# I. List of Participants

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Akbari, Marjan (Sendai, Japan)
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Ansari, S.M. Razaullah (Aligarh Muslim University, India)
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Ehgamberdiev, Shuhrat
(Ulugh Beg Astronomical Institute of the Uzbek Academy of Sciences, Uzbekistan)
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Hariawang, Irma Indriana (Institute of Technology Bandung, Indonesia)
Hayashi, Masahiko (The University of Tokyo, Japan)
Hidayat, Bambang (Indonesian Academy of Sciences, Indonesia)
Hirai, Masanori (Fukuoka University of Education, Japan)
Hosoi, Hiroshi (Kwassui Women's College, Japan)
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Jun, Yong Hoon (Kyujanggak Institute for Korean Studies, Korea)
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Lee, Eun Hee (Konkuk University, Korea)
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Li, Liang (University of Science and Technology of China, China)
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Nam, Moon-Hyon (Konkuk University, Korea)
Narike, Tetsuro (Daito Bunka University, Japan)
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Okazaki, Akira (Gunma University, Japan)
Orchiston, Wayne (James Cook University, Australia)
Ozawa, Kenji (Anhui Normal University, Japan)
Qu, Anjing (Northwest University, China)
Renshaw, Steven (Kanda University of International Studies, Japan)
Saijo, Keiichi (National Museum of Science and Nature, Japan)
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Shiraishi, Masato (Zhongguo Yanjiusuo, Japan)
Sôma, Mitsuru (National Astronomical Observatory of Japan, Japan)
Soonthornthum, Boonrucksar (National Astronomical Research Institute of Thailand, Thailand)
Stewart, Ron (James Cook University, Australia)
Strom, Richard (ASTRON, Netherlands)
Tajima, Toshiyuki (National Astronomical Observatory of Japan, Japan)
Tanikawa, Kiyotaka (National Astronomical Observatory of Japan, Japan)
Tanokura, Mizuho (Gunma University, Japan)
Vahia, Mayank N. (Tata Institute of Fundamental Research, India)
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Yokoo, Hiromitsu (Chiba University of Commerce, Japan)
Yoshida, Fumi (National Astronomical Observatory of Japan, Japan)
Yoshida, Seiko (Muroran Institute of Technology, Japan)

## II. Conference Program

Session A – H (Pre-modern times)

Session I – N (Modern times & Other recent research)

Invited talk: 40min + 10minQ&A,  Oral talk: 20min + 5minQ&A

### Oral Papers

September 6 (Mon):

10:30－10:45AM,  Opening address and short announcement by NAKAMURA, Tsuko (SOC Chair) and SÔMA, Mitsuru (LOC Chair)

<Session A>  [Chair: Ôhashi, Y.]

10:45－11:35AM,  VAHIA, Mayank (Invited, p.8)
Megaliths in India and their possible relation to astronomy

11:35－12:00AM,  MENON, Srikumar M. and VAHIA, Mayank N. (p.8)
Megalithic astronomy in South India

0:00－1:30PM
Lunch

<Session B>  [Chair: Nakamura, T.]

1:30－2:20PM,  MAEDER, Stefan (Invited, p.9)
The archaeology of the "Big Dipper" -- Some recent findings from Japan and Europe

2:20－2:45PM,  HARIAWANG, Irma I., SIMATUPANG, Ferry M. and RADIMAN, Iratius (p.9)
Orientation of Borobudur's East Gate measured against sunrise position during vernal equinox

2:45－3:10PM,  YANG, Hong-Jin, CHOI, Go Eun, MIHN, Byeong-Hee and AHN, Young Sook (p.10)
Analysis of Korean stone star chart using 3D scan measurement

3:10－3:35PM,  RENSHAW, Steven L. (p.10)
Prospects for scholarship in the archaeoastronomy and cultural astronomy of Japan: Interdisciplinary perspectives

3:35－4:00PM
Tea Time

<Session C>  [Chair: Ansari, R.]

4:00－4:50PM,  TAJIMA, Toshiyuki (Invited, p.11)
National Astronomical Observatory of Japan and the postwar Japanese optical astronomy

4:50－5:15PM,  JUN, Yong Hoon (p.11)
Western astrology introduced in nineteenth-century Korea

5:15－5:40PM,  HOSOI, Hiroshi (p.12)
Theories about cosmic structure in ancient and medieval Japan

September 7 (Tue):

<Session D> [Chair: Orchiston, W.]

9:20－9:45AM, SARMA, U K V (p.12)
Planetary models as expounded by Bhāskara in his commentary on *Āryabhaṭīya*

9:45－10:10AM, LEE, Eun Hee and AHN, Young Sook (p.13)
Tenmon bunya nozu of Sibukawa Harumi and star maps of Joseon

10:10－10:35AM, AHN, Sang-Hyeon (p.13)
Drawing method of the Korean Star-Chart, Chonsang-Yolcha-Punya-Ji-Do

10:35－10:45AM
Tea Time

<Session E> [Chair: Orchiston/Nakamura]

10:45－11:35AM, NHA, Il-Seong and NHA, Sarah L. (Invited, p.14)
A classification of timekeeping instruments in East-Asian countries and inventory of significant relics prior to pendulum clocks

11:35 – 12:00AM, TANIKAWA, Kiyotaka and SÔMA, Mitsuru (p.14)
How were eclipses memorized when there were no astronomers?

0:00 – 1:30PM
Lunch

<Session F> [Chair: Débarbat, S.]

1:30－2:20PM, ANSARI, S.M. Razaillah (Invited, p.15)
A survey of Arabic-Persian sources on astrolabe extant in India and on the Indian school of astrolabe-makers

2:20－2:45PM, KIM, Sang Hyuk and LEE, Yong Sam (p.15)
An analysis on the operation mechanism and restoration of Song I-Yeong's armillary clock

2:45－3:10PM, LEE, Yong Bok (p.16)
Production and application of Ganpyeongui during Joseon Dynasty

3:10－3:35PM, ÔHASHI, Yukio (p.16)
Two systems of Indian astronomy

3:35－4:00PM
Tea Time

<Session G> [Chair: Sôma, M.]

4:00－4:50PM, QU, Anjing (Invited, p.17)
Planetary theory in China

4:50－5:15PM, NAKAYAMA, Shigeru (p.17)
The merit and demerit of geometrical representation in the history of Chinese calendrical science

5:15－5:40PM, LI, Liang, LU, Lingfeng and SHI, Yunli (p.18)
The accuracy of the eclipse calculation of the Huihuilifa

September 8 (Wed):

<Session H> [Chair: Soonthornthum, B.]

9:20－10:10AM, EHGAMBERDIEV, Shuhrat (Invited, p.20)

Emergence of modern astronomy and astrophysics in Uzbekistan

10:10－10:35AM, SÔMA, Mitsuru and TANIKAWA, Kiyotaka (p.18)

Investigation of the Earth's rotation using ancient Chinese occultation records

10:35－11:00AM, AKBARI, Marjan and AKHLAGHI, Mohammad (p.19)

Little known astronomer in the late Islamic period; a study of Qāsim-Alī Al-Qāyinī's manuscripts

11:00－11:10AM

Tea Time

<Session I> [Chair: Vahia, M.]

11:10－11:35AM, JOCHI, Shigeru (p.19)

The movement of observation center in the eastern Han Dynasty, China

11:35 – 12:00AM, STROM, Richard, ZHAO, Fuyuan and ZHANG, Chengmin (p.20)

Could Oriental annals have recorded optically-bright $\gamma$-ray bursts?

0:00 – 1:30PM

Lunch

<Session J> [Chair: Ehgamberdiev, S.]

1:30－2:20PM, HAYASHI, Masahiko (Invited, p.21)

Nobeyama radio observatory and the history of radio astronomy in Japan

2:20－2:45PM, SAIJO, Keiichi (p.21)

The transition of characteristics in Japanese celestial globes of Edo era from the collection of National Museum of Nature and Science

2:45－3:10PM, HIRAI, Masanori and FUJIWARA, Tomoko (p.22)

Two bronzed planispheres preserved in England since 1878 and Japan since 1683

3:10－3:35PM, NAM, Moon-Hyon, HAHN, Young-Ho, SEO, Moon-Hwo and LEE, Jai-Hyo (p.22)

A restoration of 15th century Korean king Sejong's striking Clepsydra at National Palace Museum of Korea

3:35－4:00PM,

Tea Time

<NAOJ Campus Tour and Welcome Party>

4:00－5:30PM

NAOJ Campus Tour

5:30－8:00PM,

Welcome Party at Cafeteria

September 9 (Thu):

<Session K> [Chair: Strom, R.]

9:20－9:45AM, DÉBARBAT, Suzanne (p.23)
A peculiar manuscript from Delisle's jesuit correspondence

9:45－10:35AM, RENSHAW, Steven L. (Invited, p.10)
Prospects for scholarship in the archaeoastronomy and cultural astronomy of Japan: Interdisciplinary perspectives

10:35－10:45AM
Tea Time

<Session L> [Chair: Jochi, S.]

10:45－11:35AM, MATSUURA, Kiyoshi (Invited, p.24)
Star Mandaras, as visual images in which Buddhism coexists with astronomy or astrology

11:35 – 12:00AM, LEE, Ki-Won, AHN, Young Sook, MIHN, Byeong-Hee and KIM, Bong-Gyu (p.24)
Incheon Meteorological Observatory and Comet Herschel-Rigollet

0:00 – 1:30PM
Lunch

<Session M> [Chair: Nha, I.]

1:30－2:20PM, SOONTHORNTHUM, Boonrucksar (Invited, p.25)
The emergence of astronomy in Thailand

2:20－2:45PM, HIDAYAT, Bambang (p.25)
The sky and the Agro-Bio-Climatology of Java: Need critical reevaluation due to environmental changes

2:45－3:10PM, YOSHIDA, Seiko (p.26)
The flying Hirayama: Escape from asteroid families

3:10－3:35PM, NAKAMURA, Tsuko (p.23)
A lunar map *Taiin-no-Zu* depicted in 1813 by a Japanese Feudal Warlord

3:35－4:00PM
Tea Time

<Session N> [Chair: Hidayat, B.]

4:00－4:50PM, ORCHISTON, Wayne and WENDT, Harry (Invited, p.26)
The contribution of the ex-Georges heights experimental radar antenna to Australian radio astronomy

4:50－5:15PM, STEWART, Ron, GEORGE, Martin, ORCHISTON, Wayne and SLEE Bruce (p.27)
A retrospective view of Australian solar radio astronomy. 2: 1960-1985

5:15－5:40PM,
Summary (STROM, Richard)

September 10 (Fri):

<One-day Bus Tour to Suwa & Nobeyama>

8:30AM, Departure of Tour Bus

## Poster Papers (September 6 – 9)

1. MAEDER, Stefan (p.30)
   The Sword, the Snake & the Turtle - Three constellations from pre-modern China?
2. OH, Gilsun (p.30)
   Replications of ancient star maps by a computer
3. NARIKE, Tetsuro (p.31)
   Guo Mo-ruo and Babylonian astronomy: The origin of the Chinese Twelve-Branch
4. OZAWA, Kenji (p.31)
   Discovery of degrees in Ancient China
5. YOKOO, Hiromitsu (p.32)
   Accuracy of north-south orientation by the Indian-circle method of a gnomon and the use of the recorded ancient orientations
6. ÔHASHI, Yukio (p.32)
   Mathematical astronomy of SEKI Takakazu and SHIBUKAWA Harumi --- Understanding and overcoming the Chinese traditional calendars in the Edo Period of Japan
7. ÔHASHI, Yukio (p.33)
   Astronomy and mathematics of Yixing
8. EHGAMBERDIEV, Shuhrat (p.33)
   Ulugh Beg's catalogue of stars and al-Sufi's sky map
9. VAHIA, Bambang, YADAV, Nisha and MENON, Srikumar (p.34)
   Foundations of Harappan Astronomy
10. LEE, Yong Bok and AHN, Young-sook (p.34)
    Analysis of solar eclipses records in Samguksagi
11. KIM, Sang Hyuk, LEE, Yong Sam and LEE, Min Soo (p.35)
    An analysis on the operation mechanism and 3D restoration of Ongnu in Sejong Era
12. OKAZAKI, Akira and TANOKURA, Mizuho (p.35)
    An examination of astronomical records in Vietnamese historical source
13. CHOI, Go-Eun, KIM, Dong Bin, LEE, Yong Bok, AHN, Young Sook and LEE, Yong Sam (p.36)
    A study of Korean Astronomical Almanacs for the period of 1864 – 1945
14. ANDROPOULOS, Jenny, ORCHISTON, Wayne and CLARK, Barry (p.36)
    Williamstown Observatory and the development of professional Astronomy in Australia
15. COTTAM, Stella, ORCHISTON, Wayne and STEPHENSON, Richard (p.37)
    The 1882 transit of Venus and the popularisation of astronomy through the pages of the New York Times
16. HAFEZ, Ihsan, STEPHENSON, Richard and ORCHISTON, Wayne (p.37)
    Al-Sufi's investigation of stars, star clusters and nebulae
17. ORCHISTON, Wayne and LUCIUK, Michael (p.38)
    Ronald McIntosh and the role of the amateur in New Zealand meteor astronomy
18. ORCHISTON, Wayne and PEARSON, John (p.38)
    The Lick Observatory and the development of professional astronomy in Western Australia
19. ORCHISTON, Wayne and PEARSON, John (p.39)
    The Lick Observatory and the development of solar astronomy in India
20. ORCHISTON, Wayne, DUERBECK, Hilmar W. and TENN, Joseph S. (p.39)
    Filling a void: The life and times of the Journal of Astronomical History and Heritage [cancelled]
21. ORCHISTON, Wayne, DUERBECK, Hilmar, GLASS, Ian, MALVILLE, Kim, MARSDEN, Brian, SIMONIA, Irakli, SLEE, Bruce, STEPHENSON, Richard, STROM, Richard, WHITTINGHAM, Ian and WIELEBINSKI, Richard (p.40)
    History of astronomy at James Cook University, Australia
22. PEARSON, John and ORCHISTON, Wayne (p.40)
    The Lick Observatory and the development of professional astronomy in Indonesia
23. SAUTER, Jefferson, SIMONIA, Irakli, STEPHENSON, Richard and ORCHISTON, Wayne (p.41)
    The legendary fourth century Georgian total solar eclipse: fact or fantasy?
24. WELLS, Bill and ORCHISTON, Wayne (p.41)
    Early scientific astronomy on the American Northwest Coast: Captain Cook's Sojourn at Nootka Sound in 1778

# Abstracts of Oral Papers

## Megaliths in India and their possible relation to astronomy

**M N VAHIA**, Tata Institute of Fundamental Research, Mumbai, India (vahia@tifr.res.in)

Several thousand megaliths have been identified in different parts of India. These include dolmen, menhirs, circular stone arrangements etc. They are found in all regions from Afghanistan to the southern tip of India as well as in eastern India. They are generally believed to be either sepulchral or symbolic burials. However, they have specific orientation in cardinal directions as well as specific method of manufacture. These are dated from 3000 BC to 500 BC based on the buried material found in them. We will briefly discuss these patterns of these megaliths and discuss their characteristics. We will then discuss a specific group of stone circles found in the region of central India. A cluster of several hundred stone circles dating to between 800 to 500 BC have been identified in the Junapani region of central India. These stone circles tend to have diameters of the order of a few meters. Only a few have been excavated and found to contain secondary burial of humans, animal bones, iron implements and gold ornaments. Around 35% of these stone circles have one or more stones in the periphery that have characteristic cup marks. We have surveyed and studied 56 of these circles of which 19 have stones with cup marks on them. We show that the cup marked stones are not randomly kept and the cup marks themselves have specific patterns. Typically the cup marks make parallel lines or orthogonal sequences on the stones and these tend to be aligned either radially or tangentially to the circle or both. They are also found along specific angles with respect to the north. The preferred direction are 118, 208 and 334 degrees to the north. We will discuss the orientation of these cup marks in the overall orientation of the stone circles and discuss their possible relation to seasons and astronomy.

## Megalithic Astronomy in South India

**Srikumar M. Menon**, Faculty of Architecture, Manipal Institute of Technology, Manipal, India (srikumar.menon@gmail.com)
**Mayank N. Vahia**, Tata Institute of Fundamental Research, Mumbai; Adjunct Faculty, Manipal Advanced Research Group (MARG), Manipal University, Manipal, India (vahia@tifr.res.in)

The megalithic monuments of peninsular India, believed to have been erected in the Iron Age (1500BC 200AD), can be broadly categorized into sepulchral and non-sepulchral in purpose. Though a lot of work has gone into the study of these monuments since Babington first reported megaliths in India in 1823, not much has been understood about the knowledge systems extant in the period these were built in science and engineering, especially mathematics and astronomy. We take a brief look at the archaeological understanding of megaliths, before taking a detailed assessment of a group of megaliths (in the south Canara region of Karnataka state in South India) that were hitherto assumed to be haphazard clusters of menhirs. Our surveys have indicated positive correlation of sight-lines with sunrise and sunset points on the horizon for both summer and winter solstices. We identify 5 such monuments in the region and present the survey results for one of the sites, demonstrating the astronomical implications. We also discuss the possible use of the typologies of megaliths known as stone alignments/avenues as calendar devices.

## The Archaeology of the „Big Dipper" – Some recent findings from Japan and Europe

**Stefan Maeder**, Kokugakuin University, Faculty of Letters, 4-10-28 Higashi, Shibuya-ku, 150-8440 Tokyo, Japan (sjdmaeder@aol.com)

The "Big Dipper" in *Ursa Major* was and is the most conspicuous asterism in the northern sky. Furthermore it is circumpolar and could be used as a means for identifying the apparent celestial northern pole, respectively the "center of heaven", also in times when due to precession there was no actual pole-star. This holds true for a time span from at least the later $4^{th}$ millennium B.C. until the present. Its importance for the history of religion is recorded in various mythologies geographically ranging from ancient Mesopotamia, Egypt, Greece and Rome to the Germanic sphere, India, Siberia, China, Korea and Japan, not to mention the Americas.

For 150 years there have been scattered reports on so-called cup-marked stones showing the "Big Dipper" from Switzerland, France, Germany and England. These isolated cases were regarded as coincidence and an astronomical interpretation dismissed by most archaeologists. The author was also inclined to regard these early reports as wishful thinking until he stumbled across two early representations of the "Big Dipper" in Japan, which correspond to a finding in 2006 of a confirmed neolithic representation on Baimiaozi-mountain, Mongolia, China. All of these representations include an extra cup-mark/star between the upper stars of the bowl, Megrez and Dubhe. This inconspicious star, BSC 4439, is about as bright as *Alcor* and is of assistance in locating *Thuban* (*α-draconis)*, which was the star closest to the pole at around 2800 B.C.. One striking feature about the worldwide representations of the "Big Dipper" is the fact that it is mostly rendered mirror-inverted. The presentation will introduce the revised and newly found archaeological evidence from Japan and Europe by comparing it to hitherto known representations of the "Big Dipper" from Mesopotamia, Egypt, China and Korea.

## Orientation of Borobudur's East Gate Measured Against Sunrise Position During Vernal Equinox

**Irma I. Hariawang**, **Ferry M. Simatupang**, Astronomy Research Division, Faculty of Mathematics & Natural Sciences, Institut Teknologi, Bandung, Indonesia (irma.hariawang@gmail.com)
**Iratius Radiman**, langitselatan, Indonesia Astronomy Online Media

Borobudur is a Buddhist temple which has been built around the year 800 (Soekmono, 1976). This temple is located in Magelang, Central Java, Indonesia with coordinates 7 degree 36m 30,49s south latitude and 110 degree 12m 10,34s east longitude.

Sunrise observations conducted at the temple site on March 19 to 20 in the year 2009 and 2010, during the sun at Vernal Equinox. The result of this observation is that the sun was rose as far as 3.5 arc minutes north of the east gate. With this result, then we can recalculate the position of sunrise at the time when temple was constructed.

By calculating the effects of precession of gamma point, we recalculate the sunrise position at the Vernal Eqinox at the time when temple was constructed. Computed using a rigorous method (Meeus, 1997) we got shift of sun's declination -6.6705 degrees, a negative sign indicates the direction of declination is calculated from the point east to the south. These results are then summed with measurements obtained at observation, got result -6.61 degrees shift to south from the east gate of the temple. This value has a difference of 1 degree of Borobudur's latitude that is equal to -7.5 degrees. 1 degree is the measurement error. These results support the hypothesis that the east gate of the temple at the time of construction during Vernal Equinox was tilted equal with its latitude, with the aim that when the sun transit in the zenith of Borobudur, the main stupa does not have a shadow.

## Analysis of Korean stone star chart using 3D Scan measurement

**Hong-Jin Yang, Go Eun Choi, Byeong-Hee Mihn, Young Sook Ahn**, Korea Astronomy and Space Science Institute, Deajeon, Korea (hjyang@kasi.re.kr)

Korea has a long history of star map and remains various heritages from prehistoric period. The most representative one is a stone star chart, CheonSangYeolChaBunYa- JiDo(天象列次分野之圖) engraved on the flat stone in A.D. 1395. The stone star chart contains 1,467 stars with various sizes and inscriptions including the history of the star map, oriental cosmology, stars at meridian when twilight for each 24 seasonal division, and so forth. Inscription of the star chart describes that it originated from Goguryeo dynasty(高句麗, 37B.C.-A.D.668). Due to wearing down the stone star chart of A.D. 1395, a replica was made during the era of King Sukjong(肅宗, 1674-1720).

We scan the two stone star charts, and measure the location of all stars relative to the north pole and their radii within 0.1mm accuracy with 3-dimensional high-resolution instrument. Using the 3-D measuring data, we examine correlation between the size of the engraved star-markings and the brightness of their corresponding stars, and compare quantitatively the two stone star charts about stellar radii and position of the stars.

We also compare the Korean stone star chart with the Chinese Suzhou(蘇州) stone star chart of A.D. 1247 in terms of composition of content, pattern and name of constellation, observing position, and so forth.

## Prospects for Scholarship in the Archaeoastronomy and Cultural Astronomy of Japan: Interdisciplinary Perspectives

**Steven L. Renshaw**, Kanda University of International Studies, 1-4-1 Wakaba, Mihama Ku, Chiba 261-0014 Japan (stever@gol.com)

Japan’s modern contributions to knowledge in astronomy and astrophysics are numerous. However, with few sites of astronomical alignment and virtually no ancient records of scientific development, the country is often perceived to have little of archaeoastronomical interest. Yet there are many research areas related to Japan’s long history with the sky that are both fascinating and deserving of attention. Examples include inquiries into how astronomical associations were driven by political and cultural needs or how complex intercultural contact and migration affected adoption of astronomical practice. Such research requires perspectives and methodologies that include not only astronomy and related physical sciences but social sciences and humanities as well. While it may be difficult for scholars to cross the methodological and epistemological boundaries of their respective disciplines, the products of such study, when conducted rigorously, provide valuable insights not only into what was known and practiced in observational astronomy, but the ways in which the society understood and utilized celestial phenomena, thus providing valuable input into a broader understanding of the culture and its rich history.

Contemporary and prospective research is discussed, and two examples are summarized in more detail: One represents an interdisciplinary approach to understanding the cultural significance of the asterism *Subaru* (Pleiades) and contains an assessment of early seasonal phenomena, analysis of star lore related to polity and daily life, and sociological consideration of modern associations with cultural identify. The second involves diffusion of innovation and looks at the social side of adoption of calendrical methods and associated practices. It includes political and intercultural analysis of adaptation that sometimes seemed erratic but was nevertheless consistent with perceived cultural needs and values.

Research in Japan’s archaeoastronomy and cultural astronomy may not yield another Stonehenge, but interdisciplinary scholarship with astronomy as the base can help in understanding complex cultural associations and thus add to knowledge of the commonality that all cultures may have in their historical links with the sky.

## National Astronomical Observatory of Japan and the postwar Japanese optical astronomy

**Toshiyuki TAJIMA**, National Astronomical Observatory of Japan, 2-21-1, Osawa, Mitaka, Tokyo 181-8588, Japan (toshiyuki.tajima@nao.ac.jp)

National Astronomical Observatory of Japan plays a role of a center of excellence in Japanese astronomy today. At the time of immediate aftermath of the Meiji Restoration, however, when the predecessor of NAOJ was established, it had characteristics quite different from what it is now. In a course of its century-long history, the Observatory had changed its characteristics and role entirely. In this essay, I would like to trace a brief history of NAOJ from its establishment as an observatory (Kanshoudai) attached to the Department of Astronomy in University of Tokyo. Then I will take notice of the construction of three large instruments — two optical (and infrared) telescopes and one radio telescope —, examining how it can be related to the transformation of NAOJ, what significance they had, and what they had brought to NOAJ and Japanese astronomical community. Particularly, I would like to focus on the effort of astronomers to build Japan New Large Telescope, Subaru in 1980-1999, comparing with the case of the Gemini Telescopes which were also planned and built just around the same time in U.S.

## Western Astrology introduced in Nineteenth-Century Korea

**JUN, Yong Hoon**, Kyujanggak Institute for Korean Studies, Seoul National University, Seoul, 151-742, KOREA (sunbijun@gmail.com)

Because of its rarity, the *Sŏungyo* 星要(Essence of Stars), the only book on Western astrology during the Chosŏn 朝鮮(1392~1895) Kingdom, deserves attention. According to recent study, this is a handwritten book of 84 pages by Nam Pyŏng-ch'ŏl's(南秉哲, 1817~1863), a Korean Confucian scholar and astronomer. From the seventeenth century Korea witnessed a vast inflow of Western astronomy and calendar system (Shixianli 時憲曆) but no text on Western astrology has been referred to. So *Sŏungyo* is an exceptional case which shows the introduction of Western astrology into Korea in the nineteenth century.

I found that Nam's source book was a Chinese fortune-teller Ni Ronggui's (倪榮桂, 1755~?) *Zhongxi xingyao* 中西星要 (Essence of Stars in China and West) and it could trace its origin back to Ptolemy's (ca. 85~ca. 165) treatise on astrology, *Tetrabiblios*. Ni's book depended on two different sources, European and Arabic astrology. Some texts of Arabic astrology were translated into China in the fifteenth century. In the seventh century European astrology was introduced by Jesuit missionaries and Chinese co-workers. These two, however, commonly originated from Ptolemy's *Tetrabilblos*. Consulting my recent study of the *Sŏungyo* 星要, I will describe a long history of introduction of Western astrology into Korea via Chinese translations.

## Theories about cosmic structure in ancient and medieval Japan

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Many researchers of the history of Japanese science believe that Japanese in ancient and medieval periods had little interest in cosmic structure. It is true that the legends in "Kojiki" and "Nihonshoki", the oldest existing history books in Japan, say little about the stars. But it only means that people who lived in Yamato, the central region of the ancient Japan state who had transmitted those legends, were not interested in stars. In the $7^{th}$ century, the Japanese government introduced Chinese astronomy and astrology, however calendar calculators supported not the Theory of Konten(Huntian), the major theory in China at the time, but the Theory of Gaiten (Gaitian). I surmise it was the influence of the culture of the Liang dynasty, especially Buddhism. In medieval periods, when Buddhism wielded most influence, the Theory of Gaiten was unified with the Theory of Buddhism Shumisen(Sumeru-parvata), and many Japanese supported this theory. On the other hand, the onmyoji-astrologist supported the Theory of Konten. In the early modern era, when Jesuits came to Japan, then the onmyoji Kamo-no- Akimasa learned western astronomy from priests, and was baptized. I infer that he thought western astronomy reinforced the Theory of Konten. For that reason I assume that, as the theory about cosmic structure in western astronomy was closely related with Christian belief, Akimasa became Christian.

## Planetary models as expounded by Bhāskara in his commentary on *Āryabhaṭīya*

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In Indian astronomical tradition, one can find a clear description on planetary models, namely the eccentric and epicycle models. These models explain some of the celestial phenomena such as the variation in the brightness of the planets etc. The first text which mentions these models is the *Āryabhaṭīya* of Āryabhaṭa, composed in 499 AD. By virtue of being very terse in nature, several commentaries have been authored on it and one of the brilliant expositions is the *Āryabhaṭatantra-bhāṣya*, of Bhāskara I, (c.629 AD).

Āryabhaṭa, towards the end of the *kālakriyāpāda*—the third chapter of *Āryabhaṭīya*—gives a succinct account of planetary models in about five verses. Bhāskara, besides his exposition on this section, has introduced and discussed the topics, such as the correction due to the longitude of the local place known as *deśāntara-saṃskāra* etc., that are not explicitly stated in *Āryabhaṭīya.* He explains the *mandakarma*, which is equivalent to the 'equation of center' correction in modern astronomy. He then proceeds to discuss the epicycle model explaining the reason for introducing it. A graphic description of how to draw sketches on the ground, for a geometrical representation of these models is quite interesting. *Bhāskara* then explains the other correction namely the *śīghrakarma*, which is the equivalent of heliocentric to geocentric transformation. The present paper aims to discuss this section of the commentary, with several illustrations and in a language that is palatable to a modern reader.

## Tenmon bunya nozu of Sibukawa Harumi and Star maps of Joseon

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Tenmon bunya nozu 天文分野之圖 is a valuable star map which is uniquely existed in the Shoushi-li 授時曆 based planispheres. In 1677, it was made by Sibukawa Harumi 澁川春海 (1639-1715) who was a famous astronomer of the Edo period made the first Japanese own calendar, Jokyo-leki 貞享曆. Generally, it was known that Tenmon bunya nozu based on the observational data of Shoushi-li and it was related with the Korean star map Chonsang yulcha bunya jido 天象列次分野之圖. Additionally, however, we found that it was also referred another Korean star map, Honchundo 渾天圖 which was made in similar period. Meanwhile, shape and disposition of circumpolar and other parts were partially modified by Harumi. In this study, it will be discussed on the relationship between Tenmon bunya nozu and Korean star maps with the characteristics of the Tenmon bunya nozu.

## Drawing Method of the Korean Star-Chart, Chonsang-Yolcha-Punya-Ji-Do

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A drawing method of the Korean stele star-chart, Chon-Sang Yol-Cha Punya-Ji-Do, is investigated. The star-chart was engraved in December 1395 A.D. in the lunar calendar, based on a rubbing of an earlier stele. The chart is a circular display of the sky centered on the north celestial pole. This is a typical extent star-chart, whose comparable example is the Suzhou planisphere engraved on stone in 1247 based on an earlier drawing of 1193 A.D.. We devised a drawing method based on several observational facts of the star-chart itself, including the projection method, the center of the equator circle, and the width of lunar lodges and twelve equatorial sectors, and the positions of equinoxes. In order for the method to be self-consistent, only information in the scripts on the star-chart is considered. The method is also compared with the description on the drawing method of extent star-charts described in Chinese history books. The relationship between the extent star-chart and the ancient sky-globe is discussed.

**An Classification of Timekeeping Instruments in East-Asian Countries and Inventory of Significant Relics Prior to Pendulum Clocks**

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Timekeeping instruments are known to be various types with regard to their functions. In order to survey and inventory surviving relics in a global scale, classification scheme ought be required. In the last two triennials or so, a number of anonymous researchers may have been attempted for the museum duty or private hobby, but theirs are not exposed to others hiding in a shelf or in a back of drawer. There are, fortunately, two independent attempts by Juergen Hamel(2004) and Nha Sarah L.(2004, 2006) are known. The former is the glossary classification of all astronomical instruments with sundials as a part, and the latter the sundials in the Far Eastern countries with some detailed classification.

The present paper is a classification of timekeeping instruments prior to pendulum clocks as a partial fulfillment of long-term project of the classification of all kinds of astronomical instruments. Contents of this paper will show (1)classifications of numerous East-Asian timekeeping instruments and (2)limited demonstrations of historic instruments and of their significances.

**How were eclipses memorized when there were no astronomers?**

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There has been a total or annular eclipse in almost all small areas of the world at least every one hundred years. But strangely enough, a very small number of eclipses, or sometimes none, has been memorized by the people who lived there. Fortunately, we have several examples in ancient Greece and sporadic examples in Japan and Russia such that special historical events took place together with the eclipses, and memorized by special writers. Citing these examples, we propose three conditions for the eclipses to be memorized by people and remained in the history. We argue that one of the oldest mythological records in Japan, which is frequently interpreted as an experience of watching a total eclipse, may satisfy the three conditions. If it is the case, then some insight into the ancient history of Japan is possible. As a by-product of our argument, the traditional and widely-spread idea of worshipping the Sun-God in ancient times may be denied.

## A Survey of Arabic-Persian Sources on Astrolabe extant in India and on the Indian School of Astrolabe-Makers

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It is well known that the most important instrument developed by Islamic practical astronomers was the *Astrolabe* (in Arabic *Asturlâb).* According to Matvievskaya and Rozenfeld (1983), out of 767 treatises written on astronomical-mathematical instruments by Islamic astronomers, 349 tracts were on astrolabe. Here we are interested in presenting the contribution of Medieval Indian astronomers to the promotion of this important instrument.

1. We present first details of extant standard treatises/tracts on astrolabe : four Arabic tracts by al-Bîrûnî (d.1048) are extant in Indian collections. Bîrûnî translated into Sanskrit the most important one: "*Exhaustive study of possible Method of Construction of the Astrolabe*" (*Istî'âb al-Wujûh al-Mumkina fî San'at al-Asturlâb).* Others are: One tract by Muhîuddîn al-Maghrabî( d.1290) , and 3 tracts by Bâhâuddîn al-'Âmilî (d.1622) . A Persian tract "*Twenty Chapters on Astrolabe*" by Nasîruddîn Tûsî (d.1270)) is extant with about 70 manuscripts in India and Pakistan. Further, we present details of about 50 tracts/treatises extant in Indian collections including about 40 by Medieval Indian scholars.

2. A school of astrolabe-makers sprang up in India also during the Mughal period. We report briefly this school of Alahâh Dâd and his descendants: The Lahore school , after Sarma.

3. During the Sultanate (pre-Mughal)) period, a court astronomer of Sultan Fîrûz Shâh Tughlaq (d.1388), Mahendra Sûrî, wrote in Sanskrit the *first* book on astrolabe: *Yantrarâja*. This book initiated a spade of Sanskrit tracts on astrolabe. We report briefly the recent works by Sarma and Ohashi.

## An Analysis on the Operation Mechanism and Restoration of Song I-Yeong's Armillary Clock

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The purpose of this study is to build an armillary clock(Korean pronunciation called "*Honcheonsigye*") that duplicates the structure and operational mechanism of the armillary clock that *Song I-Yeong*(宋以穎, 1619~1692) built in 1669. To achieve the comprehensive understanding of the clock that was necessary for such a task, thorough investigations into its history and working mechanism were undertaken. Its historical significance in relation to the developmental history of astronomical and timing devices was examined. Each of many different parts was analyzed for its structure and mechanism, and the connections between different parts and operational mechanism were investigated. Finally blueprints of the armillary clock were drawn, an organic system of the different parts was worked out, and a new model and eventually an operational apparatus was successfully built.

In constructing his armillary clock, *Song I-Yeong* combined the structures and mechanisms found in East Asian traditions of horological instrumentations with those of clockwork devices developed in Islam and West. It represented the most advanced state available at the time. By reconstructing an operating model duplicating his armillary clock, we could clearly and systematically understand the actual operation mechanism of *Song I-Yeong*'s Armillary Clock.

## Production and Application of Ganpyeongui during Joseon Dynasty

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A lot of western astronomical knowledge were influenced to late Joseon Dynasty passing through China. Astronomical instruments, star maps, and astronomical books were imported from China, which were made or written by western Jesuit priests. One of them is Ganpyeongui(簡平儀) that is named as organum Ptolemei or Rojas Astrolabe. It is used as a kind of astrolabe accessory for finding the Sun's rising and setting time, and the duration of day and night at any latitudes and seasons.

Ganpyeongui remains at two museums which are The National Falk Museum and The Museum of Shilhak. Former one was made precisely by Joseon astronomers in 1718, who had worked at the Royal Observatory in Joseon Dynasty. We study how it is producted and applied for making calendar. Especially we analyze the accuracy of the instruments for production and application.

## Two Systems of Indian Astronomy

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The origin of Indian astronomy has been controversial for centuries, sometimes due to the Indian communalistic view as well as Western imperialistic view. Now we should investigate the history of Indian astronomy from astronomical point of view without modern prejudice. We can read several Indian original sources both in original Sanskrit as well as English translation thanks to several Indian and Western savants who were well versed in both of Sanskrit and astronomy. We should succeed their efforts, and investigate the development of Indian astronomy from purely scientific point of view.

In the history of astronomy in India, the *Vedāṅga* astronomy is the first systematic mathematical astronomy. And then, the Classical Hindu astronomy was created, which became the basis of later Hindu calendars etc. which are still used in modern India. These two systems are quite different. In this paper, I would like to discuss these systems from astronomical point of view, and compare them with ancient Mesopotamian astronomy and ancient Greek astronomy respectively.

In the case of the *Vedāṅga* astronomy, some people suspected that it was influenced by ancient Mesopotamian astronomy, but I shall show that they are independent, and they were created at their own places which are located at different latitude. In the case of the Classical Hindu astronomy, there are certain similarities with ancient Greek geometrical planetary model, and there should be certain Greek influence, but there is also certain Indian originality. We should investigate the development of geometrical planetary model in India.

## Planetary Theory in China

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Planetary theory had been one of the most important part in Chinese mathematical astronomy since the existing oldest Chinese calendar-making system, the *Santong li*, was compiled in 104 BC. The aim of planetary theory in traditional Chinese astronomy is designed for calculating its true geocentric longitude at arbitrary given time. Quite different from the geometrical system in Western tradition, the Chinese planetary theory always took the numerical model which was constructed with some astronomical tables. Its theory consists of two parts:

1. Made use of an astronomical table in a synodic period and interpolation, its mean geocentric longitude of the planet will be determined. This step is permitted under such a hypothesis that both of the planet and the earth are in mean motion around the sun. Taking Mars in the *Jiyuan li* (1106AD) as an example, the result shows that the average error of its mean geocentric longitude in a synodic period is about 4'.
2. Made use of another astronomical table and a related function to calculate the deviation between the true and mean geocentric longitude of the planet. In this talk, we will try to reveal the astronomical meaning of this step in Chinese planetary theory.

Roughly speaking, the evolution of planetary theory in China could be described as follows: Before the phenomena of irregular movement of the earth's and planet's revolution were discovered by Zhang Zixin in around 550AD, only was its mean geocentric longitude of planet calculated by calendar-makers. We call that it is the period of double-circle model.

From Liu Zhuo's *Huangji li* (600AD) to Yixing's *Dayan li* (724AD), an algorithm for the deviation between the true and mean longitude of planet was made use. This deviation was supposed caused by the equation of center of planet only while the earth moved around the sun in mean motion. We call that it is the period of circle-elliptic model. In the *Chongtian li* (1024AD), the equation of center of the earth was incorporated in the deviation between the true and mean geocentric longitude. From then on, no substantial changes were made on the planetary theory in traditional Chinese mathematical astronomy. We call that it is the period of double-elliptic model.

## The merit and demerit of geometrical representation in the history of Chinese calendrical science

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In 1957 when I read the galley proof of Needham's volume 3, I found he completely missed the significance of calendrical science. At Needham puzzle no.1, 'Why Scientific Revolution did not occur in China.' I thought that calendrical science is most important exact science of the East: the counterpart of Kepler-Newton tradition of mathematical astronomy in the West. So, I decided my Ph.D. thesis topic to be on calendrical science of China and wrote to Yabuuti to work with him who spent his whole career to work on Chinese calendrical astronomy, though his work was not known outside of Japan as he never published in English. My Ph.D. thesis was devoted on the analysis of on the Shoushi li of the 13th century, which I consider the crowning achievement of traditional Chinese astronomy.

During the 1960s, I collaborated with Yabuuti on the translation of Shoushi li. We could not understand the physical meaning of the concepts, 'Limit Degree' in its planetary theory. Yabuuti applied modern Keplerian as well as Greek geometrical model but it did not work. He gave it up in 1967 saying it's incomprehensible from the view-point of modern astronomy.

I asked a Chinese historian of mathematics Chu Anjing who rigorously applied Whiggish geometrical approach but could not reach to a clear cut geometrical concept. I reconsidered what Takebe hinted in his commentary of the Shoushi li, and reached a conclusion that what we have been looking for was modern geometrical concept. Actually it was algebraic concept that cannot be expressed nicely in geometrical terms. Thus, what Yabuuti called modern astronomy was actually geometrical, while traditional East Asian astronomers employed purely numerical or algebraic. Yabuuti's geometrical approach is good for us to understand Chinese astronomy in modern way but it is occasionally misleading because of its Whiggishness.

## The Accuracy of the Eclipse Calculation of the Huihuilifa

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Besides the traditional and official astronomical system *Datongli* (大統曆, literally "Great Union System of Calendrical Astronomy"), there was another astronomical system named *Huihuilifa* (回回曆法, The Muslim system of calendrical astronomy) also officially adopted by the Bureau of Astronomy（欽天監）in Ming China(1368-1644). These two astronomical systems were used and compared with each other by the Ming Bureau of Astronomy until the end of the Ming Dynasty. Many former articles of the topic of these two astronomical systems do not deal with research on the eclipse prediction accuracy of them. In this paper, based on the copy of *Huihuilifa* collected in the Interior Department of the National Archives of Japan in Tokyo（日本内阁文库）, which is the original version of Bei Lin's rewriting of *Huihuilifa* in 1447, the eclipse accuracy of this calendar was analysized with the method through the computer software which was developed by ourself. And then we compare it with the eclipse calculation of *Datongli*. From these calculation and some original documents that recorded in the *True Records of the Ming Pure Emperor* (明實錄 MingShilu), we concluded that the accuracy of *Huihuilifa* is not better than *Datongli* as to the middle of eclipse, but on the calculation of the magnitude of eclipse, the *Datongli* couldn't hold its advantage over *Huihuilifa*. The reason of these features is related to the calculation accuracy of the moon location in *Huihuilifa*.

## Investigation of the Earth's Rotation using Ancient Chinese Occultation Records

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Records of ancient solar eclipses have been used for the investigation of the variation of the Earth's rotation speed. In addition they can be used to study whether or not the Moon's tidal acceleration has been constant since the ancient times. Lunar occultations of planets and bright stars were often observed and recorded in ancient China, but visible areas of lunar occultations are usually wide, and therefore they are rarely usable for our studies. However, we show here that some of such events play an important role to determine the Earth's rotation. The lunar occultations of Venus on 503 August 5 and of Saturn on 513 August 22 recorded in the Chinese history book Weishu are such examples because the former was observed just after rising in the east and the latter was observed just before setting in the west, and therefore the combination of them sets limits of the Earth's rotation parameter. There is another example of using a record of an occultation. A total solar eclipse was observed by Plutarch, who was a Greek philosopher and biographer in the 1st century, but the date and place of the eclipse was not known. With the help of the records of a total solar eclipse and an occultation in China we derive the most probable date and place of Plutarch's eclipse.

## LITTLE KNOWN ASTRONOMER IN THE LATE ISLAMIC PERIOD; A STUDY OF QĀSIM-ALĪ AL-QĀYINĪ'S MANUSCRIPTS

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It is widely believed that the advance of science in the Islamic world after the mid-15th century suffered a decline. For the purpose of for the purpose of examining this belief, a work Qāsim-Alī al-Qāyinī (ca. 1685 A.D.) was chosen based on previous works which had considered it a valuable source in the History of Optics and had not been studied before. After studying his major Optical manuscript titled "Manāzir wa Marāyā" it was found very interesting that the majority of his propositions relating to natural phenomena are not merely geometrical definitions and that proofs were related to Astronomy. As an example, in one case, which had not been explained in previous Astronomical and Optical manuscripts, he tried, lacking a vigorous proof, to show how a special point in a room can be lit up by the Sun light trough out the year. In another example, he proves the formation of rainbows based on the position of the Sun and Observer and interestingly uses mountains in his proofs which were not employed before. His particular interest in Astronomy led us to a general study in his other works and it is worthy to note that out of the 19 works that have been attributed to him, 11 are devoted to Astronomy and fascinatingly none have been thoroughly studied yet! Previous to this work on "Manāzir wa Marāyā", only one of his other manuscripts on commentary of the Quran had been studied. Much more work is required to study his Astronomical manuscripts to obtain a better understanding of al- Qāyinī, the century he lived in and the general state of science in the late Islamic period. After all, due to all the not-yet studied manuscripts that exist, maybe this decline is not as rapid as previously assumed.

## The Movement of Observation Center in the Eastern Han Dynasty, China

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Chinese astronomers observed the sun shadow length and knew the winter solstice and summer solstice then made Chinese Luna-Solar calendar. They used the 8 "Chi" (about 240cms) height gnomon because the sun shadow length would be 6 "Chi" length at the vernal equinox day and the autumnal equinox day, that is to say, the ratio of the right triangle would be 3:4:5 at the Huang He river (or Yellow River) basin.

One of the oldest mathematical arts of the "Shu" in Qing dynasty was discovered in 21st century and kept at the Yuelu School, Hunan University, China. There was a kind of Pythagoreans' theorem in the "Shu", therefore the author supposes that ancient Chinese astronomers and mathematicians understood the right triangle ratio of 5:12:13.

In the Eastern Han dynasty, Chinese astronomers moved to southern observation center and observed the sun shadow length. But the sun shadow length at the vernal equinox day was 5.25 "Chi" lengths and one of the autumnal equinox days was 5.5 "Chi" lengths. And the author supposes if Chinese mathematicians decided the 24 seasons by not even days, that is to say, they did not used "Pingqi Method" (lit. even season method).

## Emergence of modern astronomy and astrophysics in Uzbekistan

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The Ulugh Beg Astronomical Institute of the Uzbek Academy of Sciences (Tashkent astronomical observatory in 1873-1966) is the oldest scientific institution not only in Uzbekistan, but in the whole of Central Asia. During its almost 140 years' history, UBAI staff worked on different problems of astronomy, geodesy, meteorology, seismology, gravimetry etc. Many of these problems, such as the determination of geographical coordinates of Central Asian localities, time service, solar watch, satellite ranging have had a big practical importance. In the present paper we reviewed the main astronomical branches on which UBAI has worked. Before opening Mt.Maidanak, UBAI was mostly known as an astrometric institution. Today the institute is still continuing some "classical" duties, such as global geodynamics and plate tectonics (UBAI hosts two ground based beacons of the GPS system located in Tashkent and Kitab as well as the French DORIS system beacon). But the main fields of research is now being conducted in the field of astrophysics. These are: non-stationary stars, open clusters, extragalactic astronomy, physics of the solar corona, helioseismology, asteroids, site testing etc.
Theoretical investigations are concentrated in relativistic astrophysics of magnetized compact objects (neutron stars, black holes etc.), non-stationary models of galaxy formation.

## Could Oriental annals have recorded optically-bright γ-ray bursts?

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The brightest optical flash yet observed from a γ-ray burst (GRB) was, for half a minute, a naked-eye object. Several other GRBs have produced optical transients only slightly fainter, and there is strong evidence that in a significant number of cases, observations began too late to record the peak magnitude. We consider the statistics of over 300 GRB transients and argue that, based upon these data, many such optical events would have been visible to the unaided eye in the course of human history. We consider the likelihood of discovering relatively short optical flashes with the unaided eye, and the probable brightness required. The most likely repositories of historical observations are records from the Orient, and we have located and discuss a number of candidates from Chinese sources. All of the records uncovered thus far fall short, however, of being ideal GRB candidates. We consider the value of such observations, should any very likely ones be uncovered, to modern astrophysics.

## Nobeyama Radio Observatory and the History of Radio Astronomy in Japan

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I review the history of radio astronomy in Japan with emphasis on the Nobeyama Radio Observatory and its scientific achievements. The history of radio astronomy in Japan traces back to the early 1950's, when a 10 m equatorial telescope was built in the Mitaka campus of Tokyo Astronomical Observatory (TAO; current NAOJ) and started solar and later cosmic radio observations at 1.4 - 3 GHz. While a 24 m spherical mirror telescope in Mitaka and a 26 m antenna at the Kashima campus of the Radio Research Laboratory (current NICT) was used for radio astronomy in the 1960's, millimeter wave astronomy was recognized as an important direction for the future. The 6 m millimeter wave telescope was then built in Mitaka in 1969, when the Cosmic Radio Division was established in TAO. Along with the discoveries of new molecular species and transitions in the interstellar space with the 6 m telescope in the 1970's, molecular line spectroscopy was known to be a fruitful field. In 1970, the Science Council of Japan recommended that a large aperture millimeter wave radio telescope should be build. It took 7 years of pioneers efforts until the full funding for the Nobeyama 45 m telescope and 5 element 10 m interferometer in 1977. They were completed in the early 1980's and started to produce world frontier science for Japanese astronomers.

## The transition of characteristics in Japanese celestial globes of Edo era from the collection of National Museum of Nature and Science

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Investigation of Japanese celestial globes manufactured in Edo era shows development and popularizations of Japanese astronomy during Edo era. We have the largest collection of celestial globes in Edo era in National Museum of Nature and Science, eight of about forty existing celestial globes. From investigation, characteristics of each globe such as refered star maps, manufacturer, date, skill and so on are found.

From the comparative study of eight celestial globes and related globes in other location, they are found to be classified into three types. First-type: celestial globes manufactured mainly in the early term of Edo era, which had been designed following on traditional Chinese star maps. Second-type: globes manufactured in middle term of Edo era following on 'Tennmon Seisyou'(1699), Harumi Shibukawa's new star map based on his observation. Third-type: globes manufactured in late term of Edo era following on star maps influenced from western astronomy through 'Gisyo Kousei'(1752). However, this classification dose not fit for all globes, because manufacturer of each globe has different astronomical background. Some discussion on this matter is also shown in this paper.

## Two Bronzed Planispheres preserved in England Since 1878 and Japan Since 1683

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Two bronze planispheres had been discovered in Japan and in England. Diameter 35 cm.3 cm thick, two magnetic compass on the edge, star map of the Chinese-style circular stars of about 1,400 on the center and the equator, the ecliptics, the lunar lodge(xiu),the borders of the lunar lodge, Milky Way are displayed.

We had carried out to study the Planisphere which had been preserved in National Scottish Museum, Edinburgh since 1878 ,which we had an opportunity to examine in 2004 and compared our results with the "Bundo no kiku" (Planisphere) preserved in Saga National Museum, Saga prefecture, Japan ,which we had studied since 1980.

"Planisphere" in 1878 (Meiji 11) is extracted from the Japanese Junk (the sailing ship) wrecked on the coast of the Izu Islands, Japan, on the record and was housed in the Royal Scottish Museum (the old National Museums of Scotland) in Edinburgh UK.

At first in UK it's a compass equipped with the celestial astrograph which based on old Japanese observation and represented a portion of heavens visible stars in old Japan but as it becomes to study the Asian old planisphere actively scholars made clear it to be Chinese celestial astrograph. While in "Bundo no kiku" as a similar type instrument as the Planisphere the back-writing of it shows clearly the replica making in 1668 for surveying instrument of the army.

Based on present paper it seems substantially not to be any difference between the Planisphere and "Budo no kiku", but we find several differences obviously. According to our result there seems to be the parent-child relationship between the Planisphere and "Bundo no kiku" making together in 1668 or the Planisphere might be an accurate replica of "Bundo no kiku" of which made to keep as an art exhibition after 1668. If it be true any more "Bundo no kiku" will be found in future, Japan.

## A Restoration of 15th Century Korean King Sejong's Striking Clepsydra at National Palace Museum of Korea

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The Striking Clepsydra *Jagyeongnoo* at Time Annunciating Pavilion *Borugak* was made by Palace Guard and court engineer Jang Yeong-sil under the commission of King Sejong (r. 1418-1450) in 1433. It was installed at *Gyeongbokgung* where the Royal Observatory *Ganeuidae* was located. It has been used as the standard timekeeper since the first day of July, 1434. According to the striking clepsydra, the noon, and the curfew alert time and the curfew lifting time of the capital city Hanyang (now Seoul) were announced by bell sounds. During the *Joseon* dynasty (1392-1910), there were two reproductions and/or repairs in 1536 and in 1618 respectively. King Sejong's clock was burned out during the Imjin War in 1592. In 2004 National Palace Museum of Korea set out to reconstruct King Sejong's clock and the began to display the reproduction to public from November 2007. The uniqueness of this clepsydra was its capability of announcing twelve double-hours and five night-watches with its points automatically with visual and acoustic signals. This paper will describe the processes of reproduction systematically in terms of mechanical and functional details. It encompassed four major part following the order of time-signal flow; 1) the clepsydra, 2) digitalized time signal generator, 3) mechanical power amplifier, and 4) visual and acoustic time-announcer. And features and the origins of the clepsydra will be discussed.

## A peculiar manuscript from Delisle's jesuit correspondence

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During a search in Delisle's correpondence (*Observatoire de Paris* Archives), exchanged with Jesuits both in Asia and in Europ, was found an *Histoire du Japon traduite du Chinois par M. l'Evêque d'Ecrinée*. Joseph-Nicolas Delisle (1688-1768) was an astronomer who began to collect letters and astronomical observations from 1709, having in mind to use them for writing an historical treatise on astronomy. This short history, via chinese language, recalls many different aspects of Japan, its inhabitants, their uses,… A sub-title writes *Prêté par le R. P. Patouillet,* a French Jesuit who never went to Asia, meaning that it twas kept by Delisle. A search is made to understand why this manuscript is in astronomical archives of an astronomer who was in Russia and Siberia (about twenty years), became a Professor in the *Collège Royal* in Paris and ended his life as an *Astronome de la Marine* in France.

## A Lunar Map *Taiin-no-Zu* Depicted in 1813 by a Japanese Feudal Warlord

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In pre-modern Japan astronomical activities culminated during 1790s - 1830s. Telescopic observations of planets and stars were mainly conducted by telescope-making artisans and relevant amateur astronomers, while professionals represented by the Shogunal astronomers showed no interests to such a theme. Several elaborate sketches of the Sun, Moon and planets from the above time now exist. Among them, the material I introduce here is very unique in that it is not simple sketches of the Moon but a colored "lunar map" composed from observations at various phases --- very similar to the European selenographical maps eagerly observed and published in the latter half of the 17$^{th}$ century.

This lunar map entitled "*Taiin-no-zu*" (Figure of the Moon) was depicted by Hotta Masatami a feudal warlord based on his own observations of 1813. He painted it responding to the order of his father. We found out that the father also had let a vassal of a different warlord draw another lunar map in 1799.

This lunar map of 1813 is characterized by very detailed description of the lunar surface features, suggesting the use of high-magnification telescopes such as Gregorian reflectors. In particular, light rays emanated from the craters Tycho and Copernicus are drawn so realistically and artistically that their description does rival those by Cassini (1679) and La Hire (1702). Although keen interests in Europe towards the selenography in the late 17$^{th}$ century were motivated by the then belief that the Moon was a habitable and creature-bearing world, the reason why Masatami and his father were so enthusiastic in making lunar maps is unknown. We speculate that they wanted to confirm by themselves a copperplate engraving of the Moon published in 1796 by the famous artist Shiba Kokan, whose print was based on the lunar sketches of 1655 by Jesuit astronomer C. Scheiner.

## Star Mandaras, as visual images in which Buddhism coexists with astronomy or astrology

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Star Mandaras belong to Esoteric Buddhist paintings of Japan, and are also called *Hokuto Mandara*. These paintings are varieties of the graphic diagram of Buddhist deities depicted in regular systematic arrangement in conformity with certain iconographical rules, and used in Esoteric Buddhist rituals to wish for longevity or to protect the nation and the people from disasters by worshipping the stars and constellations. As there are no works similar to Star Mandaras in composition in India, nor in China or in Korea, Star Mandaras are thought to have their origins in Japan. In spite of being said that Star Mandaras are created in the middle of the Heian period (10-11c), the oldest extant example of these paintings is made after the late Heian period (12c). These paintings can be generally categorized as either circular or square in form, and they depict the stars and constellations: the Big Dipper, the Nine Planets, the Twelve Constellations of the Zodiac and the Twenty-eight Stellar Mansions centering around *Ichiji-kinrin*. It seems that the arrangement of these images is based on the ideas of Esoteric Buddhism itself, however, it has close connection with the knowledge of astronomy or astrology. We can also see the aspect in which religion and science live together. The principle of the composition of Star Mandaras should be defined.

## Incheon Meteorological Observatory and Comet Herschel-Rigollet

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The Incheon Meteorological Observatory was established (in Korea) by the Japanese government in 1904; from 1910 (i.e., Japan's Annexation of Joseon) to 1945 (i.e., the end of World War II), the observatory carried out the functions previously undertaken by Gwansang-gam (觀象監; the Royal Astronomical Bureau of the Joseon dynasty). The primary objectives of the observatory were to observe weather and earthquake patterns, publish astronomical almanacs, and so on. An astronomical dome was built around the observatory (completed on March 30, 1929) and a 6-inch (f/15) equatorial telescope was set up six months later. According to our investigation, the telescope was definitely used for observations of Herschel-Rigollet (35P/1939 O1, 1939VI, 1939h) and Kaminsky (1939i) comets in 1939 and the solar eclipse in 1941; other observations might have been made using this telescope. In particular, the observation records for the Herschel-Rigollet comet obtained by Yumi Shigelu (弓滋), a Japanese astronomer, were published in the next year; (1940). However, the astronomical community did not pay much attention to these records. In this paper, we present some details about the Incheon Meteorological Observatory and also present the observation data on the Herschel-Rigollet comet recorded by Yumi. In addition, we discuss the accuracy of Yumi's observation data by comparing it with the data derived from well-studied orbital elements.

## The Emergence of Astronomy in Thailand

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Astronomy was introduced to Siam (Thailand) for over 300 years ago in the reign of King Narai, the Great. First astronomical observatory was built in Loburi province by French missionaries and various astronomical instruments were brought to Siam at that time. After King Narai, astronomy had been neglected for over 180 years until the reign of King Rama IV whence astronomy became more popular. Members of the royal family, King Rama IV in particular, was very interested in astronomy and hence became the patronage of modern astronomy in Siam. King Rama IV himself made the precise calculation of the time and location of the total solar eclipse which could be observed in Siam on August 18, 1868. However, modern astronomy in Thailand was developed quite slowly due to the slow development in educational system in the past.

Up to several decades ago, the policy on the development of astronomy and astrophysics both in education and research has been endorsed in the national education as well as science and technology plans.

Research and education in Astronomy have been offered in major public universities since 1930. In 2001, the Basic Education Curriculum B.E. 2544 was established and has stated the learning substance into 8 subject group including science. Within science subject group, astronomy and space is one of the 8 substances. In 2004, the Thai cabinet approved the proposal on the establishment of the National Astronomical Research Institute of Thailand (NARIT). NARIT is the main astronomical institute of the country which plays important roles not only in astronomical researches but also supporting astronomical educations and outreach activities.

## The sky and the Agro-Bio-Climatology of Java: Need critical reevaluation due to environmental changes

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The Javanese agricultural calendrical system which has been used since the 9th century is a manifestation of the need to establish the exact dates for agricultural activities and the related rituals. The sky phenomena were used together with natural phenomena on the earth to determine the seasons.

The calendar system named "Pranotomongso" was proclaimed by the King of Surakarta in Central Java (1855). The text accommodated the guidance on how to employ the sky phenomena and include them into the tropical year that was divided into seasons to serve the need for agricultural activities. Environmental perceptions was part in their view of change and, accordingly, in the ethics of preserving the nature.

The peasant farmers were bound by traditional practice to cultivate the lands in the proper way and at the appropriate times to obtain the maximum yields of crops. Like any other system of calendar the observable smallest unit of time is called the day. Months varied from 23 to 43 days to accommodate the specific character of the season called "mangsa", the whole tropical year was divided into 4 unequal length of "mangsa". The first two "mangsa" comprised 6 unequal length of months. The sequence was reversed in the following six months so as to complete one tropical year. Leap year was introduced to maintain synchrony with the tropical year. The constellations Orion and Crux were decsribed.

The development of indigenous astronomical systems in tropical cultures centered toward a reference system consisting of zenith and nadir as poles and the horizon as a fundamental circle. Influences, due to interactions with Indian and Islamic cultures, left their marks in the time keeping.

Now man-made efforts penetrated the natural setting, and disrupted the harmony of nature as well as ecological imbalances. That has made the traditional time keeping difficult.

## The Flying HIRAYAMA: Escape from Asteroid Families

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Escaping from early trend of Japanese astronomical studies after the Meiji Restoration, HIRAYAMA Kiyotsugu(1874-1943) opened up a new field, research on the motions of asteroids using advanced techniques of celestial mechanics such as secular perturbation theories. On the other hand, his later studies in astrophysics using his capture theory of stars eventually resulted in failure in spite of his eagerness.

A hypothesis of resisting medium was an important idea of his researches on asteroids, and a key idea of his capture theory of stars. Hirayama's capture theory is that a mass of resisting particles in the interstellar space can capture several stars passing through it, and that the stellar energy can be provided not by the sub-atomic energy or the annihilation of matter but by the energy originated from meteoric materials, or resisting particles. However, nobody supported his conjectures.

Our report is an essay in order to place his conjecture of stellar energy in the history of astronomy from 1920 to 1932. Why did he reject the theory of stellar evolution in the style of Eddington? We will consider the subject under the following heads: (1) his attitude toward the theory of annihilation of matter; (2) his attitude toward the sub-atomic energy hypothesis; and (3) a lack of chemical approach in Japanese astronomers in those days.

Although Hirayama escaped from familiar region of his asteroid families, he could not make a landing on another new field in Japanese astronomical studies.

## The Contribution of the Ex-Georges Heights Experimental Radar Antenna to Australian Radio Astronomy

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During the late 1940s and throughout the1950s Australia was one of the world's foremost astronomical nations owing primarily to the dynamic Radio Astronomy Group within the Commonwealth Scientific and Industrial Organisation's Division of Radiophysics. The earliest celestial observations were made with former WWII radar antennas and simpler Yagi aerials, before more sophisticated purpose-built radio telescopes of various types were designed and developed.

One of the recycled WWII antennas that was used extensively for pioneering radio astronomical research was an experimental radar antenna that initially was located at the Division's short-lived Georges Heights field station but in 1948 was relocated to the new Potts Hill field station in suburban Sydney. In this paper we describe this unique antenna, and discuss the wide-ranging solar, Galactic and extragalactic research programs that it was used for.

**A Retrospective View of Australian Solar Radio Astronomy. 2: 1960-1985**

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By the early 1960s, the Australia had earned a worldwide reputation as a leader in solar radio astronomy research. By this stage the highly successful Dover Heights, Dapto, Potts Hill, Murraybank and Fleurs field stations of the CSIRO Division of Radiophysics had been de-commissioned to make way for the 64-m Parkes Radio Telescope and the construction of the radioheliograph at Culgoora in north-western New South Wales. The leader of the group investigating the active sun, John Paul Wild, had been awarded a large grant by the Ford Foundation for half of the cost of the Culgoora radioheliograph.

This paper follows the historical contributions from Australian scientific organisations, the CSIRO Division of Radiophysics, the Universities of Sydney and Tasmania, in the area of solar radio astronomy from 1960 until the demise of the Culgoora radioheliograph operation in 1985. The four criteria which can be attributed to the outstanding success of the Australian research effort during this period are:

i. Timing and serendipity,
ii. Innovative design,
iii. Support and funding, and Early outstanding scientific results.

# Abstracts of Poster Papers

## The Sword, the Snake & the Turtle - Three constellations from pre-modern China?

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This talk is intended not as a line-up of definite results, but as a basis for discussion of four combined motives on a Chinese coin-charm: 1. the "Big Dipper", 2. the sword, 3. the turtle and 4. the snake. The occurrence of astral symbolism on early coins made from bronze, silver or gold has long since been corroborated by thousands of specimen from the Greek, Celtic, Roman and of course the Chinese cultural spheres. Generally speaking these types of currency roughly date from the 4$^{th}$ century B.C. to the 4$^{th}$ century A.D. in Europe and from the Han-period (206 B.C. – 220 A.D.) through to the 19$^{th}$ century in China. At least from about the 1$^{st}$/2$^{nd}$ centuries A.D. coins were regarded as auspicious objects in China. Non-currency types of coins displaying cosmological symbolism like e.g. the "Big Dipper", the dragon, the snake, the turtle and the tiger were constantly cast as charms until the 19$^{th}$ century.

The characteristic arrangement and rendering of the four initially mentioned symbols allow for a hypothetical identification of three hitherto unknown Chinese constellations, namely the sword, the snake and the turtle, which –together with the "big dipper" - surround the pole of the ecliptic at even distances to each other and to the pole itself. The pole of the ecliptic according to the hypothesis is represented by the center of the coin, which was cast as an open-work square. In fact the four symbols form a cross-shape around the center just as the one certain and the three hypothetical constellations are aligned around the pole of the ecliptic. The sword-constellation consists of the central stars of *Cygnus* (without the outer wing-stars). The snake-constellation contains *Corona Borealis* as the distinct central coil, the four northern stars of *Hercules* as its head and the three northern stars of *Bootes* as its tail. The head, shell and tail of the turtle-constellation are accurately represented by the six major stars of *Cassiopeia*, the feet by two smaller stars immediately south of the celestial "W"-shape. These representations are found on a type of bronze coin that was first issued between 578 and 580 A.D.. All representations are rendered mirror-inverted as is also the case with a variety of prehistoric astronomical depictions from China and Europe.

## Replications of Ancient Star Maps by a Computer

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Ancient star maps are one of the major themes in the study of the history of astronomy in East Asia. However, in doing such research, there have been serious limitations because photos and figures of those star maps reproduced in books and papers were often too small or too unclear to discriminate minute letters and marks written in the charts. To alleviate this inconvenience, as an engineer who is familiar with using CAD software, I have for years replicated historic star maps of China, Korea and Japan using personal computers. Concrete techniques to reproduce large-format prints of the maps from the original ones will also be explained in my presentation. Computer-replicated maps are able to represent details precisely and clearly, and are easy to correct, update and print.

I present here the replications of several Asian ancient star maps, which are three Chinese, two Korean and two Japanese ones. Namely, the Chinese maps are: (1) Section of Schall von Bell Star Map (赤道南北總星圖 屏風, 1634), (2) Huntian Yitong Xingxian Quantu (渾天壹通星象全圖, 1826) and (3) Fang Sing-tou (方星圖, 1711), the Korean ones are (1) Hwangdo Nambuk chong-songdo (黃道南北總星圖, 1743) and (2) Honhap Byongpung-songdo (混合屛風星圖, ), and the Japanese ones are (1) Coloring star map on six-section-fold screen (六幅彩色天文圖屛風, 1759-1834) and (2) Chusei-gi Zu(中星儀圖, 1827).

## Guo Mo-ruo and Babylonian Astronomy: The Origin of the Chinese Twelve-Branch

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Guo Mo-ruo 郭沫若 (1892-1978) is one of the representative politician, novelist and historian in modern China, who first came to Japan in 1913, and was educated there. Because he was involved in communism activities after his return to the continental China, the opposing general commander **Jiang Jie-shi** 蒋介石 announced that Guo was guilty, and he exiled himself to Japan in 1928. In Japan he devoted himself to the study of the history of ancient China, and as a result, he recognized that reliable materials for his study were among the oracle-bone and the bronze inscriptions and needed to learn them.

The 22 characters of the Trunk-Branch 干支 appear very often in the oracle-bone inscriptions, whose system was originally contrived for the calendar. When he started learning the oracle-bones, he was much interested in the Trunk-Branch and studied its origin.

It is remarkable that in studying the twelve characters of the Twelve-Branch (十二支 12 zodiacal signs), he paid attention to the Babylonian astronomy**;** other Chinese at that time did not want to look for clues of the origin outside their own ancient civilization. On the other hand, western scholars had directed attention to clay tablets of cuneiform letters and pictorial materials since the 2nd half of the 19th century**;** German people were particularly eager in studying Babylonian astronomy .

For his study, Guo utilized mainly the book *Handbuch der Altorientalischen Geisteskulture* (1929, HAOG) by Alfred **Jeremias.** Although the book title seems to suggest no relation to astronomy, but actually the main theme of this book is ancient astronomy. HAOG includes not only wriiten materials but also many useful astronomical pictures. In my presentation I discuss how Guo made efforts to relate the Chinese Twelve-Branches to the Babylonian signs of zodiacal constellations.

## Discovery of Degrees in Ancient China

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This paper discusses a concept of degrees in ancient China and clarifies the theory of angle measuring for celestial coordinates. Ancient Chinese people were able to measure celestial coordinates without using a trigonometric function or a concept of radian. It has been known that "*tu*" (度) was used as a unit of the angle, and "*chhih*" （尺）as a unit of the length in China. The two main theses of this paper are as follows. First, we develop the concepts of the above Chinese two rules as measuring units and clarify their nature. The unit *tu* was used to know celestial angles of an inferior planet, the Sun and the Moon. The other is the unit *chhih*, which was used to measure a length between a superior planet and an arbitrary star, or a length of comet's tail. Secondly, this paper reports discovery of a formula for angle measurements in degrees, used by the people in the Han Dynasty (206B.C.–23A.D.).

The formula was not explicitly written in historical records. But it is possible to restore the formula from a picture of the cyclic quadrilateral in *Zhou Bi Suan Jing* (周髀算经) , and a carving on *Wu Liang Shrine* (武梁祠), depicting the woman and the man who turn a compass and a ruler to the sky. The former literature is the oldest and most famous mathematical text book of the Han Dynasty, and the latter is one of the oldest sculptures at the same time. The concrete mathematical form and meaning of the formula will be shown at the conference. Our study indicates that the formula provides angle-measuring errors of slightly larger than one degree for 11-31 degrees, but less than 1 deg. for other angle values.

## Accuracy of north-south orientation by the Indian-circle method of a gnomon and the use of the recorded ancient orientations

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The Indian circle method was used to know the north-south orientation in ancient worlds. The extension of the base line near the gnomon is possible by the use of several concaved mirrors reflecting sunlight as a bright spot in the mirror. The extention over the hill is possible by the help of flat places on the hill. The astronomical high accuracy is archived bythe naked eye to see reflected images of sun on the water surface sisilar to the use of the pinhole type projection aparatus. The accuracy of the survey projects buiding ancient capitals in Japan shows their north-south orientation errors are the same to the atronomical accuracy of the Indian circle. We propose to measure north-south orientations printed on their ground of 68 Kokubunji temples build at AD741 by the order of Japanese emperor. The active faults near the several temples would rotate their orientatins.

## Mathematical Astronomy of Seki Takakazu (關孝和) and Shibukawa Harumi (澁川春海) ------- Understanding and Overcoming the Chinese Traditional Calendars in the Edo Period of Japan

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Until the Edo (江戸) period (1603–1867), the Chinese classical calendars were exclusively used in Japan. The *Xuanming-li* (宣明暦) (9th century) was still used at the early Edo period, and its error was already apparent at that time. So, some people, including Seki Takakazu (關孝和) (ca.1640–1708) and Shibukawa Harumi (澁川晴海) (1639–1715), tried to study more accurate Chinese calendar, particularly the *Shoushi-li* (授時暦) (13th century). It is said that Seki, who was good at theoretical mathematics, understood the mathematical rational of the *Shoushi-li* more deeply. On the other hand, Shibukawa, who was an able practical astronomer, found that the *Shoushi-li* was not enough accurate. In the Chinese classical calendars, including the *Xuanming-li* and the *Shoushi-li*, the solar perigee was fixed to the point of winter solstice, but Shibukawa noticed that it was not true at his time. He found it through information based on Western astronomy. So, he decided to use a better position of the solar perigee, and also considered the terrestrial longitudinal difference between China and Japan. He became the first Japanese astronomer who made Japanese own calendrical system, which was named *Jōkyō-reki* (貞享暦) (used from 1685). His practical ability led him to success.

## Astronomy and Mathematics of Yixing

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Yixing (一行)(AD 683 – 727) was a Chinese Buddhist monk and astronomer in the Tang (唐) dynasty (AD 618 – 907) in China. He was a great figure of Esoteric Buddhism, and is well known that he made an excellent calendar entitled *Dayan-li* (大衍暦) in AD 727, which was once used in Japan also. In this paper, I would like to discuss his contribution in the field of astronomy and mathematics. I shall discuss a possible influence of Indian astronomy on Yixing in his new definition of *"mieri"* (滅日) in the *Dayan-li*. And also, I would like to discuss his method of interpolation which was used in the *Dayan-li*. Yixing started some new methods of interpolation. The meaning of his interpolation is controversial, and I would like to present my own view regarding the origin of the Yixing's interpolation method, and compare with another view of Qu Anjing. Anyway, his method can be understood as a natural development of Chinese interpolation developed in Sui and Tang dynasties.

## Ulugh Beg's catalogue of stars and al-Sufi's sky map

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Ulugh Beg (1394 – 1449) at the age of 17 became the ruler of Maverannakhr (Transoxiana), a part of his grandfather Amir Temur empire between the rivers Syrdarya and Amudarya whose capital was Samarqand in what is now Uzbekistan.

In 1420 Ulugh Beg built a gigantic observatory in Samarqand. Many years of activity of the Samarqand's observatory resulted in the Zij Ulugh Beg. The main part of the Zij is a catalog of 1,018 stars was not known in Europe until 200 years after its original compilations. However according to the dates of its compilation, 1437, and number of stars included it was the first observational catalogue to have been compiled since the second century, when Ptolemy reproduced the Hipparchos catalogue in his Almagest.

In order to recognize the stars he used *Book of fixed stars* of Abdul-Rahman al-Sufi, a tenth-century Iranian astronomer. Ulugh Beg ordered a copy of this book for his library. It contains seventy-four color drawings of the constellations. However, he found that the greater part of stars from al-Sufi's book are situated differently from their appearance in the heavens. So, he decided to determine their positions by own observations.

## Foundations of Harappan Astronomy

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Harappan Civilisation that flourished between 2500 and 1900 BC in western India and present day Pakistan, is one of the largest Bronze Age civilisations in the world. It is known for its several urban centres housing several thousand people with density of the order of ten to fifteen thousand per half a square km. Given that the civilisation lacked the knowledge of iron or horses the scale of their organisation is truly magnificent. It is therefore inconceivable that they would not have had strong astronomical traditions, if nothing else for calendrical and seasonal purposes. However, their astronomical knowledge is completely unknown. We therefore attempt to create a model of the possible astronomical knowledge that may have existed in the civilisation based on their intellectual capabilities derived from the archaeological evidence. We define the basic astronomical ideas that they would have found useful and interesting. We then analyse various aspects of Harappan sky and its relation to astronomy. We identify important stars and star patterns that would have been associated with specific seasons by the Harappans. Based on this we speculate on the nature of their observatories and observation techniques that they should have had. We show that there is an interesting association of this with a Harappan object where unusual patterns are depicted. This study is therefore an attempt at reverse engineering to look for the astronomical knowledge of a civilisation whose other capabilities are known. We hope that such interplay of ideas will enrich both archaeology and archaeo astronomy.

## Analysis of Solar Eclipses Records in Samguksagi

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Many kinds of astronomical phenomena were recorded in the Samguksagi(三國史記) that are the history of three kingdom period between BC 57 and AD 935. The number of records are over 250. Among them the solar eclipses is 67 records. We calculate and estimate the phenomena by computer logic for comparing with records in the Samguksagi. They are coincident with the records nearly 90%. Most of the records are appeared in Chinese historical books.
We study on the correctness of records using the calculated results and another astronomical phenomena. Some historians have been doubt about the historical records before the 4th century during the three kingdom period, which are not based on the real historical facts. We show two kinds of scientific evidences against the doubtful idea. One is that most of records are agreed with calculated results. The other is that some records can't be found in Chinese historical books.

## An Analysis on the Operation Mechanism and 3D Restoration of *Ongnu* in *Sejong* Era

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*Ongnu*(玉漏, Jade Clepsydra) is water clock made by *Jang Yeong-sil*(蔣英實) in 1438. It is not only automatic water clock that makes sounds every time by striking bell, drum and gong, but also astronomical clock that shows sun's movement over time. *Ongnu*'s power mechanism is used a water-hammering method(水激式) applied to automatic time-signal apparatus. The appearance of *Ongnu* is modeled *Gasan*(假山, pasted-paper imitation mountain) drawn *Binpungdo*(豳風圖, landscape of hard farming work scene) at foot of the mountain. The structure of *Ongnu* divide into top of the mountain, foot of the mountain, flatland. There are located sun-movement device, *Ongnyeos*(玉女, jade female immortals; I) and Four Gods(四神, shaped of animal-like immortals) in top of the mountain, *Sasin*(司辰, jack hour) and *Musas*(武士, warriors) in foot of the mountain, Twelve Gods(十二神), *Ongnyeos*(II), *Gwanin*(官人) in flatland. In this study, we could clearly and systematically understand the time-announcing mechanism of each puppets. Also we shows the working mechanism of sun-movement device. Finally, we could complete 3D model of *Ongnu* based on this study.

## An Examination of Astronomical Records in Vietnamese Historical Source

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We examined some articles on planetary phenomena in two Vietnamese historical sources, Viet Su Luoc (VSL) and Dai Viet Su Ky Toan Thu (TT), by comparing their description with the results of a simulation.
1) Among three articles (AD1153--1767) on a planet trespassing on another, two of them are consistent with the calculated apparent distance (0.5 deg and 3.1 deg) between both planets at the dates described.
2) Among 18 articles (AD1097-1772) which describe daytime appearance of Venus with the date or the month when it occurred, 14 of them are found reasonable.
3) Among seven articles (AD1448-1719) on apparent close approaches between the Moon and a planet, three of them are very reasonable (apparent distances of less than 1 deg between the Moon and a planet), one is marginally acceptable (a possible one-day shift of the date) and the other three are hardly acceptable (apparent distances of larger than 5 deg).
We also present some results of our examination of the articles on solar and lunar eclipses in VSL and TT.

## A Study of Korean Astronomical Almanacs for the period of 1864 – 1945

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We study Korean astronomical almanacs issued from 1864 (the first reign of Emperor Gojong) to 1945 (the end of World War II). During this period, Korea had undergone many changes such as the Gabo Reform in 1894, the enforcement of the Gregorian calendar in 1896, the Japan's Annexation of Joseon in 1910 and so forth. As the influence of these circumstances, the regulation and organization of the office responsible for publishing an almanac were reformed several times. Naturally, the format and content of a Korean astronomical almanac also had a lot of changes. For example, the Gregorian date and seven days of the week are added to the bottom of each lunar date in the almanacs of 1896 – 1908. Since then, the almanacs mainly consist of the Gregorian date. Regarding content, the longitudes of 127° 30′ E and of 135° E were used as the standard time during the periods of 1909-1912 and 1913-1945, respectively. In addition, there were changes in the system of hours, the reference point for the calculations of sunrise/sunset and true new/full moon times, and so on. In this paper, we review the regulation and organization of the office which took charge of publishing a Korean astronomical almanac for the period of 1864-1945, a cataclysmic era in Korean history. We also give full detail of various changes in the almanacs issued during that period.

## Williamstown Observatory and the Development of Professional Astronomy in Australia

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During the early 1850s the colony of Victoria was enjoying a succession of gold rushes, and as the population of the fledgling settlement of Melbourne rapidly grew, an urgent need arose for an accurate local time service. Thus, Williamstown Observatory was founded at the port of Williamstown in 1853. Under the dynamic direction of Robert Ellery, the Williamstown Observatory quickly added meteorological and tidal observations, geodetic surveying and non-meridian astronomical observations to its portfolio, and by the time it closed in 1863 it had already played a key role in the early development of professional astronomy in Australia. Ellery went on to direct Melbourne Observatory—Williamstown's successor—and in the process build an international reputation in astronomy, meteorology and scientific entrepeneurship.

In this paper we will discuss the founding and chequered history of the Williamstown Observatory, its scientific instruments and the ways in which they were used to contribute to Australian and international astronomy.

## The 1882 Transit of Venus and the Popularisation of Astronomy through the Pages of the *New York Times*

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After the disappointments of the 1761 and 1769 transits of Venus, the nineteenth century pair, in 1874 and 1882, offered astronomers the next opportunity to use these rare events in a bid to pin down a value for the solar parallax and hence that fundamental yardstick of Solar System astronomy, the astronomical unit. Only the 1882 transit was visible from the USA, and on the fateful day amateur and professional observers were scattered across the nation. While the value for the solar parallax derived from their combined observations was a significant improvement on the range of values obtained in the eighteenth century, there was considerable disquiet about the logic of using transits of Venus in this way when alternative approaches were available.

In this paper we discuss some of the observers who observed the 1882 transit from American soil, summarise the scientific results from the overall American endeavour and examine ways in which reports on the transit in the pages of the *New York Times* helped generate a heightened public awareness of astronomy.

## Al-Sufi's Investigation of Stars, Star Clusters and Nebulae

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The distinguished Arabic astronomer, Al-Sufi (AD 903–986) is justly famous for his *Book of the Fixed Stars*, an outstanding Medieval treatise on astronomy that was assembled in 964. Developed from Ptolemy's *Algamest*, but based upon al-Sufi's own stellar observations, the *Book of the Fixed Stars* has been copied down through the ages, and currently 35 copies are known to exist in various archival repositories around the world. Among other things, this major work contains 55 astronomical tables, plus star charts for 48 constellations. For the first time a long-overdue English translation of this important early work is in active preparation.

In this paper we provide biographical material about Al-Sufi and the contents of his *Book of the Fixed Stars*, before examining his novel stellar magnitude system, and his listing of star clusters and nebulae (including the first-ever mention of the Great Nebula in Andromeda).

## Ronald McIntosh and the Role of the Amateur in New Zealand Meteor Astronomy

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Ronald McIntosh (1904-1977) was a journalist with a passion for astronomy, and in 1928 was the founded Director of the Meteor Section of the New Zealand Astronomical Society (later the Royal Astronomical Society of New Zealand). Supported by a small by very active group of fellow-observers, between 1929 and 1946 McIntosh published a succession of research papers in local and international astronomical journals (including the prestigious *Monthly Notices of the Royal Astronomical Society*), thereby demonstrating that amateur astronomers could still make a major contribution in this area of astronomy.

In this paper we provide biographical material on McIntosh, discuss his meteor observations and publications, and comment briefly on important non-meteor contributions he made to New Zealand astronomy.

## The Lick Observatory and the Development of Professional Astronomy in Western Australia

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Between 1889 and 1932 the Lick Observatory maintained a vibrant solar research program and sent a succession of expeditions to the far corners of the globe in order to observe solar eclipses and add to our knowledge of the solar corona and the chromosphere. These expeditions were major logistical exercises that relied mainly on visual, photographic and spectroscopic observations during the brief moments of totality.

In this paper we focus on the Lick Observatory's expedition to Wallal, Australia, to observe the 21 September 1922 total solar eclipse, and after discussing the personnel, their equipment and their observations (including the 'Einstein experiment') we view this very successful expedition in the context of the overall development of professional astronomy in the state of Western Australia.

## The Lick Observatory and the Development of Solar Astronomy in India

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Between 1889 and 1932 the Lick Observatory maintained a vibrant solar research program and sent a succession of expeditions to the far corners of the globe in order to observe solar eclipses and add to our knowledge of the solar corona and the chromosphere. These expeditions were major logistical exercises that relied mainly on visual, photographic and spectroscopic observations during the brief moments of totality.

In this paper we focus on the Lick Observatory's expedition to Jeur, India, to observe the 22 January 1898 total solar eclipse, and after discussing the personnel, their equipment and their observations we view this very successful expedition in the context of the overall development of solar astronomy in India.

## Filling a Void: The Life and Times of the *Journal of Astronomical History and Heritage*

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In 1998 the *Journal of Astronomical History and Heritage* (*JAH*$^2$) was launched as a new outlet for those wishing to publish papers on the history of astronomy. The journal has since developed rapidly and become an important publication venue for those conducting research in all fields of historical astronomy, including aspects of Asian and Oriental astronomical history (i.e. our ICOA constituents). With support from a distinguished international Editorial Board, the journal has grown from two issues per year to three, and now features increasing numbers of colour pages.

In this paper we review the founding and development history of the journal, examine the range of research and review papers that have been published since 1998, and discuss some of the possible future directions that we are currently exploring.

[This paper is cancelled by the authors]

## History of Astronomy at James Cook University, Australia

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The Centre for Astronomy at James Cook University (JCU) in Australia has been offering totally internet-delivered Master of Astronomy degrees since 2003 and Doctor of Astronomy and Ph.D. degrees since 2004. In 2005 a new dimension was added with unique offerings in the history of astronomy at both Masters and Doctoral levels. With the aid of 1 full-time staff member and 10 adjunct staff, 4 students have now graduated with Ph.D. degrees, 1 student died from cancer after completing the first draft of his thesis, and 14 students are currently enrolled in Ph.D. degrees. In addition 12 students have completed Master of Astronomy degrees in history of astronomy, and there are 3 students who are currently enrolled for Masters degrees.

As part of its commitment to the international development of history of astronomy, the Centre for Astronomy also arranges boutique 'invitation only' history of astronomy conferences in March each year, and produces the *Journal of Astronomical History and Heritage*

## The Lick Observatory and the Development of Professional Astronomy in Indonesia

**John Pearson and Wayne Orchiston**, Centre for Astronomy, James Cook University, Townsville, Queensland 4811, Australia (starsjohn@roadrunner.com; Wayne.Orchiston@ jcu.edu.au)

Between 1889 and 1932 the Lick Observatory maintained a vibrant solar research program and sent a succession of expeditions to the far corners of the globe in order to observe solar eclipses and add to our knowledge of the solar corona and the chromosphere. These expeditions were major logistical exercises that relied mainly on visual, photographic and spectroscopic observations during the brief moments of totality.

In this paper we focus on the Lick Observatory's expedition to Padang, Sumatra, to observe the 17-18 May 1901 total solar eclipse, and after discussing the personnel, their equipment and their observations we view this very successful expedition in the context of the overall development of professional astronomy in Indonesia.

## The Legendary Fourth Century Georgian Total Solar Eclipse: Fact or Fantasy?

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For decades, scientists have sought to explain a miraculous darkening of the sky described in medieval Georgian accounts of the life of St Nino. This event is purported to have swayed King Mirian of Georgia to accept Christianity as the state religion in the early 300s AD, making it particularly significant to historians. Various clues—a precise geographical location, the general time of day, a sudden onset of darkness, the duration of the obscuration, and the psychological reaction of its observers—are evidence that an historical total solar eclipse could be the basis of the story.

In this paper we carefully examine all of the evidence and conclude that a total solar eclipse probably was observed at this time.

## Early Scientific Astronomy on the American Northwest Coast: Captain Cook's Sojourn at Nootka Sound in 1778

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Between 1768 and 1778 England's premier maritime explorer, James Cook, made three much-published and very successful expeditions to the Pacific, when important contributions were made to anthropology, botany and zoology, not to mention maritime astronomy. Astronomy played a vital role in navigation and coastal cartography, and consequently there were astronomers on all three Pacific expeditions. On the final voyage Cook would lose his life in Hawaii, but not before exploring the northwest coast of the American continent. Three astronomers, Bayly, King and Cook himself, formed part of retinue of this two-vessel expedition, and during the sojourn of the *Resolution* and *Discovery* at Nootka Sound they set up their observatories and used a variety of instruments to carry out important astronomical observations.

In this paper we review the rationale for Cook's third voyage, discuss the Nootka Sound stop-over, provide biographical information about Bayly, Cook and King, examine their scientific instruments and review their astronomical observations.