Special Feature

Landscape and Historicity of Korean Science of the Early to Middle Nineteenth Century

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The Review of Korean Studies Volume 13 Number 1 (March 2010): 91-119

Introduction

The topics in the history of premodern Korean science treated most often have been either the brilliant results obtained during the reign of King Sejong in the early fifteenth century or the patterns of acceptance of Western sciences and the responsive transformation of traditional science after the seventeenth century when Western learning began to reach the Korean peninsula. In particular, the history of late Joseon science has been a topic, related to the question of the modernity of late Joseon society, that a great number of researchers from disciplines such as Korean history, Korean philosophy, and Korean literature have paid attention to. The trend of research from the late 1990s to the present saw a concentration of research that views characteristics and transformations of traditional Korean science after introduction of Western science from a fresh perspective.[1] Due to accumulations of such research, the contours of the landscape and historical development of seventeenth to eighteenth-century traditional Korean science, particularly around astronomy and calendrical science, began to reveal themselves.[2]

However, there is comparatively less research on the nineteenth century, and the landscape of traditional Korean science in the nineteenth century remains unclear. While there were state-led projects to absorb Western astronomy and calendrical science and to adopt the new western calendar in the seventeenth to eighteenth century, no comparable nineteenth century initiatives have been uncovered. It is still not clear whether such initiatives existed at all. Nor is it clear why comparable nineteenth century initiatives are lacking. Due to state-led initiatives in astronomy and calendrical science, there were a significant number of scholars who were exchanging and discussing ideas on the topic by the late eighteenth century. Scholars who had knowledge of astronomy and calendrical science, of course, did exist in the nineteenth century. Their numbers, however, appear to have been far smaller,

1. There are five recent doctoral dissertations that discuss the trends and readings of the introduction of western science in the fields of astronomy and geography: Oh Sang-hak (2001), Koo Mhan Ock (2001), Lim Jong Tae (2003), Jun Yong Hoon (2004) and Park Kwon Soo (2006).
2. For landscape and historicity of Korean science in the late eighteenth century , see Moon Joong-Yang, "18segi huban joseon gwahak eui yeoksa sigan" (Historical time of late eighteenth- century Korean Science) (forthcoming). Because this article is a sequel to that article, landscape and historicity of Korean science up to the eighteenth century will not be discussed in detail in this article.

and their activities more sporadic, than their eighteenth century predecessors.

However, there were nevertheless noteworthy developments in the nineteenth century. For example, piecemeal knowledge of natural science is listed in *Oju yeonmun jangjeon sango* (五洲衍文長箋散稿, Random Expatiations of Oju) in the early nineteenth century; writings of Choe Hangi (崔漢騎, 1803-1877) during the 1830s and 1840s; cosmological discussions of Yi Cheong (李田青, 1792-1861) and Choe Hangi in mid-nineteenth century; production and widespread circulation of astronomical charts and world maps such as *Honcheonjeondo* (渾天全圖) and *Yeojijeondo* (輿地全圖); and professional studies of astronomy and calendrical science of Nam Byeongcheol (南秉哲, 1817-1863) and Nam Byeonggil (南秉吉, 1820-1869). However, scientific discourse of the nineteenth century does not accord with the process of historical development of eighteenth century science. It is also not clear where the scientific achievements of the nineteenth century were headed. Korea was soon "opened" to the world, *gaehwa* (開化, westernization) became the goal of the age, and modern science began to enter the country in an intimidating way under imperialistic pressures. Considering how well seventeenth and eighteenth-century Korean Confucian scholars understood and synthesized scientific knowledge of the East and the West using their fully mature Neo-Confucian understanding of the natural world, it is questionable how satisfactorily the Korean Confucian scholars of the nineteenth century responded to the great waves of nineteenth–century, cutting-edge Western science.

This article intends to draw the landscape of early to mid-nineteenth-century traditional Korean science using recent noteworthy research on the topic. Instead of revealing what is new about the nineteenth-century landscape, this article aims to display the comparative difference between the nineteenth century and eighteenth century and the genealogy of knowledge of science on which the discourses of nineteenth-century Korean Confucian scholars were based. In addition, I want to provide a preliminary overview of the representative scientific accomplishments of nineteenth-century Korea in the context of the late nineteenth-century high imperialism, when modern science and technology were rushing into Korea.

Professional Studies of Astronomy and Calendrical Science in Nineteenth-century Korea and their Historical place

Normal Scientific Activities after the Establishment of Bongukryeok during the Late Eighteenth Century

It is well-known that the Joseon dynasty completed its adoption of the western calendar system based on the notion that the earth was a sphere, as well as spherical trigonometry, by the late eighteenth century. The study of astronomy and calendrical science had been monopolized by the Chinese emperor, and it was a long and tortuous path of learning for the Koreans to self-master mathematical astronomy by studying texts such as *Xinfa suanshu* (新法算書, New Mathematical Books, 1645), *Shuli jingyun* (數理精蘊, Collected Basic Principles of Mathematics, 1722), Lixiang *kaocheng* (曆象考成, Compendium of Calendrical Science and Astronomy, 1723) and *Lixiang kaocheng houbian* (曆象考成後編, Sequel to the Compendium of Calendrical Science and Astronomy, 1742).[3] Although *Shixianli* (時憲曆) was able to be proclaimed in 1654, allowing the usage of *ilgwaryeok* (日課曆, Simple Calendar), more learning was necessary for the establishment of *chiljeongryeok* (七政曆, Astronomical almanac). Efforts toward satisfactory adoption of the Western calendar system came to fruition some 150 years later, during the decades of the 1780s and 1790s. *Chiljeong bobeop* (七政步法, Calculations of seven governors, 1798) signaled the final transition to the new calendar system by fully absorbing the *Lixiang kaocheng houbian* system, which is considered the final form of the Western calendar system. As a result, the Joseon dynasty was able to establish its own *Bongukryeok* (本國曆, National almanac), different from China's *Cheonggukryeok* (清國曆, Chinese almanac), before the end of eighteenth century.[4]

After that, however, there were no meaningful state-led projects in astronomy and calendrical science in Korea. The 1818 publication of *Seo-un-*

3. The reason behind the great length of time is that such materials were often too difficult for self-learning. It must also be noted that the Chinese calendar system continued to be updated and upgraded even after *Xinfa suanshu*.
4. It was the most splendid achievement since the initial establishment of the national almanac some 350 years prior, *Chiljeongsan naepyeon* (七政算內編, Inner Books of the Calculations of the Seven Governors, 1444).

gwan-ji (書雲觀志, Treatise on the Astronomical Bureau) by *Gwansanggam* (觀象監, The Astronomical Bureau) official Seong Judeok (成周悳) is the only exceptional example. *Seo-un-gwan-ji*, as is already well-known, is a document which records details of the activities and history of the Royal Astronomical Bureau. Along with *Sangwigo* (象緯考, 1770) of *Dongguk munheon bigyo* (東國文獻備考, Reference Compilation of Documents on Korea), it contains organized information on the changing astronomical activities of the state around the institution of the Royal Astronomical Bureau during the eighteenth century. There were no records of state-led projects on astronomy and calendrical science in historical primary sources such as the Annals of the Joseon Dynasty and the later-updated *Sangwigo* by Yi Manun (李萬運). Even so, it cannot be said that the Korean government's level of calculation and understanding of calendar system substantially declined during the early nineteenth century. It is most likely, given the completion of the adoption and establishment of the Western calendar system during the last years of the eighteenth century, that regular calculations continued within the normal scientific paradigm and there was no additional need for modification and supplementation.

While the foregoing cannot be seen as a decline in the Korean government's ability to calculate and understand the calendar system, a sense of confidence in it nevertheless appears to have declined. The principles of distribution of the twenty-four solar terms, an accumulation of errors due to precession of the equinoxes, and confusion in calculating the solar eclipse during the reign of King Sunjo (1800-1834) are evidence that testify to such a decline. According to the 1811 calculation of the Royal Astronomical Bureau, the 1813 winter solstice was to have occurred on the last day of October. That prediction was troubling, as there was no precedent of a winter solstice occurring in October instead of November. Believing that this error resulted from accumulation of errors due to precession, the Korean government dispatched the calendar system expert Kim Yeong (金泳) to Beijing. The Chinese had solved the issue by moving the leap month of August 1813 to the leap month of February 1814, so that the winter solstice would come in November. The solution was found by abandoning the principle of distributing the twenty-four solar terms by reflecting upon the non-uniform motion of the heavens, relying on instead the more traditional principle of placing the winter solstice within the month of November.

Seong Judeok, the author of *Seo-un-gwan-ji*, clearly perceives and criticizes the abovementioned problems.[5] The Korean government, however, did not have an alternative plan besides the mere following of the Qing calendar. The problem of calculating the solar eclipse arose in 1823. The duration of the solar eclipse for the following year, as calculated by the Royal Astronomical Bureau, came out to be an impossible ten minutes and thirteen seconds. Anticipating that this result was not accurate, the Royal Astronomical Bureau official Kim Geom (金檢) was dispatched to Beijing to gain advice on the matter. Li Gongchen (李拱辰), minister of the Chinese Astronomical Bureau, even scolded Kim Geom for coming to Beijing for such an easy-to-solve matter, saying that the result is correct and could be understood by a mere reading of *Gujinjiaoshikao* (古今交食考).[6] Such an issue would not even have arisen in the late eighteenth century. Given the absence of King Jeongjo-era (1776-1800) experts such as Seo Hosu (徐浩修) and Kim Yeong, the abovementioned issue is a clear indication of a lack of confidence in the field of Korean astronomy and calendrical science during the nineteenth century.

Where does the abovementioned lack of confidence in Korean calculations of the calendar system come from? It is likely that the unavailability of accurate astronomical data played the most critical role. The lack of astronomical data based on actual measurements was the biggest obstacle behind the perfect adoption and establishment of the Western calendar system in Korea. As is well-known, the Korean government could not calculate the longitude of Seoul until the late eighteenth century, and the longitudes and latitudes of the fixed stars had to be borrowed from 1744 data of *Yixiang kaocheng* (儀象考成, Compendium of the imperial astronomical instruments) from 1768. *Jungseonggi* (中星記, The Table of Meridian Transits), which established the time system using Seoul as the center in 1789 (some 130 years after the initial establishment of the Western calendar), did so by merely modifying the original Chinese data to the Korean location (Moon 2008a: 268-272). Seong Judeok recorded that state of affairs in Korea in his *Seo-un-gwan-ji*. Seong argues that the most up-to-date data based on actual measurements are absolutely necessary because the adjustment of Chinese data could never be equal to actual measurements taken in Korea due to constant changes in precession of the equinoxes.[7]. In Korea, according

5. Seong Judeok, ed., *Seo-un-gwan-ji* (tr., by Moon Joong-Yang, Somyeong chulpan), 318-320.
6. *Jeungbo munheon bigo* (增補文獻備考), *Sangwigo*, Vol. 1, 10-11.
7. Of course, the value of precession does not change. Since Mei Wending (梅文鼎), however, Chinese and Korean astronomers believed that its value was constantly changing and

to Seong, new measurements hadn't been taken since 1754 (an apparent reference by Seong appears to the data of *Yixiang kaocheng*), and there were not even efforts to gather up-to-date Chinese data. Considering the state of affairs in Korea, it is not surprising that most Korean scholars working on the calendar at the time were not confident in their calculations.

Korean Scholars' Learning of Astronomy and Calendrical Science and the Final Accomplishments of Traditional Astronomy and Calendrical Science

Normal scientific research and activities under the *Lixiang kaocheng houbian* regime since the late eighteenth century were carried out by private individuals as well as the state. The time period around the year 1800 was when certain groups of Korean scholars studied imported texts on astronomy and calendrical science such as *Shuli jingyun* (1722), *Lixiang kaocheng* (1723), and *Lixiang kaocheng houbian* (1742) and recorded their responses to the texts. There were a quite a few scholars who read cutting-edge texts on astronomy and calendrical science such as *Shuli jingyun* and *Lixiang kaocheng*. Hwang Yunseok, was a Honam district scholar who sought to gain up-to-date knowledge through connecting with Seoul scholars. His persistent search for *Liuli yuanyuan* (律曆淵源, a compilation of *Shuli jingyun*, *Lixiang kaocheng* and *Liuliu zhengyi* (律呂正義)) is another example of such a trend. Far from being a small group of exceptions to the larger body of Confucian scholars, scholars with interest in astronomy and calendrical science became quite numerous by this time. Supported and led by the state projects on astronomy and calendrical science, the late eighteenth century was a period when a great number of prominent scholars such as Seo Myeongeung, Seo Hosu, Yi Gahwan, Yi Byeok, Yi Seunghun, Jeong Cheoljo, Jeong Hujo, Hong Daeyong, and Hong Ryanghae studied mathematical-astronomical texts such as *Shuli jingyun* and *Lixiang kaocheng* and discussed them together.

Such conditions partly continued into the early nineteenth century. The reading list Hong Seokju (洪奭周) made for his younger brother Hong Gilju (洪吉周) around the year 1810 included a number of broad and deep texts on astronomy and calendrical science published in eighteenth-century China,

therefore it needed to be constantly recalculated.

such as *Shuli jingyun*, *Lixiang kaocheng*, and *Lixiang kaocheng houbian*, and *Yixiang kaocheng* (1752). If early seventeenth-century texts such as *Jihe yuanben* (幾何原本) and *Xinfa suanshu* served as the most authoritative study material into the middle of the eighteenth century, the abovementioned reading list shows the newly found depth of scientific knowledge of the early nineteenth century. Hong Gilju is particularly interesting, as he went beyond mere study and tried a different but easy method of calculation. In *Gihasinseol* (幾何新說, written around 1816), Hong suggested his unique calculating methods based on traditional Korean calculation methods, using selected exercises from *Shuli jingyun*. After reading *Lixiang kaocheng*, Hong wrote *Hogakyeonrye* (弧角演例, written around 1814) a mathematics text written to supplement aspects of spherical trigonometry. In doing so, Hong organized and added to the mathematical knowledge of spherical trigonometry, which did not exist in the tradition of Chinese mathematics, and supplemented the methods of calculation listed in *Lixiang kaocheng* (Jun 2004b).

The abovementioned abstruse and distinctive mathematical research was possible because of his family's pedigree as well as the intellectual environment of Seoul academic circles. His mother Seo Yeongsuhap was particularly talented in mathematics, and she deeply influenced Hong's study from an early age. Seo Hosu, the author of *Surijeongonbohae* (數理精蘊補解), and Seo Yubon (徐有本), the author of *Gihamonggu* (幾何蒙求, 1808), both maternal relatives of Hong Gilju, were well-versed in astronomy and calendrical science. Kim Yeong, a key figure in the state project on astronomy and calendrical science during the King Jeongjo era along with Seo Hosu, was a close friend of Hong Gilju. Kim Yeong also provided valuable help to Hong's mathematical research. Therefore, the groundbreaking mathematical research of Hong Gilju during the first decade of the nineteenth century was conducted in the context of research done on astronomy and calendrical science by members of his family as well as the trend of learning of academic circles in Seoul.

Research conducted subsequent to the distinctive and interesting mathematical research done by Hong Gilju and other Seoul-based scholars during the first two decades of the nineteenth century remains unsubstantiated to this day. Research on astronomy and calendrical science by Choe Hangi is an exceptional case. As is well known, Choe Hangi collected texts on western science from various disciplines and studied them during the 1830s and 1840s. *Euisang lisu* (儀象理數, written after 1835) and *Seupsan jinbeol* (習算津筏, 1850) are products of such learning of western science. However, the two books were largely incomplete. *Euisang lisu*, for example, in condensing and discussing *Lixiang kaocheng* and *Lixiang kaocheng houbian*, did not discuss their most important component - the method of calculating the orbit of sun using the elliptical orbit. Furthermore, *Euisang lisu* only discussed volume three, without even touching upon volumes one and two. Although *Seupsan jinbeol* is a discussion of *Shuli jingyun*, it only discussed basic issues in the beginning part of *Shuli jingyun* and did not touch upon important parts of the book. Choe Hangi had financial difficulty maintaining his life in Seoul and did not make a substantial connection with other scholars living in Seoul. Despite his most active efforts, the incomplete state of his study of astronomy and calendrical science reveals a great deal.

In contrast to Choe Hangi's incomplete work, studies by some of other Seoul-based scholars appeared to have continued despite missing source materials. The brilliance of the approximately twenty book publications on astronomy and calendrical science by brothers Nam Byeongcheol and Nam Byeonggil during the 1850s and 1860s testifies to this continuance. Nam Byeongcheol, who remained at the center of power during the mid-nineteenth century through prestigious government positions including *Daejehak* (大提學), was representative of scholar-officials of this era. He often served as minister of the Royal Astronomical Bureau and left a number of publications on astronomy and calendrical science (Moon 2000; Lee 2001). Nam Byeonggil's *Siheon giyo* (時憲記要, 1860) is a grand comprehensive survey of all known theories and calculation methods up to *Lixiang kaocheng houbian*, and it was comprehensive enough to be a text of instruction for officials of the Royal Astronomical Bureau. His *Seonggyeong* (星鏡, 1861) is a collection of all knowledge of fixed stars up to *Yixiang kaocheng xubian* (1845). While Nam Byeongcheol's *Chubo sokhae* (推步續解, 1862) is an exposition of Chinese mathematician Jiang Yong(江永)'s *Tuibu fajie* (推步法解), it does not discuss all of its contents. While Nam mentions new methods and explanations to calculate the orbits of the sun and moon as well as the solar and lunar eclipses based on elliptical orbit theory, he does not discuss the calculations for the five stars. His *Euigi jipseol* (儀器輯說, written around 1859) is a comprehensive survey of the structures and the instructions pertaining to scientific instruments for astronomical observation. Because of its comprehensive and detailed description of scientific instruments for astronomical observation that older works such as *Gukjo yeoksanggo* (國朝曆象考, 1796) and *Seo-un-gwan-ji* (1818) did not touch upon, *Euigi jipseol* can be considered as a text that synthesizes information pertaining to all traditional scientific instruments for astronomical observation during Joseon dynasty.

Historical Place of Korean Scholars' Natural Knowledge

The preceding section of the article discussed the overall landscape of nineteenth-century Korean science in the field of astronomy and calendrical science and its historical place within the context of the greater East Asian academic community. In this section, I will carry out a genealogical contemplation of natural philosophical discussions of natural knowledge among nineteenth-century Korean scholars from a different angle.

Trends of Cosmological Contemplation in Eighteenth-century Korea

Korean scholars' intellectual response to the influx of western knowledge of astronomy and geography based on the concept of a spherical Earth and trigonometric astronomy which had been entering Korea since the seventeenth century was, as is well known, a fine reinterpretation and reconstitution of it based on Neo-Confucian cosmology and perspectives on nature. Kim Seokmun (金錫文) and Seo Myeongeung (徐命膺) read western science using the framework of *Xiangshuxue* (象數學), while Yi Ik (李瀷) and Hong Daeyong 洪大容) read it within the *qi* (氣)-based paradigm. While they differed in their reading methods, they nonetheless were in consensus that western science was based on empirical and positive data as well as a precise mathematical foundation. While they recognized the superiority of western science in forming apt and convincing explanations of existing conditions, they nevertheless believed that western science did not (or could not) explain the true principle of nature. Yi Ik and Hong Daeyong sought to explain the true principle of nature using the mechanism of *qi* which pervaded the whole universe; Kim Seokmun did so using the *yin-yang* and the numerological *yijing* (易經)-based numbers; and Seo Myeongeung sought the ultimate logic of the sphericity of the Earth using the *xiantiantu* (先天圖, pre-heaven diagram). The result of such interesting cosmological contemplation during the hundred years after the late seventeenth century was the deconstruction and concomitant reconstitution of the astronomical knowledge of western science under the traditional paradigm of East Asian science, leading to a more sophisticated and refined cosmology.

Such an approach to reading western astronomy and cosmology by seventeenth and eighteenth-century Korean scholars is generally common among Confucian scholars in East Asian academic society. For example, the approach of Korean scholars is not different from how the members of the Fang Yizhi (方以智, 1611-1671) school of thought in Chinese Jiangnan used the idea of the mechanism of circling *qi* to read and reconstitute knowledge of western science, but that approach soon became forgotten after Mei Wending established the more precise and positive paradigm of research in astronomy and calendrical science after the late seventeenth century. Furthermore, because the Japanese imported *Tianjing huowen* (天經或問, Queries on the Classics of Heaven, two volumes in 1675 and 1681, respectively) of You Yi (遊藝), a member of the Fang Yizhi school, the *qi*-based cosmology of the Fang Yizhi school even became widespread and popular in Japan long after its decline in China. Compared to China and Japan, the Korean case proves to be a bit different. While seventeenth and eighteenth-century Korean scholars' mathematical reading proved to be highly refined and accurate, their reading based on the mechanism of circling *qi* remained episodic and rudimentary. *Yijing*-based cosmology and its reconstitution of the astronomical knowledge of western science of Kim Seokmun and Seo Myeongeung, for example, remained unparalleled even compared with their Japanese and Chinese peers. However, the *qi*-based reading of Yi Ik and Hong Daeyong, for example, explaining the sphericity of the Earth and its motion, continued as episodic discussions only.

Where does such difference come from? Two background factors are relevant. One is the growing interest at that time in a *yijing*-based understanding of nature among Korean scholars since Seo Gyeongdeok (徐敬德, 1489-1546). As can be seen in the *Ujuseol* (宇宙說) of Jang Hyeongwang (張顯光, 1554-1637), around the year 1600 when western science first entered Korea, cosmological contemplation of Korean scholars generally took place within the paradigm of *Xiangshuxue*. It was natural for Korean scholars, who completely digested and applied Shao Yong (邵雍, 1011-1077)'s *Xiangshuxue* in understanding and contemplating nature, to use the *yijing*-based cosmology to perceive foreign western astronomical knowledge.

Another is the fact that texts that could have functioned as "nutrition" for *qi*-based discussions of natural knowledge had not entered Korea even up to the end of the eighteenth century. For example, texts of Christian missionaries such as *Huanyouquan* (寰有銓, Commenting on Aristotle's *De Caelo*, 1628) and *Kongji gezhi* (空際格致, Investigation of the Atmosphere, 1633) are based upon the four elements theory, which repudiates the concept of *qi* as well as the mechanism of the "great rotation" of *qi*. However, they allow rich *qi*-based cosmological contemplation by reinterpreting the "the theory of three strata in the atmosphere" (*sanjishuo* 三際說), which argues that the earth's circumference made of water and earth is encircled by the strata of air and the strata of fire. Furthermore, original and refined discussions of the cosmology based on the concept of *qi* and the mechanism of the "great rotation" by the members of Fang Yizhi school were also based on the contents of introductory texts on western astronomy and climatology such as *Qiankun tiyi* (乾坤體義, Discourses on the Heaven and Earth, 1605) and *Kongji gezhi* (1633).[8] However, it appears that such texts were not introduced to Korea until the late eighteenth century, and even if they were somehow introduced, no record of their discussion is extant.

The two abovementioned background factors were the setting behind the reasons why Korean cosmological contemplations were lofty and imaginative via *Xiangshuxue* while remaining rudimentary (although free and interesting) around the concept of *qi*. However, Korean scholars' unique and interesting cosmological contemplations based on *Xiangshuxue* during the hundred years since the late seventeenth century arrived at a state of lull by the late eighteenth century. It is obvious in a way, as Mei Wending-inspired precise and empirical learning and researching of astronomy and calendrical science from the late eighteenth century, and further specialization of those working in such disciplines, reduced the room for more metaphysical contemplations of cosmology. Refined and deep cosmological contemplations based on *Xiangshuxue*, such as that of Seo Myeongeung (1716-1787), could not be seen from scholars in the Korean academia who were active around the year 1800, such as Seo Hosu, Yi Gahwan, and Hong Gilju, who studied more specialized astronomy and calendrical science texts such as *Lixiang kaocheng* and *Shuli jingyun*.

8. By "members of the Fang Yizhi school," I mean that group of Chinese scholars that formed an active network of discussions in the seventeenth century starting with Xiong Mingyu (熊明遇, 1579-1651) and Fang Kongzhao (方孔炤, 1591-1655), followed by Fang Yizhi (1611-1671), You Yi (1614-1684), Jie Xuan (揭暄, 1625-1705), and Fang Zhongtong (方中通, 1633-1698). Their representative works are: *Tianjing huowen qian houji* (1675, 1681) of You Yi, *Xuanji yishu* (璇璣遺術, Transmitted Discourse on the Heavenly Motions) of Jie Xuan, and *Wuli xiaoshi* (物理小識, Small Encyclopedia of the Principles of Things, 1644) of Fang Yizhi. Fang Zhongli (方中履, 1638-1686), the son of Fang Yizhi, summarized his predecessors' findings in his *Gujin shiyi* (古今釋疑, 1682).

Entrance of New Cosmological Knowledge in the Nineteenth Century

During the nineteenth century, however, new “nutrition” entered Korean academia. Texts that contain previously-unknown discussions of cosmology begin to enter Korea beginning in the late eighteenth century, and certain scholars began to read them and formulate new cosmological perceptions. They were the same texts that Chinese and Japanese scholars read and used to formulate refined *qi*-based cosmological perceptions.

Kongji gezhi (1633) is an important example. *Kongji gezhi* was written by Christian missionary Alphonsus Vagnoni (1566-1640), referencing Aristotle’s *Meteorologica*. It is an introductory text to the European climatological and geological science of the Middle Ages, which is in turn based on the Ancient Greek four elements theory. The main part of the book introduces the fundamental characteristics of the four elements theory, and uses the discussions of the four elements to argue the sphericity of the earth. It drives the point further by arguing that the spherical earth has to stay in the middle of the universe. For Christian missionaries, the four elements theory was divine providence given by God. Most texts on western science that were written and published in early seventeenth-century China were immediately introduced to Korea. However, *Kongji gezhi*, published in 1633, did not immediately enter Korea. The earliest known instance of its introduction and circulation was when Yi Ik’s students such as An Jeongbok and Yun Donggyu read and circulated it amongst themselves in the middle of the eighteenth century. However, considering that eighteenth-century Korean scholars hardly mention anything about the main content of the book such as the four elements theory and the three spaces theory, it is highly likely that the book did not catch the attention of most Korean scholars at the time. An exception is Jeong Yakjeon(丁若銓)’s discussion of the four elements theory as a response to the 1790 civil service examination question on the five phase theory. Because of his answer, Jeong Yakjeon later suffered during the nineteenth century when anti-western sentiments were high in the government. Despite this, *Kongji gezhi* and its discussions of the four elements theory and three spaces theory nevertheless began to make its way into the cosmological contemplations of Korean scholars.

Second, texts on the previously unknown *qi*-based cosmological contemplations of the Fang Yizhi school of thought began to be circulated and read in Korea during the nineteenth century. The first instance of this was perhaps the referencing of *Wuli xiaoshi* by Fang Yizhi and *Gujin shiyi* by Fang Zhongli in Yi Deokmu(李德懋)'s *Cheongjanggwan jeonseo* (青莊館全書, Complete Works of Yi Deokmu, 1795). However, the contents of *Wuli xiaoshi* and *Gujin shiyi* were not mentioned, so it is safe to assume that Yi Deokmu did not pay attention to them in great detail. However, the cosmological contemplations of the Fang Yizhi school were nevertheless introduced to Korea sometime during the late eighteenth century, and certain Korean scholars during the nineteenth century begin to pay attention to them some 150 years after the Fang Yizhi school's works were first published in China.

The third example is Michel Benoist (1715-1774)'s *Diqiu tushuo* (地球圖說, Explanations of Maps of the Worlds, published in 1767). It is the text that officially introduced the theory of Nicolaus Copernicus to China. *Diqiu tushuo* was published after the Vatican removed *De revolutionibus orbium coelestium* (On the Revolutions of the Heavenly Spheres) from its list of banned books in 1757. While Chinese scholars had episodic exposure to discussion of the earth's rotational motion and heliocentric theory, they did not know about it in detail until this book was introduced to China.[9] It is unclear when *Diqiu tushuo* was first introduced to Korea. As Choe Hangi's work during the 1830s and 1840s as well as Yi Gyugyeong(李圭景)'s *Oju yeonmun jangjeon sango* does not mention anything about heliocentric theory, it can be guessed that Korean scholars did not know about *Diqiu tushuo* or heliocentric theory into the 1840s.[10] However, Choe Hangi and Yi Cheong read *Diqiu tushuo* in the 1850s and began to apply it to their work on natural knowledge.

The last of the important texts that entered Korea starting from the nineteenth century were the texts on the latest up-to-date western science published in Shanghai. Christian missionaries William Milne and Alexander Wylie and their collaborator Li Shanlan (李善蘭, 1810-?) translated *Jihe yuanben* (幾何原本) in 15 years (1852-1867), collected and published mathematical books on calculus as *Daiweijishiji* (代微積拾級) in 1859, and translated and published William Whewell's book on dynamics as *Zhongxue* (重學, first edition published in 1859). In addition, they translated and published J. F. W.

9. The concept of a spherical and rotating earth by Kim Seokmun, Hong Daeyong and Jeong Yakjeon did not have to do with the heliocentric theory, as their works still thought of the earth as in the center of the universe.

10. In *Oju yeonmun jangjeon sango,* Yi Gyugyeong uses *Chourenzhuan* (疇人傳) of Juan Yuan (阮元) to discuss Michel Benoist. Therefore, it cannot be assumed that Yi Gyugyeong himself read *Diqiu tushuo.*

Herschel's introductory book on astronomy, *Outlines of Astronomy* (1849) as *Tantian* (談天, 1859). Benjamin Hobson (1816-1873) published a number of books on western medicine in 1850s,[11] as well as an introduction to new scientific knowledge in the fields of optics, electromagnetics, and chemistry in *Bowu xinbian* (博物新編, 1855).

Such introductions of western science by Christian missionaries in the mid-nineteenth century marked the earnest beginning of western science's introduction after the very first introduction of it in its still-confused form some 200 years prior. Along with the publication of new scientific texts, scientific discussions of Chinese intellectuals also changed. Now, attempts to synthesize traditional Chinese science with western science or absorb western science within the existing paradigm of traditional Chinese science could no longer succeed. Although insistence upon partial preservation of traditional science and western science's Chinese origins continued, there were new voices that argued for a clear demarcation of Chinese and western sciences as well as the need to learn superior, up-to-date western science. Publications of *Haiguo tuzhi* (海國圖志, 1842)[12] and *Yinghuan zhilue* (瀛環志略, 1848) in support of the self-strengthening movement are examples of such new importuning.

It is difficult to determine when and how many of the abovementioned texts from Shanghai entered Korea before its opening. However, as can be seen from Choe Hangi's writings from the 1850s, *Tantian* (1859), *Bowu xinbian*(1855), and books on western geography and weapons technology such as *Haiguo tuzhi* and *Yinghuan zhilue* were introduced in the 1850s. While Choe Hangi is the only one known to have utilized such texts in his own work, it is important to note that western scientific knowledge of the mid-nineteenth century was being introduced to Korea at this time. Of course, it is equally significant how a Korean Confucian scholar such as Choe Hangi read and understood the contents of western modern science.

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11. He wrote and published texts such as *Quanti xinlun* (全體新論, 1851), a specialized text on anatomy and physiology which includes descriptions of individual body parts and 192 drawings of the body; *Xiyi luelun* (西醫略論, 1857), a sequel to *Quanti xinlun* that discusses methods of examination and treatment; internal medicine text *Neike xinshuo* (內科新說, 1858); and the gynecology and pediatrics text *Fuying xinshuo* (婦嬰新說, 1858).
12. *Haiguo tuzhi* is a revision of *Sizhouzhi* (四洲志) by Lim Zexu (林則徐, the man who led the First Opium War). It was revised by Wei Yuan (魏源, 1794-1856), and published in 1842 in 60 volumes and in 1852 in 100 volumes. It includes maps of the world and nations as well as knowledge of human geography. It also includes entries on western science, the calendar, and weapons technology.

Inversion of European Medieval Cosmology

Vagnoni's most important assertion when he edited and published *Kongji gezhi*, which features European knowledge of climatology and atmospheric science from the Middle Ages, was the demonstration of the concept of a spherical earth based on the four elements theory of Aristotle, as well as a repudiation of the function and concept of traditional Chinese *qi* and reposition of *qi* (air) as one of the four elements along with fire, water and earth. He undertook this because he believed that *qi* was the foundation of the universe and biological life for Confucian scholars, and the concept of *qi* was seen as an obstacle to believing in an omnipotent God. Of course, Chinese scholars did not read *Kongji gezhi* as Vagnoni intended. It was difficult to treat *qi* as just another element under the East Asian natural paradigm that views *qi* as the foundation of the universe. Furthermore, this assertion's link to Christianity further tainted its credibility. Therefore, Chinese scholars such as those in the Fang Yizhi school of thought did not recognize the four elements theory, and continued to treat *qi* as the foundational substance of the universe and its operation. The layered structure of the atmosphere and other explanations of the atmospheric phenomena were deconstructed and then absorbed into the *qi*-based cosmology.

It was similar in nineteenth-century Korea. The four elements theory could not even be discussed under the political current of anti-western learning in the late eighteenth and early nineteenth century. Even so, the theory of the layered structure of the atmosphere as recorded in *Kongji gezhi* was a "nutrient" that allowed richer cosmological contemplations. The debate between Jeong Yakjeon and Jeong Yakyong (丁若鏞) over the observations of a comet is a good example. Jeong Yakjeon, in his letter to Jeong Yakyong discussing his observations at Heuksando, wrote that the comet moved from the west to the east, while its tail was pointing to the east instead of the west. If the comet was really moving from the west to the east, its tail must point to the west to reflect such movement. Jeong Yakjeon found the reason behind that phenomenon in the earth's rotational motion. In other words, while the comet moves to the east from the west within the stratum of fire, the rotational movement of the atmosphere (which rotates along with the earth itself) is faster than the stratum of fire. Influenced by the faster movement, the comet's tail points to the east instead.

Here, we see the epistemological turn that changes the European medieval theory of the atmosphere based on the four elements theory into evidence for the earth's rotational motion. While the four elements theory and the theory of the layered structure of the atmosphere in *Kongji gezhi* was used to explain the divine providence behind the spherical earth fixed in the center of the universe, Jeong Yakyong transformed them into evidence explaining the rotation of the earth. Jeong Yakyong's reasoning, which differs from that of Jeong Yakjeon, is also interesting. Jeong Yakyong displayed his disagreement with Jeong Yakjeon's observation by arguing that comets are ice-like objects--crystallizations of the rise of *sugi* ("water *qi*") in the "cold heaven"--which therefore cannot move in the stratum of fire. Interestingly, the theory of the layered structure of the atmosphere based on the four elements theory, as can be found in *Kongji gezhi*, is nevertheless used in Jeong Yakyong's reasoning--as can be seen in his thinking that the strata of *qi* (air) and fire are covering the earth and that "cold heaven" belongs to the stratum of *qi* (air).[13]

Cosmological contemplation through repudiation of the European medieval cosmology occurred in full in the *Unhwa cheukheom* (運化測驗, 1860) of Choe Hangi. At a glance, the first volume of *Unhwa cheukheom* appears to be a recapitulation of the first two chapters of the first volume of *Kongji gezhi*. However, while the structure of the two may be similar, the content of *Unhwa cheukheom* was filled with new assertions repudiating the earlier claims. First, Choe Hangi refuted the four elements theory. *Qi* was something that exists not only in the atmosphere, but throughout the universe. Choe also did not recognize the logic of the spherical earth and matter-motion theory based on the four elements theory. As can be seen from the opening words of the book, "the sun, moon and stars move by relying on *qi*,"[14] Choe Hangi denied the fundamental notion of *Kongji gezhi* that celestial bodies move on their own.[15] Likewise, Choe also denied the distinction made between the linear movement

13. According to *Kongji gezhi*, the stratum of *qi*, which is underneath the stratum of fire (467,935 *li* and 82 *zhang* thick), is about 250 *li* thick. It is further subdivided into three zones. The uppermost zone is very hot due to its adjacency to the stratum of fire, and the bottommost zone is relatively cool because it is next to the earth itself. The middle zone, which is far from both the sky and the ground, was thought of as a cold place where snow forms. Jeong Yakyong's "cold heaven" refers to the middle zone.

14. *Unhwa cheukheom,* vol.1, "Gijicheungpo (氣之層包)," 65.

15. *Kongji gezhi,* vols.1-2. According to this, all motion in creation can be divided into 'natural motion' and 'violent motion.' 'Natural motion' is further subdivided into 'circular motion' and 'linear motion.' 'Circular motion' is the natural circular motion of celestial bodies, and 'linear motion' is the vertical linear motion that moves heavy matters such as the soil to the center of the universe while moving light matters such as fire to the edge of the universe. For a detailed discussion of these concepts, see *Kongji gezhi*, volumes1 and 2, and 11-12.

beneath the lunar sky and the circular movements of celestial bodies in *Kongji gezhi,* and asserted that all motion of celestial bodies is carried out by a single *qi* of the universe. Ultimately, if the linear up-and-down movements are not innate, the *Kongji gezhi* 's notion that such movements cause the earth to be a sphere also cannot be accepted.

After denying the four elements theory and the theory of movement of celestial bodies based on the four elements theory, Choe Hangi used the theory of layered structure of the atmosphere to prove his *giryunseol* (氣輪說, Theory of the *Qi's* Globe). According to *Kongji gezhi*, the universe, from the center of the universe (the earth's center) to the underside of the moon's orbit, is divided into four strata of earth, water, *qi* and fire. The stratum of *qi* is further divided into three zones. For Choe Hangi, the earth, water and fire of the four elements were merely *qi's* of earth, water and fire. They were merely individualizations of one general *qi*. If so, the layering of the strata of the four elements was identical to the layering of strata of *qi*. In other words, conceptualizations of the sky such as 'lunar sky'(月輪天), 'solar sky'(日輪天), and 'stellar sky'(星天) were also layerings of different spaces of *qi*. That is the basis of the *giryunseol* of Choe Hangi. Choe writes in *Unhwa cheukheom* that the earth's ground has stifling *qi* that encases the earth. The *Qi* of the Moon, Sun, Mars, Jupiter and Saturn are layered and circle the Earth.[16] The European medieval cosmology that explains the spherical earth and the strata of the atmosphere using the four elements in *Kongji gezhi* was transformed by Choe Hangi into the mechanism of "great rotation" of gigantic globes made of layered strata of *qi*.

Incomplete Learning of the Fang Yizhi School's Cosmology and Criticisms of it Based on the Four Elements Theory

It is also interesting to see that, as with the European medieval cosmology as recorded in *Kongji gezhi*, the cosmology of the seventeenth-century Fang Yizhi school also appears in the cosmological contemplations of Korean scholars. Compared to the introduction of *Tianjing huowen* in Japan, the introduction of Fang Yizhi's *Wuli xiaoshi* of and *Gujin shiyi* by Fang Zhongli (son of Fang Yizhi) occurred in the late eighteenth century in Korea, and were circulated among certain groups of scholars in Korea starting during the nineteenth century.

16. *Unhwa cheukheom*, vol.1, "Gijicheungpo," 65.

While Yi Deokmu made a limited comment on them in the late eighteenth century, his grandson Yi Gyugyeong made a thorough introduction of the content of *Wuli xiaoshi* and *Gujin shiyi* in his *Oju yeonmun jangjeon sango* (1830). *Wuli xiaoshi*, in particular, was the most-often-referenced text (221 times) in the field of astronomy and calendrical science. *Gujin shiyi* is also referenced 31 times. You Yi and Jie Xuan's contemplations of the structure and operation of the universe based on the mechanism of 'great rotation of *qi*' as listed in *Wuli xiaoshi* and *Gujin shiyi,* as well as other important theories such as 'the optical theory of fat light and thin shadow' (*guangfei yingshou shuo* 光肥影瘦說), 'the theory of westward movement' (*zouxuan shuo* 左旋說) and 'the tidal theory' (*chaoxi shuo* 潮汐說) are all introduced in *Oju yeonmun jangjeon sango*. In his book, Yi Gyugyeong thoroughly explained 'the theory of westward movement' of Jie Xuan using the 'the theory of eastward and westward movement' from the twelfth volume of *Gujin shiyi*.[17] He also introduced and explained the 'optical theory of fat light and thin shadow' in detail using the *Wuli xiaoshi* and *Gujin shiyi* as references.[18] In addition, Yi explains Xiong Mingyu's discussion on the tides[19] as listed in *Gujin shiyi* as well as You Yi's discussion on the tides as listed in the "Tides" section of the second volume of *Wuli xiaoshi*.[20]

Jeonggwanpyeon (井觀編, written around 1860) of Yi Cheong (李晴, 1792-1861) even used the narrative structure of *Wuli xiaoshi* and *Gujin shiyi*. In other words, it used the similar categories corresponding to related topics, and a similar narrative style of adding the author's opinions on each topic following the explanations of the relevant records from ancient texts. In particular, Yi Cheong quotes and references records primarily from *Gujin shiyi*, far more so than those of *Wuli xiaoshi*. The *Qi*-based cosmology of the Fang Yizhi school was splendidly resurrected in Korea some 200 years later.

Among its contents, the critical appraisal of 'the optical theory of fat light

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17. *Oju yeonmun jangjeon sango,* part on Heaven and Earth, chap. on Astronomy, section on General Remarks of Astronomy, "Demonstration of Eastward and Westward Motion 左旋右旋辨證說."

18. *Oju yeonmun jangjeon sango,* part on Heaven and Earth, chap. on Astronomy, section on an Itemized Discussion of Astronomy, "Demonstration of Every Light 諸光辨證說." The records of "Guangfei yingshou shuo 光肥影瘦說," "Quanglun 光論," and "zhuanquang 轉光" were cited from *Wuli xiaoshi* vol. 1, and "riti daxiao 日體大小" was cited from *Gujin Shiyi,* vol. 12.

19. See Xiong Mingyu, *Gezhicao*(格致草), "Haichaoxi海潮汐," 131-2. (Inserted in *Zhongguo kexue jishu dianji* 中國科學技術典籍通彙 Tianwenjuan 天文卷, book 6)

20. *Oju yeonmun jangjeon sango,* part on Heaven and Earth, vol. on Geography, chap. on the Tides, "Demonstration of the tide." As a matter of fact, Yi Gyugyeong mistook You Yi's "tidal theory" for that of Jie Xuan, in writing the entry.

and thin shadow' by Yi Cheong is particularly interesting. 'The optical theory of fat light and thin shadow' starts by pointing out that the exaggerated size of the sun in western astronomy was due to an error in its optics,[21] and suggests a new optical theory. The core content of the new theory is that westerners do not know that the sunlight is always fat and the shadow on the earth is always thinner, so that westerners miscalculated the vanishing point of shadow. According to Fang Yizhi School's new optical theory, the shadow's length (and the shadow's vanishing point) that westerners calculate is shorter than it appears, and that is the why westerners overestimated the size of the sun to be 165 times larger than the earth.[22] Members of the Fang Yizhi school took great pride in their theories believing that such debates had not been resolved (Zhang 1987:185-190). Yi Cheong, however, criticized 'the optical theory of fat light and thin shadow' of the Fang Yizhi school using the theory of layered atmosphere (based on the four elements theory) of *Kongji gezhi*.

According to the cosmology of the four elements theory, the earth is covered by the stratum of *qi* with a thickness of 250 *li*. The stratum of fire exists on top of the stratum of *qi* and its thickness is an astonishing 460,000 *li*. The celestial bodies such as the sun, moon and five stars exist in the space outside of the stratum of fire.[23] What Yi Cheong insists is that, considering the existence of the stratum of *qi* and fire, the concerns of the members of Fang Yizhi school were unfounded. The stratum of fire is a mere 250 *li* away from the earth's surface, and the heat of the stratum of fire was thought to be far stronger than the heat of the sun. Even so, humans on the surface cannot feel the heat from the stratum of fire. In addition, if the sun is some 165 times larger than the earth, human beings never have to worry about the sun's heat coming from some 10,000,000 *li* away from the earth. The lunar sky above the stratum of fire would resist the sun's heat, and the cold layer beneath

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21. The problem was that, if the sun were 165 times larger than the earth, the size of the sun would have to be twice the distance between the earth and the sun and people could not survive the heat of such a gigantic sun. *Gujin Shiyi*, vol.11, "Size of Sun," 1125-1126; *Jeong-gwanpyeon*, vol. 1, "Size of the Earth and Three Light," 30.
22. For a detailed discussion of 'the optical theory of fat light and thin shadow', see Lim Jong Tae, 2006 "Bangiji wa gehwon eui gwangbiyeongsuseol ('The optical theory of fat light and thin shadow' of Fang Yizhi and Jie Xuan)," (an essay presented at the National Annual Assembly of History, History of Science Session, May 27, 2006).
23. Detailed discussions of the space around the earth within the paradigm of the four elements theory are well-summarized in *Kongji gezhi*, vol. 1, 8-9.

the stratum of fire would also inhibit such heat.[24] As did Jeong Yakyong, Yi Cheong used the cosmological scheme based on the four elements theory to refute the Fang Yizhi school's new optical theory. Of course, such discussions of Yi Cheong did not touch upon the root of the problem.

The Learning of Modern Astronomy with the Heliocentric Theory and its Qi-based Reconstitution

In this last section, I want to review the new discussions of astronomy and cosmology in *Diqiu tushuo* (1767) and the introduction and reading of the Christian missionaries' up-to-date texts on western science by Korean scholars.

Reference to Michel Benoist's *Diqiu tushuo*, which includes the Copernican-heliocentric theory with discussion of the rotational earth, does not appear in Korean texts written before 1850. Yi Cheong, along with another exception, Choe Hangi, was the only scholar who introduced his thoughts on *Diqiu tushuo* after reading it. Yi Cheong, in the "Motion of the Earth" section of *Jeonggwanpyeon*, goes through ancient Chinese records that could be interpreted as the rotational earth theory, as well as how authoritative Chinese texts on astronomy such as *Lixiang kaocheng* and *Yixiangzhi* introduced the rotational earth theory but did not accept it as the truth.[25] In addition, Yi introduces and explains how *Kongji gezhi* sought to refute the rotational earth theory.[26] Yi Cheong did not make a clear decision between the contradictory opinions. It appears that Yi did not read *Diqiu tushuo* even when he first started to write *Jeonggwanpyeon*. It seems that Yi later read *Diqiu tushuo* and wrote about the rotational earth theory in great detail. However, Yi nevertheless did not recognize Benoist's assertion as something valid.

Considering that Yi Cheong, who read *Diqiu tushuo* in the 1850s, did not accept the rotational earth theory, it is likely that Korean scholars during the mid-nineteenth century generally also did not accept it. In this context, Choe Hangi stands out as a clear exception. His views can be seen in *Unhwa cheukheom* (1860), which established the basis for *qi*-based cosmology by refuting European medieval cosmology, as well as *Jigu jeonyo*

24. For Yi Cheong's discussion on this issue, see *Jeonggwanpyeon*, vol. 1 "Size of the Earth and Three Light," 32.
25. *Jeonggwanpyeon,* vol. 5 "Motion of the Earth," 35.
26. *Jeonggwanpyeon,* vol. 5 "Motion of the Earth," 38.

(地球典要, 1858). *Jigu jeonyo* is a condensed recapitulation of the contents of *Diqiu tushuo, Haiguo tuzhi* (1842), and *Yinghuan zhilue* (1848). The first volume of *Jigu jeonyo* summarizes *Diqiu tushuo,* and the remaining twelve volumes reference mid-nineteenth century texts such as *Haiguo tuzhi* and *Yinghuan zhilue* with the perspective that it is necessary to learn western modern science over traditional Chinese science. *Jigu jeonyo* contains both seventeenth-century Copernican cosmology as well as nineteenth-century European geography—scientific knowledge that was developed some 200 years apart. Aside from the interesting content, *Jigu jeonyo* is also attention-grabbing in the sense that it was the first work that endorsed the heliocentric structure with the rotational earth theory in Korea.

What is even more interesting is the inclusion of "The Tides(潮汐)" and "Discussion on *qi*'s Change (論氣化)" sections in volume one of *Jigu jeonyo* as additions to its discussions of *Diqiu tushuo*. The content of "The Tides" is a re-summarization of "The Tides" records of *Chucheukrok* (推測錄, 1836), and it changed *piryun* (被輪, surface globe) to *giryun*(氣輪, *qi*'s globe). In addition, while *Chucheukrok* touched upon the functions of *qi* between the earth and the moon using the ebb and flow of the tide, Choe's work is different in the sense that it links the tides to the larger system of the universe's motions.[27] The aim of "Discussion on *qi*'s Change" was to present the principles behind the *giryunseol* (氣輪說, the Theory of the *qi*'s Globe). It saw that all phenomena of the universe result from the rotary motion of the universal *qi*'s globe. If the ebb and flow of the tide is the result of the application of the *qi*'s globe of the earth and the moon, the cold and heat also result from the application of *qi*'s globe between the earth and the sun. Choe believed that, in the end, all universal phenomena are results of the rotary motion of *qi*.[28] That is the core principle of the 'Theory of the *qi*'s Globe.' Choe Hangi concretized and clarified his 'theory of the *qi*'s globe' using the heliocentric theory with the motion of the earth from *Diqiu tushuo*.

By the 1860s, Choe Hangi began to show his responses to the texts on cutting-edge mid-nineteenth-century western science. If *Singi cheonheom* (身機踐驗, 1866) is a reorganization of Hobson's writings on nineteenth-century medicine, *Seonggi unhwa* (星氣運化, 1867) was new summary of Herschel's *Tantian* (1859), an introductory text on astronomy. Herschel's *Tantian* was

27. *Jigujeonyo,* vol. 1, "The Tides," 24.
28. *Jigujeonyo,* vol. 1, "Discussion on the *qi*'s change," 25-26.

a mid-nineteenth-century work of western astronomy, published some 200 years after that of *Diqiu tushuo*. *Tantian* features explanations of Kepler's laws of planetary motion (based on Isaac Newton's law of universal gravitation) and even more difficult phenomena of celestial motions called 'perturbation' (*shedong*, 攝動). In astronomy, 'perturbation' refers to instances where motions of planets and asteroids deviate from the Kepler's elliptical orbit and principle of areal velocity. Such instances occurred because of gravity. For example, while Uranus is supposed to move along the elliptical orbit according to the Kepler's laws of planetary motion, it moves along a different trajectory because of the gravity of Neptune. That is 'perturbation' (*shedong*).[29]

Choe Hangi, however, discovered distinct evidential content in *Tantian* that could prove and complete his 'theory of the *qi*'s globe.' One is that all planets, not just the earth, rotate on their axes.[30] For Choe, this was the decisive evidence that proves his assertion that all celestial bodies are surrounded by rotating *qi* that spins them. Another was 'perturbation'. In other words, Choe Hangi accepted and absorbed the assertion of *Tantian* on the phenomenon of 'perturbation' as proof that the rotation of *qi* between the celestial bodies produces every astronomical phenomena. Choe Hangi praised the part on "perturbation" (*shedong*) by saying that it proves how all the stars in the universe form a single system around the circling *qi*.[31] For Choe Hangi, 'perturbation' was not a deviation from the Kepler's principles. Instead, it was proof that all changes and motions of the celestial bodies occur according to the principle of 'the theory of the *qi*'s globe.' It therefore implied more of a phenomenon in which celestial bodies pull each other due to the rotation of *qi*. Choe Hangi says, "…'perturbation' is the movement occurring between the opposing forces of pulling and resisting." "While all planets are separated by great distances, they nevertheless pull and push each other because of the rotating *qi* amongst them."[32] It is obvious that such forces of push and pull could not be read as gravity. The 'perturbative power' (*sheli,* 攝力) meaning gravity in *Tantian* is defined as "an object in the sky always falls straight down to the ground. There is a force that always makes

29. For discussions on this phenomenon of perturbation, see *Tantian*, vol. 14, 29-33.
30. *Jeungbo myeongnamlu chongseo* (增補明南樓叢書), vol. 5, "Prefce of Seonggi unhwa," 103c.
31. *Jeungbo myeongnamlu chongseo* (增補明南樓叢書), vol. 5, "Prefce of Seonggi unhwa," 103c~103d.
32. *Jeungbo myeongnamlu chongseo*, vol. 5, "Introductory Remarks of Seonggi unhwa," 106a.

it fall straight down and it is called 'perturbative power' (*sheli*)."[33] For Choe Hangi, who earlier read *Kongji gezhi* and transformed the motion theory of the four elements theory into the basis of his theory of the *qi*'s globe, there was no difference between 'perturbative power' (*sheli*) as defined here and the force that drives heavy objects to their original place.[34]

Choe Hangi therefore reinterpreted the up-to-date European astronomy of the nineteenth century, and incorporated it into the *qi*-based paradigm. Theories of modern astronomy included in *Tantian* made his theory of the *qi*'s globe more sophisticated, and he transformed *Tantian's* modern astronomy into a *qi*-based cosmology based on his theory of the *qi*'s globe system.

Epilogue: Historical Character of the Final Traditional Science

So far, we've reviewed the state of nineteenth century Korean science from the perspectives of specialized astronomy and calendrical science as well as natural philosophy. Attention-grabbing representative accomplishments of traditional science before the "opening" are texts of astronomy and calendrical science written and published by brothers Nam Byeongcheol and Nam Byeonggil and the reinterpretation of modern astronomy as can be seen in *Seonggi unhwa* of Choe Hangi. I now want to critically evaluate them for their historical characteristics and significance.

Twenty or so books published on astronomy and calendrical science by the Nam brothers during the 1850s and 1860s were the grand finale of scholarly learning by Seoul-based scholars since the eighteenth century. Nam Byeongcheol's case is particularly interesting, as he expounds alternate discourses of science. He differentiated astronomy and calendrical science from Shao Yong's *yijing*-based cosmology, and did not recognize the theory of "the Chinese origin of Western learning" (Moon 2000:99-117). *Yijing*-based understanding of nature and "the Chinese origin of Western learning" theory

33. *Tantian*, vol. 8, "Dongli (動理)," 1-2. Also to speak of its size, "according to Newton, all celestial bodies have the power to pull each other toward them. Such power is directly proportional to their respective weights, and inversely proportional to the square value of the distance between them." This is obviously speaking of Newton's law of universal gravitation.
34. Therefore it seems relevant that "Dongli" of *Tantian*'s volume eight is excluded from *Seonggi unhwa*.

were commonly accepted among Korean scholars since the eighteenth century, and Nam Byeongcheol clearly deviates from convention here. However, it is nevertheless important to note that works of astronomy and calendrical science by the Nam brothers do not deviate from the general paradigm of synthesis between traditional Chinese science and western science established by Mei Wending (1633-1721).

The conditions of science in Korea should be compared to the conditions of contemporary China and Japan at the time. Chinese astronomy and calendrical science did not differ much from that of Korea until the mid-nineteenth century. In other words, under the Sino-centric paradigm of "the Chinese origin of Western learning," narratives of synthesis established in *Lixiang kaocheng* and *Shuli jingyun* continued without much change into the early part of the nineteenth century. As can be seen from the state publication of *Yixiang kaocheng xubian* in 1845 and the revised publication of *Chourenzhuan* of Juan Yuan in 1849, Mei Wending's paradigm of synthesis remained dominant until the 1850s in China. Under that paradigm, unearthed aspects of traditional science in ancient texts became more important than new and modern science from Europe itself. However, that trend changed after the mid-nineteenth century. Starting in 1851, up-to-date European texts on science began to be translated and published in Shanghai. The First Opium War changed Chinese discourses on science. Newly-stimulated scholars argued for the need to actively learn new scientific technologies instead of ancient knowledge, and books such as *Haiguo tuzhi* and *Yinghuan zhilue* were published by those engaged in the Self-Strengthening movement in the changed context.

The situation in Japan was even more different. As can be seen from the introduction of western anatomy in the translated text *Kaitai Shinsho* (解體新書, 1774) and the introduction of Newtonian physics via *Rekishou shinsho* (曆象新書) around the year 1800, knowledge of modern western science began to enter Japan as early as the late eighteenth century. Things changed even more after Matthew Perry's opening of Japan. The establishment of the Nagasaki Naval Training Center (海軍傳習所), established in 1855) with hired western teachers of mathematics, as well as a number of translation efforts by Christian missionaries, further aided Japanese learning of nineteenth-century modern mathematics. *Yozan yoho* (洋算用法, 1857) of Yanagawa Shunshan (柳川春三) even included materials of advanced algebra and calculus that paralleled *Daiweijishiji* (代微積拾級, 1857), a translation done by Qing mathematician Li Shanlan and Christian missionary A. Wylie in Shanghai.

Rapid introduction and learning of modern western science in China and Japan in the nineteenth century was paralleled in a limited way in Korea by Choe Hangi's writings that reflected European knowledge of modern science during the 1850s and 1860s. *Seonggi unhwa* (1867) is a representative text of Choe Hangi based on a reading of *Tantian,* a translated nineteenth-century European introductory text on astronomy based on Newtonian physics. However, *Seonggi unhwa* nevertheless transformed some of *Tantian*'s contents and became the foundational text for Choe Hangi's theory of the *qi*'s globe. His theory of the *qi*'s globe was the consilience of his *qi*-based studies as a system of knowledge that encompasses the entire universe.

However, Choe Hangi's work was not, in a macroscopic point of view, so different from the efforts of Fang Yizhi school some 200 years before, as they both reinterpreted and reconstituted knowledge of western astronomy into traditional *qi*-based mechanisms. The only difference between them was time, as the Fang Yizhi school reconstituted still-confused and contradictory European science of the seventeenth century, while Choe Hangi reinterpreted modern astronomy of the nineteenth century. They were both similar in the sense of pride they took in their work. Claiming that western science was only good at explaining certain phenomena but not the fundamental principles behind them, the members of the Fang Yizhi school took great pride in their work by claiming that they were able to investigate and reveal such fundamental principles. Choe Hangi's pride on his theory of the *qi*'s globe was equally great. He criticized the limitations of western science by arguing, "while books such as *Bowu xinbian* and *Tantian* discovered this theory (the earth's rotation on its axis and heliocentric theory), they were not able to figure out the fundamental principle behind the movements of divine *qi* around the universe."[35] Choe Hangi took great pride in his theory of the *qi*'s globe, believing that he had figured out what western scientists had not. However, the Fang Yizhi school's original and interesting paradigm of understanding nature became diminished and forgotten in China by the establishment of precise and empirical research paradigm of Mei Wending in the late seventeenth century. In Korea, however, a *qi*-based understanding of nature was revived by Choe Hangi in the nineteenth century.

Lastly, it is important to note that Chinese scholar-mathematician Li Shanlan, who had aided Wylie in publishing *Tantian* in Shanghai, understood

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35. *Jeungbomyeongnamlu chongseo*, vol. 5, "Introductory Remarks of *Seonggi unhwa*," 105a.

Tantian differently than did Choe Hangi. Li Shanlan evaluated, as follows, the achievements of western astronomy included in *Tantian* in its preface: "We now know that the orbits of the five planets and the moon are elliptical because Kepler discovered his laws (of planetary motion). The laws show that velocity and area are proportional. However, while Kepler discovered the laws, he did not understand why [they were] so. It was Newton who discovered the principle behind them."[36] As can be seen from the quote, Li Shanlan accurately understood that the Newton's law of universal gravitation was the principle behind elliptical orbit of the planets and how that became the founding principle of modern physics. The case of Li Shanlan was fundamentally different from works of Wang Xichan (王錫闡) and Mei Wending, who reinterpreted western science within the traditional Chinese paradigm of science. Choe Hangi's understanding of western science during the 1850s and 1860s, however, still did not deviate from the traditional paradigm of East Asia. Not only did it not deviate from tradition, Choe Hangi's work was even a greater intensification and sophistication of traditional paradigm in its efforts to understand the laws of nature including human society.

(This work was supported by a grant from the Korea Research Foundation funded by the Korea of Government (MEST) (KRF-2007-361-AL0016)

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36.*Tantian,* "Preface of Li Shanlan," 1b.

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Abstract

We can find noteworthy astronomical developments in nineteenth century Korea from the following facts: piecemeal knowledge in the natural sciences as listed in *Oju yeonmun jangjeon sango* (Random Expatiations of Oju) in the early nineteenth century, Choe Hangi's writings during the 1830s and 1840s, cosmological discussions of Yi Cheong and Choe Hangi in the mid-nineteenth century, production and widespread circulation of astronomical charts and world maps such as *Honcheonjeondo* and *Yeojijeondo*, and professional studies of astronomy and calendrical science by Nam Byeongcheol and Nam Byeonggil during the 1850s and 1860s. This article aims to explore the comparative differences between the nineteenth century and eighteenth century and the genealogy of scientific knowledge on which the discourses of nineteenth-century Korean Confucian scholars were based. In addition, I want to make a preliminary overview of the representative scientific accomplishments of nineteenth century Korea in the context of the late-nineteenth-century high imperialism, when modern science and technology were rushing into Korea. In conclusion, we can see that most works of astronomical science and the cosmological contemplations of Korean scholars did not deviate from the general paradigm of synthesis between traditional East-Asian science and western science until the late nineteenth century, although they were unique and interesting.

Keywords: Korean traditional science, Yi Gyugyeong, Yi Cheong, Choe Hangi, Nam Byeongcheol, Fang Yizhi school,

Submission: 2010. 1. 4. Referee/Revision: 2010. 2. 2. Confirm: 2010. 2. 11.