A Study of Stone Star Charts in Korea and China

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Abstract

Cheonsangyeolchabunyajido (天象列次分野之圖) and *Suzhou* (蘇州) star maps are representative stone star charts in Korea and China and they have been engraved on a stone slab in A.D. 1395 and 1247, respectively. Constellations in each stone star chart are based on the oriental constellation system of *Butiange* (步天歌). We compare the two stone star charts in terms of position of stars, connecting pattern, number of stars and so forth. As a result, we find notable differences between the two star charts such size of star, shape of constellation, number of star, etc. Constellations in the Korean star chart are almost identical to those of Korean *Butiange*. However, some constellations in *Suzhou* star chart are quite different in shape or number of star from those of Chinese *Butiange* or *Xinyisangfayao* (新儀象法要). We find several incomplete constellations in the *Suzhou* star chart such as missing of star's name or figure, erroneous connectings between stars and so forth. We also analyze the Korean star chart using the 3D measurement data. And find that stars in the replica (17C) are mostly shift in the clockwise, compare with the original (14C). It might caused by the correction of precession when making the replica.

1. Introduction

Korea and China have a long history of astronomy, remaining a large amount of astronomical relics such as star charts, observational records, observational instruments

and so forth. Many Korean star maps and star markings are reported from prehistoric period to *Joseon* dynasty. Recently some astronomical markings are being reported in Korean dolmens which are the typical tomb of Bronze age in Korean peninsula (Yang 2004; Yang *et al.* 2010). In Korea, the 28 oriental constellation system appeared in *Goguryeo* mural star paintings. It is known that 25 *Goguryeo* tombs have star paintings and most star paintings are identified with the oriental 28 constellations as well as the Sun, the Moon and so forth (Park & Yang 2009; Kim 1961). In particular, *Deokwhari* #2 (~5C) and *Jinpari* #4 (~6C) of *Guguryeo* tombs are known to have whole 28 oriental major constellations. Star paintings in *Goguryeo* tombs have various sizes of stars, and it shows the Korean tradition of indicating the brightness of the stars as the various sizes of star in *Cheonsangyeolchabunyajido* (天象列次分野之圖) of *Joseon* dynasty.

Cheonsangyeolchabunyajido (hereafter, *Cheonsang*) is the most representative star chart in Korean history. *Cheonsang* was engraved in a stone slab in A.D. 1395, the early *Joseon* dynasty. The map contains 1,467 stars with various sizes and individual stars are engraved in such a way that its area is linearly proportional to the visual magnitude (Yang 2009; Park 1998). According to the inscription of the *Cheonsang*, the star chart is based on an astronomical chart from *Goguryeo* (B.C. 37 ~ A.D. 688) that had been sunk into the river in *Pyeongyang* (平壤) during the war. Park (1998) statistically analyzed the position of stars and found that the epochs of the stars are mixed around first and fourteenth centuries. Recently Yang (2009) measured the position and size of stars in *Cheonsang* using the 3-D measuring instrument, Breukmann. There are two stone star charts of *Cheonsang* and they were manufactured in era of King *Taejo* (AD1392~1398) and King *Sukjong* (1675~1720). In this study, we compare the two star charts of *Cheonsang* quantitatively using the 3D measurements of the position and size of stars.

China also has a long history of star maps. The most earliest relic depicting the 28 oriental constellations is a lacquered box discovered in the tomb of *Zeonghouyi* (曾侯乙墓) dating B.C. 430 years. It is known that the 28 oriental constellation system was established during *Xihan* (西漢, BC 206 ~ AD 23) dynasty, and the most earliest 28 constellation painting was discovered in *Xihanmu* (西漢墓, B.C. 73 ~ A.D. 6). *Chenzhuo* (陳卓) first compiled three kinds of Chinese constellations and published a star catalogue, *Sanjiaxingjing* (三家星經) around late third century. And later, a new constellation system, *Butiange* (步天歌), was systematized by *Danyuanzi* (丹元子)

around eighth century, and the *Butiange* gradually replaces the former constellation system (潘鼐 & 崔石竹 編著 1998).

The first star charts engraved on a stone were discovered in two tombs of *WuYue* (吳越, AD 907~978) period (北京天文館 1987; 潘鼐 編著 2009). The star charts individually contain ~180 stars and they are engraved on the ceiling of the burial chamber with the Milky Way. It is known that the tombs were constructed during in A.D. 942~952. The most famous stone star chart is now keeping in *Suzhou* (蘇州), and it was engraved in A.D. 1247. The *Suzhou* star chart is the first full-scale stone star chart in Chinese history. The *Suzhou* star chart contains 1,441 stars and follows the *Butiange* constellation system. The *Suzhou* map also has an inscription below the star chart like Korean *Cheonsang*. The inscription of *Suzhou* map contains the astronomical knowledge of the day such as celestial structure, celestial equator, the ecliptic, the Sun, the Moon, the Milky Way, the oriental constellation system and so forth. It is known that the observational epoch of the *Suzhou* star chart is the period of *Yuanfeng* (元豊, A.D. 1078~1085). It is known that *Suzhou* star chart originate from the star maps in *Susoing* (蘇頌)'s book, *Xinyisangfayao* (新儀象法要), which was published in 1094~1095 (陳美東 編著 1996). In Ming dynasty, another stone star chart was made in *Changsu* (常熟). The *Changsu* star chart obeys the *Sanjiaxingjing* constellation system and contains 1,464 stars. Although the *Changsu* star chart were engraved in later, the *Suzhou* star chart is known to be the most outstanding stone star chart in China.

We study Korean stone star chart, *Cheonsang*, and compare it with Chinese *Suzhou* stone star chart in terms of position of stars, shape of constellation, number of stars and so forth.

2. Korean stone star chart (天象列次分野之圖)

Cheonsang is one of the representative astronomical properties in Korean history. There were two stone star charts during *Joseon* dynasty (A.D. 1392~1910), and they were manufactured in fourteenth and around seventeenth centuries which correspond to the era of King *Taejo* (太祖) and King *Sukjong* (肅宗) of *Joseon* dynasty, respectively. The later one is known to be a replica of the original. The original was designated as Korea's national treasure (國寶 228號) and the replica was to be Korea's treasure (寶物 837號). Both of them are now preserved in the National Palace Museum of Korea (國

立古宮博物館). From the inscription of the chart, we could understand that the stone star chart originated from *Goguryeo* dynasty.

There have been many researches on the *Cheonsang* star chart. Maurice Courant firstly introduced the Korean *Cheonsang* star chart to the western countries through his book 'Bibliographie Coreanee' in 1894 (Maurice 1974; Lee *et al*. 2008). Rufus (1913; 1915; 1944) studied the star chart and estimated that the observational epoch of the stars was around first century. North Korean Ri (1982) also estimated the observational epoch of stars dating between late 5C and early 6C. Since then several Korean scholars studied the *Cheonsang* and estimated the observational epoch of the stars dating between B.C. 1C and A.D. 6C. Park (1998) found that the epoch of the stars in *Cheonsang* are mixed the first and fourteenth centuries. Most stars with declination lower than 50 degrees represent the night sky of the first century, the era of *Goguryeo*, while stars located higher than 50 degrees are positioned to represent the epoch close to the fourteenth century, the era of early *Joseon* dynasty. Park also found that a few pattern of constellations in the back-side of the original are similar to the shape of Chinese *Butiange* constellations while the pattern of constellation in the front-side of the original is similar to the constellation of replica. Thus, Park suggested that star chart in the back-side of the original had been engraved earlier than the front-side of the original. Until now, most researches are based on the replica because the star chart in original is already extensively damaged.

In order to compare the star chart between the original and the replica quantitatively, we use 3D high resolution measuring data of the position and size of stars in *Cheonsang*. Position and size of stars, inscription and size of the star chart are precisely measured by 3D measurement (Yang 2012). We compare the star charts, which are in the front-side of the original and in the replica. Figure 1 shows the distribution of differences for the size of stars between the two star charts. Generally stars in the replica have large radii than those of in the original. Differences between the radius of stars in the two star charts increase with the angular distance from the north pole in fig 1. It may caused by the wear of the surface of the original. We also compare the position of the stars in the two star charts. Figure 2 and 3 show the distribution of differences for the position of stars between the two star charts, and distribution of differences for the stars' azimuth between the star charts, respectively. The dashed line and dotted line in fig. 2 denote the angular distances of 1° and 2°, respectively. In Fig 3, we know that stars in the replica are entirely shifted in the clockwise, compare with

the original. The shift of the stars might caused by the correction of precession in the replica. Figure 4 shows the position of stars in the two stone star charts and it is reproduced by 3D measurement data. White and black circles in fig. 4 indicate the position of stars in the replica and the original, respectively. Circles in fig. 4 have only positional information. It is known that size of star and brightness have a good correlation in *Cheonsang* (Park 1998). Thus, we also examine the correlation between the size and brightness of the stars and find that brighter stars have larger radii.

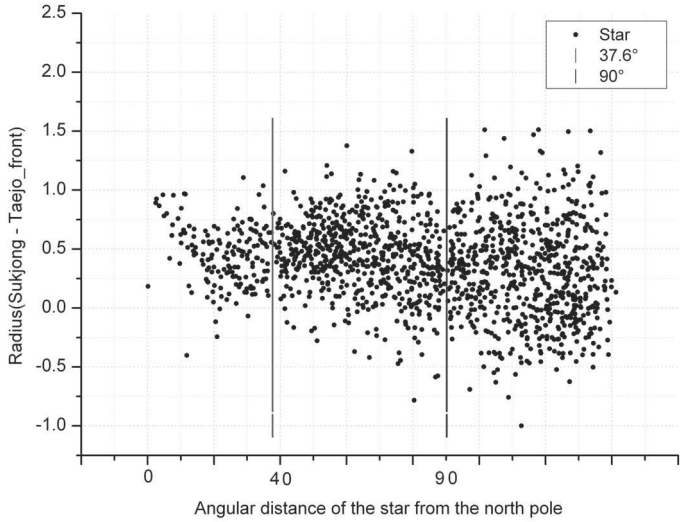


Fig. 1. Distribution of differences for the size of stars between *Cheonsang* and *Suzhou* star charts.

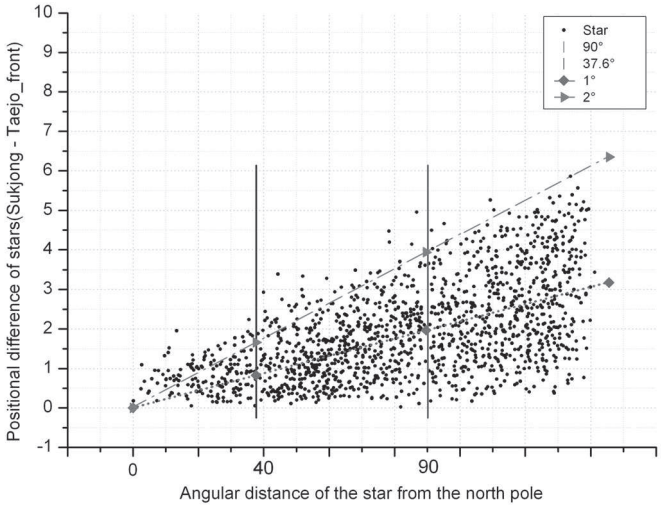


Fig. 2. Distribution of differences for position of stars between *Cheonsang* and *Suzhou* star charts.

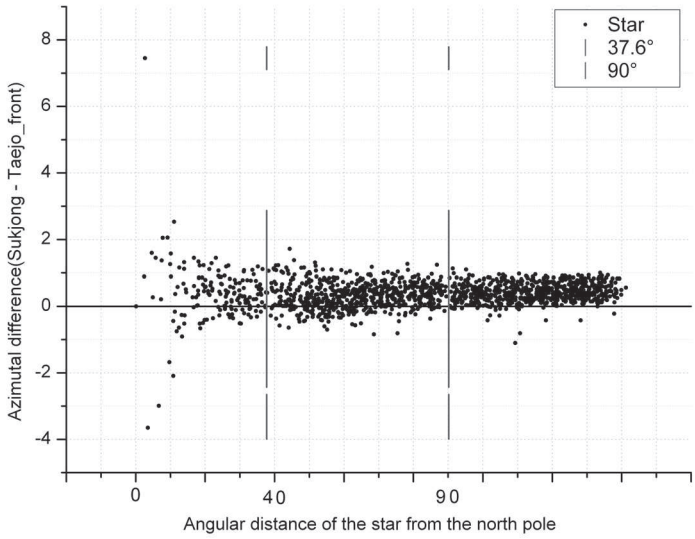


Fig. 3. Distribution of differences for azimuth of stars between *Cheonsang* and *Suzhou* star charts.

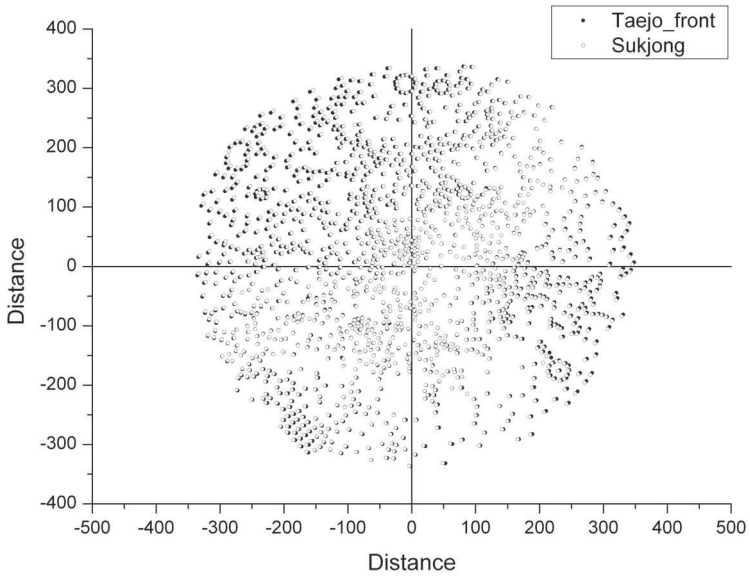


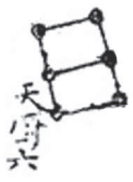
Fig. 4. Position of stars in *Cheonsang* (white circle) and *Suzhou* (black circle) star charts.

3. Comparison of *Cheonsang* and *Suzhou* star charts

Cheonsang and *Suzhou* star maps are representative stone star charts in Korea and China and they have the same oriental constellation system of *Butiange* (步天假). Korean and Chinese star charts were engraved on a stone slab in A.D. 1395 and A.D. 1247, respectively. Chinese constellation book, *Butiange* was introduced to Korea and it was published in Korea. Kim *et al*. (2009) compared Korean *Butiange* of the early *Joseon* dynasty and Chinese one of *Sui* dynasty (隋代, 581~618) written by Wang *Ximing* (王希明). They found several differences between the two constellation books in terms of shape of constellation, number of star, connecting pattern of constellation and so forth. Thus, we compare the star chart in *Cheonsang* and *Suzhou* in terms of position of stars, connecting pattern, number of stars and so forth. *Cheonsang* has 1,467 stars with various sizes and a circumpolar circle corresponding to the latitude of 37.7° that is in accord with the latitude of the capital of *Joseon*, *Hanyang* (漢陽). *Suzhou* star chart has 1,441 stars and observational latitude is 34.49°, which corresponds to the latitude of *Kaifeng* (開封). The two star charts mostly same, perticularly in the constellation system, but we find notable differences between the two star charts as followings;

- unlike the *Cheonsang*, stars in *Suzhou* star chart are indistinctive in size
- number of star (34)
  : 氐, 鼈, 趙, 人星, 奎, 天將軍, 大陵, 天船, 天廩, 天苑, 天園, 子, 孫, 天相, 稷, 張, 翼, 列肆, 市樓, 少微, 文昌, 天梱, 傳舍, 天廚, 右旗, 天市右, 天弁, 輦道, 天田, 鉤, 器府, 天困, 騰蛇, 羽林

Table 1. 天廚 - number of stars shown in four different star charts.

			
Cheonsang (6)	*Suzhou* (5)	Chinese *Butiange* (6)	*Xinyisangfayao* (6)

- connecting pattern of constellation (15)
  : 騎官, 九坎, 扶筐, 造父, 天陰, 弧, 尚書, 天柱, 內階, 八穀, 天床, 九卿, 常陳, 宗人, 七公

Table 2. 常陳 - shape of constellation shown in four different star charts.

			
Cheonsang	*Suzhou*	Chinese *Butiange*	*Xinyisangfayao*

- name of star (41, *Cheonsang*/*Suzhou*)
  : 離瑜/璃瑜, 天溷/天圂, 天紀/天己, 左梗/左更, 右梗/左更
  天矢/屎, 扶筐七/拱相, 天樽/天尊, 三公/三師, 內平/內屏, 太子/太平
  屏/內屏, 三公內座/三公, 五帝/五帝座, 女御宮/御文, 敗苽/敗瓜, 苽/匏瓜, 天將軍/天大將軍, 司空/土司空, 牽牛/牛, 須女/女, 內杵/杵, 羽林/羽林軍, 東壁/壁, 東井/井, 柱下史/柱史, 弧九/弧矢, 稷五/天稷, 五諸侯/內五諸侯, 尚書/五尚書, 鈇鉞/斧, 天理/大理, 帝座/座, 天門/大門, 附耳/聽附耳, 軍南門/庫南門, 靈臺/臺, 天讒/讒, 郎將/郎星, 土公史/土公, 土公/土公吏
- peculiar or missing stars (4+5)

In order to know the cause of the difference, we also compare the difference with the additional star maps in Korean and Chinese *Butiange* and *Xinyisangfayao* (新儀象法要). We know that constellations in *Cheonsang* are almost identical to those of Korean *Butiange*. However, some constellations in *Suzhou* star chart are quite different in shape or number of star from those of Chinese *Butiange* or *Xinyisangfayao*. The number of star for 34 constellations in *Suzhou* star chart is different from those in *Cheonsang*. We find 15 constellations with different shape or connecting form, and find 41 stars with different name in both star charts. We also found 9 stars they are shown in only one star chart.

The inscription of the *Suzhou* star chart says that the star chart consists of 1,565 stars but, we count the whole stars in *Suzhou* and confirm 1,441 stars. We found

several errors in the *Suzhou* star chart such as missing of star's name or figure, number of stars, incomplete connecting between stars and so forth.

4. Summary

We study Korean stone star chart, *Cheonsang* using the 3D measurement data. There are two stone star charts manufactured in 14C and 17C thus we compare the star charts in terms of position and size of stars quantitatively. The later one is known to be a replica of the original, and the original has two star charts on both sides of the stone slab while the replica has only one side star chart. Park (1998) reported that star chart in the back side of the original has a few differences in terms of position of stars from the other star charts in *Cheonsang*. In this study, we compare the location of stars in the front side of the original with that of replica, and find that stars in the replica are mostly shift in the clockwise, compare with the original. It might caused by the correction of precession when making the replica. Most stars in replica are located within the 2° angular distance from the position of stars in the front-side of the original. We also find that stars in the replica generally have large radii than those in the original. We examine the correlation between the size and brightness of the stars, and find that brighter stars have larger radii.

Korean *Cheonsang* and Chinese *Suzhou* star maps were engraved on a stone slab in A.D. 1395 and A.D. 1249, respectively. Constellations in each stone star chart are based on the oriental constellation system of *Butiange*. Thus, we compare the star charts in *Cheonsang* and *Suzhou* in terms of position of stars, connecting pattern, number of stars and so forth. We count engraved stars in *Cheonsang* and *Suzhou* and confirm 1,467 and 1,441 stars, respectively. Although the two star charts use the same constellation system, we find notable differences between the two star charts. Unlike the *Cheonsang*, stars in *Suzhou* star charts are indistinctive in size. And we find many differences in the two star charts in terms of number of stars, shape of constellations, name of star, and so forth. In order to know cause of these differences, we compare the differences with the star maps in Korean and Chinese *Butiange* and *Xinyisangfayao* (新儀象法要). We find several incomplete constellations in the *Suzhou* star chart such as missing of star's name or figure, erroneous connections between stars and so forth.

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