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Shared Ideas, Divergent Approaches: The *Hydromethods of the Great West* (*Taixi shuifa* 泰西水法) and the Question on Tides

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Abstract: One of the questions about natural phenomena asked in the *Hydromethods of the Great West* (*Taixi shuifa* 泰西水法; 1612) (hereafter *TXSF*), composed by the Italian Jesuit Sabatino de Ursis with the support of the Chinese official Xu Guangqi 徐光啟, concerns the causes of sea tides. The idiosyncratic answer given in the *TXSF* serves as an example for the Jesuit missionaries' strategically motivated approach to the transfer of knowledge through the translation of Western scientific thought into Chinese. From a chronological overview of the attempts made both in the East and in the West to theoretically conceptualize the causes of the cyclical occurrence of ebb and flow, the comparison reveals that despite being based on totally different cosmologies, the related insights were virtually on a par. The aim to nevertheless convince the audience of the *TXSF* of the superiority of Western sciences resulted in a particular rhetoric and a division of tasks in

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** In this issue of *CAHST*, the book title *Taixi shuifa* 泰西水法 has been translated differently by the authors of two separate articles, one as *Hydromethods of the Great West* in this article, the other as *Hydraulic Methods of the Far West* in "Introduction of the Archimedean Screw Pump to East Asia during the Seventeenth and Eighteenth Centuries." *CAHST* would like to retain these translations as they are, so as to highlight the difficulties in translating such titles and the authors' differing interpretations. (This article was copyedited by Charlie Zaharoff.)

1 Research interests: History of science and technology in premodern China, intercivilizational knowledge transfer. Email: sabine.kink@uni-tuebingen.de

the composition of the tides paragraph. In order to verify the success of this joint effort of de Ursis and Xu Guangqi, a change of perspective from the transmitter to the receiver side is necessary. Thus, the paper also explores the work's reception in later Chinese works dealing with this topic.

Keywords: Jesuits, tides, *Hydromethods of the Great West*, Sabatino de Ursis, Xu Guangqi, knowledge transfer, late Ming

摘要:《泰西水法》(1612年)由意大利耶稣会士熊三拔与中国官员徐光启合著,其中对潮汐成因给出了独特解答,体现了耶稣会士在为传教而译介西方科学思想的过程中所采取的策略性知识转移方法。纵观东西方就潮汐涨落成因从理论上提出的概念化解释可以发现,尽管东西方在宇宙观方面大相径庭,对潮汐的见解却相差无几。然而,为了体现西方科学的优越性,《泰西水法》通过特殊的修辞来论述潮汐,相关段落的撰写分工也较为特别。为了验证熊三拔和徐光启的合作效果,需要将视角从知识传播方向转向接收方,进而分析《泰西水法》在后世相关中文著作中的反响。

关键词: 耶稣会士, 潮汐, 泰西水法, 熊三拔, 徐光启, 知识转移, 晚明

I learn from Professor Giles that Chinese writers have suggested two causes for the tides: first, that water is the blood of the earth, and that the tides are the beating of its pulse; and secondly, that the tides are caused by the earth breathing.

George Darwin (1845–1912)²

1 Introduction

The words quoted above by George Darwin, a British astronomer, mathematician, and renowned expert on the tides, reflect the sense of superiority in scientific questions that had gradually set in in the Western world since the early sixteenth century. Heralded by the cultural upheavals during the Renaissance, new perspectives, methods, and approaches were developed that in the end would break the long-standing claim to authority over knowledge and scholastic learning made by institutions like the universities or the Catholic Church. But with regard to the understanding of tidal phenomena in particular, the claimed European scientific edge over China was relatively recent. This article will show that related insights on both sides of the globe were still virtually on a par when the Jesuits started to gain a foothold in the Middle Kingdom towards the end of the sixteenth century. Thus, it does not come as a surprise that the answer to the Chinese question about the cause of the sea tides given in the *Hydromethods of the Great West* (*Taixi shuifa* 泰西水法; 1612) (hereafter TXSF) still strictly followed the traditional concepts of Aristotelian cosmology that had controlled the curriculum of the Jesuits for decades, avoiding any hint at the

2 See Darwin (1898).

groundbreaking new insights already underway in the West.

This treatise, jointly written by the Italian Jesuit Sabatino de Ursis (1575–1620) and the notable official and Christian convert Xu Guangqi 徐光啟 (1562–1633), is well known for the introduction of three hydraulic pumps usable in agriculture. But in addition to that, in its fifth chapter entitled “Some Questions about Hydromethods” (Shuifa huowen 水法或問) and within the context of the Aristotelian theory of the Four Elements (*sixing lun* 四行論), it also deals with principles of water that are significant for a variety of natural phenomena, among them the tides.

Sabatino de Ursis was born in Lecce and joined the Society of Jesus in Naples in 1597. From late 1598 onwards he continued his studies in Rome, before embarking for East Asia in Lisbon in 1602. Originally bound for the mission in Japan, after years of further preparation in Macao he was redirected to China. Matteo Ricci (1552–1610), one of the pioneers of the Jesuit China mission, expected that de Ursis’s mathematical skills would help to attract the attention of high-ranking Chinese scholar-officials and win them over to the Christian creed so that they could serve as door openers to the imperial court in Beijing.³ In the context of this strategically motivated knowledge transfer from West to East, Xiong Sanba 熊三拔, as de Ursis was called in China, started to compose the *TXSF* together with Xu Guangqi three years after he finally arrived in Beijing in 1607.⁴

Today, it is common knowledge that the tides are caused by the gravitational pull

3 See Baldini (2008, 41). In the course of the Nanjing persecution (1616–1617), de Ursis was expelled to Macao, where he died in 1625. For de Ursis’s biography see Bertuccioli (1991, 498–500); von Collani (2011) in *Encyclopedia Stochastikon* at <http://encyclopedia.stochastikon.com/>; Dehergne (1973, 75); and Pfister ([1932] 1971, vol. 1, 103–106). Literature about his co-author, Xu Guangqi, is substantial. More recent examples are Blue (2014); Bray and Métaillé (2001); and Chen (2003).

4 In Greater China, the *TXSF* has been examined by Hsu Kuang-Tai 徐光台 (2008), mainly with regard to the introduction and reception of the Aristotelian Four Elements Theory during the Ming Qing transition and the role of Xu Guangqi for chapter 5 of the *TXSF*. Zhang Baichun 张柏春 and Tian Miao 田淼 (2010), in their analysis of the transmission of Archimedean mechanical knowledge to China, also refer to the *TXSF*, whereas Zhang Baichun (1995) closely examines the mechanical features of its three water-lifting devices. This topic is further investigated in an article by Su Yunmeng 苏云梦 and Shi Yunli 石云里 (2017), who focus on the Archimedean screw in particular. In his detailed analysis of the transfer of Western natural philosophy to China, Sun Chengsheng 孙承晟 (2018) discusses chapter 5 of the *TXSF* in addition to other Jesuit works. Zou Zhenhuan 邹振环 (2011, 191–222) describes the background of the creation of the *TXSF* as well as its contents and reception, and in his 2017 contribution moreover highlights the outcome of later efforts to implement its technologies in the Jiangnan area. Finally, Liu Geng 刘耿 (2018) gives insights into the crucial role of the Beijing Zhalan Cemetery for this work. In the West, to date, substantial contributions have been limited to specific questions. To name only the most important ones, Vogel (2010) with reference to the *TXSF* compares the traditional Western and Chinese explanations for the origin of salt and brine, while Kurtz (2012) focuses on the rhetorical strategies used in its prefaces and Cigola (2015) on the origin of its technical illustrations.

of the moon and, to a lesser extent, that of the sun on the earth. A closer look, however, quickly reveals that regarding a thorough understanding of the overall system of ebb and flow, things are not quite that simple, as a multitude of other astrophysical and geographical factors have to be taken into account as well. Therefore, it is obvious that despite continuing and careful observations by scholars undertaken over time and space, correct and comprehensive explanations in this context could not crop up until the related physical and astronomical facts were better understood.

Corresponding efforts in Europe, which culminated in the abandonment of the geocentric model of the divinely created universe, had already been intensified during the Renaissance by scholars such as Nikolaus Copernicus (1473–1543) or Galileo Galilei (1564–1642). Nevertheless, the knowledge de Ursis brought with him to China was still fully in line with traditional paradigms, relating ebb and flow more or less vaguely to some kind of influence of the moon and the sun.

In China, tidal phenomena also constituted an integral part of the accepted cosmology, which, however, was of a totally different nature, as it originated from a primordial form of energetic vitality called *qi* 氣. Despite this different framework, in traditional China, just like in the West, the tides were explained by the strong correlation between the moon and water, which caused the sea to go up and down in accord with the periodic lunar waxing and waning. The prevailing naturalistic concepts—despite being challenged during the Song dynasty (960–1279) by Neo-Confucianists like Ouyang Xiu 歐陽修 (1007–1072) or Wei Liaoweng 魏了翁 (1178–1237)—were still state of the art when the Jesuits started trying to win over influential Chinese scholars for their own proselytizing ends at the end of the sixteenth century. Thus, the short section about the tides in chapter five of the *TXSF* vividly reflects the shared ideas and levels of contemporary Chinese and European knowledge. But at the same time, it is also characteristic for the rhetorical strategy in such learned works of the early Jesuit translation project, resulting in a distinctive approach.

Against this background the present article serves two main purposes. For one thing, it aims to provide an overview of the most important Chinese and European explications of the causes of ebb and flow. First, the Chinese debate on this topic will be scrutinized in chronological order, starting from the earliest written testimonies during the Warring States period (475–221 BCE). After that, a closer look will be taken at the European developments until the year 1602, when Sabatino de Ursis left for China, before comparing the gist of these Eastern and Western attempts to theoretically and philosophically conceptualize the everlasting cyclical influence of the moon on the

oceans.⁵

The second objective is to evaluate within this specific framework the idiosyncratic explanations of the sea tides (*haichao* 海潮) provided in the *TXSF*. After contextualizing them within the “Some Questions about Hydromethods” chapter, the relevant statements will be analyzed step by step and in detail. Here, particular emphasis is placed on the way in which the knowledge is presented: instead of limiting it to the factual evidence in a narrower sense, the topic was used by de Ursis to demonstrate innovative methods of the Renaissance scientific approach combined with the strict scholastic Aristotelian line of argument that was part and parcel of the comprehensive academic education of the Jesuits. This demonstration was in line with the principles of an “indirect mission,” which through “science, engineering, and the apostolate of the book” aimed at arousing the interest of possible Chinese converts (von Collani 2018, 4).⁶ Additionally, their learned treatises served the Jesuits as a conveyer of a more or less apparent religious message, because they were all in principle written “to the greater glory of God.” The question will be raised whether this second goal is discernible in the passage on tides as well. But were the authors of the *TXSF*—as postulated by Matteo Ricci—nevertheless able to accommodate their Chinese readers by striking a balance between demonstrating an alleged Western superiority in the sciences on the one hand and winning trust and confidence of their readers on the other? Which role did Xu Guangqi as a collaborator of de Ursis play in this undertaking? These aspects are even more important, as the *TXSF* was written at an early stage of the Jesuits’ missionary work in China, when they still lacked experience in this regard. After the content-related, structural, and linguistic analysis of the tides paragraph mainly from the perspective of the transmitter side, a preliminary assessment of the reaction of the receivers will be given by throwing a concluding glance at the reception of the *TXSF*’s explanations in later Chinese works on the topic.

5 On the Chinese side, relevant research on tidal phenomena has been done for example by Song Zhenghai 宋正海 (2012), Shi Yunli (1993), Yang Zuosheng et al. (1989), or in the form of a compilation with annotations of ancient Chinese treatises on tides by the Chinese Study Group for the Compilation of Ancient Historical Documents on Tides (1980). Sun (2018), in his chapter on the *TXSF*, also touches upon this issue. For the Western side, certainly Cartwright (1999 and 2001) stands out, while Emery and Aubrey (1991), Laird (1990), and Hooper (2004) deal with more detailed questions. Comparative presentations of the topic are found in Needham and Wang (1970) and in Cartwright (2001), but these works have a clear emphasis on either the developments in China or in Europe, respectively.

6 “Indirect mission” is part of the method of accommodation, which goes back to the Jesuit Visitor Alessandro Valignano (1539–1606) and subsequently was put into practice by Matteo Ricci and his brethren. Among others, Claudia von Collani (2000; 2018) has extensively analyzed this method, which is characterized by an indirect proselytizing of the elites through the transmission of science and technology, an openness towards the Chinese system of values, the use of books as a door opener, and the interpretation of classical Confucianism as a monotheistic religion.

2 Traditional Chinese explanations of the tides

In the Chinese understanding, the whole cosmos originated from *qi* 氣, a primordial form of energetic vitality which subsequently manifested itself dualistically in a hot *yang* 陽 and a cold *yin* 陰 “quality.” The latter then condensed and thus materialized into water, whose *qi*-essence in the next step became the moon.⁷ This shared subordination to cold *yin* of both the moon and water stood at the center of the Chinese explanation of the tides, which additionally was embedded in an overarching system of mutual resonances (*ganying* 感應) affecting things belonging to the same category. The consequence for the matter at hand is that, regardless of the huge distance and the amounts involved, the daily rising and setting of the moon was considered to have an evident influence on all kinds of moisture. Because *yin* and *yang* were simultaneously perceived as forces of an opposing nature, their constant and wavelike expansion and contraction not only explained the periodical waxing and waning of the moon itself but also the corresponding influence on the rise and fall of sea levels.

Thus, the tides, with their cyclical but at times unpredictable occurrence, are a prime example for traditional Chinese cosmology. As it was the main task of the emperor to implement through his reign the heavenly order on earth, studies of astronomical phenomena in general were of utmost importance for his government. From this perspective, the early findings about the causes of the tides on the part of the Chinese scholar-officials appear as a side effect of this imperially endorsed observation of the movement of the celestial bodies.⁸ Still, the earliest direct references to the tides in the *Master Lie* (*Liezi* 列子; Warring States period, 475–221 BCE) or *The Classic of Mountains and Seas* (*Shanhai jing* 山海經; late Warring States period) were purely descriptive in nature and characterized by animistic traits. Likewise, the remarks on natural phenomena in the Western Han dynasty (206 BCE–25 CE) *Master Huainan* (*Huainan zi* 淮南子), which clearly bear a Daoist diction, continued to be embedded into myth and allegories, with the tides being caused by a bird that stirs up the waters.⁹

The causal link to the influence of the moon is first discernible in *Inner Classic of the*

7 One of the standard references for these ideas is the Western Han dynasty (206 BCE–25 CE) *Master Huainan* (*Huainan zi* 淮南子), particularly its third chapter, the “Celestial Patterns” (*Tianwen xun* 天文訓). See also Major (1993, 62ff). As most examples from the Chinese classics here only serve to illustrate the overall context described, if not indicated otherwise the related passages are taken from online sources such as the Chinese Text Project available at <https://ctext.org/>.

8 The following explanations are mainly based on the section on “Sea Tides” in volume 3 of Needham’s *Science and Civilisation in China* series (Needham and Wang 1970, 483–494).

9 The relevant part in chapter 17, “A Forest of Persuasions” (*Shuolin* 說林), reads as follows: “There is a bird that stirs up the waves. On account of this, [even] the Earl of the [Yellow] River avoids the tides, for he fears the bird’s sincerity” (鳥有沸波者，河伯為之不潮，畏其誠也). Translation following Major et al. (2010, 704).

Yellow Emperor (Huangdi neijing 黃帝內經),¹⁰ which states: “Therefore, when the moon is full, the waters of the sea are abundant in the west. . . . When the empty moon is reached, the waters of the sea are abundant in the east.”¹¹ Such observations became more precise in the Eastern Han dynasty, when Wang Chong 王充 (27–97) made an early effort to objectify strange natural phenomena instead of equating them with some kind of heavenly induced retaliation for human behavior.¹² Thus, in the chapter “Falsehoods in Written Accounts” (*Shu xu 書虛*) of his *Discourses Weighed in the Balance* (*Lun heng 論衡*; ca. 80), he tried to counter popular myths of tidal bores with more rational explanations. To this end Wang established a microcosmic “respiration theory” for rivers, comparing the flow of their waters to the pulsation in human blood vessels or the constant pulmonary in and out of *qi*,¹³ and combined it with a lunar-centered macrocosmic approach, saying: “Finally the rise of the wave follows the waxing and waning moon, smaller and larger, fuller or lesser, never the same.”¹⁴

Among Chinese scholars this combination of the respiration theory with a lunar theory to explain the tides slowly gained ground and was further complemented in the following period. For example, in his syncretic *Master who Embraces Simplicity* (*Baopu zi 抱朴子*),¹⁵ the Jin period scholar Ge Hong 葛洪 (283–343) clearly differentiates between the morning (*chao 潮*) and evening (*xi 汐*) tides respectively.¹⁶ From the Tang dynasty (618–907) onwards, a stronger focus on the actual structure of the universe as a whole and of the earth in particular was added to the traditional, purely organic *yin-yang* cosmology.¹⁷ And even though the underlying causes were still far from being fully understood, empirical observations of the tides and the conclusions drawn from them gradually became more precise and complex. Thus, Dou Shumeng 竇叔蒙 (fl.

10 The time of origin of this fundamental book on Chinese medicine is still discussed controversially, but presumably it was not written before the first century BCE. The *Inner Classic of the Yellow Emperor* applies the principles of the macrocosm (*yin* and *yang*, the five elements, but also environmental factors like heat or coldness, wind, dampness, etc.) directly to the human microcosm, which thus reflects the outer world.

11 “故月滿則海水西盛，……至其月郭空，則海水東盛。” (own translation above). The whole passage describes the correlation between the lunar phases and human health and constitution, which are more robust at full moon.

12 For an excellent survey of the traditional Chinese concepts of nature, see Vogel and Dux (2010) with Harbsmeier (2010, 220–254) on “*ziran* 自然” or “what is so of itself” in particular.

13 “夫地之有百川也，猶人之有血脈也。血脈流行，汎揚動靜，自有節度。百川亦然，其朝夕往來，猶人之呼吸，氣出入也，天地之性，上古有之。” For an extensive translation of the relevant passage of the *Discourses Weighed in the Balance*, see Needham and Wang (1970, 485–488).

14 “濤之起也，隨月盛衰，小大滿損不齊同。” Translation by Needham and Wang (1970, 488).

15 For the undue classification of Ge Hong as a Daoist alchemist, see Sivin (1969; 1978).

16 According to Needham and Wang (1970, 489), Ge Hong 葛洪 “also offers a strange alternative theory that the tides are due to the ‘overflowing’ of the Milky Way, which passes under the sea in the diurnal revolution of the heavens.”

17 For this topic, cf. the 2012 and 2015 writings by Song Zhenghai. He speaks of an outright new “tide theory in terms of the structure of the universe” (*tiandi jiegou lun chaolun 天地結構論潮論*).

762–779) in *On Ocean Waves* (*Haitao zhi* 海濤志; ca. 770) supplemented earlier findings about the daily delay in the times of high water by taking into account seasonal influences on the tidal range. Moreover, Dou created a graphical method for predicting the times of tides at given coastal points, anticipating the later development of outright tide tables.¹⁸ Finally, the additional influence of the sun on the tides is first explicitly mentioned by Lu Zhao 盧肇 (818–882) in his *Rhapsody to the Sea Tides* (*Haichao fu* 海潮賦).¹⁹ But at the same time, folk tales like the one about tidal phenomena continued to enjoy unbroken popularity in China. One example here is the story about King Qian Liu 錢鏐 (852–932) taming the tidal bore of the Qiantang River by ordering his army to fire their arrows into the raging torrent.²⁰

During the Song dynasty, induced by increasingly practical and commercial considerations, detailed and amazingly precise tide tables started to be created for individual harbors, as for example the one for the seaport of Ningbo contained in the *Illustrated Discourse on the Tides* (*Haichao tulun* 海潮圖論, 1026) by Yan Su 燕肅 (961–1040).²¹ Indeed, the up and down of the sea had affected the lives of sailors as well as of coast dwellers and their activities for a long time, and so Shen Kuo (also: Gua) 沈括 (1031–1095) in his 1088 *Dream Pool Essays* (*Mengxi bitan* 夢溪筆談) added further topographical and geographical details indispensable for correct high water prediction. Similar to Europe, it was maritime trade which spurred these efforts,²² but in China the improvement of agricultural activities and the promotion of the production of salt along the coast certainly mattered as well.²³ Nevertheless, after the Song dynasty—despite ongoing discussions on possible explanations of the tides—no further tangible

18 In a nutshell, he developed an x-y plot combining the phases of the moon with the observed times of the tides, extrapolating from it the daily lag of tides.

19 Lu assumed that when the hot sun in the evening went down it entered the ocean somewhere in the west, causing an explosion leading to a tidal wave.

20 These arrows were directed against the irascible Sea Spirit of a legendary virtuous minister who had been treated unjustly by his own king and after his suicide was thrown into the river. For this tale see Barmé (2011).

21 See Needham and Wang (1970, 491–492).

22 Cf. Zhang (2015, 128–142), where she shows how, within the framework of the traditional cosmology, a multi-layered Chinese empirical maritime literature including non-official travelogues and peaking at the time of Zheng He's voyages could only selectively contribute to the ongoing discourse about the Four Seas and their characteristic features. In contrast, European ambitions to gain control over the oceans early on constituted an exceptional incentive for efforts of "escaping the sea's fury through prediction" (Parker 2014, 1).

23 In the *Illustrated Boiling of Sea Water* (*Aobo tu* 熬波圖), compiled by Chen Chun 陳椿 (1293–1335) in 1334, the impact of tidewater on salt production is described. During the hot season, with its high demand for saltwater, additional channels stretching to the sea and adducing the tidewater directly to the production places were opened, while at the same time dykes had to be built to protect these areas against uncontrolled inundations. This vividly illustrates that at that time fiscal and commercial needs were among the main driving forces for a better understanding of for example tide cycles. See Yoshida (1993, 18–19, 120–126).

advance on the theoretical side was made until the arrival of the Jesuits in the latter half of the sixteenth century.²⁴

To sum up, after early descriptions that were still entirely steeped in legend, Wang Chong in the Eastern Han was the first to establish a macrocosmic theory relating the tides to the influence of the moon on water and to combine it with the microcosmic idea of the earth breathing. Over time, the observation of tidal phenomena and the related conclusions became more precise and systematic, resulting for example in the use of outright tide tables. However, traditional concepts together with popular folk tales continued to exist in parallel. So, despite some practically oriented progress during the Song period, from that time onwards the overall state of theoretical knowledge about the tides in China seems to have stagnated.²⁵

3 Western ideas and sources on the topic

Let us now turn to the other side of the globe. As in China, the earliest purely descriptive accounts of devastating floods or unpredictable currents here are found in texts of religious origin, reflecting the strong belief in divine causes for such phenomena. The Old Testament with its tale about the Deluge is a well-known example, but Homer's description of Odysseus escaping the tidal whirlpool caused by Charybdis sucking and spouting water in the strait of Messina thrice a day (*Odyssey*, XII, 105–107) is also connected to the notion of revenge or punishment by all-powerful gods.²⁶

Early efforts to explain the ebb and flow of the sea crop up in the writings of Plato

24 In the Yuan and Ming dynasties, earlier concepts were merely disputed and at least in part rejected, for example by the Yuan scholar Shi Boxuan 史伯璇 (ca. 1299–1354) in his *Outer Chapters of a Glimpse into Complete Collection in Four Treasuries* (*Guankui waibian* 管窺外編). Similarly, Yu Siqian's 俞思謙 (late eighteenth cent.) *Collected Writings on the Sea Tides* (*Haichao jishuo* 海潮輯說), published during the Qianlong period in 1781, was just a compilation of older works. See Song (2015, 2).

25 This, however, was not a unique phenomenon limited to the exploration of the reasons for ebb and flow. Instead, a general stagnation of knowledge development is discernible in traditional China during the Yuan and Ming periods. Qian Wenyuan (1985) identifies an excessive propensity for ideological and societal continuity, discouragement of or even scorn for intellectual investigations about nature and technology, and "bureaucratic straitjackets" like the civil service examinations as some of the main culprits for this "Great Inertia."

26 For the example of the tidal whirlpool in the strait of Messina mentioned in the *Odyssey* see <http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.01.0136%3Abook%3D12%3Acard%3D73>. Biblical references to phenomena reminiscent of the tides provide only vague indications of possible causes for those abrupt changes in water levels, as for example in Job 38.8: "[God] shut up the sea with doors, when it brake forth, as if it had issued out of the womb." See Wallis (1999, 308). Archaic Indian texts speak of the breathing of a monstrous sea god causing the cycles of the tides, but the oceans are also compared to water in a cauldron that curiously, due to the lunar impact, is heated and thus caused to rise with the increase of the moon. See Cartwright (1999, 6).

(ca. 428–348 BCE), who, in line with an animistic approach, still believed that the earth was a large animal and that the oscillation of fluids inside of it caused the tides. His disciple Aristotle (ca. 384–322 BCE) was not yet able to find a more satisfying explanation for tidal phenomena, much to his own disappointment. In *Meteorologica* (Bk. II.8) he only states in general terms that waves are caused by winds, and that earthquakes, which sometimes coincide with an eclipse of the moon, are often accompanied by violent tidal waves.²⁷ Thus, even though a tidal cycle is neither mentioned nor directly associated with the moon’s phases, he is at least able to relate an unusual rise and fall of the ocean surface to certain lunar constellations.

Today we know that one of the main reasons for Aristotle’s failure was his geocentric model of the universe. The first to base his corresponding explanations on the heliocentric system was Seleucos the Chaldean (fl. ca. 150 BCE), an astronomer of the Persian Gulf region.²⁸ He developed his own theory of the tides, in which the different positions of the moon in the zodiac are directly correlated to ebb and flow. Moreover, taking a more structural approach, he believed that the revolution of the moon resisted the “whirling” motion of the earth. Therefore, the air between the two bodies is diverted and, falling onto the oceans, agitates the waters into tidal waves (Heath [1913] 2013, 305). These ideas were taken over by the Stoic philosopher Poseidonius of Apameia (135–51 BCE). In his writings, he described the tides as caused by the combined action of sun *and* moon, and he seems to have been the very first in the West to record the daily tidal delay for different places along the coast.²⁹

Finally, in his *Naturalis historia* (Bk. II, ch. 99–102), the Roman naval commander and philosopher Pliny the Elder (23–79 CE) touched upon the issue of the influence of the moon observable—though to a far lesser extent—in smaller waters like lakes, rivers, or even enclosed springs. But what is more, in his view the lunar power influenced animals and plants as well. Thus, when the moon is close to the earth, all creatures depending on water are filled and replenished with moisture, while plants also feel the lunar influence (II, 102). Therefore, vegetables are best harvested while the moon is on the wane (XVIII, 75).³⁰ As these astrological explanations were based on a presumed influence of the celestial bodies and their movements on created things, the church took an ambivalent stance on this matter. Such explanations were seen as standing in the

27 See <http://classics.mit.edu/Aristotle/meteorology.2.ii.html>.

28 The heliocentric system actually goes back to the Greek astronomer Aristarchus of Samos (ca. 310–230 BCE).

29 Like those of Seleucos, the ideas of Poseidonius were preserved in detailed quotations in Strabo’s (63 BCE–23 CE) *Geographica*, which later became one of the most important sources for the retrieval of ancient knowledge in Renaissance Europe.

30 All these assertions are taken from the English translation of *Naturalis historia* by John Bostock and H. T. Riley (1855) as provided online by The Perseus Digital Library at <http://www.perseus.tufts.edu/hopper/>.

way of the belief in an almighty God. The issue was only settled during the European Renaissance by dividing the discipline into two branches: whereas “judicial astrology,” dealing with the supposedly predictable effects on the destinies and affairs of human beings, was considered heretical, so-called “natural astrology” was accepted by the Catholic church because it turned out to be an indispensable amendment to the scientific explanations not only of medical but of meteorological and natural phenomena.³¹

Unfortunately, these early findings about the causes of the tides were almost completely lost over the subsequent “dark centuries,” so to speak, giving China the explanatory lead in that field for quite a time. The only—quite remarkable—exception in this regard is a text by the Anglo-Saxon Benedictine monk Bede the Venerable (ca. 672–735). His *De temporum ratione* (*The Reckoning of Time*; ca. 725) is based on astronomical observations and gives a fairly good account of the tide cycles.³² Though in large part Bede follows Pliny’s *Naturalis historia*, he does not merely apply “swelling” or “breathing” theories, which similar to China were still popular in Europe at his time,³³ but rather assumes that the waters of the oceans are somehow “dragged” (*protrahitur*) around the world by the moon.

After this, however, there was silence for more than 500 years, until efforts to better understand the natural world and the cosmos were revived in Europe from the twelfth century onwards. A new impulse for novel approaches to our topic had cropped up in the form of a ninth-century work written by the famous Arabic astrologer Albumasar (Abu Ma‘ shar; d. ca. 886).³⁴ His treatise *Introductorium in astronomiam* showed a keen interest in explaining the underlying causes of the tides in terms of the perceivable physical nature of the cosmos instead of conjuring supernatural forces whenever

31 Similar to the Chinese concept of mutual correspondences, Western astrology, fully systematized and correlated with Aristotelian natural philosophy in Ptolemy’s *Tetrabiblos* in the second century CE, assumes that because the moon has a moist quality, the water of the sea tries to get as close to it as possible, as things of the same “nature” (*cognata virtus*) tend to join each other. By analogy, the influence of the phases of the moon is related to the course of certain diseases.

32 For Bede and his work, see the translation plus an extensive introduction and commentaries by Wallis (1999). The main subject of his comprehensive manual *The Reckoning of Time* is the medieval computus, which is the measurement of time for constructing a Christian calendar. Bede is also deemed the compiler of the first known European tide table, which almost two centuries after its Chinese counterpart was inscribed into the London Bridge around the year 1220.

33 Organic respiration theories about the tides had been popular throughout the Middle Ages and had even “captivated as remarkable a mind as Leonardo da Vinci, who actually tried to calculate the size of the world lung” (Needham and Wang 1970, 494).

34 The re-transmission into pre-Renaissance Europe of the knowledge of ancient Greek philosophers, which had been preserved in Arab texts, became possible through extensive Latin translations of these texts.

necessary.³⁵ It strongly influenced a short survey titled *Questio de fluxu et refluxu maris* and attributed to the English scholar Robert Grosseteste (ca. 1175–1253), who around the year 1250 stated that water and air in general respond to the movement of heavenly bodies by virtue of their heat-dependent condensation and rarefaction, which respectively draws them toward or away from the center of the universe. Moreover, there is an efficient as well as a material cause behind ebb and flow. The former consists in the heating of the sea by the rays of moonlight and—in varying degrees over the year—of sunlight; the latter lies in the saltiness of seawater. It is this saltiness that prevents vapor from leaving, so that the oceans “swell” under the rising moon.³⁶

Similar to China, this renewed interest in rational theoretical explanations in Europe was supplemented by a purely practical approach on the part of common sailors observing the influence of the phases of the moon on tides and currents wherever they went. It notably was their knowledge that proved indispensable for making correct tide tables, which appeared later here than in China, but with the rise of commercial shipping quickly gained importance as well.

However, and at least on the face of it in striking similarity to China, from the thirteenth century until the year 1602, when Sabatino de Ursis finally embarked from Lisbon on his journey to Asia, no tangible breakthrough had yet been achieved with regard to new insights into the fundamental principles of tidal phenomena.³⁷ This is also reflected in the relevant statements of the Coimbra commentaries on the Aristotelian works, which contained the complete body of knowledge in natural philosophy available at the end of the sixteenth century and formed the foundation of the Jesuit curriculum at that time.³⁸ In the volume on *Meteorologica*, the influence of the

35 See Cartwright (1999, 15). Cartwright assumes that Albumasar’s writing, which according to Lemay (1962) in large part follows that of Aristotle, is mainly based on the works of the Persian astronomer Seleucos, see above. In any case, Albumasar had concluded that it was neither the light of the moon nor the warmth generated by it that caused the tides, because these occurred at full and at new moon in similar fashion. The significance attributed to Albumasar in the question of the tides is reflected by the fact that within this context he is one of the references cited in the 1593 Coimbra commentary on Aristotle’s *Meteorologica* (Colegio de la Compañía de Jesús [1593] 1594, tract. 8, cap. 6, 81–83).

36 See the studies by Laird (1990) on the significance of Albumasar’s findings for Grosseteste, and Dales (1966), who provides an English translation of Grosseteste’s *Inquiry into the Causes of the Tides* (Dales 1966, 468–473).

37 Interestingly, the few relevant treatises published in Europe from the thirteenth to the end of the sixteenth century for the most part were written by Italian astronomers and philosophers like Jacopo Dondi, Federico Delfino, and Girolamo Borro. Essentially entitled *Del flusso e riflusso del mare*, these studies more or less reiterated current knowledge, but might have been familiar to de Ursis.

38 The Coimbra commentaries were written by Jesuits and published in three stages between 1592 and 1606. As textbooks accompanying the philosophy course, their focus was simultaneously on the interpretation and discussion of the relevant Aristotelian works as well as on the systematization of teaching. For this topic, see for example Casalini (2017).

moon and the sun and the possibility of an intermittent rarefaction and densification of water are mainly discussed as causal factors for the rise and fall of the ocean surface.³⁹ But it remains unclear whether it is the movement of the moon as such, its light, or perhaps some other kind of “hidden force” transmitted by the heavenly bodies that is responsible for this influence, and so the specific mechanism behind tidal phenomena in the end has to be left open.

This shows that the imminent cognitive leap in understanding the cosmos and thus the causes of ebb and flow indeed came too late for the related concepts de Ursis took with him to his final destination in China.⁴⁰ Nevertheless, at the time the young Jesuit left Europe, the general shift away from the traditional Aristotelian worldview to a modern scientific approach to natural phenomena marked by experiment, exact measuring, mathematical formulations, and the establishment of distinct epistemological categories was already underway.⁴¹ But the heated open debate which culminated in the abandonment of the firmly established but dead-end Ptolemaic geocentric model and thus paved the way for a deeper understanding of the causes of the tides was just about to set in.

A final comparison reveals that despite being based on different cosmologies, the development of ideas about tidal phenomena in China and Europe showed notable

39 See *Commentarii Collegii Conimbricensis Societatis Iesu In Libros Meteorum Aristotelis Stagiritæ* (Colegio de la Compañía de Jesús [1593] 1594, tract. 8 [De Mari], cap. 5 [Variae philosophorum sententiae de effectrici causa marini aestus] and 6 [Eorum sententia, qui causam marini aestus in Lunae vim conferunt], 80–83). Other than those on *Physica* or *De coelo*, the commentary on Aristotle’s *Meteorologica* was the first one to omit the original Aristotelian text and give just a summary of its key messages in order to make them fit into the tight curriculum of the philosophy course.

40 In Europe at that time, the existing body of empirical knowledge about nature was increasingly augmented by a systematic mathematical approach, which allowed them to establish more comprehensive principles or laws for these phenomena. See Davids (2006, 67) and throughout. Given the fact that, as we know from the preface by Xu Guangqi, the *TXSF* was written approximately between 1607 and 1612, de Ursis certainly was not acquainted with the upcoming tidal theories that partly took into account the rotation of the earth, as for example those by Galileo Galilei or William Gilbert (1544–1603), because these were published later. For the further European development in this regard up to the final solution of the tidal riddle by Newton, claiming that it was the gravitational attractions of the moon and, to a lesser extent, the sun together with the earth’s rotational energy that causes the tides (*De motu corporum in gyrum*, 1684 and *Principia*, 1687), see Cartwright (1999, 25–34), and Hooper (2004).

41 According to Peterson (1973), all Jesuit Chinese writings on natural philosophy until the 1660s can be regarded as entirely Aristotelian and dedicated to a teleological mode of explanation. Still, they were “not misrepresenting the prevailing tenor of contemporary European knowledge” (315–316). One should also keep in mind that the discovery of new scientific theories does not automatically mean that these findings are widely accepted, as was the case with mathematical mechanics in general and Galilei’s theory of motion in particular, which for decades were fiercely resisted by the defenders of philosophical orthodoxy. On this subject see Palmerino (2004), especially the chapter “Seventeenth-Century Theories of the Tides as a Gauge of Scientific Change” by Hooper (2004, 199–242).

commonalities. Thus, on both sides the basic discovery of the correlation of ebb and flow with the phases of the moon supplemented by the influence of the sun went hand in hand with the great popularity of breathing or respiration theories and a remarkable persistence of legend and lore. Moreover, concurrent efforts at a systematization and more rational explanation of the empirical findings can be recognized, while at the same time practical—or more precisely fiscal and commercial—considerations constituted an important motivation to better cope with the rise and fall of water levels. Finally, preceding the arrival of de Ursis in China, a long period of ostensible scientific stagnation had affected both sides. The next section will show in which particular way the *TXSF* deals with our subject matter.

4 The explanation of tidal phenomena in the *Hydromethods of the Great West*

Altogether, the *TXSF* consists of five textual sections followed by a sixth chapter with illustrations. Beyond the technical instructions for the construction of pumps, it explains the building of wells and cisterns and refers to methods for probing the quality of and healing with water, including a paragraph about hot springs as well as the first description in China of the distillation of plant medicines. The section about the tides is found in the “Some Questions about Hydromethods” chapter, which for the most part is theoretical in nature and focuses on the “principles of water” (*shuili* 水理) within the context of the Aristotelian theory of the Four Elements (*sixing lun* 四行論).⁴² Chinese scholars, who visited the Jesuit residence in Beijing frequently, had raised questions about the characteristics of water and related natural phenomena, and Xu Guangqi subsequently wrote down and further elaborated the explanations de Ursis had to offer in response.⁴³ In this way a variety of subjects were addressed, among them seawater and its saltiness, the hydrological cycle on earth, the quality of spring

42 Within the context of this chapter, the term *sixing* 四行 clearly refers to the Aristotelian concept of the “Four Elements,” which more correctly would be “Four Primary Elements” (*si yuanxing* 四元行) as against the Chinese concept of “Five Phases” (*wuxing* 五行). Against this, Elman (2005, 119) claims that the expression “Primary Elements” (*yuanxing* 元行) was first introduced only about two decades later by Alfonso Vagnone (Gao Yizhi 高一志; 1566–1640) in his *Investigation into Celestial Phenomena* (*Kongji gezhi* 空際格致; ca. 1633).

43 As against the preceding four chapters of the *TXSF*, which are introduced as “composed and explained” (*zhuanshuo* 撰說) by de Ursis and only “noted down with the brush” (*biji* 筆記) by Xu Guangqi, the latter with his “extensive explanations” (*yanshuo* 演說) was much more actively involved in volume 5 in the spelling out and transliteration of Western ideas presented orally (*shuzhi* 述旨) by de Ursis. This issue is scrutinized by Hsu Kuang-Tai (2008) and will be referred to further down in this essay as well. Nevertheless, in order to do justice to the contributions of both authors of the *TXSF*, in the following the corresponding statements are neutrally expressed from the perspective of the *TXSF* as a whole.

and underground water, the origin of rain, snow, and hail, and the use of water in farming.

One of the rhetorical questions was: “Why is it that there are morning and evening tides in the case of seawater?” The *TXSF*’s reply begins with the following introductory remarks:⁴⁴

If one investigates the things and examines the seasons, and if one fathoms the principles (*qiong li* 窮理) and exploits the numbers (*ji shu* 極數), then there is no doubt about [the correctness of] the theory of [water] responding to the moon (*ying yue zhi shuo* 應月之說). (de Ursis and Xu [1612] 1965, fol. 5.5a, 1645)⁴⁵

In this very first sentence, Western and Chinese aspects of the examination of natural phenomena are blended together. On the one hand, there is the universal importance of considering things thoroughly instead of limiting oneself to dispelling one’s doubts;⁴⁶ on the other, one should attend to the numbers in this context. In the Chinese understanding, the term *ji shu* actually stood for numerological practices deemed superstitious by the Jesuits, but here it additionally alludes to mathematical skills and with them an emphasis on quantification, as we will see later on.⁴⁷ In any case, the audience is drawn into an atmosphere of trustworthiness and familiarity conducive to the subsequent explanation of the lunar theory, which was well known to them:

44 The following translation of the complete *TXSF* passage on tides is based on the *First Collectanea of Heavenly Studies* (*Tianxue chuhan* 天學初函) edition compiled by Li Zhizao 李之藻 (1565–1630) in 1626 (de Ursis and Xu [1612] 1965, fol. 5.5a–6a, 1645–1647).

45 “察物審時，窮理極數，即應月之說，無可疑焉。”

46 The key concept of Neo-Confucian moral philosophy, that is, “investigating things and exhaustively mastering principles” (*gewu qiongli* 格物窮理), is modified here: as the ideologically charged term *gewu* 格物 was appropriated by the Jesuits to express in Chinese their own Latin term *scientia* or “systematized knowledge” that, according to Standaert (1994, 399), for them always included the superior goal of “finding god,” it might have been intentionally left out here to avoid any affront on the Chinese side. It was substituted by the neutral *cha wu* 察物, which has a similar meaning. For a differentiation between *gewu* 格物, *gezhexue* 格致學 (natural studies), and *kaozhengxue* 考證學 (evidential studies) in this context, cf. Elman (2010). For the topos of “doubtlessness,” see Spence (1984, 146), where he cites a passage from the preface by Matteo Ricci to his *Elements of Geometry* (*Jihe yuanben* 幾何原本; 1607): “[Our scholars] say that investigation using reason can lead to scientific knowledge, while someone else’s opinions lead only to my own new opinions. A scientific knowledge is absence of doubt; opinion is always accompanied by doubt.”

47 The term *ji shu* 極數 usually refers not only to the skills in numerology but also to the practices of fortune telling by throwing milfoil stalks or divining-straws. In the context of the *TXSF*, however, it could also be understood as “bringing the [skills in the use of the] numbers to the utmost.” In this reading, it would be in line with the preface Xu Guangqi wrote for the *TXSF*. There he praises the missionaries for their mastering of the “teaching of numerological regularities underlying phenomena” (*xiang shu zhi xue* 象數之學), clearly referring to mathematical skills. In any case, the expression has an ambivalent meaning here.

[This theory says:] As the moon is *yin* essence (*yinjing* 陰精) and [belongs to] the same [category of] things as water, whenever there is damp moisture and cold humidity within the whole cosmos (*huanyu* 寰宇), the moon rules over these [phenomena]. Since they [that is the moon and water] are of the same category, they necessarily draw near to each other. The moon is the origin of moisture and is able to bestow it downwards [to the earth]. Therefore, if a square receptacle (*fangzhu* 方諸)⁴⁸ is turned towards the moon, one obtains water in it. But since the moon [that way] is of benefit downwards [to the earth], water also moves up to the moon, because it wants to get near to it. For that reason, wherever the disc of the moon reaches, water is caused to grow (*zhang* 長), and so the morning and evening tides result. (de Ursis and Xu [1612] 1965, fol. 5.5a, 1645)⁴⁹

As explained above, this causal relationship between the moon and water had long been accepted not only in China but also in the West, and indeed was also part of the Coimbra commentary on the Aristotelian *Meteorologica*.⁵⁰ In the *TXSF*, however, it is notably described using the characteristic Chinese terminology alone, and in full accordance with the traditional Chinese cosmology based on *yin-yang* and the system of mutual correspondences as recorded earlier in the *Master Huainan*. But it seems that by this mode of depiction, the authors have accommodated the readers' fundamental ideas of the subject matter only to the extent that they are now prepared for a rather abrupt shift away from their familiar surroundings and towards a modified interpretation of the lunar theory, which in contrast to the Chinese variant is based on Aristotelian teachings and strictly physical principles.⁵¹ This shift is necessary to explain the upward movement of the tides, which actually runs counter to the traditional Chinese idea that water has an inherent tendency to flow downward.⁵² The *TXSF* continues:

48 *Fangzhu* 方諸, literally "square all" or "perfectly square," is a utensil in the form of a mirror or bowl made from bronze, stone, or shells and used for collecting water on moonlit nights. The significance of dew condensing on the mirror by Needham and Wang (1970, 89–90) is attributed to some kind of "philosophical superstition." Wang Chong in his *Discourses Weighed in the Balance* also takes a critical stance in this regard. For this topic, cf. Tang (1935).

49 "月為陰精，與水同物，凡寰宇之內，濕潤陰寒，皆月主之。既其同物，勢當相就。月為濕本，濕能下施，故方諸對月，而得水焉。月既下濟，水亦上行，欲就于月。故月輪所至，水為之長，而成潮汐也。"

50 "quod compertum sit Lunam humidis corporibus dominari . . ." See Colegio de la Compañía de Jesús ([1593] 1594, 82). For the same reason, the moon is here correlated with the female sex.

51 This shift is also reflected by a change in the vocabulary, as in the following the rather blurred expression "to grow" (*zhang* 長) for the ascending of water is replaced outright by "rising" (*sheng* 升).

52 This concept goes back to the book *Mencius* (*Meng zi* 孟子) (Warring States period, 475–221 BCE), with its famous water metaphor describing human nature in the first "Gaozi" chapter (告子上): "'It certainly is the case,' said Mencius, 'that water does not show any preference for either east or west, but does it show the same indifference to high and low? Human nature is good just as water seeks low ground. There is no man who is not good; there is no water that does not flow downwards.'" (孟子曰：水信無分於東西。無分於上下乎？人性之善也，猶水之就下也。人無有不善，水無有不下) (Mencius [ca. fourth century BCE] 1970, 160).

[Moreover,] when the tide is growing, [not only in the sea but also] in rivers and streams, creeks and mountain torrents as well as basins and containers, there is no place where [the water] would not be growing. When it is growing, air (*qi* 氣) enters and the water therefore becomes lighter, and when the tide is falling, air exits, and the water therefore becomes heavier again. Now, if someone takes a jar, fills in water and weighs it every day, its weight will vary. In accordance with that, when the tide rises (*sheng* 升) it [that is the water] is getting lighter and when it falls it is getting heavier. (de Ursis and Xu [1612] 1965, fol. 5.5a-5b, 1645-1646)⁵³

First, the *TXSF* specifies the scope covered by its theory: it is not only the sea that shows a tidal reaction to the moon, but all other waters on earth as well. Only then does it break this phenomenon of “growing” and falling waters down to its basic mechanism. It simply consists in an in and out of *qi* 氣 or “air,” immediately reminiscent of the respiration theories well known to the Chinese but popular in the West as well.⁵⁴ But here the *TXSF* is not primarily focused on breathing; it rather tries to explain the mechanism of this phenomenon within the framework of the Aristotelian doctrine, that is through the interaction of the elements Water and Air.

At the beginning of the “Some Questions about Hydromethods” chapter it is said that depending on their weight, “all [physical] things constituted by the Four Elements have their original place” (de Ursis and Xu [1612] 1965, fol. 1a, 1637: 四行之物，各有本所). Therefore, water is situated beneath air, which is lighter, but above the still heavier earth. The natural tendency of water to run down to the sea and gather in this low-lying ditch results from this. Nevertheless, it can temporarily leave its original place and, as in case of the rising tides, move upwards. This is possible because all elements besides Fire are able to mutually tolerate each other, so that for example Water can have an “Air component” (*qifen* 氣分), as in the case of alcohol, which consequently is lighter than water. But Air is not only lighter than Water, it also tends to move upwards to its own original place, and in this process it draws the water up with it in the

53 “當潮長時，江河溪澗，以及盆盎，無處不長。長則氣入，水為之輕，潮降氣出，水復故重。今人以餅盛水，每日權之，輕重不等，則潮升時輕，潮降時重耳。”

54 Even though the character *qi* 氣 is consistently translated here as “air,” it should be kept in mind that for the Chinese reader *qi* remained inseparably associated with its original notion of “breath” or “vapor,” which was connected to some kind of ubiquitous primordial energy and as such always meant more than just something material. In other sections of the *TXSF*, however, instead of “air,” *qi* 氣 is rather used to express “steam” or “vapor.” For the etymology of the character *qi* 氣, see Zhang (1999, 76ff). In addition to this notion of the tides breathing the air in and out, the idea was widespread in Europe in medieval times that the total amount of water in the oceans periodically expanded and shrank due to a transformation of air into water and vice versa. This idea goes back to the Arab geographer Al-Masudi (ca. 888-957) and was taken up in Europe by Egidio Colonna (1247-1316), Prior General of the Augustinian Order and one of its most influential theologians of his time. See Russo (2003, 22).

direction of the moon and thus against expectation makes it rise.⁵⁵

In the *TXSF*, this material effect, which not only differentiates “air” from the Chinese notion of *qi* but also from the somewhat similar Western concept of *pneuma*, is demonstratively proven by a weight experiment, which in our modern view of course is rather obscure and in fact is not found in Aristotle’s teachings.⁵⁶ For de Ursis, this correlation meant an excellent opportunity to insert one of the features of the superior Western scientific approach into the all too familiar explanations of the tides up to that point. The described experiment suggests that *qi* has a measurable weight that is much lighter than that of water and therefore reduces the total when admixed to it. But that which has a measurable weight must be a tangible object, even if it is invisible, and thus something totally different from the Chinese understanding of *qi*. Accordingly, this almost casual confrontation of the readership with a “misinterpretation” of one their basic cosmological principles not only serves to explain how tidal waters can rise, defying common sense, but also sheds a different light on *qi* itself. The whole passage, moreover, is a fine example of the Jesuits’ often rather flexible use of the Four Elements theory when it came to the explanation of apparent anomalies in nature.⁵⁷

55 Further down, the “Some Questions about Hydromethods” chapter describes the cycle of water on earth, including the oceans and rivers as well as rain and snow. There, the movement of water from lower to higher levels, which is actually contrary to its (inner) nature, is said to have two different reasons: in line with Aristotle’s *Meteorologica* it can be explained either as a distillation-like evaporation caused by the warmth of the sun, making water ascend alongside air, or—beyond Aristotle—as a consequence of the moon’s attraction, which causes it to grow at certain times (de Ursis and Xu [1612] 1965, fol. 8b, 1652: 其從下而上, 得為江河者, 或受日溫, 隨氣上騰, 或受月攝, 因時而長). In the *TXSF*’s interpretation of the latter, the moon-induced growing, heat obviously does not play a role, which is remarkable insofar as Aristotle and all other writers up to that point usually explained such a change in volume, be it of vapor or of water as such, with a temperature gradient. This finding suggests that the main reason for the *TXSF*’s peculiar interpretation in the case of the tides was indeed to present *qi* as nothing but material air.

56 The experiment described in the *TXSF* resembles the determination of the specific weight or density following the Archimedean principle. In our case, however, even if air were indeed to enter and exit water in variable proportions and the volume in the jar was kept exactly constant over time, the experiment mentioned in the *TXSF* does not make much sense, as dissolving air in water has very little impact on the specific weight. In a more general form, however, the change of weight as one of the causes for the rising and falling of water with the tides is found in the writings of Albertus Magnus (before 1200–1280), whose *Libri quattuor meteororum* was first published in 1481. In book II, ch. 3.6 “De causa fluxus maris” of the 1651 edition, in the context of rivers flowing not only into the sea but also back from it in an upward direction, we read: “videmus enim quod hoc facit leve, quod si movetur sursum per naturam, numquam recedet de sursum in deorsum: et grave quod naturaliter movetur deorsum, nunquam per naturam ascendet de deorsum in sursum” (What is light moves upwards, what is heavy moves downwards, and never in the opposite direction) (Magnus [1481] 1651, 58). Therefore, in the case of mixtures of heavier with lighter things—for example water and air—they must move to a place in between those originally occupied by each of the two components.

57 See Peterson (1973, 301–302, 305).

Still, what the scientific approach of Renaissance Europe cannot explain rationally is *how* the influence of the waxing and waning moon on water is transmitted. This concerns a crucial difference between the Chinese and the Western conceptions: whereas in the context of Chinese cosmology the primordial *qi* acts as a kind of mediator in the whole universe, regardless of distance,⁵⁸ in the Western understanding this transmission could be explained only by invoking the auxiliary discipline of astrology.⁵⁹ Before turning to this field, the *TXSF* makes it clear that the preceding statements are valid only for the visible rising and falling of the oceans:

It is only that in places with small [amounts of] water the rising and falling is so slight that it is something not perceived by human beings. Since the waters of the sea, however, are vast, they are [even] poured into rivers and streams [at high tide], and as they rise and fall, fill up and [later] dry out [again], the facts and principles involved (*shili* 事理) become evident. This is the reason why one only speaks of “sea tides” (*haichao* 海潮), [but not of tides in places with small amounts of water]. (de Ursis and Xu [1612] 1965, fol. 5.5b, 1646)⁶⁰

This differentiation between waters of different sizes once more underlines the importance of a proper classification of the relevant parts of the object under investigation. Thus, tidal waves in rivers and streams are a consequence of the ebb and flow of the sea and as such a manifestation of the scientific principles described thus far. The impact of the moon on much smaller amounts of water, however, does not cause a tidal up and down, but has a different effect which in the Western understanding pertains to the field of astrology and thus has to be delineated from the statements made before. In this new context, animals come first:

58 Needham wrote about the implications of this distinctive Chinese way of thinking about physical laws that in contrast to the Western atomistic approach, their own predilection for a concept of waves and continuity rendered an explicit discipline of dynamics unnecessary, and had the side effect that the idea of action at a distance—an issue still discussed controversially in Europe throughout the seventeenth century—never seems to have been problematic for them. See Needham and Wang (1962, 60), and also Hooper (2004, 199). Thus, according to Needham, “essence” (*jing* 精) in ancient Chinese concepts of the physical world is almost translatable as “radiant energy.” Such “sympathetic” influences are radiating through the continuum as conveyers of mutual interaction (Needham and Wang 1962, 31–32).

59 The synchronizing effect of the moon, which in fact does not differ significantly from the Chinese notion, is described in Book I.2 of Ptolemy’s *Tetrabiblos* as follows: “as the heavenly body nearest the Earth, the Moon bestows her effluence most abundantly upon mundane things, for most of them, animate or inanimate, are *sympathetic* to her and change in company with her; the rivers increase and diminish their streams with her light, the seas turn their own tides with her rising and setting, and plants and animals in whole or in some part wax and wane with her” (Robbins 2001, 7 [italics added]).

60 “獨小水之處，升降甚微，人所不覺。海水既大，灌注江河，升降盈涸。事理顯然，故獨稱海潮也。”

But [the influence of the moon] not only concerns [vast amounts of] water! Whenever it comes to the creatures of the aquatic family (*shuizu zhi wu* 水族之物), on the fifteenth day of the lunar month the air [inside of them] has increased, whereas on its last day it has decreased. Therefore, at new moon the brains of fish (*yunao* 魚腦) shrink, while at full moon clams (*bangge* 蚌蛤) are stout. (de Ursis and Xu [1612] 1965, fol. 5.5b, 1646)⁶¹

The presented example was most familiar to the Chinese audience, as it had cropped up previously in *Master Lü's Spring and Autumn Annals* (*Lüshi chunqiu* 呂氏春秋) and then in the *Master Huainan*, though in the context of *yin* and *yang*.⁶² The same topic, however, was common knowledge in Europe too, as we have seen in the remarks about Pliny the Elder's *Naturalis historia* above.⁶³ Interestingly, in both cases these findings about the moon are connected to a distinct classification of the objects involved: on the Chinese side, it is “the creatures with scales and shells [that] make up the class of creeping and hiding things, [which is] subject to *yin*”⁶⁴ and thus experiences a periodic waxing and waning. Instead, in the Western classification, going back to Aristotle's *Historia animalium*, it is the “bloodless creatures” like crabs, clams, or oysters that are regarded as “cold and fluid (or moist)” and thus more sensitive to the moon than others. The brains of fish are also “naturally [moist and] cold to the touch,” implying that they react to the moon as well.⁶⁵ But regardless of the exact classifications, we are again dealing with a striking similarity between Western and Chinese ideas. The same principle also applies to vegetation:

But furthermore, [the lunar influence] not only concerns aquatic animals! As herbs and

61 “不獨水矣。凡水族之物，月望氣盈，晦即氣縮。故月虛而魚腦減，月滿而蚌蛤實也。”

62 The relevant passages are firstly: “The virtuous one is the ruler of all people, the moon is the origin of accumulated *yin*. At full moon clams are stout, as their accumulated *yin* is full; at new moon they are empty, as their accumulated *yin* has waned” (own translation of 德也者，萬民之宰也。月也者，群陰之本也。月望則蚌蛤實，群陰盈；月晦則蚌蛤虛，群陰虧。 [emphasis added], in “Proficiency” (*Jingtong* 精通), “The Third Month of Autumn” (*Jiqiu ji* 季秋紀), *Master Lü's Spring and Autumn Annals* (*Lüshi chunqiu* 呂氏春秋; late Warring States period, 475–221 BCE). The second passage is: “The moon is the fundament of *yin*. Therefore, when the moon wanes, the brains of fish shrink; when the moon dies, wasps and crabs shrivel up” (月者，陰之宗也，是以月虛而魚腦減，月死而羸虻蟪。 *Master Huainan*, ch. 3. Translation by Major et al. 2010, 116).

63 *Naturalis historia* Bk II.102: The moon “replenishes the earth [*terras saturat*]; when she approaches it, she fills all bodies, while, when she recedes, she empties them. From this cause it is that shell-fish grow with her increase.” <http://www.perseus.tufts.edu/hopper/text?doc=Perseus%3Atext%3A1999.02.0137%3Abook%3D2%3Achapter%3D102>.

64 “介鱗者，蟄伏之類也，故屬於陰。” *Master Huainan*, ch. 3, adapted translation by Major et al. (2010, 116).

65 For an English translation of Aristotle's *Historia animalium*, see “The Internet Classics Archive” by Daniel C. Stevenson, here Bk. I.16 at http://classics.mit.edu/Aristotle/history_anim.mb.txt. In the Coimbra commentary on *Meteorologica* (82), the influence of the moon on the human brain as formulated by Galen is described: “Pretaerea cerebrum, quod humiditate abundat, Lunae varietatem & mutationes sequitur . . .”

trees and all created things [on earth] (*bai chang* 百昌) depend on moisture and use it to generate air [inside], there is therefore none [among them] that would not be responding to the moon's waxing and waning (*yue kuiying* 月虧盈). So, when the moon is full, the air is nourished, and when it is empty, it runs dry. For this reason, after the first and before the last quarter of the moon one should not cut down bamboo or trees and use them as timber. In this case they are easily wormy, because they are producing air (*sheng qi* 生氣) inside. But if one cuts them down as timber after the last and before the first quarter of the moon, then they are not wormy and produce little resinous oil (*zhirun* 脂潤), as [there is] nothing else but only substance. (de Ursis and Xu [1612] 1965, fol. 5.5b, 1646)⁶⁶

Such detailed astrological observations and the resulting recommendations for practical action were an important part of the calendar both in China and Europe. For example, Bede the Venerable, in striking similarity to the *TXSF*, recommends in his work that timber should be felled only during a fixed period of the waning moon because otherwise it will be wormy inside.⁶⁷ However, whereas in Europe the judicial branch of astrology had been banned as superstitious by the Catholic Church during the Council of Trent in the middle of the sixteenth century, the Chinese had left the system of lucky and unlucky days handed down from the ancient sage-rulers more or less unquestioned.⁶⁸ According to Hsu Kuang-Tai (2006), the crucial difference in this context is that whereas in the Chinese understanding the correspondence between heaven and earth was a mutual one, the Western concept was based on a unidirectional

66 “又不獨水族矣。草木百昌，苟資濕潤，以為生氣，無不應月虧盈。月滿氣滋，月虛氣燥，故上弦以後，下弦以前，不宜伐竹與木，以為材用。是者易蠹，生氣在中也。下弦以後，上弦以前，伐而為材，即不作蠹，為少脂潤，空質而已。”

67 In Bede's *De temporum ratione*, in the astrological chapter "What the power of the moon can do" (cap. 28: *De effectiva lunae potentia*), we find a comment on book 4 of Ambrosius *Hexameron*:

the same is true of the inner parts of trees. The art of the architects and their daily experience [confirms these words of St Ambrose. They] teach that one should take particular note that the trees from which sailing ships are to be fashioned, [or any public works to be constructed,] be felled between the fifteenth day of the Moon and the twenty-second. For timber felled during these eight days will remain immune from rot (*materies immunis servatur a carie*), but **wood felled on the other days** will turn to dust within a year, **consumed from within by the destructive action of worms** (*interna vermium labe exesa in pulverem vertitur*). (Wallis 1999, 80–81 [emphasis added])

These are much more detailed instructions than those in Pliny's work, which also gives general guidelines of this nature. Bede's description is in line with the Islamic calendar, which, as opposed to its Chinese counterpart, does not start at new moon but with the first crescent. This explains the variance of the times recommended for cutting wood.

68 For an overview of the difference between Chinese official calendars and the popular Chinese almanacs as well as their respective characteristics, see Smith (1992, 1–24). Smith underlines the significance of "cosmological kingship" in China, where both forms of time recording were used in parallel until the fall of the empire in 1911.

influence of the celestial bodies on the sublunar sphere.⁶⁹ As such, it was impossible for the latter to have an impact on the former and thus for human beings to be held responsible for bad harvests, droughts, or earthquakes. In the Chinese understanding, however, the corrupted terrestrial *qi* could ascend to the skies and negatively influence the heavenly bodies. In that way, wrong decisions or other failures by the ruler in particular could lead to natural disasters, entailing enormous consequences for the dynasty. This “astrological *qi*,” as Hsu Kuang-Tai calls it, is from the Chinese point of view the implicit topic of the next sentence, in which the Aristotelian understanding of *qi* as “air” is again intermingled with the traditional Chinese notion:

This indeed is just like the meaning [of the statement that] because in spring and summer the air [inside plants] is sprouting, while during autumn and winter it is restrained (*han 斂*), [therefore] the hatchets and axes are permitted [in the forests on the hills] only in the proper seasons (*fujin shiru 斧斤時入*). (de Ursis and Xu [1612] 1965, fol. 5.5b, 1646)⁷⁰

Here, part of the information alludes to Vitruv’s (ca. 80–70 BCE–after ca. 15 BCE) magnum opus *De architectura* (ca. first century BCE), which was definitely an important source for other parts of the *TXSF* as well. In its second book, Vitruv speaks in similar terms of the appropriate season for cutting timber: it should not be cut down in spring because at that time the trees need all their vigor to produce leaves and fruits, so that the wooden texture itself turns loose and feeble.⁷¹ At the same time, in its original context, the latter part of the above sentence—a citation from the *Mencius*—of course has nothing to do with the rationally explainable physical effects of “material air” on the growth of plants, but is part of a program of good governance by a virtuous ruler in accordance with the laws of the cosmos.⁷² By combining it with the Vitruvian connotation and placing it at the end of the explanations of the influence of the moon

69 It has to be emphasized, however, that this dichotomy is not universally valid for the Western world, as the Jewish tradition and the pre-logical worldview of European antiquity followed diverging concepts.

70 “亦猶春夏氣滋，秋冬氣斂，斧斤時入之意也。”

71 Vitruvius II.9.1: “Materies caedenda est a primo autumno ad id tempus, quod erit antequam flare incipiat favonius. vere enim omnes **arbores** fiunt praegnantes **et omnes suae proprietatis virtutem efferunt in frondem anniversariosque fructus**. cum ergo **inanes et tumidae** temporum necessitate eorum fuerint, **vanae fiunt et raritibus inbecillae**.” See Krohn (1912 [emphasis added]).

72 This phrase stems from the very first chapter of the book *Mencius*, where the appropriate times for the activities of the peasantry are described:

If you do not interfere with the busy seasons in the fields, then there will be more grain than the people can eat; if you do not allow nets with too fine a mesh to be used in large ponds, then there will be more fish and turtles than they can eat; if hatchets and axes are permitted in the forests on the hills only in the proper seasons, then there will be more timber than they can use. (不違農時，穀不可勝食也；數罟不入洿池，魚鼈不可勝食也；斧斤以時入山林，材木不可勝用也。) (*Mencius* [ca. fourth century BCE] 1970, 51 [emphasis added])

on water, the *TXSF* seems to try to detach this sentence from its otherwise supernatural implications and turn it into an example for its own more rational interpretation: adequate knowledge about such processes can be used to the advantage of farmers cutting wood for certain purposes—no more, no less. In this way, the “proper season” in this depiction is intended to appear no longer as some kind of “lucky season” that has to be regarded in the context of statecraft. Rather, it simply constitutes part of a commonplace instruction for work based on reason.

It is possible, however, that the audience understood this as a hidden affront to the traditional Chinese perception and its overarching implications. That it was set out in one of the Jesuit works would have made the provocation seem even worse to those who took a critical stance vis-à-vis the missionaries.⁷³ Interestingly, writing fifty years later on the very same context of the influence of the moon on plants, the Jesuit Johann Adam Schall von Bell (1591–1666), renowned calendar expert at the court in Beijing, substituted the term *sheng qi* 生氣 or “producing air” with the innocuous expression of “generating moisture” (*shi* 濕), leaving the citation from the *Mencius* entirely out.⁷⁴ In any case, the *TXSF* unswervingly brings its own explanations to an end:

By these words it becomes absolutely clear that the moon is the master of water, and that therefore, wherever the disc of the moon [is above them,] all waters are rising, and thus [also] the sea tides are responding to the moon. (de Ursis and Xu [1612] 1965, fol. 5.5b–6a, 1646–1647)⁷⁵

This last sentence is nothing else than a summarization of its argumentation or, in other words, a concluding application of the Western *quod erat demonstrandum*

73 For the handling of this problematic part of the *TXSF*'s tides passage in later citations by Chinese scholars, see below. During the Nanjing persecution of 1616–1617, several members of the Jesuit mission were put on trial for their alleged subversive actions. Sabatino de Ursis was among those banished to Macao, where he died in 1620. For the role of Yang Tingyun 楊廷筠 (1562–1627) in defense of the Jesuits, see Standaert (1988). Adrian Dudink, however, is of the opinion that it was mainly de Ursis's involvement in astronomical affairs that led to his prosecution. The Nanjing Board of Rites official and Buddhist adept Shen Que 沈淮 (1565–1624), main instigator of the persecution, curiously did not give any concrete reason why de Ursis should be expelled. But it is well known that he was not willing to accept the involvement of Westerners, among them de Ursis, in the calendar reform. Cf. Dudink (2001, 196, 209–210, 218ff). On the other hand, the mere reference to expressions like the Lord Creator (*zaowu zhi zhu* 造物之主), as for example in question seven of the *TXSF*'s “Some Questions about Hydromethods” chapter, sufficed in Edo-period Japan to place the work on the index of banned books. For this topic, cf. Ōba and Fogel (2012, chaps. 3–4).

74 For the introduction of Western astrology to China in the late Ming and early Qing periods through the translation of parts of Ptolemy's *Tetrabiblos* by Adam Schall von Bell, see Han (2011; 2013). For the text of Schall von Bell, *Dispelling Delusions about the Annotations to the Civil Calendar* (*Minli puzhu jiehuo* 民歷鋪註解惑), see Schall von Bell (1662).

75 “由此而言，月為水主，月輪所在，諸水上升，海潮應月，斯著明矣。”

formula by which the thesis established in the beginning is reiterated and labeled as proven.⁷⁶ By using this formula, the *TXSF* once again underlines its scholastic approach, and indeed, the argument in the tides passage has systematically followed the rules of Aristotelian deductive reasoning. First, the principal assertion is made that water, which belongs to the same category as the moon, wants to be close to its master and thus periodically rises up in its direction. This rising, visible in the form of the sea tides, seems to go against the nature of water, but the apparent contradiction can be resolved by an elastic use of the Aristotelian laws. Thereafter, a second, more specific proposition is introduced: all created things on earth depend on water. Thus, they should respond to the moon accordingly. That this—despite the minute quantity of water involved—can be really observed with animals or plants in the form of an alternating contraction and expansion is sufficient proof of the initial general proposition.

5 The joint effort of composing the tides paragraph

An examination of the text of the *TXSF* confirms the finding that the traditional tidal theories in Europe and China had much in common: both sides considered the moon to be the master of all things belonging to the category of moisture, and thus responsible for the periodical up and down of water and corresponding phenomena in plants or animals. Therefore, in order to make a contribution that would stand out against these shared ideas and underline the superiority of Western learning, de Ursis had to come up with something else. Obviously, the reiterated accentuation of a scientific approach typical for Renaissance Europe to questions of natural philosophy reflects this attempt. To this effect, the tides passage structurally follows the Western rules of logical reasoning, combined with a likewise characteristic emphasis on proper classification, a clear demarcation between the sciences and natural astrology, the need for quantification, and the experimental verification of the observations made.

Still, if we go deeper into the text, the Jesuit role is put into perspective, as it was undoubtedly Xu Guangqi's part to literarily depict the causal relationship between the moon and water in thoroughly Chinese terms. This concerned not only the wording itself, which basically posed no linguistic challenge to the literati audience because the text contains neither transliterations nor neologisms to express Western

76 This formula was first introduced in Euclid's *Elements*, in part translated into Chinese by Matteo Ricci together with Xu Guangqi in their *Elements of Geometry* (*Jihe yuanben* 幾何原本; 1607). It is a marker of conclusion for any mathematical proof, but was used in other fields of science as a sign of successful argument as well.

terms unknown to them.⁷⁷ Instead, fixed formulas from the Chinese canon (the theory of [water] responding to the moon [*ying yue zhi shuo* 應月之說], the moon is *yin* essence [*yue wei yinjing* 月為陰精]) are used, and already the introductory sentence avoids an expression like *gewu* 格物 or *scientia*, which usually stood for the superior endeavor of the Jesuits to find God through science and thus might have startled the readers.⁷⁸

In addition, the appearance of the square receptacle and even more so of the different citations from the classics create an atmosphere of familiarity for the Chinese scholars.⁷⁹ A look at the sources which obviously underlie the tides passage nevertheless suggests a pronounced amalgamation of Eastern and Western facets: beyond more general references like the *Master Huainan* or the Aristotelian writings (*Meteorologica*, *Historia animalium*), the *Mencius* and *Master Lü's Spring and Autumn Annals* stand out on the Chinese side, while the Occident is represented for example by Pliny the Elder's *Naturalis historia* and Ptolemy's *Tetrabiblos*. The selection from the tremendous corpus of Chinese literature of appropriate passages corresponding in meaning to their Western counterparts clearly carries the signature of Xu Guangqi, as de Ursis would certainly not have been able to accomplish this task without the support of his Chinese collaborator.

The Jesuit himself probably drew on the passage on the ocean tides in the Coimbra commentary on *Meteorologica*, which refers explicitly to Pliny and Ptolemy. Both are listed there together with other sources to be consulted in the context of the lunar theory.⁸⁰ While Ptolemy's astrological explications just appear between the lines of the *TXSF*, statements from the recommended chapters of the writings of Pliny, Albertus Magnus, and Ambrosius (here as cited by Bede) are paraphrased more concretely or—at least in short parts—even quoted indirectly, as for example is the case with the destructive action of worms in timber. In addition to that, concepts from the Coimbra commentary itself are used in the *TXSF*. The idea of an intermittent rarefaction and densification of water that is circumscribed in the *TXSF* by the entering and exiting of *qi*

77 For a discussion of the three ways used by the Jesuits and their collaborators for expressing Western terms in Chinese, see Standaert (2000, 292–293).

78 Whether the selective omission in this place was indeed intentional or if this is rather an incidental finding must be further scrutinized by an intra- as well as inter-textual analysis. In any case, short but direct references to the creation of the cosmos or to “the Lord Creator” (*zaowu zhi zhu* 造物之主) in the “Some Questions about Hydromethods” chapter crop up three times.

79 For Peterson (1973, 311), this systematic presentation of knowledge within a framework of tradition and authoritative texts is characteristic of the argumentation of the Jesuits in their Chinese treatises.

80 Tract. 8 (De Mari), cap. 6 (Colegio de la Compañía de Jesús [1593] 1594) enumerates Ptolemaeus (lib. 2.12), Cicero, Plinius (lib. 2, cap. 97), Strabo, Averroes, A. Magnus (*Meteororum* lib. 2, tract. 3, cap. 6), Albumasar, Alensis, Thomas [Aquinas], Scotus, Ficinus, Cardinal Contarenus, Levinus, Ambrosius (*Hexameron* lib. 4, cap. 7), and Basilius.

in and out of water is also addressed in the commentary, though this mechanism is regarded as unlikely there.⁸¹ Moreover, the question whether the influence of the moon results in outright tides of *all* waters or only those of the sea is discussed extensively in chapter 7 of the commentary. The *TXSF* clearly takes this issue up twice: when it talks of the water growing “in rivers and streams, creeks and mountain torrents as well as basins and containers,” and then again with the remark that “one only speaks of ‘sea tides,’ [but not of tides in places with small amounts of water].”⁸² These findings suggest that de Ursis had studied the relevant chapter at some time, even though it is not clear whether the Coimbra commentary on *Meteorologica* was extant in Beijing when the *TXSF* was written.⁸³

But what is more, while Xu Guangqi was obviously the one responsible for striking the right chord with the readers of the *TXSF* through the wording and the delicate interweaving of learned citations from Chinese and European authoritative texts, and as such seems to dominate the scene with regard to the content, possible further ambitions of de Ursis become discernible within this setting. That he uses common conceptual ground as an arena for insisting on the material properties of *qi* might have been motivated above all by the scientific need for quantification, but it also alludes to an issue perceived by the Jesuits as hindering their religious intentions. This issue concerns the use of the character *qi* 氣, which constituted one of the basic principles of traditional Chinese cosmology and actually stood for a form of energetic vitality. In the tides paragraph of the *TXSF*, however, an effort is made by means of the weighing experiment to deprive this *qi* of its original connotations.

According to Standaert, the use of common Chinese terms or expressions in the joint cultural translations of Jesuits and their collaborators hints at a certain degree of

81 See Colegio de la Compañía de Jesús ([1593] 1594, tract. 8, cap. 6): “an potius aquis citra ulla rarefactionem & addensationem loco motis . . .” Besides, after having been drawn up towards the coast, the waters are relinquished again and then contract under their own weight (suapte pondere in decliniora resilient).

82 In Colegio de la Compañía de Jesús ([1593] 1594, tract. 8, cap. 7), we read that the waters of rivers (fluviales), torrents (amnes), and wells (putei) all react more or less similarly to those of the sea, even though this effect is sometimes hindered by structural impediments of the terrain or the like such that it is hardly discernible. However, “not all water has the *original aptitude* to be moved reciprocally [up and down] by the moon, but only that of the sea” (sic ergo non omnis aqua nativam habet aptitudinem, ut a Luna reciproco fluxu moveatur, sed marina duntaxat) [*italics added*].

83 Verhaeren’s Beitaug Catalogue lists both the 1593 Lisbon and 1594 Lyon editions of the Coimbra commentary on Aristotle’s *Meteorologica* (nos. 1372 and 1374), but leaves open when they probably arrived in Beijing. The other sources mentioned above are even more difficult to trace, as neither Plinius nor A. Magnus nor Ambrosius is listed in the Beitaug Catalogue. For the availability of Western books in this early phase of the Jesuit China mission in general, see for example Golvers (2018).

correspondence in meaning which “had as a result that Aristotelian philosophy was explained in (Neo-)Confucian terms” (Standaert 2000, 293), which could have been taken as a demonstration of the Chinese philosophical system’s supremacy over the Western one. With regard to *qi*, however, the situation was more complicated. Zhang Qiong has pointed out that right from the beginning, the omnipresent concept of *qi* had startled Matteo Ricci, who deemed it a severe obstacle to the Jesuit missionary task.⁸⁴ Ricci realized that it threatened to reduce all modes of existence, including ghosts, spirits, and the souls of the deceased, to a common mechanism and thus—in Zhang Qiong’s words—to deprive the universe of the “infinite ontological gap between God and the world,” indispensable for Christian salvation (Zhang 1999, 80). To tackle this problem, the prevailing spiritual connotations of *qi* had to be countered by purposely attributing it lifeless, purely material, and as such measurable qualities, and to this end the authors ostentatiously rationalized it by depicting it time and again as the element air in the *TXSF*. The explanation of the abnormal rising of water with the tides—for which Renaissance knowledge actually offered no convincing solution—was obviously perceived by de Ursis as an excellent opportunity to restore the crucial gap between this and the other world.

Thus, beyond its scientific claim, the creative insertion of the weight experiment in the tides paragraph can be seen as a strategically motivated and deliberate move by the Jesuit. In my view, this finding hints at a first step of advancement of the Jesuit translation project after an initial period of “spontaneous diffusion,” which in the classification by Standaert (2003) lasted from about 1582 to 1610.⁸⁵ Whether the applied method can be equated with an intended violence towards the Chinese readers, as Zhang Qiong has described it (1999, 101), requires further evidence, but the demonstrative introduction of the weight experiment in the *TXSF* certainly is a case in point here. At any rate, from this perspective an indirect and more or less “willful infiltration of Christian beliefs in the scientific textbooks translated into Chinese” is

84 Already in his *The True Meaning of the Lord of Heaven* (*Tianzhu shiyi* 天主實義; 1603), Matteo Ricci had made it clear that the inaccuracy of Neo-Confucian terms and their improper categorization of all modes of existence as manifestations of the same universal *qi* was responsible for the untenable blurring of the dichotomy between the physical or material and the spiritual world. See Zhang (1999, 87–88). This holistic approach endangered the Christian concept of a realm of the numinous and supernatural, which for the Jesuits was the sphere of God, angels, and souls, and made possible a spiritual union of man with Heaven already in this world. This also explains their dismissive attitude towards the texts of Neo-Confucian philosophy in general.

85 Standaert (2003) distinguishes three distinct phases of that transmission process: after a period of rather “spontaneous diffusion” from 1582–1610, Niccolò Longobardo (1565–1654) initiated a more elaborate translation project that was carried out during the 1620s and 1630s. This peak was followed by an aftermath that Standaert calls the “failed attempt” (1678–1683), as Ferdinand Verbiest’s (1623–1688) ambitious project *Study of Fathoming Principles* (*Qiongli xue* 窮理學), a sixty-volume work on Renaissance natural philosophy, mechanics, meteorology, geography, and so forth, was ultimately rejected by Emperor Kangxi.

discernible between the lines of our passage (Elman 2005, xxvii). But as we have seen, a tangible effort is made in the *TXSF* to disguise this provocation by inserting it into a distinctly accommodative setting, and this again was the task of Xu Guangqi. The only additional confrontation of the readers, though less pronounced, is found in the citation of the proper seasons for cutting wood from the book *Mencius*, where the character *qi* 氣 is again used in a subtle and ambiguous way.

Altogether, the provocative aspect in the tides passage of the *TXSF* is—at least at first sight—of a subordinate nature. Instead, what stands out is the smooth amalgamation of Eastern and Western explanations based on strikingly similar concepts. Thus, both authors of the *TXSF* played their part in composing this short paragraph—one by giving it a scientific touch and placing a hidden religious allusion conducive to the Jesuit missionary efforts, the other by skillfully integrating Western and Chinese notions of the tidal theory and making them into a digestible answer to the question about the tides. How the result of this joint effort was perceived on the Chinese side will be outlined in the next chapter.

6 Reception by late Ming literati

Despite their religious and thus potentially offensive undertones, the *TXSF*'s explanations on the tides indeed attracted the attention of a number of Chinese scholars, as a brief look at the later reception of this paragraph reveals.⁸⁶ Soon after its first publication in 1612, the *TXSF* was presented in its entirety to a wider public within the *First Collectanea of Heavenly Studies* (*Tianxue chuhan* 天學初函) in 1626. And not only that: the passage on tides was also quoted in the major works of several Ming literati who were particularly interested in Western learning. Thus, members of the “Fang School” (*Fang shi xuepai* 方氏學派) incorporated Jesuit ideas about natural phenomena into their own syncretistic writings, in which they extensively tested and hybridized them with notions of Chinese cosmology as well as empirical data gathered by seafarers or found in local records, thereby consciously breaking the customary isolation between these traditions.⁸⁷

⁸⁶ For this preliminary examination of the reception of the tides passage, relevant records available at the Diaolong 雕龍 database portal through CrossAsia at <http://crossasia.org/> were consulted.

⁸⁷ See Zhang (2015, 165). As against the followers of Wang Yangming, who exclusively stressed the cultivation of the mind at the expense of the study of external things, the group around Fang Yizhi 方以智 revived the Neo-Confucian Cheng-Zhu 程朱 teaching of the Song dynasty with its emphasis on the world of things and phenomena. Though they were basically positive about Western learning, one of the main points of contention with the Jesuit approach was that the latter favored the ancient Confucian tradition, which better suited their religious ambitions. Moreover, the close collaboration of the members of the Fang School blurs the individual ideas of its adherents to some extent. Cf. also Lim (2008, 140–145).

Accordingly, Xiong Mingyu 熊明遇 (1579–1649), a forerunner of the group who was in personal contact with de Ursis and other Jesuits, inserted the tides passage into his cosmological treatise *Draft on the Investigation of Things* (*Gezhi cao* 格致草; 1648), appearing almost as a whole and without any amendments under the heading “Tides of the Sea” (*Hai chaoxi* 海潮汐).⁸⁸ Moreover, he was the only one of these scholars who left the concluding and possibly offensive allusion to the wise ruler from the book *Mencius* intact in his citation.⁸⁹

A decade later, however, Fang Kongzhao 方孔炤 (1591–1655), another member of the group, included an abbreviated version of the TXSF’s explanations in his *Combined Commentaries on Critique of Time in Yi Learning* (*Zhouyi shilun hebian* 周易時論合編; 1660), to which he added the prosaic annotation “this is like breathing” (*ru huxi ran* 如呼吸然) right after the first sentences describing the *yin*-based mutual correspondence between moon and water, and well in front of the TXSF’s own explicit rendering of *qi* as air, which is hereby clearly assigned a secondary role.⁹⁰ One finds the same assessment of the Aristotelian explanation of the tides as but one example of the traditional Chinese respiration theory extending back to Wang Chong’s *Discourses Weighed in the Balance* in the works of Fang Kongzhao’s son Fang Yizhi 方以智 (1611–1671), who together with his disciple Jie Xuan 揭暄 (1613–1695) openly rejected the religious framework of the Jesuits’ knowledge transfer while at the same time highly appreciating its scientific content.⁹¹

Jie Xuan, who was originally “an ardent Ming loyalist” and later gained a high

88 Xiong Mingyu wrote prefaces to de Ursis’s *Explanation of the Gnomon* (*Biaodu shuo* 表度說; 1614) and Diego Pantoja’s (1571–1618) *The Seven Overcomings* (*Qi ke* 七克; early 1610s). Besides that, he acted as a collaborator in the compilation of the *Explication on the Celestial Sphere* (*Tianwen lue* 天問略; 1615) by Manuel Dias. As Xiong Mingyu did not openly criticize the Jesuit writings with regard to their religious allusions, his works during the reign of Emperor Qianlong repeatedly appeared on the lists of banned books. See Fung (1997, 307). Therefore, among the mentioned works by members of the Fang School, the *Draft on the Investigation of Things* is the only one that is included neither in the prestigious *Complete Collection in Four Treasuries* (*Siku quanshu* 四庫全書, hereafter SKQS) nor in its sequel, the *Complete Collection in Four Treasuries Continued* (*Xuxiu Siku quanshu* 續修四庫全書, hereafter XXSKQS). For Xiong Mingyu’s reaction to Western natural studies, also see Hsu (1996; 2006).

89 The provocative comparison of the instruction for cutting wood that is potentially wormy because it has “generated air inside” to the canonical saying about the axes from the *Mencius* was entirely left out in all later citations by members of the Fang School. The selective omission of single terms which in one way or another were deemed inappropriate to the topic is exemplified by the expression “all created things” (*bai chang* 百昌), which is found in the *Draft on the Investigation of Things* but nowhere else.

90 As Fang Kongzhao’s work was published only posthumously in 1657 by his son Fang Yizhi, this modification of the tides passage might have been carried out by the latter.

91 See Zhang (2015, 202). This positive assessment, however, did not exclude critical remarks by the Fang scholars about the limitations and the reliability of the Jesuit insights. Their ambivalent approach was reinforced by the fact that they were followers of the Neo-Confucian Cheng-Zhu tradition, which was opposed by the Jesuits, who favored an ancient version of Confucianism that they deemed more compatible with their own religious convictions. Cf. Lim (2008, 142ff).

reputation for his cosmological theories, discusses the question of the tides at length in his *Description of the Legacy of the Jade Armillary Sphere* (*Xuanji yishu* 璇璣遺述; draft 1675) (Lim 2008, 140).⁹² As to the causal force behind this phenomenon, he distinguishes between the lunar attraction (*she* 攝) and the respiration (*huxi* 呼吸) of primordial *qi* (*yuanqi* 元氣) by the earth. Within this framework, he then paraphrases the explanations from the *TXSF* as well, judiciously inserting the *TXSF*'s subsequent remark about the moon's immediate attraction of water at the appropriate point. But here, again, the whole passage is succinctly classified as pertaining to the breathing theory and not further questioned with regard to the weighing experiment.

This appropriation goes even further in You Yi's 游藝 (ca. 1612–after 1684) *Queries on the Patterns of Heaven* (*Tianjing huowen* 天經或問; composed ca. 1675).⁹³ Like his fellow scholars he subordinates the passage to his interpretation of the respiration of the earth, but in contrast to them as an anonymous quotation without any hint at his source. What is more, in the same chapter he makes it even more clear than the others that although he does not reject the Four Elements theory as a whole, he by no means agrees with the Jesuit interpretation of the underlying substrate of the rising waters. To this end, he juxtaposes the citation of the *TXSF*'s words with his own theory, which defines the Four Elements as different stages in the condensation process of *qi*, with "air" being nothing other than its uncoalesced primordial form. This, of course, makes the weight experiment redundant, so it is dropped here. That way, the mechanism of the rising and falling of ebb and flow is explained by You Yi in the Jesuit way, but based on his adapted version of China's classical tradition.⁹⁴

These tide-related examples illustrate that despite their basically favorable attitude, the Fang scholars increasingly took a critical stance towards Jesuit science, which all too often had turned out to be a conveyor of the Christian creed. Therefore, they used a syncretistic approach, working to detect inconsistencies in the related treatises, actively proposing their own alternatives, and at the same time incorporating notions of Western knowledge deemed suitable for their own *qi*-based cosmology, which as a whole was left untouched.

Altogether, and regardless of their scientific correctness, the flexibility and creativity

92 The *Description of the Legacy of the Jade Armillary Sphere* was first published in the *XXSKQS* in 1765. For a discussion of Jie Xuan's theory of the tides, see Shi (1993).

93 The paragraph on tides (*chaoxi* 潮汐) is found in vol. 4, fol. 27b–30a, of the *SKQS* edition of the *First Collection of Queries on the Patterns of Heaven* (*Tianjing huowen qianji* 天經或問前集).

94 See Lim (2008, 158–159). In vol. 4 of the *Queries on the Patterns of Heaven* under the heading "Four Elements and Five Phases" (Sixing wuxing 四行五行), You Yi's restoration of the universality of *qi* might have contributed to paving the way for the inclusion of this work into the *SKQS*, despite the fact that he had once been a disciple of Xiong Mingyu, whom he quotes time and again. More generally, on the Chinese integration of domesticated Western ideas about natural philosophy into their own body of knowledge, resulting in a hybrid construct, see Elman (2005).

of contemporary approaches to the tides question on both sides, East and West, is remarkable. At the same time, this short case study about the immediate exchange of ideas on a *micro*-historical level makes clear that, generally speaking, beyond its function as a mere conveyor of information, knowledge can be seen as one of the “Four Ways of Worldmaking” (Vogel and Souza 2012), closely interlinked with the dimensions of wealth, meaning (or ideology), and power. Looking at our example from this *macro*-sociological perspective, the ability to explain the rising of water with the tides represents a means for gaining sovereignty in matters of interpretation of the physical world, and in consequence of the cosmos as a whole. In this connection, the strategic thrust of both sides was different: while for the Jesuits the transfer of knowledge to China served the higher purpose of convincing their interlocutors of the superiority of Western natural philosophy and thereby of the Christian creed, the related reception by Ming literati aimed at a revival of their traditional *qi*-based cosmology within the wider context of substantial learning (*shixue* 實學). But neither side in this undertaking shied away from adapting and transforming the current knowledge about tidal phenomena in order to suit their own specific ends. Thus, a well-packaged but challenging statement made in the *TXSF* was taken up by the Fang scholars, who domesticated it and dealt with it “on their own terms,” aiming, however, at a renewal of ancient knowledge rather than its synthesis with something new.

7 Concluding remarks

This preliminary analysis of the reception of the *TXSF* passage on the tides has shown that despite—or precisely because of—its ambivalent and in part provocative character, it was considered worthy of discussion by different Chinese scholars in the ensuing period. This means that the joint effort by Xu Guangqi and de Ursis to enhance the appeal of this topic worked out in the end. Beyond tracing the strikingly similar explanations for the tides that Europe and China had to offer at that time, this essay has pointed at characteristic features of the presentation of these shared concepts to the Chinese audience. Without doubt, the ability of the authors to successfully combine their respective expertise—de Ursis by supplementing Aristotelian learning with innovative methods, Xu Guangqi by integrating Eastern and Western ideas within an explanatory setting that could both accommodate the audience while attracting their attention to the European scientific approach—was crucial for this undertaking. Whether this holds true for the *TXSF* as a whole and for other parts of the “Some Questions about Hydromethods” chapter in particular remains to be investigated. In any case, the tides paragraph constitutes only five percent of this chapter, in which a wide range of other natural phenomena related to water are discussed. As for the majority of these examples, the underlying Western concepts differ much more from

their Chinese counterparts than in the case of the tides. Therefore, the approach to their explanation points to other characteristics and thus might illuminate additional facets of the joint endeavor of Xu and de Ursis.

In the case of the sea tides question, it was precisely amidst the concepts most familiar to them that Chinese readers were confronted with a potentially startling re-interpretation of *qi*, one of their own key concepts. Even though this kind of well-packaged but conscious provocation—in contrast to de Ursis’s involvement in astronomical affairs and the calendar reform—presumably played no major role in the accusations raised against him and other Jesuits in the Nanjing persecution (1616–1617), it deserves further scrutiny with a focus on the rhetorical methods and the underlying missionary strategies discernible in Jesuit treatises in general. As the *TXSF* was written in an early phase of the Jesuit China mission, the comparison of the tides paragraph with similar explanations in later Jesuit works (in addition to an *intra*-textual approach) promises further insights into the development of the strategy of the Jesuit translation project over time.

In this regard, a case in point is certainly *Investigation into Celestial Phenomena* (*Kongji gezhi* 空際格致; ca. 1633), written by Alfonso Vagnone.⁹⁵ Within its systematic rendering of the Aristotelian doctrine, it also contains a sub-chapter on the tides, although it keeps much closer to the Coimbra commentary on *Meteorologica* than the *TXSF*.⁹⁶ Thus, instead of trying to convince the readers of the material properties of *qi*, Vagnone’s book explains the attraction of water by a “hidden virtue” (*yinde* 隱德) of the moon, which has an effect even from that distance. This means that in comparison to the *TXSF*, the similarity between Eastern and Western concepts of the tides is even more pronounced in this later Jesuit work. Does this hint at an outright adaptation of the Jesuit translation strategy due to changed circumstances? And how did learned circles perceive this modification in the explanations of the tides? These and other questions will help to better understand the significance of the *TXSF* and of the underlying intentions of its authors in particular.

In any case, and notwithstanding their eventual failure to convince the Chinese

⁹⁵ *Investigation into Celestial Phenomena* is at the center of the doctoral thesis currently being carried out by Anna Strob MA, PhD candidate at the Department of Chinese Studies at Eberhard Karls University of Tübingen, and associated researcher of our Tübingen project on the *Investigations of the Earth’s Interior* (*Kunyu gezhi* 坤輿格致) and the *TXSF*.

⁹⁶ In *Investigation into Celestial Phenomena*, all four chapters of the Coimbra commentary dealing with the tides within the section on the sea (Colegio de la Compañía de Jesús [1593] 1594, tract. 8 [De Mari], cap. 5–8) are addressed. The content is strongly abbreviated for the most part, but several passages deemed crucial by Vagnone are translated verbatim into Chinese. Just like in the *TXSF*, in Vagnone’s work the sea tides follow the movement of the moon as the master of all things belonging to the same category, denoted here as *yin*. Moreover, here it is the sea itself that brings forth a lot of *qi*, which periodically has to be sent out and thereby causes the rising of water.

literati of the supremacy of Western natural philosophy and consequently of the Christian creed, the Jesuit missionaries certainly *did* influence the learned discussions on the Chinese side, albeit not in the way they intended. Nevertheless, whereas in China the related traditional cosmological concepts, despite an ongoing discussion and a temporary phase of questioning during the Song period, had so far been left untouched, in the West an increasingly fierce competition for new ideas had already set in prior to de Ursis's departure to China. The accompanying changes in the scientific approach to the natural world were already discernible in the *TXSF*. They finally culminated in the ground-breaking findings of Isaac Newton, who in 1687 claimed that it was the gravitational attraction of the moon together with the earth's rotational energy that causes the tides. In the end, these insights would supersede all previous explanations, including those of the *TXSF*.

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