on the night of February 13^{th}, it became "perfectly round;" but when it moved to C on the night of February 14^{th}, two "ears" appeared on each side of it ("oblong"). Although the picture of Saturn (Fig. 12) in the *YJS* does not conform to that of Locher (Fig. 13), the clouds near the horizon

Fig. 12 Galileo's drawings of stars in Nebulae Orion (**a**) and Praesepe (**b**)

Fig. 13 Picture of Saturn in YJS

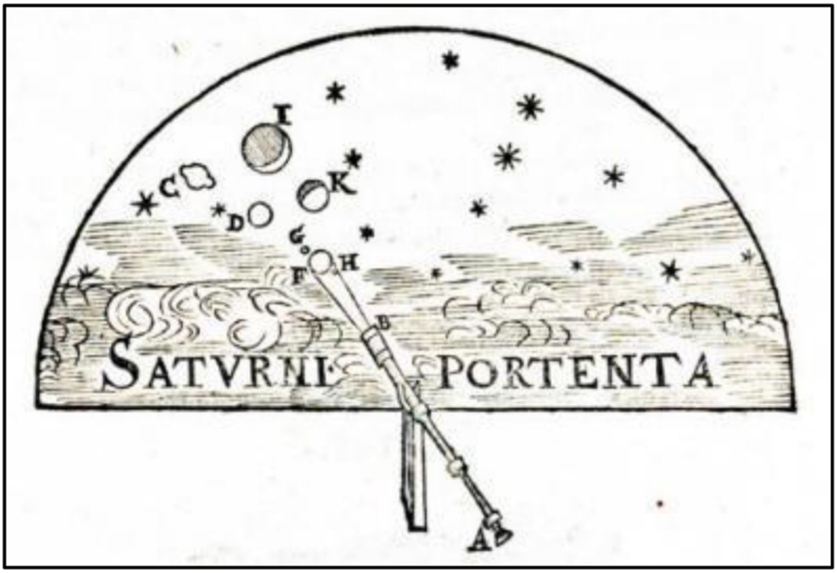

Fig. 14 Picture of Saturn in Disquisitiones

still indicate a connection. Otherwise, they look very different. Apart from the absence of the telescope, Venus and the moon, one feature of Fig. 12 is that it contains three clearly marked constellations that belong to the Chinese system of constellations, namely, Tiger (参 Seng), Net (畢Bi) and Heavenly Boat (天船 Tianchuan) from left to right, while the three stars near the upper opening of Tiger is Mouth (觜 Zi), although they are not joined by lines.

With the help of *Stellarium*, a planetarium software, we can show that Fig. 13 reflects the real situation in the early evening sky on February 13th 1614 (Fig. 14), as the positional configuration of Saturn, Venus and the moon at that time indicates. Hence, we wish to ask whether Fig. 12 also reflects a real situation at the sky described by Chinese constellations, and if so, which date. Since it takes Saturn about 29.5 years to complete one circle on the ecliptic, its position among the fixed stars will change much slower than other major planets. Another astronomical software *Alcyone Ephemeris* helped us to determine the range of Saturn's longitude for the celestial area shown in Fig. 12 within the time span from 1610, the publication of Galileo's *Sidereus nuncius*, to 1626, the completion of Schall's *YJS*. It falls between 70 degrees and 85 degrees and corresponds to a date between May 1619 and April 1620 (Fig. 15). Since the constellation Net is very close to the celestial equator and its 'mouth' is roughly open to the east, the scenario depicted in Fig. 13 must have been happened on the

Fig. 15 Saturn on the western horizon of Ingolstadt in the early evening of February 13th 1614

western horizon. Otherwise, the 'mouth' of the Net should be downward rather than upward.

Based on such reconstructive methods, the illustration of the *YSL* (Fig. 12) concurs with astronomical patterns observable during the nights between November 1619 and April 1620. If we take the big star right above Saturn in the illustration as the brightest star in that area, namely, the Gate of Heaven (天關 Tianguan), then the time span can be further narrowed down to the nights between late 1619 and early 1620. According to the biographical record of Schall, he arrived in Macao on July 15th 1619 and stayed there until the summer of 1622. The illustration of the *YJS* thus is actually a pictorial record of a telescopic observation of Saturn that Schall made in Macao (Figs. 16 and 17) inspired by the similar picture in the *Disquisitiones.*

One conclusion from this comparison is that, while in Macao, Schall was doing much more than learning the Chinese language. Charged with preaching the gospel and proselytizing Chinese emperors, Schall was meant to impress the Ming dynasty with his astronomical knowledge and help reform the calendar. Schall, who had studied with the German Jesuit Johann Schreck (Chinese name 鄧玉函 Deng Yuhan, 1577–1630) conducted astronomical observations on his way to the East and this comparison suggests that he was also training his ability in Macao, making observations on the phenomena based on Galilei and Locher's descriptions of Saturn. As the illustrations confirm, through these studies he also

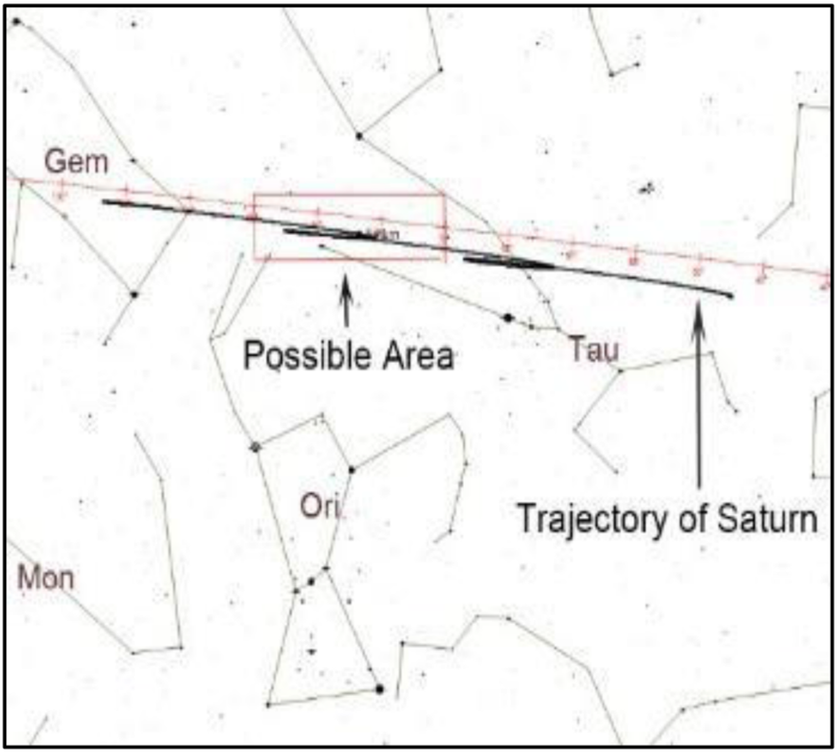

Fig. 16 The Trajectory of Saturn from 1610 to 1626

learned about Chinese constellations, possibly from Jesuit mentors such as Sabatino de Ursis (Chinese name 熊三拔 Xiong Sanba, 1575–1620) and Diaz who had already worked for years in the hinterland of the Ming dynasty but were expelled to Macao as a result of the suppression of Catholic missionaries during the Nanjing Incident of 1616 stirred up by Shen Que (沈漼, ?–1623). Both of them had published Chinese books introducing European astronomy, and de Ursis had even conducted a systematic investigation of Chinese astronomy and submitted a report in response to the inquiry of the supervisor of the Japan vice-province of the Society of Jesus, Alessandro Valignano (Chinese name 范禮安 Fan Li'an, 1539–1606) concerning the Chinese calendar and its reform (D'Elia 1960: 32–43). Diaz, for instance, is known to have regularly adapted examples and calculated numbers for China and, as Henrique Leitão has suggested, marks a "move from the first initial attempts at presenting Western science to China to a new phase in which Chinese preferences and interests become crucial in the composition of scientific books by the Jesuits in China." (Leitão 2008: 121) Seeing how Schall gained his knowledge from European books and

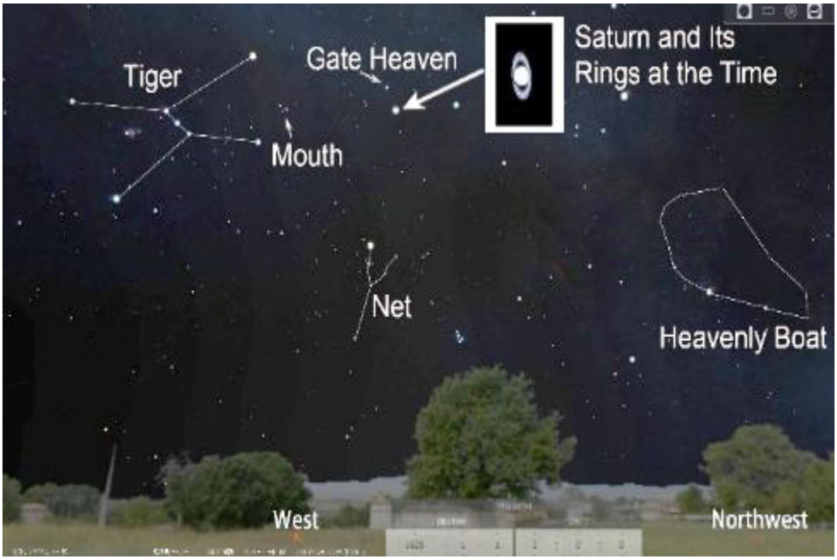

Fig. 17 The position of Saturn on the western horizon in Macao in the early morning of January 1st 1620

reflected on his experience by illustrating that the *YJS* adds an important nuance to this narrative of transmissive technological components and a changing astronomical worldview.

The comparison above also sheds new light on the quality of the astronomical work done by the Jesuits in Macao in the seventeenth century. Due to the scant information about telescopes sent to Macao or constructed there, it is suspected that the work done by the Jesuits "could only remain traditional: that is consisting mainly in observations of oppositions, eclipses, equinoxes and solstices" (Baldini 2008: 60). However, Schall's telescopic observation suggests another possibility, because it seems quite unreasonable to think that, as a young astronomer designated to enter the Chinese court, Schall would have limited telescopic observation solely to Saturn now that he already had good knowledge of the controversies and novelties of the astronomical works by such modern astronomers as Galilei and Locher. Hence, a more acceptable story seems to be that he conducted systematic observations to a certain extent with the telescope and noted down the results. The "Picture of Saturn" in the *YJS* is just one example of such observations and notes which found its way eventually into a published book. These works were quite modern in Schall's time and they played a special role at least in the Jesuit dissemination of modern European astronomy in China.

The choice and changes that Schall made in the astronomical images, as well as the differences between the *YJS* and the *Telescopium*, substantiate that, in content, purpose and style, the *YJS* should be considered as an independent work authored by Schall on the basis of the knowledge that he learnt from various European sources and won from his own experience.

The eight studied astronomical images are adapted basically from two sources, namely, Galileo's *Sidereus nuncius* and Locher's *Disquisitiones*. With them Schall illustrated six discoveries by Galileo, but he only based his images of the moon and the nebulae on Galileo's work. For the images of the phases of Venus, the Jovian satellites, the sunspots, and the Saturn's strange outlooks, he turned to Locher. These are not random selections. Locher's illustrations of these phenomena are far more magnificent and impressive than those of Galillei, and therefore more appropriate for a promotional book like the *YJS*. For the same reason, Galillei's diagrams of the moon are more suitable for Schall's agenda, because while Locher's book contains just a single drawing of the moon on its first quarter. (Locher 1614: 58; Kopal 1969), Galilei's pictures in the *Sidereus nuncius* illustrate a changing view of the moon in different phases, which better showcases the usefulness of the telescope. As far as the telescopic view of the fixed stars is concerned, Galillei's own illustrations are good enough for the purpose of the *YJS*, whereas the topic is not broached at all in Locher's book.

Besides the aforementioned reasons, Schall must have another, and probably more important, consideration in choosing Locher for the phases of Venus and Jovian satellites, namely, the cosmological controversies over the interpretation of the new phenomena in question. In his *Istoria* published in 1613, Galillei openly enlisted the phases of Venus, the Jovian satellites and the sunspots in support of the heliocentric theory of Nicolaus Copernicus (1473–1543), which triggered a fierce debate involving not only astronomers and philosophers, but theologians and Church authorities as well. Also at issue was his discovery of the sunspots and the defects on the surface of the moon which contradicted the orthodox cosmological dogma of Aristotle about the perfect status of the celestial bodies. In fact, Locher's *Disquisitiones* is a response to these controversies, as the subtitle of the book, *de controversiis et novitatibus astronomicis*, suggests.

The book begins with an argument for the importance and validity of mathematical method in the study of astronomy, especially physical astronomy, and then takes on the grand issue of the world system. Both the old concentric system and new heliocentric system are refuted for obvious absurdities in astronomy and physics, while the geo-heliocentric system proposed by Tycho Brahe (1546–1601) is eventually hailed as most valid as follows:

> Certainly, it is appealing to many astronomers at this time because it is very consistent with the heavenly phenomena, and it shares nothing with Copernicus and much with Ptolemy. It removes superfluous celestial movement and explains everything easily by means of fewer orbs. (Graney 2017: 80)

The new telescopic discoveries of the phases of Venus, the Jovian satellites and the sunspots, being understood as bodies very close to the sun in this part of the book, are cited as phenomena in support of the opinion that the five planets ("wandering stars") are centered on the sun rather than the earth. With the Tychonic system as a cosmological prerequisite, the book then unfolds a discussion of the astronomical and physical properties of the moon, the sun, Venus, Jupiter, and Saturn, where the telescopic observations of these bodies are analyzed in detail.

Locher was a master's candidate and a student of logic and mathematics in 1614 at the University of Igolstadt, and the *Disquisitiones mathematicae* was written there with the help of the professors of mathematics at the university, especially "under the supervision of Christopher Scheiner of the Society of Jesus" as Locher noted with bold letters on the title page of the book above his own name (Graney 2017: 2, 4, 12, 242). Since the University of Ingolstadt was a major Jesuit university and Scheiner a leading Jesuit astronomer working there, Locher's book functioned much as a mouthpiece of the Society of Jesus, as well as the Church of Rome, over the cosmological issues involved in the interpretation of the new telescopic discoveries. This provides another reason why Schall decided to select Locher's book in his presentation of the telescopic discoveries concerning Venus, Jupiter and the sun: on the issues covered in the *YJS* he was trying to stick to the official standpoint of both the Society of Jesus and the Catholic Church in Rome. To make his commitment in cosmology more clear, he even slightly changed Locher's original illustrations of Venus and Jovian satellites to highlight the geocentric feature of the latent cosmological scheme of the *YJS*.

The picture of Saturn was changed mostly by comparison. Its topic was cosmologically less sensitive within European clerical debates than the other images. For the targeted Chinese readers, however, the randomly dotted background stars in Locher's original picture were less attractive and genuine than staging an egg-shaped Saturn before a scenery full of Chinese constellations. It would not have been very wise to randomly draw some Chinese constellations and then put Saturn in an unreasonable position. Illustrating an actual observation of the night-sky provided readers with an astronomical basis, a sense of authenticity. Preparing the astronomical images for the *YJS*, Schall considered the official position of the Catholic

Church on cosmological issues, Chinese traditions of representing astronomical contents, and issues of authenticity. When using familiar elements of the recipient culture Schall moved within the general paradigm of acculturation employed by Jesuits in the China mission.

Acknowledgements

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Endnotes

1 Schall's first work in Chinese is a treatise on the eclipses completed in 1624 (See Tang Ruwang 湯若望 et al. 1624. *A Brief on the Prediction of the Eclipses* (測食略 *Ceshi lue*). In: *Treatises onCalendrical Astronomy according to the New Method from the West* (西洋新書 *Xiyang xinfa lishu*), Vol.23, preserved in the Kyujanggak Archives, Shelf Number 3418.32.23).

2 The earliest known version of the *YJS* is preserved in the Kyujanggak Archives in Korea as a part of the *Treatises on Calendrical Astronomy according to the New Method from the West* (西洋新法曆書 *Xiyang xinfa lishu*) . The bylines at the very beginning of the body text of this version are "Tang Ruwang from the West Ocean dictates (西洋湯如望述 Xiyang Tang Ruwang shu)", and "The Disciple Li Zubai redacts (後學李祖白述 Houxue Li Zubai ding)" (Tang Ruwang 湯若望 and Li Zhubai 李祖白 1626). There is also a version printed with the same set of printing blocks after Li Zubai's execution in 1665 during the lawsuit against Schall wherein Li Zhubai's line is deleted and Schall's line is changed into "Tang Ruowang from the West Ocean Composes (西洋湯著 Xiyang Tang Ruowang zhu)".

3 This is the only published English translation of the Latin text, which reflects the basic idea of the text. It contains various mistakes and deviations from the Latin text, which are, however, irrelevant for the analysis of the images.

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