Program and Abstracts

The Takebe Conference 2014

A Satellite Conference of Seoul ICM 2014

August 25 – 30, 2014

Ochanomizu University, Tokyo, Japan

Domestic Organizing Committee
for
the Takebe Conference 2014

August 25, 2014

Introduction

This booklet contains abstracts of the lectures which are given at the Takebe Conference 2014. They are placed in Chapter 3 Plenary Lectures, Chapter 4 Special Lectures in Japanese and Chapter 5 Short Oral Presentations. The list of participants with no presentation is located in Chapter 6. Some basic and useful facts on the Takebe Conference 2014 are summarized in Chapter 1.

In Chapter 2 you find the Program of the Conference. The first day (August 25) is the registration day. The Public Lectures in Japanese are scheduled on this day. From the second day (August 26) to the last day (August 30) all lectures are given in English.

Appendix is a short article on Takebe Katahiro and his Mathematical Works. This is extracted from the English translation [MorimotoOgawa2012] of the *Tetsujutsu Sankei*.
August 25, 2014

Domestic Organizing Committee
The Takebe Conference 2014

はじめに

この小冊子は、建部賢弘国際会議 2014 の予稿を集めたものである。招待講演は第 3 章に、特別講演は第 4 章に、口頭発表は第 5 章に載せられている。一般参加者のリストは第 6 章にある。第 1 章はこの会議に関する基礎事項がまとめられている。

この会議のプログラムは第 2 章にある。第 1 日 (8 月 25 日) は登録日で、また日本語による 4 講演が「公開講演会」として行われる。第 2 日 (8 月 26 日) から第 5 日 (8 月 30 日) は英語による講演である。

付録として「建部賢弘と彼の数学著作」という小論文が載っているが、これは、『綴術算経』の英訳 [MorimotoOgawa2012] よりの抜粋である。
2014 年 8 月 25 日

建部賢弘国際会議 2014
国内組織委員会

Contents

Chapter 1

Takebe Conference 2014

In the occasion of the 350th anniversary of Takebe Katahiro (建部賢弘, 1664 - 1739), an international conference on traditional mathematics in East Asia and related topics is organized in his honor.

Korea hosts ICM 2014 during August 13-24, 2014 in Seoul. In 2013 President Miyaoka of the Mathematical Society of Japan (MSJ) circulated a letter of Professor Hyeonbae Kang, Chair of the Parallel Scientific Activities Committee of the ICM 2014 concerning the Satellite Conferences for ICM 2014. We, a group of MSJ, applied for this call. Our Takebe Conference 2014 has been recognized as one of the satellite conferences of the Seoul ICM 2014.

http://www.icm2014.org/sc/

Seki Takakazu (関孝和, ? - 1708) and Takebe Katahiro are two most distinguished Japanese mathematicians of the Edo period (1603 - 1868). In 2008 Professor Komatsu Hikosaburo organized the International Conference on the History of Mathematics in Commemoration of the tercentenary of Seki Takakazu at the Tokyo University of Science. (See [KKL2013].) The Takebe Conference 2014 follows the Seki Conference 2008.

1.1 Main Themes and Activities

At the Takebe Conference 2014 we examine recent trends and achievement in the history of traditional mathematics in East Asia. Topics include, but are not limited to the following themes:

1. Mathematics of the "Seki school" especially of Takebe Katahiro,
2. Traditional mathematics in East Asia (China, Japan, Korea, etc. in alphabetical order),
3. Traditional mathematics versus Western mathematics in East Asia.

1.2 Program of the Conference

Program is roughly as follows:

- Mon, August 25: Registration day; Public Lectures in Japanese.
- Tue, August 26: Opening ceremonies followed by plenary lectures and short oral presentations; conference reception in the evening.
- Wed, August 27: Plenary lectures in the morning; city excursion in the afternoon.
- Thu, August 28: Plenary lectures and short oral presentations; International Organizing Committee in the evening.
- Fri, August 29: Plenary lectures and short oral presentations.
- Sat, August 30: Plenary lectures in the morning; closing ceremonies at noon.

For the details, see Chapter 2.

1.3 Venue of the Takebe Conferennce 2014

Faculty of Science, OCHANOMIZU UNIVERSITY
http://www.ocha.ac.jp/en/index.html
2-1-1 Ohtsuka, Bunkyo-ku, Tokyo 112-8610, Japan
Campus Phone Information： 03-3943-3151

1.4 Lunch

University Cafeteria on campus will provide lunch at reasonable prices between 11:30 and 13:30.

1.5 Accommodation

For accommodation during your stay in Tokyo, you participants are requested to book a room by yourselves. We suggest the Toyoko-Inn, Tokyo Korakuen Bunkyo-kuyakusho Mae, which is situated in the vicinity of the conference site and provides you with a clean and safe accommodation with reasonable price about 7500 yen for a single room per night. We refer you to the hotel web page

http://www.toyoko-inn.com/hotel/0081/eng/index.html

You can find there English, Chinese, Japanese and Korean pages.

Invited speakers are accommodated at the following:

- Toyoko Inn Tokyo Korakuen Bunnkyo-kuyakusho Mae
  Address: 2-2-11, Koishikawa, Bunkyo-ku, Tokyo Postal Code: 112-0002
  Tel: +81-(0)3-3818-1045 Fax: +81-(0)3-3818-1048
- Tokyo Inn Tokyo Monnzen-nakacho Eitaibashi
  Address: 1-15-3, Eitai, Koto-ku, Tokyo, Postal Code: 135-0034
  Tel: +81-(0)3-5646-1045 Fax: +81-(0)3-5346-1046

The closest station of “Toyoko Inn Tokyo Korakuen Bunnkyo-kuyakusho” is Kōrakuen Station on Marunouchi Subway Line, while the closest subway station of Ochanomizu University (conference site) is Myōgadani Station on the same subway line.

1.6 Public Transportation

Public transportation (for example, subway) is very convenient for travel within Tokyo.

There are two international airport in Tokyo, Narita and Haneda, which are both connected to the hotel by public transportation. Please refer the web page of the hotel.

1.7 The Proceedings

The Proceedings of the Takebe Conference 2014 will be in English and published by the Mathematical Society of Japan (MSJ), hopefully as one of the "Advanced Studies in Pure Mathematics" (ASPM). The registered participant will receive a free copy.

Editors of Proceesings: Ogawa Tsukane & Morimoto Mitsuo

1.8 International Organnizing Committee

Komatsu, Hikosaburo (Honorary Chair, Professor Emeritus, U. of Tokyo, Japan)
Morimoto, Mitsuo (Chair, Seki Kowa Institute of Mathematics, Japan)

Chemla, Karine (SPHERE - REHSEIS, CNRS & U. Paris Diderot, Paris, France)
Hong, Sungsa (Sogang U., Seoul, Korea)
Kim, Dohan (Seoul National U., Korea)
Kobayashi, Tatsuhiko (Seki Kowa Institute of Mathematics, Japan)
Knobloch, Eberhard (Technical U. of Berlin & BBAW, Berlin, Germany)
Li, Wenlin (Chinese Academy of Sciences, AMSS. Beijing, China)
Majima, Hideyuki (Ochanomizu U., Tokyo, Japan)
Ogawa, Tsukane (Yokkaichi U./Seki Kowa Institute of Mathematics, Japan)
Ueno, Kenji (Seki Kowa Institute of Mathematics, Japan)

1.9 Cosponsor

- Faculty of Science, Ochanomizu University

1.10 Supporting Organizations

- Mathematical Society of Japan (MSJ)
- The History of Mathematics Society of Japan
- Yokkaichi University
- Japan Society for the Promotion of Science, Grant-in-Aid for Scientific Research (C) 22540155, (C) 23501204, (C) 23540126, (C) 23540169, and (C) 24540045.

1.11 Benefactors

- Munemura, Nan'o
- Ueno, Masayasu
- Ueno, Yuji
- others

1.12 Domestic Organizing Committee

Majima, Hideyuki (Chair, Ochanomizu U., Tokyo, Japan)

Higuchi, Shoko (Yokkaichi U., Japan)
Kobayashi, Tatsuhiko (Seki Kowa Institute of Mathematics, Japan)
Morimoto, Mitsuo (Seki Kowa Institute of Mathematics, Japan)
Ogawa, Tsukane (Yokkaichi U./Seki Kowa Institute of Mathematics, Japan)
Takata, Tomohiro (Seki Kowa Institute of Mathematics, Japan)
Tamura, Makoto (Osaka Sangyo U., Japan)
Ueno, Kenji (Seki Kowa Institute of Mathematics, Japan)

1.13 Bank Account

SWIFT CODE: HYKGJPJT (The Hyakugo Bank, Ltd.)
A/C Type: 01 Branch No.: 202 (Tomida Branch)
A/C No.: 468720 Name: Takebe Conference 2014
銀行名 ：百五銀行、
支店名 ：富田支店 202、
科目 ：普通預金、
口座番号：468720、口座名：タケベコンファレンス 2014

1.14 Exhibition

In connection with the Takebe Conference 2014 there will be the Exhibition on Takebe Katahiro's 350th anniversary: "Takebe Katahiro's achievements in *wasan* (mathematics) and the *Kyōhō Map of Japan*."

- Date and Time: August 24 ∼ 30, 10:00 ∼ 16:30
- Venue: University Archive (歴史資料館), University Main Building 1F, Room 136, Ochanomizu University
- Entrance free
- N.B. Takebe Katahiro's work *Kyōhō Map of Japan* (享保日本図) and his book *Kohai Setsuyaku shū* (弧背截約集) will be displayed only on August 24 and 25.

Chapter 2

Program

2.1 August 25, Monday

Registration

- 12:00–17:00 Registration at Faculty of Science, Ochanomizu University.

公開講演会（日本語による 4 講演）
Public Lectures (Four lectures in Japanese)

- 13:00 – 13:10 開会の辞 (Opening Addresses)
- Session 1 Chair: Ueno, Kenji (上野 健爾)
  - 13:10 – 13:50 講演 (Lecture), 13:50 – 13:55 討議 (Discussion)
    Imanishi, Yuichiro (今西 祐一郎): 学術と啓蒙ー日本語表記の観点からー（Academicism and Enlightenment – from the view point of Japanese notations） p.30
  - 14:00 – 14:40 講演 (Lecture), 14:40 – 14:45 討議 (Discussion)
    Kuge, Minoru （久下　実）: 建部賢弘の日本地図について（About a Japanese map made by Takebe Katahiro） p.31
- 14:50 – 15:40 お茶 (Tea) (50 min)
- Session 2 Chairs: Feng, Lisheng (馮立昇), Ogawa, Tsukane (小川束)
  - 15:40 – 16:20 講演 (Lecture), 16:20 – 16:25 討議 (Discussion)
    Xu, Zelin (徐澤林): 建部賢弘と『授時暦』 (Takebe Katahiro and *Shoushi li* calendar) p.27
  - 16:30 – 16:55 講演 (Lecture), 16:55 – 17:00 討議 (Discussion)
    Fujii, Yasuo (藤井康生):
    授時暦と関孝和・建部賢弘の招差法　対　貞享暦と渋川春海の招差法 (The *Jujireki* (*Shoushili*) and the method of finding differences by Seki Takakazu and Takebe Katahiro versus the *Jōkyōreki* and the method of finding differences by Shibukawa Harumi) p.34

2.2 August 26, Tuesday

- 9:00 – 9:45 Opening Ceremonies
- Session 3 Chairs: Hong, Sung Sa (洪性士); Horiuchi, Annick
  - 9:50 – 10:30 Lecture, 10:30 – 10:35 Discussion:
    Ueno, Kenji (上野 健爾): Seki Takakazu and Takebe Katahiro – two different types of mathematicians – p.26
  - 10:40 – 11:20 Lecture, 11:20 – 11:25 Discussion:
    Li, Wenlin (李文林): Some Aspects of the Mathematical Exchanges between China and Japan in Modern Times p.19
- 11:30 – 12:50 Lunch (80 min)
- Session 4 Chairs: Ji, Zhigang (紀志剛); Tamura, Makoto (田村 誠)
  - 12:50 – 13:30 Lecture, 13:30 – 13:35 Discussion:
    Mumford, David: Assessing the accuracy of ancient eclipse predictions p.22
  - 13:40 – 14:20 Lecture, 14:20 – 14:25 Discussion:
    Osada, Naoki (長田直樹): Determinants and permutation groups by Seki Takakazu p.23
  - 14:30 – 15:10 Lecture, 15:10 – 15:15 Discussion:
    Ogawa, Tsukane (小川束): A Survey of Takebe Katahiro's Life and his Mathematical Ideas — A Brilliant Mathematician the Age Bred — p.22
- 15:20 – 15:30 Tea (10 min)
- Session 5 Chair: Ying, Jia-Ming (英家銘)
  - 15:30 – 15:55 Lecture, 15:55 – 16:00 Discussion
    Tamura, Makoto (田村 誠): On the problem "Litian" of Bamboo Slips of the Qin Dynasty Collected by Peking University – The way to memorize conversion ratio in the Qin and the Han mathematical books p.43
  - 16:00 – 16:25 Lecture, 16:25 – 16:30 Discussion
    Heeffer, Albrecht: Witness accounts on the introduction of Dutch arithmetic in pre-Meiji Japan. p.36
  - 16:30 – 16:55 Lecture, 16:55 – 17:00 Discussion
    Hosking, Rosalie Joan: Solving Sangaku with Tenzan Jutsu p.38
- 18:00 – 20:00 Conference Reception
  Trattoria La Croce, 4-7-10-2F, Kobinata, Bunkyo-ku, Tokyo
  Tel 03-3944-7878

2.3 August 27, Wednesday

- Session 6 Chairs: Chemla, Karine Carole; Guo, Shirong (郭世栄)
  - 9:00 – 9:40 Lecture, 9:40 – 9:45 Discussion
    Kobayashi, Tatsuhiko (小林龍彦):
    Takebe Katahiro and Nakane Genkei p.18
  - 9:50 – 10:30 Lecture, 10:30 – 10:35 Discussion
    Kim, Young Wook (金英郁):
    Mathematics of the Joseon Dynasty p.16
  - 10:40 – 11:20 Lecture, 11:20 – 11:25 Discussion
    Feng, Lisheng (馮立昇): The Mathematical Table in the Tsinghua Bamboo Strips p.11
- 11:30 – 12:50 Picture Taking & Lunch (80 min)
- 13:00 Departure to City Tour (Sightseeing Bus)
- Afternoon: Edo-Tokyo Museum, 江戸東京博物館
  Address: 1-4-1, Yokoami, Sumida-ku, Tokyo, Postal Code: 130-0015, Tel: +81-(0)3-3626-9974
- 19:00 ∼ 21:15 Tokyo Bay Cruise, 東京湾納涼船

2.4 August 28, Thursday

- Session 7 Chairs: Li, Wenlin (李文林); Osada, Naoki (長田直樹)
  - 9:00 – 9:40 Lecture, 9:40 – 9:45 Discussion
    Knobloch, Eberhard Heinrich: On the relation between point, indivisible, and infinitely small in Western mathematics p.17
  - 9:50 – 10:30 Lecture, 10:30 – 10:35 Discussion
    Sasaki, Chikara (佐々木 力): Takebe Katahiro's Inductive Methods of Numerical Calculations in Comparison with Jacob Bernoulli's *Ars Conjectandi* of 1713 p.25
  - 10:40 – 11:20 Lecture, 11:20 – 11:25 Discussion
    Majima, Hideyuki (真島秀行): When did Takebe Katahiro verify the calculation of Pi by Seki Takakazu? p.19
- 11:30 – 12:50 Lunch (80 min)
- Session 8 Chairs: Knobloch, Eberhard Heinrich; Kobayashi, Tatsuhiko (小林龍彦)
  - 12:50 – 13:30 Lecture, 13:30 – 13:35 Discussion
    Hong, Sung Sa (洪性士): Solving Equations in the early 18th century East Asia p.13
  - 13:40 – 14:20 Lecture, 14:20 – 14:25 Discussion
    Ji, Zhigang (紀志剛): Integrating Chinese and Western Mathematics in Tongwen Suanzhi p.15
  - 14:30 – 15:10 Lecture, 15:10 – 15:15 Discussion
    Ying, Jia-Ming (英家銘): Nam Pyŏng-Gil (1820-1869): A Confucian mathematician and a populariser of mathematics in late Chosŏn period. p.28
- 15:20 – 15:30 Tea (10 min)
- Session 9 Chair: Kim, Dohan (金道漢)
  - 15:30 – 15:55 Lecture, 15:55 – 16:00 Discussion
    Hinz, Andreas M.: Kyū-ren kan, the Arima sequence p.38
  - 16:00 – 16:25 Lecture, 16:25 – 16:30 Discussion
    Narumi, Fuh (鳴海風): The background of my novel about Takebe Katahiro p.41
  - 16:30 – 16:55 Lecture, 16:55 – 17:00 Discussion
    Ozone, Jun (小曾根 淳): Trigonometric function tables introduced to Japan and China in the 17th century p.42
- 18:00 – 20:00 International Organizing Committee

2.5 August 29, Friday

- Session 10 Chairs: Mumford, David; Sasaki, Chikara (佐々木 力)
  - 9:00 – 9:40 Lecture, 9:40 – 9:45 Discussion
    Chemla, Karine Carole: Transformations of division in early imperial China and their historical significance p.11
  - 9:50 – 10:30 Lecture, 10:30 – 10:35 Discussion
    Guo, Shirong (郭世栄): The Constructing methods of Magic Squares in the Chinese Book *San-san Deng-shu Tu* p.12
  - 10:40 – 11:20 Lecture, 11:20 – 11:25 Discussion
    Kim, Dohan (金道漢):
    Recent Development in Korean Mathematics p.16
- 11:30 – 12:50 Lunch (80 min)
- Session 11 Chairs: Kim, Young Wook (金英郁); Morimoto, Mitsuo (森本光生)
  - 12:50 – 13:30 Lecture, 13:30 – 13:35 Discussion
    Sarina (薩日娜): Comparative Study of Kyōhō Map by Takebe Katahiro and Kangxi's *Huang Yu Quan Lan Tu* p.24
  - 13:40 – 14:20 Lecture, 14:20 – 14:25 Discussion
    Horiuchi, Annick: Takebe Katahiro and the dynamics of science at the turn of 18th century p.14
- 14:30 – 15:00 Tea (30 min)
- Session 12 Chair: Sarina (薩日娜)
  - 15:00 – 15:25 Lecture, 15:25 – 15:30 Discussion
    Kota, Osamu (公田 蔵):
    Western mathematics on Japanese soil — A history of teaching and learning of mathematics in modern Japan — p.39
  - 15:30 – 15:55 Lecture, 15:55 – 16:00 Discussion
    Kümmerle, Harald: The institutionalization of higher mathematics in Meiji- and Taisho-era Japan p.40

2.6 August 30, Saturday

- Session 13 Chair: Xu, Zelin (徐澤林); Ogawa, Tsukane (小川束)
  - 9:00 – 9:40 Lecture, 9:40 – 9:45 Discussion
    Morimoto, Mitsuo (森本光生):
    On Volume 19 of the *Taisei Sankei* p.21
  - 9:50 – 10:30 Lecture, 10:30 – 10:35 Discussion
    Komatsu, Hikosaburo (小松彦三郎): Relation of Seki Takakazu and Takebe Katahiro p.18
- 10:40 – 11:00 Closing Ceremonies

Chapter 3

Plenary Lectures

3.1 Chemla, Karine Carole

Professor, ERC Project SAW & SPHERE, CNRS & UPD, 3 square Bolivar, 75019, France

chemla@univ-paris-diderot.fr

Title: Transformations of division in early imperial China and their historical significance

Abstract: The approach to algebraic equations that developed in East Asia depended essentially on an algorithm for the division called 除 *chu*. Further, the algorithms shaped to solve the equations, like that for the division *chu*, all depended on the place-value decimal number system. The manuscripts recently excavated from tombs sealed in early China or those bought on the antiquities market seem to indicate that no such algorithm existed at the time. They also do not show signs of the existence of a place-value number system. The lecture will discuss the hints we have about the emergence of the division *chu* as well as the consequences that its shaping brought about. It will also analyze the various types of benefits that history of mathematics in East Asia can derive from considering the history of the execution of division in ancient China.

Language: English

3.2 Feng, Lisheng (馮立昇)

Professor, Institute for History of Science and Technology & Ancient Texts, Tsinghua University, Beijing, China 100084

fenglsh@lib.tsinghua.edu.cn

Title: The Mathematical Table in the Tsinghua Bamboo Strips

Abstract: In July of 2008, through the donation of an alumnus, Tsinghua University rescued and received into its collection a mass of Warring States period (475 - 221 BCE) bamboo strips that had been smuggled out of China. This precious collection has become commonly known as the Tsinghua Bamboo Strips. These bamboo strips are very important documents. A substantial number of these bamboo strips concern Chinese classics and history, but a tiny portion, 21 strips in all, are about mathematics. When put together, they form a perfect and complete mathematical table. This presentation discusses the structure of the Mathematical Table, and shows how it may be used to multiply a two-digit number by another two-digit number, and even two-digit mixed numbers with one-half by another mixed two-digit number and one-half. The table may also be used to carry out divisions and even the extraction of square roots of certain numbers. The Mathematical Table has a decimal place value system, and its core is a multiplication table composed of the numbers from 9 to 1 and the products from 81 to 1, and the other parts are the expansion and extension of the core.

The Mathematical Table is sophisticated – it not only provides solid evidence that the Chinese had a decimal place value system at least as early as the late middle of the Warring States Period, but it also indicates that mathematics had been well developed in China by the third century BCE.

See Figure “A translation of the Mathematical Table in the Tsinghua Bamboo Strips” on Page 53.

Language: English

3.3 Guo, Shirong (郭世荣)

Professor, Institute for the History of Science and technology, Inner Mongolia Normal University, 81, Zhaowuda Road, Huhhot, Inner Mongolia, CHINA 010020

guoshirong1959@163.com

Title: The Constructing methods of Magic Squares in the Chinese Book *San-san Deng-shu Tu*

Abstract: *San-san deng-shu tu* (《三三等数図》) is a small book on magic squares written in Chinese. The literal meaning of its title is *Equal number Diagrams in Three-three Square* which is merely the name of the first magic square in the book. The contents of the book are actually constructions of eight magic squares. A hand-writing copy of the book is collected in Palace Museum in Beijing. Li Yan (1892-1963), a founding historian of mathematics in China, copied one from it which is now collected at library of Institute for the History of Natural Science, Chinese Academy of Sciences. It is photocopied and printed in the book 402 of *gu-gong zhen-ben cong-shu* (《故宫珍本叢書》, Series of Treasure Books) in 2000.

Li Yan mentioned that the book was written by some Jesuit missionary in China in 17th century or the early 18th century and its contents were from Europe, but he did not give evidence. Magic square was concerned by some people in Arabic, Indian, and European world before the *San-san deng-shu tu* was written. Studies on them also have long history in China. The 3rd order one appeared in China two thousand years ago, and some contents of higher orders magic squares or magic circles appeared in some Chinese works during the 13-17th century. Eight magic squares from order 3 to 10 are constructed in the *San-san deng-shu tu*. Their construction methods are based on an idea of frames or borders and form two recursion procedures for constructing odd or even order squares, respectively. No record about its author and writing date is found.

Application of the idea of frames or borders to construct magic squares can be found in the Medieval Orient in the 10th century. It was used by az-Zinjānī in the 13th century and Antone Arnauld in 17th century. They constructed their magic squares from outer border to inner one. In the *San-san deng-shu tu*, it is however in the reverse direction, that is, from inner border to outer. There is no evidence showing that tradition Chinese mathematicians related the idea of borders in their studies in magic squares.

In this paper, we will describe the recursion methods of the *San-san deng-shu tu* and try to compare them with other relevant methods.

Keywords: *San-san deng-shu tu*, magic square, recursion method

language: English

3.4 Hong, Sung Sa (洪性士)

Professor Emeritus, PhD, Sogang University, 35 BaekBeomRo, Mapo-Gu, Seoul, 121-742, Korea

sshong@sogang.ac.kr

Title: Solving Equations in the early 18th century East Asia

Abstract: Mathematics in the 18th century East Asia has experienced an unprecedented development. Here East Asia means the three countries, China, Japan and Korea. The history of mathematics in East Asia is basically connected through the mathematical development in China but in the early 18th century, if not in the late 17th century, the history of mathematics in East Asia became separated and showed their own contributions to mathematics in each country. As is well known, the subjects of mathematics and their presentations in East Asia were standardized in *Jiuzhang Suanshu* but the theory of equations, one of the most important subjects in mathematics has a long history from *Jiuzhang Suanshu*. Further, results on how to solve equations in the early stage were mostly lost and those in the later stage were forgotten or lightly dealt in most of the extant literatures.

Thus we take the solving equations in the theory of equations in the early 18th century East Asia and then illustrate the history of the different development of mathematics in the three countries.

First we discuss the history of mathematics in the 17th century East Asia.

In China, its most advanced contributions to the theory of equations established in Song–Yuan era were almost forgotten in the 17th century. Moreover,

mathematics and astronomy from the West were brought into China. We note that the theory of equations influenced by the then Western mathematics is much more inferior to that of Song–Yuan and that it was collected in *Shuli Jingyun* (1723).

In Japan, *Suanxue Qimeng* (1299) and *YangHui Suanfa* (1274–1275) were introduced to Japan through Korea and they were extensively studied by Japanese scholars, notably Seki Takakazu (?–1708) and Takebe Katahiro (1664–1739).

In Joseon, *Suanxue Qimeng* was republished in 1660 by Kim SiJin, which inspired the revival for the devastated Joseon traditional mathematics in the 16th century. Hong JeongHa (洪正夏, 1684–?) wrote the most important mathematics book, *GuIlJib* (九一集, 1724) whose main body was already finished before 1713. In this book, Hong completed the theory of equations.

We then discuss the differences between their approaches to solving equations in the early 18th century.

Language: English

3.5 Horiuchi, Annick

Professor, Paris Diderot University 5 rue Thomas Mann, Paris 75013, France

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Title: Takebe Katahiro and the dynamics of science at the turn of 18th century

Abstract: Takebe Katahiro is a very rare example of a scholar of the Tokugawa period whose career can be approached through many angles and through a wide variety of sources. The reason is that as a member of a high rank warrior clan and as a retainer of the Tokugawa house, his activity took place in the vicinity of "places of power". He has been in the service of two (three if we include the young Ietsugu) shogun, Tokugawa Ienobu and Tokugawa Yoshimune. In my presentation, Takebe's career will be used as an emblematic example to approach a more general theme, that of the dynamics of science in Japan at the turn of 18th century. A special attention will be paid to the growing attention science, and more particularly mathematical science, attracted at this moment, the circumstances and the reasons of this attention, the extent of the field a man of science could cover, the kind of interrelations mathematics had with other technical knowledge such as cartography and calendar science, and the process through which Chinese and Western sources have been incorporated to Japanese science.

Many sources have been scrutinized to trace Takebe's career. These are mainly: 1) the biography contained in the compilation of biographies of the Takebe family; 2) the Collection of *bakufu* retainers' genealogies, the *Kansei chōshū shokafu*; 3) The Chronicle of the Tokugawa (*Tokugawa jikki*) which provides a wealth of information about Yoshimune's actions in favor of science. A less known source is the Diary kept by the head of the Dutch factory at Dejima. Through this Diary, we know that Takebe met the Dutch delegation during their Court journey, and that he submitted a long list of questions. But

this source can also help us to reconstitute the general interest the political elite showed for scientific questions pertaining to science. A complementary way to approach it is to examine the activities of well-known scholars who gravitated round the power, such us Arai Hakuseki, Nishikawa Joken, Nakane Genkei, Katsuragawa Hochiku etc. In my presentation, I will focus on the Nagasaki interpreters who were the only men able to inform about recent development of Chinese or Western science.

Another angle through which the dynamics of science can be analyzed is the angle of the renewal of sources. Yoshimune's times is known for the decision he took in 1720 to authorize the importation of Chinese works produced under Jesuit supervision. Takebe might have played a part in the process leading to the decision. This episode is essential and shows the importance of Chinese sources in the dynamics of science of this period. This decision marks the beginning of the introduction of Jesuit science in Japan, which will have an important impact on the development of calendar science in the following years. Takebe's figure is particularly interesting because of his position at the crossroads of these different events.

Language: English

3.6 Ji, Zhigang (紀志剛)

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Title: Integrating Chinese and Western Mathematics in Tongwen Suanzhi

Abstract: It might have been widely accepted that the *Tongwen Suanzhi*（《同文算指》，1614）was translated by Metteo Ricci （利瑪竇）and Li Zhizao（李之藻）from Clavius's *Epetome Arithmaticae Practicae*（克拉維烏斯:《實用算術概要》，1583). But once you opened the *Tongbian* （通編）of *Tongwen Suanzhi*, you may read some words in the whole contents（總目）such as "supplement 8 problems"（補八條）, "supplement 5 problems"（補五條）, and "supplement in total"（俱補）which were almost added the end of each chapter's title. In fact, it was just as that Li Zhizao said in his preface "some problems were brought form the *Nine Chapters* to supplement"（間取九章補綴）. After a considerable reading the whole work, we can give a list of Chinese mathematics works which might be used by Li Zhizao, in which includes Cheng Dawei's *Suanfa Tongzong*（程大位:《算法統宗》）, Zhou Shuxue's *Shendao Dabian Lizong Suanhui*（周述學:《神道大編曆宗算會》）, Gu Yingxing's *Ceyuan Haijing Fenlei Shishu* and *Gougu Suanshu*（顧應祥：《測圓海鏡分類釋術》、《句股算術》）, Xu Guangqi's *Celiang Fayi* and *Gou-Gu Yi*（徐光啓:《測量法義》、《句股義》）. Even a surprising thing is that there are some problems which were brought from the Michael Stifel's *Arithmetica Integer* (1544). This shows both that *Tongwen Suanzhi* was not merely a translation work and the scope of the work was larger than merely the Western conception of arithmetic.

Language: English

3.7 Kim, Dohan (金道漢)

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Title: Recent Development in Korean Mathematics

Abstract: Firstly, we present a leisurely talk on the development of Korean Mathematics since 1945, especially how we succeeded in hosting ICM 2014 in Seoul.

Also, a comparison between the research trends of South and North Korean mathematics is provided, based on our analysis of the statistics of almost all the articles published by both Korean mathematicians from 2001 to 2010.

Language: English

3.8 Kim, Young Wook (金英郁)

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Title: Mathematics of the Joseon Dynasty

Abstract: We are pretty certain that Koreans have used mathematics since long time ago. Historical records tell us that some Chinese mathematics was in Korea as early as in the 7th century. But almost no records are passed down to today.

As for the history of Joseon (1392–1910), we are lucky to have the Annals of the Joseon Dynasty—detailed annual records of its history, according to which mathematicians of early Joseon were already fluent in the Chinese theory of equations, namely *Tianyuanshu* and *Kaifangshu*, for their use in the computations of calendar.

The only extant books of Korean mathematics are those written in the 17th century and thereafter. From these works we can tell how Korean mathematics had been developed from scratch in the 17th–19th centuries. The mathematics of this period divides into two parts, the theory of equations and the theory of finite series. We will explain some concrete examples of these developments.

Language: English

3.9 Knobloch, Eberhard Heinrich

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Title: On the relation between point, indivisible, and infinitely small in Western mathematics

Abstract: There is a long, fascinating story of the way European mathematicians dealt with points, indivisibles, and infinitely small quantities. The story begins in Greek antiquity. Hence the lecture consists of five parts. First of all it will discuss ancient patterns, that is, Aristotle's definition of quantities in his "Metaphysics", his pleading for the existence of indivisibles against Zeno. Aristotle always speaks in the mode of possibility in this context: something can be done. Archimedes used indivisibles in his famous letter to Eratosthenes, the so-called "Approach related to mechanical theorems", erroneously mostly called "Method" though Archimedes carefully distinguished between éphodos (approach) and trépos (method). Thus he committed a threefold sacrilege replacing Aristotle's potential infinity by an actual infinity of lines or circles.

The second section will explain Viète's and Kepler's identification of circles with polygons having infinitely many sides or angles. Kepler referred to Archimedes when he used indivisibles or notions like smallest arcs, smallest segments, when he identified points with parts of the circumference of a circle or when he calculated the volume of an apple. This concerned the certainty of mathematics and provoked Guldin's criticism. Thirdly Galileo's use of "non quanti" is discussed and Cusanus's influence on the Italian mathematician. Galileo, too, identified a circle with a polygon having infinitely many sides, yet without any justification. He carefully distinguished between "quanta" and "non-quanta" and investigated the transition from the ones to the others.

According to Leibniz's own statement Galileo was the most important author for him. Hence fourthly the lecture will describe Leibniz's reading of Galileo and his own handling of points and infinitely small quantities. Finally his process of insight will be explained. He used various definitions of such quantities among them being "smaller than any assignable quantity". Yet, this definition inevitably implied the result that these quantities must be equal to zero. Leibniz eventually recognized that indivisibles have to be defined as infinitely small quantities or quantities that are smaller than any given quantity. This definition enabled him to generalize Viète's, Kepler's, and Galileo's approach: all curves are conceived as polygons with infinitely many sides. Differently from his predecessors he justified this principle of linearization or equivalence thus putting his differential calculus on a firm, rigorous basis. To that end he rigorously proved in 1675/76 that the difference between two areas under certain straight stepped polygons and under certain curves can be made smaller than any arbitrary given quantity that is infinitely small.

Language: English

3.10 Kobayashi, Tatsuhiko (小林龍彦)

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Title: Takebe Katahiro and Nakane Genkei

Abstract: Takebe Katahiro (建部賢弘, 1664-1739) was born in Edo (present Tokyo). He became a student of Seki Takakazu (関孝和, ?-1708) when he was 13 years old. He published a mathematics book entitled *Kenki Sanpō* (研幾算法) in 1683. By this publication Master Seki and his disciples aimed to refute the unjust blame by Tanaka Yoshizane's (田中由眞) disciples. In 1685 Katahiro published the *Hatsubi Sanpo Endan Genkai* (発微算法演段諺解) and endeavored to diffuse a mathematical idea and a calculation method inaugurated by his master.

In 1692 when he was 29 years old, Takebe served Tokugawa Tsunatoyo (徳川綱豊), feudal load of Kōfu. Thereafter, he served the three *shōgun*, Tokugawa Ienobu(徳川家宣), Tokugawa Ietsugu(徳川家継) and Tokugawa Yoshimune (徳川吉宗, 1662-1733) as a faithful subject. Particularly, the 8th *shogun* Yoshimune recognized Takebe's high ability as calendrical calculator or surveyor and ordered him to complete the map of whole Japan. In addition, Yoshumune appointed him as his advisor of calendar making.

Nakane Genkei (中根元圭, 1662-1733) was born in Yagihama, Shiga prefecture. At first, he studied mathematics at Tanaka Yoshizane's school, and learned calendar from Shibukawa Harumi (渋川春海) in Kyoto. He concentrated in studies and improved his ability to such an extent that to publish, in 1685, the *Shinsen Koreki Benran* (新撰古暦便覧) , a book on calendrical calculation. Later in 1691 he published the *Shichijōbeki Enshiki* (七乗冪演式), a book on mathematics (a special case of elimination theory.)

Takebe and Nakane became acquainted with each other at the beginning of Kyōhō period (1716-1735), and both helped the 8th *shogun* Yoshimune with his calendar reform. They engaged in the started Japanese translation of *Li suan quan shu* (暦算全書) into Japanese. This encyclopedic book was transmitted from China in the spring of 1726. The translation was done mainly by Nakane, because he was versed in calendar and Chinese classic. The translation was mostly finished toward the end of 1728.

At this symposium we will discuss their contribution to calendar reform under the Yoshimune's administration.

Language: English

3.11 Komatsu, Hikosaburo (小松彦三郎)

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Title: Relation of Seki Takakazu and Takebe Katahiro

Abstract: (TBA)

Language: English

3.12 Li, Wenlin (李文林)

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Title: Some Aspects of the Mathematical Exchanges between China and Japan in Modern Times

Abstract: By the time when Li Shan-lan and A Wylie translated the textbook on analytical geometry and calculus, Japanese mathematics was still influenced by Chinese tradition. After 1867 reformation, however, modern mathematics was rising up rapidly in Japan. Till the end of the 19th.century and beginning of the 20th.century, it was China to send students to Japan to study modern mathematics. This paper observes the Sino-Japanese mathematical exchanges mainly in the first three decades of the 20th century. The influences on the development of the modern mathematics in China are analyzed, and there is a brief description about the background of the mathematical exchanges between China and Japan in earlier times.

Language: English

3.13 Majima, Hideyuki (真島秀行)

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Title: When did Takebe Katahiro verify the calculation of Pi by Seki Takakazu?

Abstract: We gave some remarks on the calculation by Seki Takakazu a few years. Seki found the so-called Aitken's delta-sequenced process in his theory, but there were some errors in his calculation and he only claimed that his approximate number of pi was a bit less than 3.14159265359. Takebe Katahiro followed Seki's method and discovered another method of calculation of π. When did Takebe verify Seki's calculation?

Language: English

3.14 Martzloff, Jean-Claude

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(Jean-Claude Martzloff will not be able to attend the conference in person, but he will contribute it by presenting an article.)

Title: Chinese Mathematics Beyond the Nine Chapters: A Not Well-Defined Domain and a Proposal of Interpretation of its Nature, Content and Purpose.

Abstract: What contemporary historians of Chinese mathematics and mathematicians alike generally call 'Chinese mathematics' is largely subsumed under the convenient label of the Nine Chapters, viz. collections of arithmetical problems, corresponding to logistics in Greek parlance. Yet, more generally, these mathematics are also associated with a bunch of results – such as the Chinese remainder 'theorem', the 'square arrays methods' (linear systems) and its generalizations to the elimination of the unknown between polynomial systems – appearing to us all the more extraordinary that they are at the same time very ancient and isolated, as well in time as in space, within the Chinese world, where they were paradoxically often deemed a minor domain of knowledge.

In opposition with this now punctually well-chartered nebula of problems and results, another significantly less well-known domain of Chinese mathematics is characterized on the contrary by the sustained importance granted to it by elites of the Chinese, Korean and Japanese worlds and by its overtly continuous mode of development.

Roughly speaking, the domain in question – called *lifa* 曆法 or *li* 曆 in Chinese (we leave intentionally but temporarily these terms untranslated) – falls under the jurisdiction of predictive mathematics intended for the prediction of all sort of astronomical, astrological and hemerological phenomena; more precisely, it consists in a significantly complex and monumental conglomeration of epistemological developments and exact or approximate mathematical procedures.

Despite sustained efforts made by historians of astronomy and mathematics, the knowledge of this domain – so important for the understanding of the development of quantitative sciences in the sinicized worlds during the antique and medieval periods – is still in its inchoative state: whereas a very large numbers of historians associate it with the calendar, as if it were merely concerned with more or less trivial questions, not really worthy of any scientific interest, others call it 'mathematical astronomy? and thus provide on the contrary heavily modernized interpretations of its whole corpus, giving thus the opposite but strange impression of having to do with works of modern mathematicians or astronomers. Still others name it 'astronomical systems? and highlight not without reason their sociological, political and economical aspects while surprisingly passing over in silence its mathematical dimension.

Whereas the variety of these various approaches is incontestably beneficial by any standards, it certainly remains extremely difficult if not impossible to reconcile their various interpretations the ones with the others. The present article will thus attempt to unravel this difficulty complexity from an internal and

historical study of the Chinese perception of various non-Chinese astronomical sources during different periods of their history. In particular, by using philological tools, we will prove that the Chinese or *li* 曆 corresponds historically the notion of 'astronomical canon', a notion well-attested in the Islamic, Indian Greek and Medieval European worlds where it is referred to as *zīj*, *karaṇa*, *κανών*, canon, *zich* and *ezich*, mostly. Thereafter, we will also try to highlight some of the key features of the mathematical aspect of these astronomical canons concerning, notably, the question of their representation of numbers (including the question of the origin of the zero), their main epistemological tenets and their overt or covert theoretical presuppositions, which are certainly an essential, but often overlooked component of the history of mathematics, well worth being investigated to the same extant as what concerns the Nine chapters tradition.

Language: English

3.15 Morimoto, Mitsuo (森本光生)

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Title: On Volume 19 of the *Taisei Sankei*

Abstract: The *Taisei Sankei* (大成算経) is an encyclopedic monograph of 20 volumes (about 900 sheets) written by three mathematicians Seki Takakazu (? - 1708), Takebe Kata'akira (1661 - 1721) and Takebe Katahiro (1664 - 1739). The compilation took 28 years from 1683 to around 1710. The book is divided into three part. The last part (Volumes 16 - 20) deals with the theory of equations inaugurated by Seki Takakazu.

With the introduction of *tiannyuanshu* (天元術) Japanese mathematicians could treat the algebraic equation of one variable. The complete understanding of the *Suanxue Qiment* (算学啓蒙, 1299) of Zhu Shijie (朱世傑) culminated in Takebe Katahiro's commentary on this book, the *Sangaku Keimō Genkai Taisei* (算学啓蒙諺解大成, 1690).

In 1674, Seki published the *Hatsubi Sanpō* (発微算法), in which he claimed to solve problems only showing the "final equation," the solution of which is the answer of the problem. But it was almost impossible to guess how Seki found the "final equation." In 1685 Takebe Katahiro wrote a detailed commentary on his master's book, the *Hatsubi Sanpō Endan Genkai* (発微算法演段諺解) and showed the *endan* (演段) to find the "final equation." The *endan* means, etymologically, "to display the steps" (to obtain the "final equation") and written by the method of side writing (傍書法), with which they could manipulate equations of one variable with symbolical coefficients. With this new method Japanese mathematicians could handle with algebraic equations with several variables.

The problems which can be reduced easily to the equation of one variable (with numerical coefficients) were called "implicit problems" (隠題) and more general problems which require several variables to formulate the equation are called "concealed problems" (伏題).

Seki solved a system of equations of several variables eliminating variables one by one to attain an equation of one variable with numerical coefficients, which is, in principle, can be solved by extracting root method (開方術).

Volume 19 of the *Taisei Sankei* is a collection of 9 implicit problems and 6 concealed problems. Each problem is provided with problem statement (問), numerical answer (答), "final equation", i.e., procedure (術) and *endan*. The style of Volume 19 follows that of *Hatsubi Sanpō Endan Genkai*.

Language: English

3.16 Mumford, David

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Title: Assessing the accuracy of ancient eclipse predictions

Abstract: Multiple studies have addressed the question of whether ancient eclipse predictions correctly predicted known past eclipses. Our approach instead is to generate thousands of synthetic eclipses, starting from random choices for the longitude of the conjunction, node and perigee, then comparing the magnitude of resulting eclipses with ancient and modern predictions. Writing code for ancient algorithms requires a detailed analysis of the text, not found in most commentaries. Working with Qu Anjing, Jayant Shah and Mark Schiefsky, we are doing this with the Almagest, multiple Indian Siddhantas and Chinese calendars. We will report on the results for the Shou Shih Li. These raise the question of how the writers of this calendar understood its remarkably accurate algorithms for lunar parallax and whether secret geometric models were known to Chinese astronomers of the Yuan dynasty.

Language: English

3.17 Ogawa, Tsukane (小川束)

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Title: A Survey of Takebe Katahiro's Life and his Mathematical Ideas — A Brilliant Mathematician the Age Bred —

Abstract: We start with a survey of Takebe Katahiro's life and his works. His life can be devided into three phases chronologically:

- 1676-1703 (13-40 years old). Period for studying mathematics under the direction of Seki Takakazu, the founder of Japanese mathematics in Edo era.
- 1704-1716 (41-53 years old). Period for serving as a shogunate retainer.
- 1717-1739 (54-70 years old). Period for serving the eighth shōgun, Tokugawa Yoshimune, and studying mathematics and calendar science.

His works were written in the first or the last periods and each book was expressive of the times. The characteristic parts of his works will be extracted briefly in connection with the period of their publication. It will be clarified that he wrote a book with explicit objectives influenced by the need of the times.

His book *Tetsujutsu Sankei* (*Mathematical Treatise on the Technique of Linkage*) was probably one of the most popular book in the history of the pre-modern Japanese mathematics. Though there have been many books and articles on it, it seems to us that the book should still be studied over again.

In my talk, we emphasize his mathematical philosophy appeared in it. In particular, we point out the relationship between his philosophy and Confucianism, the current ideas of Takebe's times, by giving a concrete example.

Language: English

3.18 Osada, Naoki (長田直樹)

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Title: Determinants and permutation groups by Seki Takakazu

Abstract: Seki Takakazu gave two eliminating procedures for a system of n equations of degree $n-1$ in his *Kai Fukudai no Hō* (Methods of Solving Concealed Problems) re-revised in 1683. Both procedures derive the formula that the determinant of the coefficient matrix $(x_{i,j})$ of a system of equations is equal to zero. Seki called the first procedure the *chikushiki kōjō* (successively multiplying each equation by coefficients of other equations). Because the first procedure was complicated, he gave the second procedure, the *kōshiki shajō* (equation shuffling and oblique multiplications), an extension of the rule of Sarrus.

We prove that this second procedure is based on the following fact in group theory. Let S_n be the symmetric group of degree n. Let D_n be the subgroup of S_n generated by a cyclic permutation $\sigma = (12\ldots n)$ and a permutation $\tau = \begin{pmatrix} 1 & 2 & 3 & \cdots & n \\ 1 & n & n-1 & \cdots & 2 \end{pmatrix}$. Let

$$S_n = \rho_1 D_n + \cdots + \rho_r D_n, \quad r = (n-1)!/2$$

be a coset decomposition of S_n with respect to D_n. Then the determinant of $(x_{i,j})$ can be written as

$$\det(x_{i,j}) = \sum_{k=1}^{r}\sum_{t=0}^{1}\sum_{s=0}^{n-1} \mathbf{sgn}(\rho_k)\mathbf{sgn}(\tau^t\sigma^s)\prod_{j=1}^{n} x_{\rho_k\tau^t\sigma^s(j),j}.$$

Here the set of representatives $\{\rho_1,\ldots,\rho_r\}$ is a set of permutations corresponding to "equation shuffling"(*kōshiki*), and products

$$\mathbf{sgn}(\rho_k)\mathbf{sgn}(\tau^t\sigma^s)\prod_{j=1}^{n} x_{\rho_k\tau^t\sigma^s(j),j}$$

are "oblique multiplications"(*shajō*).

Seki's set of representatives is incorrect when $n \geq 5$, but Matsunaga Yoshisuke, a second-generation pupil of Seki, gave a corrected set of representatives for any n in his *Kaifukudai Kōshiki shajō no Genkai* (Commentary on *kōshiki shajō* in Solving Concealed Problems) in 1715. Although Seki's procedure of "equation shuffling and oblique multiplications" contains errors, Seki's idea of the procedure is exactly correct.

Seki was the world's first mathematician with group-theoretic thinking, predating Lagrange by more than 88 years. By comparing with works by J.L. Lagrange and A.L. Cauchy, we evaluate Seki's contributions to the permutation group theory.

Language: English

3.19 Sarina (薩日娜)

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Title: Comparative Study of Kyōhō Map by Takebe Katahiro and Kangxi's *Huang Yu Quan Lan Tu*

Abstract: In this paper the author makes a comparative study of *Kyōhō Map*（享保図）by Takebe Katahiro（建部賢弘）between the year 1717 and 1728, who was a famous Japanese mathematician in the Edo period, and Kangxi's *Huang Yu Quan Lan Tu*（皇與全覧図, Complete Atlas of the Imperial Domain）between 1708 and 1718 in the Qing Dynasty. This paper starts with the comparison between the domestic and international backgrounds under which these two maps were made, including the specific processes of the making of the maps by Tokugawa Yoshimune（徳川吉宗）and Emperor Kangxi（康熙皇帝）. Then the main staff in production of the two maps are introduced and the mathematical methods applied are described as well. Finally the author makes a comparison between the natural and human factors concerned with the Kyōhō Map and Kangxi's *Huang Yu Quan Lan Tu.* The author also analyses the effects of the two maps on their subsequent map-making career.

Keywords: Takebe Katahiro；Tokugawa Yoshimune；Kyōhō's Map；Emperor Kangxi ; *Huang Yu Quan Lan Tu*

Language: English

3.20 Sasaki, Chikara (佐々木 力)

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Title: Takebe Katahiro's Inductive Methods of Numerical Calculations in Comparison with Jacob Bernoulli's *Ars Conjectandi* of 1713

Abstract: For many years I have been puzzled by a problem as to how we should understand the mathematical method to attain ingenious results in Takebe Katahiro's masterpiece *Tetshujutsu Sankei* (建部賢弘『綴術算経』*Mathematical Canon on the Art of Linking*) of 1722. Some historians of mathematics thought that Takebe's idea should be understood as a more primitive form than that of John Wallis's significant monograph *Arithmetica infinitorum*, a remarkable milestone of the transformation from the Archimedean geometry of indivisibles to the Vietan and Cartesian algebra of infinitesimals, published in 1656. This way of understanding is not totally mistaken. But, that is, I believe, insufficient.

Now I think that Takebe's method cannot be appropriately understood in the same line of thought leading to the successful formulation of mathematical induction in the history of European and Islamic mathematics. As has been pointed out, Takebe knew some traces of Chinese predecessors' art of mathematical thinking called "zhuì shù"（綴術）which is regarded to have been authored by Zu Chong zhi (祖冲之), but unfortunately now to have been totally scattered and lost.

Through careful and detailed examinations of Takebe's original text, we cannot surmise that Takebe's art of algebraic conjecturing does entirely accord with the line of thought which has been called "mathematical induction", primitive or matured, since the time of De Morgan. It should be admitted, nevertheless, that some of his way of reasoning can be thought as a very primitive form of mathematical induction in a similar level of Wallis's aforementioned treatise entitled *Arithmetica infinitorum.* In Takebe's art of conjecturing, still some elements exist which we cannot think to accord with the European and Islamic mathematical tradition leading to the notion of mathematical induction. I further think that this kind of diversity can be also seen in the art of diagnostics in traditional Chinese medicine. An incommensurable element certainly does exist between Takebe's art of conjecturing and the way of thought of mathematical induction as does between the art of diagnostics in traditional Chinese medicine and that in modern Western medicine.

In this occasion, I would like to attempt at comparing Kakebe's mathematical art of conjecturing with the mathematical thought of Jacob Bernoulli's *Ars Conjectandi* published posthumously in 1713. The *Ars Conjectandi* is regarded as a monograph on the theory of probability, but, has a certain factor arguing generally about the way of thought on mathematical induction. The

author of the treatise *Ars Conjectandi* Jacob Bernoulli (1654-1705) can be considered be an almost contemporary with Takebe Katahiro (1664-1739) and our mathematico-historical reflection may imply important dissimilarities and similarities in pre-modern Japanese and in early modern European mathematics in general.

Language: English

3.21 Ueno, Kenji (上野 健爾)

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Title: Seki Takakazu and Takebe Katahiro – two different types of mathematicians –

Abstract: Takebe Katahiro was the best student of Seki Takakazu. In 1683 when Katahiro was 19 years old he published *Kenki Sanpō* and in 1685 published *Hatsubi Sanpō Endan Genkai*, which played the definitive role to spread Seki's new mathematics. Though no evidence remained, it is very plausible that Katahiro helped Seki to develop his mathematical theory.

Although in mathematics Katahiro started his brilliant career in his youth he obtained his original results only in his late fifties. He explained by himself indirectly why it took so much time to find his original mathematics. In the last part of *Fukyū Takebe Sensei Tetsujutsu* he wrote:

> After I started to learn mathematics, looking for the easy way I suffered from mathematical rules. This is because I did not exhausted my own quality. Gradually after 60 days' struggle, I realized my born foolish quality and understood I should follow the spirits of mathematical rules([1], p.259).

He wrote "born foolish quality" but we should not understand it literally. His mathematics showed that he was interested in solving specific problems and finding deep results in mathematics like the relationship between an sagitta and the square of the corresponding arc length (11th chapter of *Fukyu Takebe Sensei Tetsujutsu*). Contrary to Takebe Katahiro Seki was interested in a general theory. For example Seki found not only a method to express algebraic equations with many unknowns but also founded elimination theory, which guarantees to solve almost all problems at his time. Since Katahiro was also a great mathematician but a different type of mathematician from Seki, it was quite difficult for him to be free form Seki's influence. The above quoted phrase tells this fact.

In my talk I will discuss differences of mathematical attitudes of Seki Takakazu and Takebe Katahiro in detail.

[1] "Selected Mathematical Works of Takebe Katahiro (1664 – 1739)", translated and Commented by O. Takenouchi and M. Morimoto, Wasan Institute.

Language: English

3.22 Xu, Zelin (徐澤林)

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Title: 建部賢弘と『授時暦』 (Takebe Katahiro and *Shoushi li* calendar)

Abstract: (TBA) The *Shoushi li* canlendar (1281) was made by Guo Shoujing (1231〜1316) and other scholars on the basis of a deep mathematical principle. This calendar gave a great influence to the development of mathematical sciences in the Japanese Edo period. It was not only a model for a Japanese calendar but also an object of research of Japanese scholars of the time. Takebe Katahiro's research on astronomy and calendar science was closely related with the calendar reform of the Tokugawa shogunate. It centered around the knowledge contained in the *Shoushi li* calendar and Mei Wenting's *Lisuan Quanshu* (Complete Works on Calendrical Astronomy and Mathematics).

In this talk, we shall discuss on Takebe's research on the *Shoushi li*.

『授時暦』(1281) は中国の元時代に、郭守敬 (1231〜1316) をはじめとする学者が編集した深い数理に基づく暦法である。その暦法は江戸時代数理科学の発展に巨大な影響を与えたが、江戸時代日本暦編成の科学基礎とモデルになっただけでなく、江戸時代知識界の興味深い学術研究対象にもなった。建部の天文暦学活動と徳川幕府の暦法改革運動と密接に関連していて、その天文暦学研究の内容は『授時暦』と『梅氏暦算全書』に含まれた知識を中心にしたのである。本論文では建部の『授時暦』研究に関する業績を論述しよう。

『授時暦経解』二巻、『授時暦術解』二巻、『授時暦数解』二巻には、執筆紀年不詳である上、署名もなかった。中島北文の『新製和暦』の附録の記事は、これらが建部の作品という間接的な証拠である。実は『授時暦議解』における日行盈縮に関する注解の後に、次のような記述がある。

> 縮初盈末の差を求むるも同意なり，是六氣の限日皆等しきを以て求る算法なり、或は限日不論者は、其術是に異る事あり、皆方程正負之術に同し、更不繁説、詳予所制『大成算経』也。

それによれば、少なくとも『授時暦議解』は建部賢弘の著作である。江戸時代『授時暦』に関するあらゆる注解書で、「六巻抄」のレベルは最高であると思われている。「六巻抄」は建部賢弘の天文暦学業績を反映しただけでなく、中国伝統数理科学を理解する重要な資料にもなったと思っている。

改暦運動が日本天文数学の発展を促進した。和算家の最も重要な成果は主に 1670 年ごろから 1800 年に至る間に取得したのである。この時期に『授時暦』を研究したピークが現れ、和算家、暦学家が『授時暦』を研究した著作が 50 種も達した。『授時暦』の先進な数学方法が和算家に大きな刺激をあげ、関孝和（？〜1708）、建部賢弘の重要な数学成果は『授時暦』を研究したうえで獲得したものである。

『授時暦議解』は建部賢弘が『元史・授時暦議』に対して行った突っ込んだ詳細な日本語注解である。「冬至刻」の部分で、歳差理論の「消長法」によって『大衍暦』、『宣明暦』、『紀元暦』、『統天暦』、『大明暦』、『授時暦』六暦の冬至時刻

を検校した。その冬至時刻表を訂正した後、『大衍』、『宣明』、『紀元』、『統天』、『大明』、『授時』六暦によって一つ一つ春秋献公以降の毎年の冬至時刻を推算した。日躔については、建部賢弘が

> 「古今暦皆以冬至為盈初、以夏至為縮初，近代西國人考之乃以冬至後六度為盈初、以夏至後六度為縮初。」

と注釈した。その注釈は西洋暦法は冬至後六度を近日点としたが、このことは建部賢弘が西方天文学を熟知していたことを明らかにする。「日行盈縮」と「月行遅疾」の暦理に対する注解は黄鼎の『天文大成管窺輯要』を全文引用して、文ごとに解釈し、特に招差法の演算過程と構造原理を詳しく解釈した。月行九道術については、建部賢弘が描いた「月行九道図」は『三才図会』を参考したわけである。清代学者の研究と比べて、建部賢弘が行った 九道術への注解はもっと歴史的価値があると思う。白道交周は白道と黄道差、 及び白道と赤道差を計算する方法で，『授時暦』の五つの重要な創造の一つである。その算法の肝心な問題はどうやって所謂白赤道正交から黄赤道正交 極数を求めるかということである。関孝和は『天文大成管窺輯要』の記載によって、『授時暦』の推黄赤道差、黄赤道内外度及び白道交周の算法を図解で説明した。建部賢弘は関孝和の『授時発明』におけるものと異なる方程を導き出して解を求めた。それだけでなく、後の注文で建部賢弘は『天文大成管窺輯要』と『授時発明』の記述材料によって、優れた数学能力で詳細に黄赤道差、白黄道差と白赤道差の計算公式を論証した。その論証過程は関孝和とは違った。要するに、関孝和の『授時発明』と比べて、建部賢弘が行った『授時暦』の「白道交周」という問題への注解は、さらに詳細で明確である。

数学知識は経験形態と理論形態とがあり、前者は実際な問題の解決を重視するが、後者は抽象化理論の構築を重視する。両者がお互いに結合して数学科学の発展を推進する。自然世界と人類社会の難問を解決する知識活動は数学知識を増やす動力である。中国数学史では、重要な数学方法は皆天文暦学における計算問題を解決するのに創立したものである。『授時暦』が江戸時代数理科学に影響を及ぼしたのは貞享暦がそれを基礎にしただけでなく、その中に人を引きつけて夢中にさせた高尚な数学方法があったからである。天元術という代数方法が和算家に理解されて使用されているにつれて、和算家が『授時暦』の算法原理の理解は容易になった。建部賢弘は江戸時代の多くの『授時暦』研究者の中で最も優れた一人である。『授時暦議解』から見れば、彼は博引傍証で、中国古代天文暦学の文献、特に『天文志』と『律暦志』及び『天文大成管窺輯要』、『三才図絵』などを広汎に閲読していた。彼がより優れた数学能力を持っていたので、暦理への理解は精確で深かった。「白道交周」という問題への注解について、建部賢弘は関孝和よりはっきりしてその原理を解釈したうえ、異なった解答方法を提出した。これは建部賢弘の科学研究上の独創精神を反映していた。経学研究モデルを持った清代学者と比べ、建部賢弘の『授時暦』への注解はより重要である。

Language: Japanese

3.23 Ying, Jia-Ming (英家銘)

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Title: Nam Pyŏng-Gil (1820-1869): A Confucian mathematician and a populariser of mathematics in late Chosŏn period.

Abstract: This paper examines the life and works of a Confucian mathematician Nam Pyŏng-Gil 南秉吉 (1820-1869) in late Chosŏn Dynasty, with a focus on his efforts in popularising the study of mathematics. Under the influence of a trend of thinking in late Chosŏn period, namely *shirhak*, or Practical Learning, Nam believed that the study of mathematics was the foundation of scientific inquiries and the ruling of a state, which lead to his conclusion that all Confucian scholars should study mathematics. Nam Pyŏng-Gil, his brother Pyŏng-Chŏl, and his good friend Yi Sang-Hyŏk collaborated in writing many astronomical and mathematical treatises. Nam Pyŏng-Gil himself wrote several commentaries for classical and medieval mathematical texts from China, and composed his own works, too. In the meantime, he published some of his and other mathematicians' works. In his final years, he compiled a compendium of mathematics, probably the most comprehensive one originally written in the whole Chosŏn Dynasty that survives to this day. It includes almost all important mathematical problems and methods in his time. Mathematically speaking, the style of his writing was not the most rigorous, even compared to mathematical texts available in contemporary Qing and Chosŏn, but his approach of arguments was usually heuristic. Considering the fact that the language in his commentaries and original works were clear and plain to the readers, and that he published several mathematical works written by himself and others, I argue that Nam Pyŏng-Gil made great efforts, not only to show that mathematics was important to Chosŏn intellectuals, but also to try to popularize mathematical knowledge to his fellow countrymen.

Language: English

Chapter 4

Special Lectures in Japanese

4.1 Imanishi, Yuichiro (今西 祐一郎)

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Title: 学術と啓蒙ー日本語表記の観点からー（Academicism and Enlightenment – from the view point of Japanese notations）

Abstract: Japanese Language uses three kinds of letters: Chinese characters, *kata-kana*, and *hira-kana*. The *kana* letters were invented more than 1000 years ago; the *kata-kana* for the reading of Chinese classics and the *hira-kana* for popular purpose. The original form of *hira-kana* was called "female letter" (*onna-de*) and used mainly by females. Thus there was a clear difference of class between two kinds of *kana* letters. This difference was maintained in books of the Edo period; academic books were written with Chinese characters and *kata-kana* while educational books with Chinese characters and *hira-kana*.

In this talk we shall discuss how this difference in using *kana* letters appeared in mathematics of the Edo period.

はじめに　古代の日本列島は無文字社会であり、日本固有の文字はなかった。日本の文字の歴史は、漢字を受け入れ学ぶことから始まった。漢字を学ぶと同時に、漢文で表現できない日本語固有の言葉を漢字を用いて書き表そうと努力した。その努力の成果が、「安」や「阿」の漢字で「あ」という音を表記する万葉仮名という表記方法の発明である。

しかし、日本語を書くのに画数の多い漢字を使用するのは面倒であり、効率が悪い。そのような不便を解消するために、①漢字の一部を利用した片仮名、②漢字の崩し字体（草書体）を利用した平仮名という、漢字とは異なる２種類の文字が作り出されることになった。その結果、日本語は、漢字、片仮名、平仮名と

いう3つの文字体系を持ち、しかも現代語ではその3つを臨機応変に使い分けるという、世界でも類を見ない言語となった。

それにしても、なぜ日本語には固有の文字が2種類も必要だったのか。それは、それぞれの発生にさかのぼれば、2種類の文字の用途が異なっていたからである。片仮名は、漢文読解という学問から生まれた文字であり、平仮名は直接学問に関与しない女性や子供のための文字として使用されていたからである。実際、平仮名は1000年前の平安時代では、「女手（おんなで）」と呼ばれていた。

このような2種類の文字の使い分けは、17世紀、江戸時代における出版においても反映されている。学問的な書物は漢字片仮名交じり、啓蒙的な書物は漢字平仮名交じり、という表記の区別である。

しかし、その区別は、規則的、教条的に墨守されていたわけではない。それとは別に、同じ文献が、片仮名、平仮名両方で出版される例も見いだされる。たとえば『平家物語』は、同じ寛永3年（1626）に漢字片仮名本と漢字平仮名本とが出版されている。このような例は少なくないが、平仮名本にはやがて挿絵が添えられるようになる。片仮名本に対しては挿絵が添えられることはほとんどない。挿絵というものは、知識に乏しい女性や子供の理解を助けるための手段、というのが、江戸時代の出版における共通の認識であった。

さて、このような片仮名本、平仮名本の問題は、和算書においてはどうなっているであろうか。沢口一之『古今算法記』（寛文6年序）は、その序文で、全7巻のうち、前半の3巻は初心者（「初学之士」）を教えるために平仮名書き、後半3巻は返り点を付した漢文訓読という、読者のレベルに対応させた表記を採用したと述べている。その観点に立てば、『塵劫記』や『算法地方大成』が平仮名で書かれているのは、学問というよりは一般の人々の実用書としての書物の性格を反映していると考えられるであろう。

建部弘賢に『算学啓蒙諺解大成』という一書がある。「諺解」とは本来は朝鮮王朝で作られた固有の文字「諺文（ハングル）」を用いた中国の典籍の注釈のことである。しかし日本ではこの語を、ハングルとは無関係に、「俗語解」の意味に用い、漢学や医学など様々な分野で「諺解」を冠する多くの注釈書が著された。俗語解とはいえ、これらの多くは漢字片仮名で書かれており、そこに啓蒙性が含まれるにせよ、あくまで学問を志向する表記態度だと考えられる。また『諺解』を名乗ることには、一般に著者の卑下・謙退の表明でもあり、学問への志向とは何ら矛盾しない。建部の著作すべてに目を通したわけではないが、『綴術算経』、『発微算法演段諺解』など他の著作も、漢字片仮名で表されているのは、建部の一貫した学問への思考が、表記の面からも窺われるということになろう。

Language: Japanese

4.2 Kuge, Minoru （久下　実）

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Title: 建部賢弘の日本地図について（About a Japanese map made by Takebe Katahiro）

Abstract: In February, 2014, the map of Japan made by the Tokugawa shogunate during the Kyōhō years (1716-1735) was found among the private collection of maps domestic and abroad, which was deposited at the Hiroshima Prefectural Museum of History. This map is called the *Kyōhō Map of Japan* and the map making was directed by Takebe Katahiro, whose 350th anniversary is celebrated this year. It is the happy coincidence that we discovered the *Kyōhō Map of Japan* has been considered lost for many years.

We shall introduce the method of map making used by Takebe Katahiro.

はじめに　平成 26 年 2 月に広島県立歴史博物館に寄託された、内外の古地図を中心とする個人コレクションに、江戸幕府が享保年間（1716-1735）に作成した「享保日本図」が含まれていることが明らかとなった。

享保日本図制作事業の中心的人物は建部賢弘であった。建部賢弘生誕 350 年という記念すべき年に、長く現存しないと考えられていた享保日本図が発見されたという奇遇もあり、建部賢弘の業績でありながら、その実態が十分に明らかでなかった享保日本図制作について、資料の紹介を兼ねて若干の考察を述べたい。

１．享保の日本地図　江戸幕府は 260 年の間、７度日本地図を完成させているが、5 度目にあたるのが、元禄年間に制作された日本地図であった。この元禄の日本図の図形は、日本列島の外形が実際と比べて、ゆがみが大きいことで知られる。８代の将軍として就任した徳川吉宗はこのことに気づき、日本の図形を修正すべく、日本地図作りを命じた。これにより作られたのが享保の日本図である。事業は享保 2 年 (1717) に始まり、最終的には享保 14 年 (1729) に完成を見たことがわかっている。

事業の指揮者は、当初、元禄日本図を指揮した北条氏命の息子の北条氏如であったが、途中 (享保 5 年ころ) から建部賢弘が主導した。

元禄までの幕府の日本図制作では、諸国から国絵図を提出させ、幕府がそれらを合成して日本総図を作成した。しかし、享保の日本図では、幕府は諸国からの絵図の提出を求めず、元禄の国絵図を再利用した。再合成するに当たり、全国各地で、遠方の目印となる山などを見通した上でその方角を測らせ、それらのデータを元に諸国の位置関係の修正を試みた。この方法を「望視交会法」と呼び、伊能忠敬も自身の測量の際にこの手法も取り入れていたことがわかっている。なお、享保の日本図制作事業が、日本地図を作成するのに、日本全土を測量した初めての事例であった。享保日本図の最大の特徴は、この「望視交会法」による作図である。

享保日本図の作成における建部賢弘の貢献は、主に「二段階による日本図の作成の提案」と、「諸藩へのよりシンプルな測量 (=幕府の裁量をより大きくした測量方法) の提案」の 2 点であったと言える。

北条氏如による地図作りは、全国一斉の調査により日本図全体を組み立てようとするものであったと考えられるが、測量データの不十分さ・不正確さからうまくいかなかったことが想像される。それに対して、建部は、日本を 8 つのブロックに分けて、まず部分図を作成し、次にそれらを組み合わせることによって日本図を完成させるという方法を採用した。この方法により、享保日本図は完成を見た。

２．松浦静山旧蔵日本図について　今回発見された日本地図は、九州の平戸藩の大名であり、博物収集家としても名高い、松浦静山の天明 5 年（1785）の識語と捺印があり、松浦静山の収集品の一つであったことがわかる。識語には図の由来について、吉宗の日本図であるとの説明もある。

本図には山川などの自然地形、街道や航路などは描かれず、国境・郡境が描かれるほか、多くの赤い線が描かれている点が特徴である。この赤い線の両端に地名が書かれており、この地名が享保日本図の望視交会法による測量の起点と標的であったことから享保日本図を作成する際の「見通し線」と判断された。また縮尺は 21 万 6 千分の 1 という享保日本図の縮尺とほぼ一致することから、オリジナルのサイズの享保日本図であることがわかった。

３．地図からわかる制作過程　見通し線については、享保日本図についての幕府の記録である『諸国見通目録』のデータと基本的に一致する。記録には、起点と目標と見通した方角が記される。今回、このデータを利用して、地図中の見通し線から磁北を割り出し、比較を試みた。その結果、国絵図の再合成に際して、図形のひずみを分散させながら合成していた可能性が高いことが判明した。

『諸国見通目録』に記される観測データには、大きく分けて、国絵図を合成するためのものと、日本図全体を組み立てるためのものがあったことが確認できた。

また、享保日本図は、元禄の国絵図を、測量結果を用いて合成したために、国境を除くと各国の図形は元禄の国絵図と変わらないとされていたが、実際に国ごとに形を比較すると、大きく変形されていることがわかる。これは、北条氏如の時の調査結果とそれを補う建部賢弘の時の調査結果を用いたと考えられる。このことは、従来の「北条のプロジェクトが行き詰まったため、建部がを立て直した」、という両者の断絶性を強調する通説に対して、完成図に北条の調査結果も反映されている可能性も指摘できる。

おわりに　本資料は当初、「測量原図」と発表、報道されたが、以下の特徴から、資料の性格を再考すべきと考える。

(1) 見通し線が、『諸国見通目録』と一致すること、

(2) 記載内容も『諸国見通目録』の項目と一致することから、両者はセット関係にあると言えること

(3) 「耳」と呼ばれる縁取りなど、保存図としての特徴を有していること

(4) 海岸線の描線が簡素化されていること、島嶼部は見通しのデータと関係のある島を選択的に描いており、ほとんどは捨象されていることから、「見通し線」こそが、本図が保存すべき対象であったと考えられる事

(5) 見通し線に結線に 1 箇所明らかな誤りが指摘できる。しかし、この誤りは作成された日本図には反映されている形跡がないことから、本図を元に日本図が作成したとは考えにくい。日本の図形ができた後、本図が作成されたと考える方が矛盾がない。

これらの特徴から、享保日本図を作成するための「原図」ではなく、享保日本図制作事業の最後に、『諸国見通目録』などとともに記録保存用に作成された図である可能性が高い。

Language:　Japanese

Chapter 5

Short Oral Presentations

5.1 Fujii, Yasuo (藤井康生)

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Title: 授時暦と関孝和・建部賢弘の招差法　対　貞享暦と渋川春海の招差法 (The *Jujireki* (*Shoushili*) and the method of finding differences by Seki Takakazu and Takebe Katahiro versus the *Jōkyōreki* and the method of finding differences by Shibukawa Harumi)

Abstract: Seki Takakazu and Takebe brothers (Katahiro and Kata'akira) established the method of finding differences (*Shōsa Hō*, 招差法) in 1680's but Shibukawa Harumi employed the *Shōsa Ho* about 10 years earlier than Seki and Takebe's when he made the *Jōkyōreki* calendar. All of them learned the method from the Chinese book *Tianwen Dacheng Guankui Jiyao* (天文大成管窺輯要). In this talk we shall discuss why Seki-Takebe and Shibukawa understood the method differently.

はじめに　渋川春海と関孝和はともに『天文大成管窺輯要』によって招差法のことを知った.

　関孝和は弟子の建部賢弘・賢明兄弟と一緒に後の和算家に「招差法」と云われる数学的方法を確立したと言われている.『天文大成管窺輯要』には観測によって得られる積差の値が載せられてはいなかった.

　『天文大成管窺輯要』の招差には, 授時暦に用いられている盈縮差の 3 次式の係数である, 定差, 平差, 立差の単語と計算方法が載せられているだけで, 数値は載せられていない.『元史・授時暦経』では定差, 平差, 立差の数値が載せられているだけである. 渋川春海も関孝和も, この定差, 平差, 立差を求めることを試みた.

　そのことが原因したのか, 渋川春海は招差法に関して関孝和とは異なる理解をして貞享暦を作った.

渋川春海の招差法　『授時解』に渋川春海の招差術が載せられている. 授時暦では, 定差と極差は観測によって得られるものと考えられていた. そのため定差と極差から平差, 立差を求める方法である.

授時暦の盈初縮末の場合

$$立差\ (c) = 31 \cdots 計算による値$$

$$平差\ (b) = 24600 \cdots 計算による値$$

$$定差\ (a) = 5133200 \cdots 観測による値$$

$$極差 = 2.401400 \cdots 観測による値$$

$$盈縮差 = [定差 - (立差 \times 初末限 + 平差) \times 初末限] \times 初末限 \times 10^{-8}$$

$$f(n) = \{a - (c \times n + b) \times n\} \times n \times 10^{-8}$$

$$f(1) = a - (b + c) = g(0)$$

$$f(2) = 2a - 4b - 8c, \quad g(1) = f(2) - f(1) = f(1) - (2b + 6c)$$

$$f(3) = 3a - 9b - 27c, \quad g(2) = f(3) - f(2) = g(1) - (2b + 6 \times 2c)$$

$$f(4) = 4a - 16b - 64c, \quad g(3) = f(4) - f(3) = g(2) - (2b + 6 \times 3c)$$

$$g(n) = g(n-1) - (2b + 6 \times nc) = a - [(2n+1)b + \{3n(n+1) + 1\}c]$$

これを

$$g(n) = a - [(2n+1)b + \{3n(n-1) + 1\}c]$$

としている．このことは, 上式の c の係数を天とすると,

$$天 = 3 \times 89 \times 88 + 1 = 23497$$

としていることから考えられる．

立差を求める　$n = 89$ とすると, $g(89) = 0$ として,

$$c = \frac{a - (2 \times 89 + 1)b}{3 \times 89 \times 88 + 1}$$

平差がわかれば立差が求められる．

平差を求める　$f(89) = 極差$ と考えて,

$$an - bn^2 - cn^3 - 極差 = 0$$

先の立差を代入する．

$$an \times 天 - bn^2 \times 天 - \{a - (2n+1)b\}n^3 - 極差 \times 天 = 0$$

$$(an \times 天 - an^3 - 極差 \times 天) + (2n \times n^3 + n^3 - n^2 \times 天)b = 0$$

$$\begin{aligned} 実（定数項） &= 5133200 \times 23497 \times 89 - 5133200 \times 89^3 - 240140000 \times 23497 \\ &= 1473400784800 \end{aligned}$$

$$法（平差の係数） = 2 \times 89^4 + 89^3 - 89^2 \times 23497 = -59930286$$

$$平差 = 実/(-法) = 24585.2 \cdots$$

平差を用いて立差を求める．

$$実（分子） = a - (2 \times 89 + 1)b = 5133200 - 179 \times 24600 = 729800$$

$$法（分母） = 天 = 3 \times 89 \times 88 + 1 = 23497$$

$$立差 = 実/法 = 31.0 \cdots$$

問題点　f(盈初限) $=$ 極差, f'(盈初限) $= 0$ とするところを, $f(89) =$ 極差, $g(89) = 0$ としたものと考えられる．これらは,『大統暦法通軌』等の太陽盈初縮末限立成より考えついたのかもしれない．

上記の渋川春海の招差法では, 平差を消去していることに注目される．西村遠里は傍書法を用いて記述しているが, 渋川春海は傍書法を理解していたのだろうか.

『関孝和全集』によれば,『関訂書』には貞享 3 年 (1686),『解隠題之法』には貞享 2 年 (1685),『解伏題之法』には天和 3 年 (1683) の年紀がある．渋川春海による貞享暦の上奏は延宝元年 (1673), 天和 3 年 (1683) であるので, 初めに上奏した時には傍書法は完成していたのであろうか.

関孝和・建部賢弘は渋川春海の極値を用いる招差法から, 適尽方級法や極値問題（最大最小値を求める問題）へと考えを進めていったと考えられる.

西村遠里が『貞享暦解』の中で「春海暦に功名ありといへとも算術に於る孝和元珪の徒と同しからさるか故なり」と述べているのは, 渋川春海と関孝和・建部賢弘の立場の違いを言い得て妙である.

これらのことから, 初めに述べたように渋川春海は招差法に関して関孝和とは異なった理解をしていたと考えられる．この招差法に対する試行錯誤が, 数式の表記法（傍書法）を発展させ, 後の和算の大きな発展を招いたことは興味深い.

文献

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Language: Japanese

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Title: Witness accounts on the introduction of Dutch arithmetic in pre-Meiji Japan.

Abstract: This paper provides an overview of the scarce occasions in which Japan came into contact with Western arithmetic and algebra before the Meiji restoration of 1868. While some studies based on Japanese sources have already been published on this period (1), this paper draws from Dutch sources and in particular on witness accounts from Dutch officers at the Nagasaki naval school, responsible for the instruction of mathematics to selected samurai and *rangakusha*. Specific sources that will be discussed are the diaries by the Dutch officers W.J.C. Huyssen van Kattendycke (partially published in Dutch), H. O. Wichers (unpublished manuscript) and the naval doctors Jan Karel Van den Broek (partially published in Dutch) and J.C.L. Pompe van Meerdervoort (published in Dutch).

The history of Japanese mathematics is a gratifying subject for study as it confronts us with basic questions on the development of mathematics. The relative isolation of Japanese intellectual culture during the Edo period provides us with almost experimental conditions for the question if mathematics evolves in some necessary order or pattern. The confrontation with Dutch mathematics at the end of this period raises the issue how foreign knowledge can and should be incorporated within existing traditions. Of the possible strategies of adaption, integration or replacement the Meiji regime chose drastically for the latter one, abandoning its own rich and flourishing *wasan* tradition. The possible choices are exemplified by the first two Japanese works on Western mathematics. The *Seisan Sokuchi* (西算速知, A short course on Western Arithmetic by Riken Fukuda, (edited by Hanai Kenkichi),1856) tried to adapt Western procedures to *wasan*. Yanagawa Shunsan criticized such approach and intended his *Yōsan Yōhō* (洋算用法, The method of Western arithmetic, 1857) to be a faithful rendering of Dutch methods and procedures but also terms and symbolic notations. We situate this revolution in Japanese mathematics within the context of foreign threat and the development of a Japanese naval force. The Dutch played a major role in placing education in Western mathematics as a condition for their support to this enterprise. We point out several connecting lines between the Nagasaki naval training program and the newly established *bansho shirabe-sho* institute. The educational approach taken in the Dutch books used for the training program fitted very well the ambitions of the Meiji regime. The influence of Dutch learning in the latter years of the Edo period may have been greater than believed.

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Language: English

5.3 Hinz, Andreas M.

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Title: Kyū-ren kan, the Arima sequence

Abstract: The origins of the *Chinese (nine linked) rings* are not known. Although legend places them into 3rd century China, the earliest extant mathematical sources stem from Europe in the early 16th century. In the East, an outstanding analysis was presented in the book *Shūki Sanpō* by the Japanese mathematician Arima Yoriyuki (1714–1783) from 1766/9, where one can find the first nine entries $1, 1, 2, 3, 6, 11, 22, 43, 86$ of the *Arima sequence* which in modern terms is given by the recurrence

$$A_1 = 1,\ \forall\, n \in \mathbb{N} :\ A_{n+1} = 2A_n - n \bmod 2\,.$$

This sequence is related to the *paper folding*, the *Lichtenberg* and the *Jacobsthal sequences*. In fact, in 1769 Georg Christoph Lichtenberg (1742–1799) pointed to a similarity of the *Nürnberger Tand* to a calculating machine for Leibnitz's dyadic number system which the latter had tried to trace back to the legendary Fu Xi. However, it seems that the full interpretation of the *baguenaudier* as a binary representation of the first 2^9 non-negative integers had to wait for a French barrister of the 19th century.

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Language: English

5.4 Hosking, Rosalie Joan

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Title: Solving Sangaku with Tenzan Jutsu

Abstract: Between the 17th and 19th centuries, mathematically orientated votive tablets appeared in Shinto shrines and Buddhist temples throughout Japan. Known as *sangaku*, they contained mathematical problems of a largely geometrical nature. In the 18th century, the Japanese mathematician Seki Takakazu developed a form of algebra known as *tenzan jutsu*. Can the algebra of Seki be applied to *sangaku* mathematical tablets? Did *sangaku* mathematicians between the 18th and 19th centuries use *tenzan jutsu*? I apply two mathematical problems from the 1810 CE Japanese text *Sanpo Tenzan Shinan* using *tenzan jutsu* to two similar problems found on a *sangaku* tablet in the Nagano Tenmangu shrine to show how *sangaku* can be solved using the traditional Japanese algebra of Seki.

Language: English

5.5 Kota, Osamu (公田 蔵)

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Title: Western mathematics on Japanese soil — A history of teaching and learning of mathematics in modern Japan —

Abstract: Until early 1870s, Japanese people learned traditional Japanese mathematics, *wasan*. Mathematics was regarded as a practical science. Many people learned elementary arithmetic as a useful knowledge for their daily lives and for their occupations. Some people studied mathematics not only as a practical knowledge but also as an art. *Wasan* was developed by them. For most of them, their primary concern was skillful solving of complicated problems. In this way, Japanese people learned mathematics through problem-solving. Only a very small number of Japanese had some knowledge of Western mathematics.

After the Meiji Restoration (1867 – 1868), Japanese Government intended to modernize Japan by introducing Western civilization, especially Western science and technology, into Japan. Modern educational system was introduced in 1872. As to mathematics, the Department of Education decided to teach only Western mathematics at all school levels — teaching of traditional Japanese mathematics was abolished. It was too radical to be carried out, however. Many teachers at that time were unfamiliar with Western mathematics. So the regulation was revised within a few months. Since then, mathematics has been taught in Japan in Western style, with some consideration on the traditional way of calculation, the use of *soroban*, in elementary arithmetic.

Among the various branches of Western mathematics, arithmetic, elementary algebra and trigonometry were not so difficult to learn for Japanese in the early Meiji era, as there were no significant differences in ideas between Western mathematics and *wasan* except technical terms and notation. On the other hand, the value of Euclidean geometry was recognized gradually by Japanese mathematicians, as Euclidean geometry was of quite different nature from *wasan* geometry.

The school system and the curriculum were established by the end of 1880s. Mathematics was regarded as a branch of pure science, with many applications in various fields, especially in physics and engineering. At secondary schools, mathematics was divided into four subjects: arithmetic, algebra, geometry and trigonometry, and each subject was taught rigorously by its own method.

In 1942, to cope with a time of crisis for the nation, sweeping revision of the syllabi of mathematics and science for secondary schools was made. The new

syllabus of mathematics was intended to develop pupils' mathematical thinking and skills through their various activities, and laid emphasis on heuristic methods. Utility and applications of mathematics were emphasized. It was a drastic change in mathematics education in Japan. The syllabus was influenced by the idea of the movement for reform of mathematics education since the early twentieth century, the traditional way of learning in Japan — learning through training — , and the New Structure Movement at that time, In this way, the idea of traditional Japanese mathematics was revived. The revised curriculum, however, was not carried out completely due to the war.

Language: English

5.6 Kümmerle, Harald

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Title: The institutionalization of higher mathematics in Meiji- and Taisho-era Japan

Abstract: In this presentation I explain the research I am conducting for my doctoral thesis which concerns the institutionalization of higher mathematics in Meiji- and Taisho-era Japan (1868-1926). My research is not restricted to the material facilities in which mathematical research took place. Instead, it uses a more abstract concept of institutions and takes socio-economical conditions in Japan into consideration as well as requirements of the international research community. The institutionalization process is regarded as being split into four concurrent subprocesses, namely formation of organizations, professionalization, standardization and disciplinization. My approach permits a more differentiated analysis than it would be possible with patterns of analysis that are primarily linear in time.

I want to provide a little background information first: A major reason why Western mathematics quickly became dominant in Meiji-era Japan was that, as a result of the Education Act (*gakusei*) of 1872, *wasan* stopped being taught in schools and came to have fewer and fewer active practitioners. That alone did not provide the capability to produce research results that could meet the standard of the international community, though, this knowledge was obtained by Japanese students who were sent to Europe to study abroad. But a transplantation of scientific disciplines is not possible without adaptations to the situation in the destination country. What is more, the notion of mathematics that Japanese brought home depended on the place and time of their studies abroad.

Although my methodical framework is not primarily linear in time, I have chosen to look at the Meiji and Taisho eras as a continuum. Otherwise the answer on institutionalization (a process spanning multiple academic generations) cannot be analyzed in depth, as I want to briefly explain: Even though Western mathematics was taught at Tokyo University by Kikuchi Dairoku (1855-1917)

since 1877, it is Fujisawa Rikitaro (1861-1933) who can be credited with bringing research oriented mathematics to Japan when he came back from Germany in 1887. But focusing the investigation of institutionalization on this one event does not provide any concrete knowledge on how Japanese mathematicians went on to carry out their research activities afterwards. Neither does it answer what influence academic mathematicians had on other scientific disciplines, nor what career paths there were for graduates who specialized in mathematics during their time in university.

I will give a presentation of my research project that wants to answer four main questions: 1. What were the characteristics of the mathematical research facilities, especially the mathematical departments and their seminaries? 2. How were the career perspectives of the students, being situated in both Japanese societal realities and the international academic community? 3. Was the relation between academic mathematics and academic natural sciences in Japan substantially different to that in Western countries? 4. How should the influence of Hayashi Tsuruichi (1873-1935) be judged against the one of Takagi Teiji (1875-1960), the first being an internationally renowned coordinator of science and the second having put forth world-class research?

Language: English

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Title: The background of my novel about Takebe Katahiro

Abstract: I am a novelist and writing especially about *wasan*, the Japanese mathematics of Edo era. My well known novel is "*The man who calculated* π", in which Takebe Katahiro plays the chief character getting a formula of π.

I would like to present here the reasons why I selected *wasan* as a theme of novel. The origin of *wasan* was Chinese mathematics, but the forms of mathematical expression and the way of enjoying them have changed in accordance with Japanese characteristics. The Japanese early mathematics books were written not in classical Chinese but in *hiragana* letters, which even common people could understand. Mathematics books with a lot of illustration were published in large quantities. It can be said that *wasan* was loved everywhere in Japan by people of every rank.

A place for worship of Japanese people used to be a *shinto* shrine, where *omiyamairi*, the custom of taking one's baby to pray for blessing, and a wedding ceremony were carried out during one's life. Many mathematics lovers dedicated a *sangaku* to the *shinto* shrine, which was a votive wooden tablets displaying problems with beautiful geometries and their succinct solutions. I appreciate the fine quality of Japanese characteristics in the custom of dedicating a *sangaku*, which can be considered as a mathematical article of present day.

It is one of the important reasons why *wasan* has become the subject of my novels.

Language: English

5.8 Ozone, Jun (小曾根 淳)

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Title: Trigonometric function tables introduced to Japan and China in the 17th century

Abstract: When we discuss the introduction of trigonometric function tables to Japan, we have to note two major related fields:

One field is the astronomical study of the calendar. The shōgun Tokugawa Yoshimune (徳川吉宗, 1684-1751) was interested in Western astronomical study of the calendar for the calendar revision, and ordered Takebe Katahiro (建部賢弘, 1664-1739) to translate the *Lisuan quanshu* (『暦算全書』, 1723) of Mei Wending (梅文鼎, 1633-1721). Takebe Katahiro entrusted the translation to Nakane Genkei (中根元圭, 1662-1733). The *Lisuan quanshu* was almost the complete book of Mei Wending and contained the trigonometry and the trigonometric function table in the *Chongzhen lishu* (『崇禎暦書』, 1636). Western knowledge of such studies of the calendar transferred to Japan via China became the theoretical foundation for *Kansei-reki* (寛政暦), which was a calendar revision in Japan used in 1798-1844. Members of astronomical department of the Tokugawa shogunate employed the knowledge of trigonometry in the work of calendar revision.

The other field is the land survey. When foreign ships arrived in Japan toward the end of the Edo period (1603-1868), the big boom of survey had occurred. It was for the military purpose to calculate the distance from a point on the land to a foreign ship approaching the Japanese shore. Many survey books dealing with such problems were published, and the cosine and sine theorem were used there. Trigonometry was widely popularized.

It can be concluded that although trigonometry was imported from China to Japan in 1727 with the *Chongzhen lishu* and accepted by the astronomy department, after more than 100 years from then, people were obliged to study trigonometry for the survey. Until now, this theory has been widely accepted.

However, we recently found the fact that a gunnery officer of the Dutch Navy already taught trigonometry to vassals of the shōgun and made them transcribe trigonometric function table in 1650.

In this talk, first we expound on the introduction of the trigonometric function table in 1650, secondly indicate what table was used in 1650, and finally demonstrate that the trigonometric function table of the *Chongzhen lishu* was also made from Pitiscus' table.

Language : English

5.9 Tamura, Makoto (田村 誠)

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Title: On the problem "Litian" of Bamboo Slips of the Qin Dynasty Collected by Peking University – The way to memorize conversion ratio in the Qin and the Han mathematical books

Abstract: In 2010, Peking University obtained a collection of bamboo and wood slips of the Qin dynasty as a donation from abroad. There are 751 bamboo slips, 4 bamboo tablets, 21 wood slips, 4 wood tablets, a wooden cup and a wooden gaming die. One of the most major subjects is on mathematics, that amount more than 400 slips, where they calculated the area of grain fields and the amount of taxes. In calculating them, middle bureaucrats often needed to convert a unit of area to another, so they seemed to memorize the conversion ratio in several ways.

In this talk, we talk about the problem *Litian* (里田) in the *Shu* of Qin Dynasty housed at Yuelu Academy (岳麓書院蔵秦簡『數』) and the Zhangjiashan banboo slips *Suanshu-shu* of Han Dynasty (張家山漢簡『算数書』), and show our interpretation of the *Litian* in the slips of Peking University.

Language: English

5.10 Yao, Miaofeng (姚妙峰)

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(Yao Miaofeng will not be able to participate in the conference.)

Title: The Translation and Influence of *Ce Liang Fa Yi* in Late Ming China

Abstract: In late Ming Dynasty, the missionaries of Jesuit came to China, bringing with them several books which were related to the western countries' classic scientific knowledge at that time. The most famous book is Euclid's Elements （《幾何原本》）, co-translated in 1607 by Xu Guangqi （徐光啓） and Ricci Matteo （利瑪竇）. In the same year, when Xu was staying at his home town, Shanghai, for his father's death, he translated and published *Ce Liang Fa Yi* （《測量法義》）, a book about measurement of length and height.

My short speech will be centered on this book and deal mainly about five points as follows. 1. The social background about measurement of height and length in late Ming Dynasty of China. 2. Whether the original copy in Latin is Clavius' *Geometria Practica* or not. 3. The content of *Ce Liang Fa Yi*. 4.

The response of the Chinese Traditional Mathematicians to the knowledge in this book, such as Xu Guangqi, Li Zhizao （李之藻）, Chen Jinmo （陳藎謨）, Chen Xu （陳訏）, Huang Baijia （黄百家）, etc. 5. The influence of this book on the irrigation projects and military weapons in then China.

Language: English

Chapter 6

Participants with no presentation

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Appendix A

Takebe Katahiro and his Mathematical Works

General references on Takebe Katahiro[1] are [Horiuchi1994] in French, [OgawaEa2008] in Japanese, [Horiuchi2010] in English, and [Xu2013] in Chinese.

The Proceedings [KKL2013] of the "Seki Connference 2008" contains many research papers on Seki and Takebe.

The following is extracted from [MorimotoOgawa2012] and modified.

At the age of thirteen, Takebe Katahiro (建部賢弘, 1664-1739) became a student of Seki Takakazu (関孝和, ? – 1708)[2] , an illustrious master of mathematics. Under the guidance of his master, he learned, among others, mathematics of the *Yuan* dynasty from the *Suanxue Qimeng* (算学啓蒙, *Sangaku Keimō* in Japanese, *Introduction to Mathematics*) [3] written in 1299 by Zhu Shijie (朱世傑, Shu Seiketsu in Japanese). By his mid-thirties, Takebe had already published three books:

- the *Kenki Sanpō* (研幾算法, *Mathematical Methods to Investigate the Minute*) in 1683,
- the *Hatsubi Sanpō Endan Genkai* (発微算法演段諺解, *Colloquial Commentary on Series of Operations in the Hatsubi Sanpō*) in 1685, and
- the *Sangaku Keimō Genkai Taisei* (算学啓蒙諺解大成, *Great Colloquial Commentary on the Suanxue Qimeng*) in 1690.

See [Morimoto2004] and [Ogawa2005].

The first book, *Kenki Sanpō*, contains answers to the problems raised in the *Sūgaku Jōjo Ōrai* (数学乗除往来, *Text on Multiplication and Division in*

[1] The names of Japanese mathematicians are written in vernacular order: family name first, followed by the given name.

[2] Seki's birth year is estimated between 1640 and 1645.

[3] At the first appearance, names of Chinese texts are followed by their Japanese reading and their English translation in parentheses.

Mathematics) written in 1674. See [Sato1996b], [Fujii2002], [Takenouchi2004], and [Takenouchi2006].

The second book, the *Hatsubi Sanpō Endan Genkai*, is an annotation to Seki Takakazu's *Hatsubi Sanpō* (発微算法, *Mathematical Methods to Explore Subtle Points*). The latter book was difficult to understand, prompting need for an annotation. See [Ogawa1994], [Ogawa1996] and [Sato1996].

The third book, the *Sangaku Keimō Genkai Taisei*, is a detailed annotation to the important Chinese work *Suanxue Qimeng* (算学啓蒙). Together with the *Suanfa Tongzong* (算法統宗, *Sanpō Tōsō* in Japanese, *Systematic Treatise on Mathematical Methods*) by Cheng Dawei (程大位, Tei Daii in Japanese, 1533–1593) of the *Ming* dynasty, the *Suanxue Qimeng* most influenced early 17th century Japanese mathematics.

Takebe Katahiro also began in 1683 an encyclopedic work,

- the *Taisei Sankei* (大成算経, *Great Accomplished Mathematical Treatise*),

in collaboration with his master Seki Takakazu and his brother Takebe Kata'akira (建部賢明, 1661–1716). See [Komatsu2007] and [Ogawa2006]. Their intent was to reveal the entirety of mathematics of their day. By the mid-1690's, they had completed a preliminary version in twelve volumes. After that, Takebe Katahiro took leave of mathematics as an appointed government official, and Seki Takakazu a respite due to illness. It was not until 1711 that the entire twenty volumes of the *Taisei Sankei* were completed, mainly due to the individual effort of Takebe Kata'akira. This evolution is recorded in the *Takaebe-shi Denki* (建部氏伝記, *Biography of the Takebe*). See [Fujiwara1954].

Between 1704 and 1715, Takebe Katahiro served as an officer of the Shogunate and completed no mathematical works. In 1716 Tokugawa Yoshimune became the eighth *shōgun*. The new *shōgun* had a keen interest in the science of calendars and mathematics, and could appreciate Takebe Katahiro's mathematical ability. He surveyed the land in 1720 and edited

- the *Kuni Ezu* (国絵図, *Illustrated Atlas of Japan*) in 1725.

Being encouraged by the *shōgun*, in addition to writing about the science of calendars, Takebe resumed writing books on mathematics. Thus he wrote in 1722 the three books:

- the *Tetsujutsu Sankei* (綴術算経, *Mathematical Treatise on the Technique of Linkage*),
- the *Fukyū Tetsujutsu* (不休綴術, *Master Fukyū's Technique of Linkage*), and
- the *Shinkoku Gukō* (辰刻愚考, *A Humble Consideration on the Time*).

A prolific author, Takebe later wrote

- the *Saishū Kō* (歳周考, *A Consideration on the Period of Years*) in 1725, and
- the *Ruiyaku Jutsu* (累約術, *Methods of Repeated Division*) in 1728.

He wrote several other books whose dates are unknown:

- the *Koritsu* (弧率, *Arc Rate*) (see [Fujiwara1941]),
- the *Sanreki Zakkō* (算暦雑考, *Various Considerations on Mathematics and the Calendar*) (see [Fujiwara1945] and [SatoS1995]),
- the *Hōjin Shinjutsu* (方陣新術, *A New Method of Magic Squares*),
- the *Kyokusei Sokusan Gukō* 極星測算愚考*, (Humble Considerations of the Observation and the Calculation of the Polestar)*,
- the *Chūhi Ron* (中否論, *Imprecision in Measurement*), and
- the *Jujireki Gi Kai* (授時暦議解, *Commentary on the Time Granting Calendar*).

Fujiwara [Fujiwara1954] claimed that Takebe Katahiro also wrote

- the *Enri Kohai Jutsu* (円理弧背術, *Studies on the Circle — Methods to Calculate the Length of Circular Arc*),

which is sometimes called the *Enri Tetsujutsu* (円理綴術, *Technique of Linkage in Studies on the Circle*). Recently many scholars raised questions about Fujiwara's claim.

In 2005, a copy of a book entitled

- the *Kohai Setsuyaku Shū* (弧背截約集, *Method of Pulvelizing Back Arc*)

was discovered. It describes Takebe's discovery of infinite expansion formula of the square of arc length in terms of sagitta, and was recognized as a book of Takebe Katahiro (see [Yokotsuka2004] and [Yokotsuka2006]).

Takebe retired in 1733, when he was seventy years old, and he died six years later in 1739, at the age of seventy five.

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