

TRIGONOMETRY AND ITS ACCEPTANCE IN THE 18TH-19TH CENTURIES JAPAN

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Abstract: *The mathematics developed in Japan during the Edo Period (1603-1867) is called Wasan (Japanese mathematics). Wasan has its roots ancient Chinese mathematics. The concept of angle, however, did not grow up either of ancient Chinese and Japanese mathematics. In the sixteenth century Jesuit missionaries as a part of their propagation activity brought Western scientific knowledge and technology into Ming China which still had been maintaining traditional academic system since ancient time. At that time Western trigonometry was introduced into China, and encounter of different mathematics thought made to mean an opening of new intelligence activities in the history of East Asian mathematics. In 1720 the eighth Shogun Tokugawa Yoshimune permitted the import of Chinese books on Western Calendrical Calculations from Qing China. From this time, openly, Japanese scientists could make to study the Western scientific and technology. It means indirect acceptance of Western knowledge via Chinese works. And they were able to know element of trigonometry and its application through the study of Chinese books on Western Calendrical Calculations. During the 17th and 19th centuries Western scientific knowledge was also introduced into Japan from Netherlands. Dutch interpreter Shiduki Tadao was one of men who studied directly trigonometry from Dutch book. He comprehended Napier's rules in plane trigonometry. In this paper we discuss the study of trigonometry by Wasan-ka and its acceptance of trigonometry from China and Netherlands in the 18th-19th centuries Japan.*

1 TRANSMISSION OF TRIGONOMETRY INTO CHINA

In seventh August, 1582, Italian Jesuit missionary Matteo Ricci (1552-1610) arrived at Macao, China. His arrival meant not only the reopening of Christian propagation in China but also transmission of Western science and technology in East Asia. M. Ricci was born in 1552 at around Macerata, Italy. In his young age he left for Rome to learn law, but in 1572 he entered to Collegio Romano, which was one of Jesuit missionary school in Europe. There he took the lectures of the natural science; mathematics, astronomy and geography etc. from Christoph Clavius (1538-1612) and other teachers.

His main purpose came to China was, of course, Christianity propagation. As a part of propagation activity M. Ricci strove to introduce Western scientific knowledge and technology. For that purpose he translated many Western academic books into Chinese in cooperation with the Chinese intelligencers. In those days especially Chinese astronomers wanted to have up-to-date astronomical information or calculation for calendar reform, therefore they had strongly interest in Western scientific knowledge or mathematics and astronomical observation technique.

One of the new mathematical information, which was brought by Jesuit missionaries, was trigonometry. As soon as it was introduced, Chinese astronomers comprehended that trigonometry is very useful as mathematics technique on calendar calculation. Moreover they devoted it to apply to astronomical observation or land surveying and so forth.

2 TRIGONOMETRIC STUDIES IN WASAN

The mathematics developed in Japan during the Edo Period (1603-1867) is called Wasan (Japanese mathematics). Wasan has its roots in Chinese ancient mathematics. Unfortunately the concept of angle did not grow up neither Chinese nor Japanese mathematics. But it was incomplete, Japanese mathematicians were able to have idea of trigonometry or trigonometric function in their original study. Here we will introduce particular example by two Japanese mathematicians.

In 1627 an elementary mathematical textbook was published by Mitsuyoshi Yoshida (1598-1672). The book title was *Jinko-ki*, means "From the Large Number to the Small Number". In the twelfth chapter of volume two in this book we find a problem, was named "Kobai no nobi no koto". The author M. Yoshida asks there that how to calculate the length of pitch of a roof and used the Pythagorean Theorem for the answer. In our modern sense we regard meaning of "nobi" as secant, that is;

$$\sec \bullet = (r + \text{nobi}) / r.$$

Katahiro Takebe (1664-1739), who was a disciple of Takakazu Seki (?-1708) and an excellent mathematician, devoted to study that how to find the length of an arc, the chord and the arrow of a circle. Finally he found an equation for the chord which expresses in a series the square of arc $\sin x$; $(\sin^{-1}x)^2$. Relating to these study K. Takebe made a numerical table for the length of the chord and the arrow in his manuscript, *Sanreki Zakko* (Calculation of the Circular Arc). We can recognize it as a kind of trigonometric function table. But he did not use any trigonometric formulae in this calculation. His method was quite based on geometry.

3 TRANSMISSION OF TRIGONOMETRY INTO JAPAN

In 1726, the second edition of Mei Wending's works *Li suan quan shu* (the first edition was compiled in 1723) was imported into Japan from China. Soon after of transmission of, K. Takebe and Genkei Nakane began to translate Mei Wending's works into Japanese. Then, in 1733, K. Takebe presented the Japanese version of *Li suan quan shu* under the title of *Shinsha yakuhon rekisanzensho* to the Shogun Yoshimune Tokugawa, containing his preface. In this preface of *Shinsha yakuhon rekisanzensho* he stresses the importance of a careful study of trigonometry.

About this time the Tokugawa government ordered the import of trigonometric function tables from Chinese traders because the editors of *Li suan quan shu* did not print the trigonometric function tables in *Li suan quan shu*. One year from the arrival of Mei Wending's works, three books of trigonometric function tables arrived at Nagasaki port.

Based on our research, we can confirm that one of the three books of trigonometric function tables is reproduced from *Chong Zhen li shu* (Chong Zhen Reign Treatise on Astronomy and Calendrical Science) which were compiled by Jesuit missionaries Jacques Rho (1593-1638) and Adam Shall von Bell (1591-1666) under the support of Chinese high rank bureaucrat Xu Guang Qi (1562-1633) and were presented to Emperor Chong Zhen.

After this, the use of trigonometric function tables began to spread among Japanese scientists. The first Japanese mathematicians to make use of trigonometry were G. Nakane and his disciples. G. Nakane has left two manuscripts; *Nichi getsu Kosoku* (The Measurement of Altitude of Sun and Moon) written in 1732 and *Hassenhyo sanpo kaigi* (The Mathematical Solution by Using Trigonometric Table). These are the earliest examples of the use of trigonometry by Japanese mathematicians.

4 THE DUTCH INTERPRETER SHIDUKI TADAO AND TRIGONOMETRY

Toward the end of the eighteenth century, the Dutch interpreter Tadao Shiduki (1760-1806) began to translate a scientific book entitled *Rekisho shinsho* (The Guide Book of

New Astronomy and Natural Science). This manuscript was composed of three volumes and completed in 1802, which was never printed. Description concerned with astronomy and physics was quite based on Johan Lulofs (1711-1768)'s *Inleidinge tot de ware Natuuren Sterrekunde of de Natuuren Sterrekundige Lessen*, which was published in Leiden in 1741.

Here, we trace the process of the introduction of Napier's rule into Japan. Baron John Napier (1550-1617) Scottish mathematician, who is well-known as discover of logarithms and inventor of Napier's rod, was first referred by T. Shiduki in *Sankaku teiyo hisan*. T. Shiduki describes Napier's homeland and his name using Chinese characters. The Chinese characters were used to mimic as closely as possible the Dutch pronunciation equivalent. Referring to Napier's rule for the right spherical triangles are wrote as follows:

1. $\cos c r = \cot A \cot B$.
2. $\cos c r = \sin a \sin b$. ($r = 1$)

These rules can be easily memorized by the expressions *cotan. ad.* and *sin. op.* Now we compare his terminology and expressions with the contents of the J. Lulofs' book as he translates, all of them are obviously leaded from the chapter of *Over de ontbindinge der regthoekige klootsche Driehoeken door vyf delen eens Cirkels*.

5 REMARKS

Japanese mathematicians completely comprehended the use of trigonometry by the nineteenth century. Then they knew that a side of inscribed regular n -polygon of a circle can be expressed by trigonometric function. Those particular examples will be found in Akiyuki Kenmochi's study *Kaku-jutsu shokei* and so forth.

Chinese books on Western calendrical calculations played an important role in bringing Western knowledge indirectly, via Chinese works, into Edo Japan. Eventually these books and those who read them served to form a bridge between the East and the West.

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