

TokyoTech (Tokyo Institute of Technology), HMA (History of Mathematics and Astronomy)
Lecture note 6: (2019)

(Mathematics and astronomy in traditional Tibet and Southeast Asia.)

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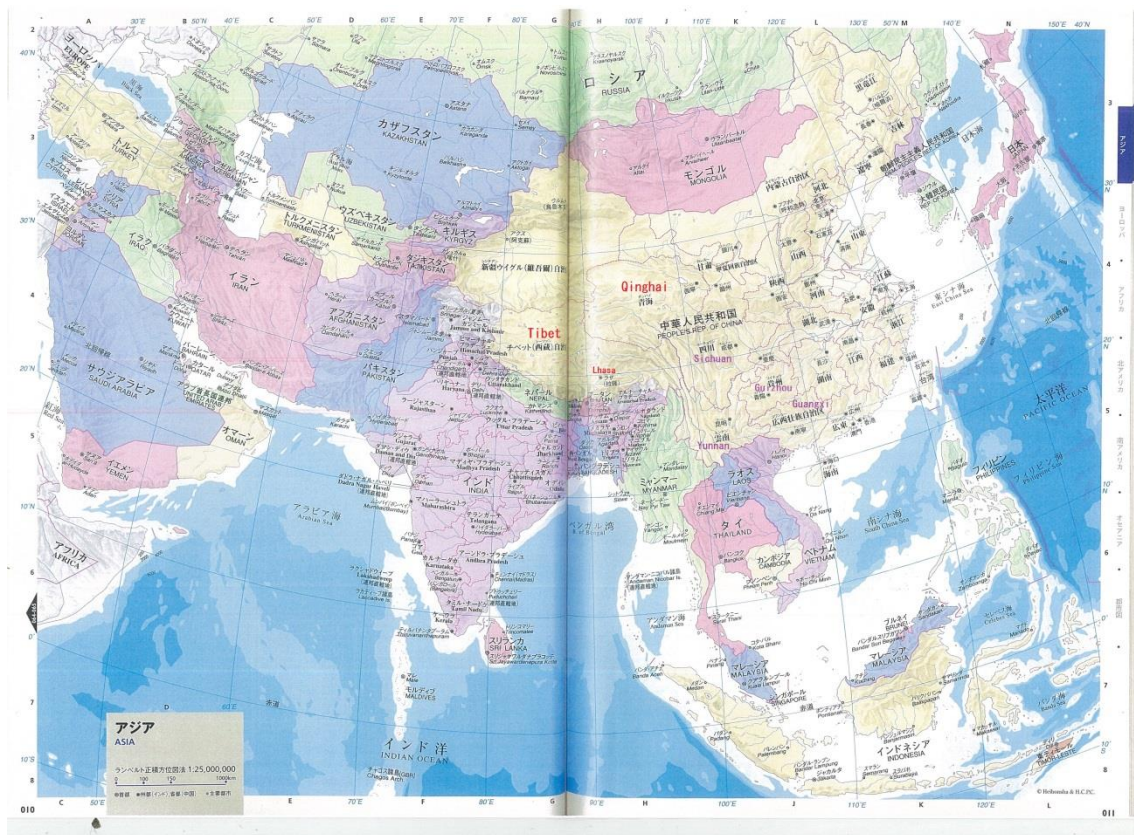
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Mathematics and astronomy in traditional Tibet



(From 『プレミアム アトラス 世界地図帳』、新訂第3版、平凡社、2017.)

**Tibet has a special tradition of mathematics and astronomy
which received influences of India and China.**

Tibetan mathematics

Tibetan numerals:

The Tibetan numerals are based on the Indian numerals.

	1	2	3	4	5	6	7	8	9	10
Tibetan numerals	藏文数码: 1	2	3	4	5	6	7	8	9	10
Tibetan words	藏文大写: གཅིག་	གཉིས་	གསུམ་	པའི་	ལྔ	དྲུག་	བདུན་	པ་ལྔ་	དགུ་	བརྒྱ་
Chinese numerals	汉文数码: 一	二	三	四	五	六	七	八	九	十

(From 张天锁《西藏古代科技简史》(1999), p.144, with my notes.)

Sand board:

In Tibet, a sand board is usually used for calculations of traditional astronomy etc.

加算の例 (356 + 437 = 793): An example of addition

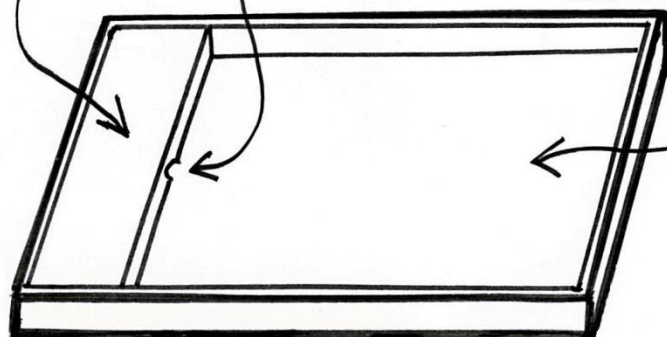
$$\begin{array}{r} 356 \\ 437 \end{array} \Rightarrow \begin{array}{r} 35 \\ 44 \end{array} 3 \Rightarrow \begin{array}{r} 3 \\ 4 \end{array} 93 \Rightarrow 793$$

Container of sand
砂を入れる箱

Doorway of sand
砂の出入り口

Pen
算筆

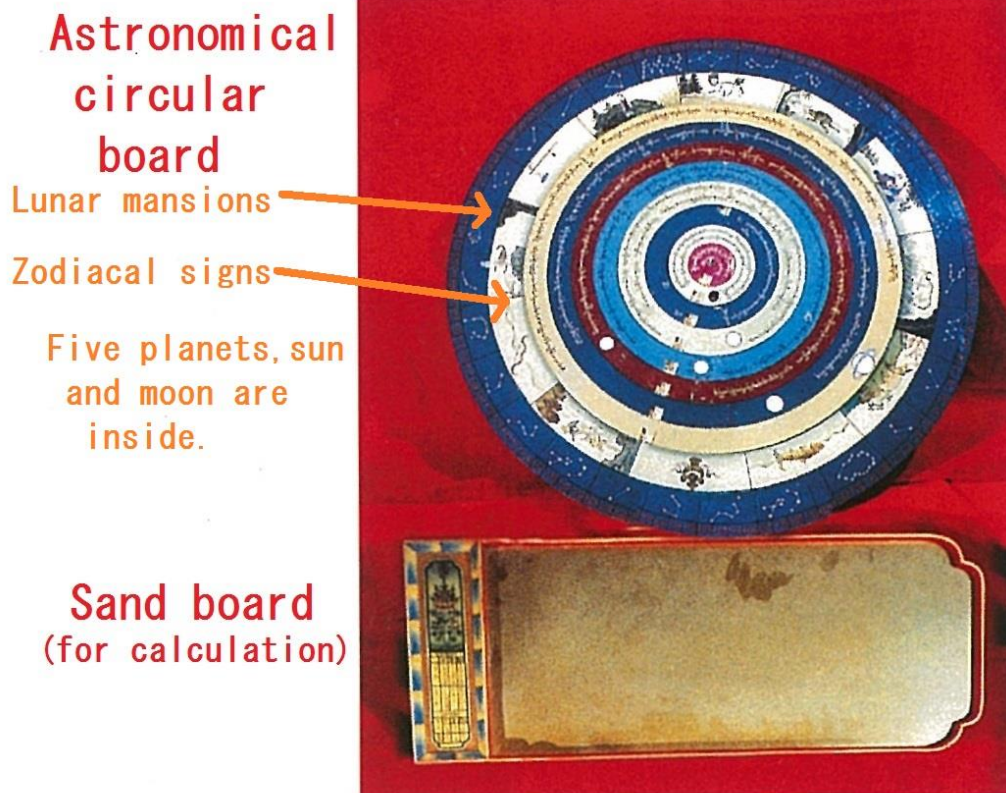
ここに
砂をまく
Sand is spread here



沙盤 Sand board

(From Ôhashi (2018-19), p.23)

Astronomical circular board and sand board:



7. 圆盘天文图和计算用的沙盘

(From 张天锁《西藏古代科技简史》(1999), with my notes.)

Tibetan astronomy

Tibetan traditional astronomy consists of 4 branches:

- “sKar rtsis” --- Astronomy based on Indian “Kālacakra” astronomy,**
- “dByangs ’char” --- Divination based on Indian “svarodaya”,**
- “Nag rtsis” --- Divination based on Chinese natural philosophy, and**
- “rGya rtsis” --- Astronomy based on Chinese *Shixian* calendar (時憲曆).**

(The *Shixian* calendar (made in 1644 and used from the next year) is a Chinese luni-solar calendar used in Qing (清) dynasty. It was made by Jesuit missionaries etc.)

Among them, the “sKar rtsis” is the fundamental theory of Tibetan traditional calendars.

The *Kālacakra-tantra* is an Indian Buddhist text of the last stage of Esoteric Buddhism, in which cosmology and calendrical astronomy are also described. It was originally written in Sanskrit, and translated into Tibetan and Mongolian. It has the commentary “*Vimalaprabhā*”, in which additional information of astronomy is also given.

According to my study, the astronomy of the *Kālacakra-tantra* is based on the Indian Classical Astronomy, and created in the 11th century in India (most probably in East India). (See Ôhashi (2000).)

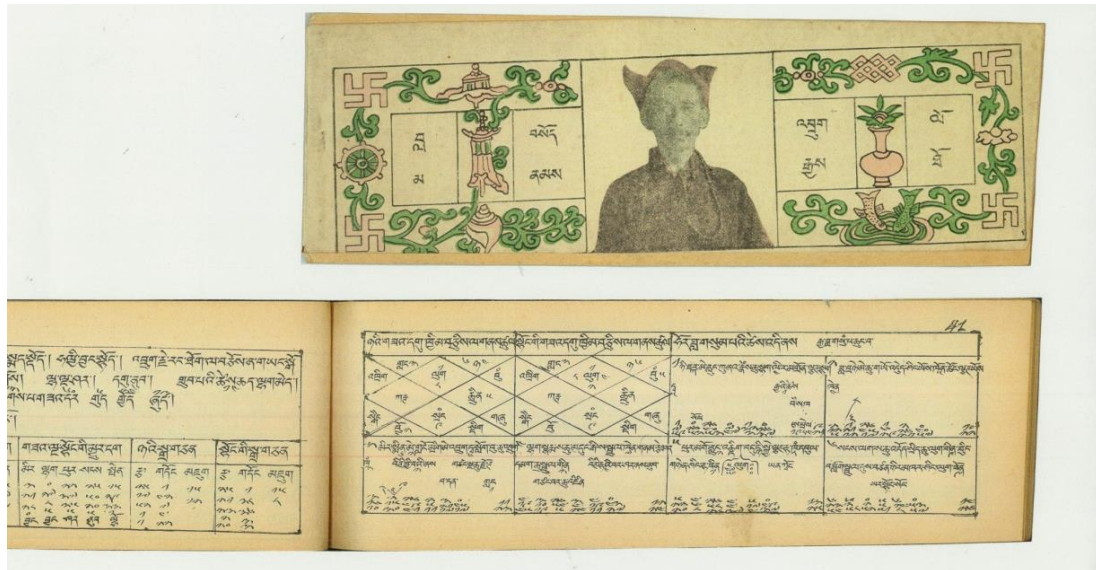
The beginning of the first 60-year cycle of the *Kālacakra* calendar is 1027 CE, and the *Kālacakra-tantra* says that it is 403 years after the year corresponding to the Hijrah. If so, the Hijrah becomes 624 CE, but the actual Hijrah is 622 CE. My hypothesis regarding this difference is as follows. There are two systems of 60-year cycle in India. The beginning of one cycle was 1025 CE in North India, and 1027 CE in South India. So, the beginning of the North Indian cycle was 403 years after the Hijra. Probably this information was incorporated in the *Kālacakra* astronomy, which uses South Indian 60-year cycle, and 2 years' difference was created. (See Ôhashi (2000).)

Tibetan traditional calendars:

A traditional Tibetan calendar published in Chengdu (成都) in China (compiled by “sMan rtsis khang” (藏医院, Medicine and astrology institute in Lhasa)):



A traditional Tibetan calendar published in Himachal Pradesh in India:

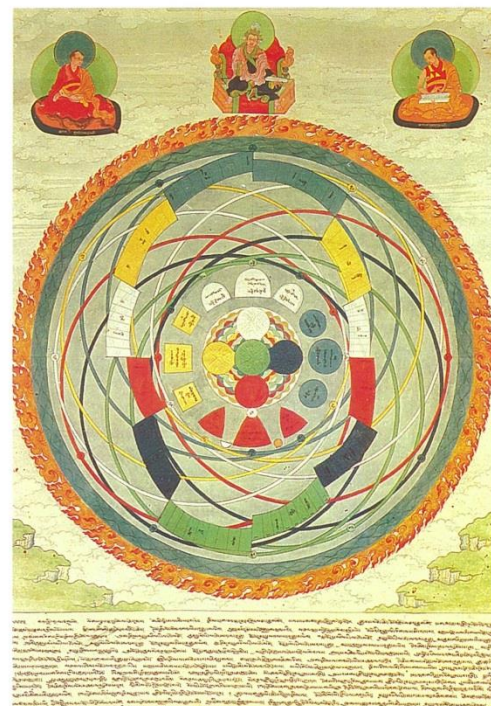


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Tibetan cosmology:



时轮经所说的宇宙构造图，见第3章16节
Cosmography based on the *Kālacakra-tantra*



渊源于汉历的太阳、宫宿、季节关系示意图，见第3章第16节末尾
The diurnal orbit of the sun in different seasons among 12 zodiacal signs. (The centre is the Mount Meru.)

(From Huang (2002))

Mathematics and astronomy in traditional Southeast Asia

(I) Introduction

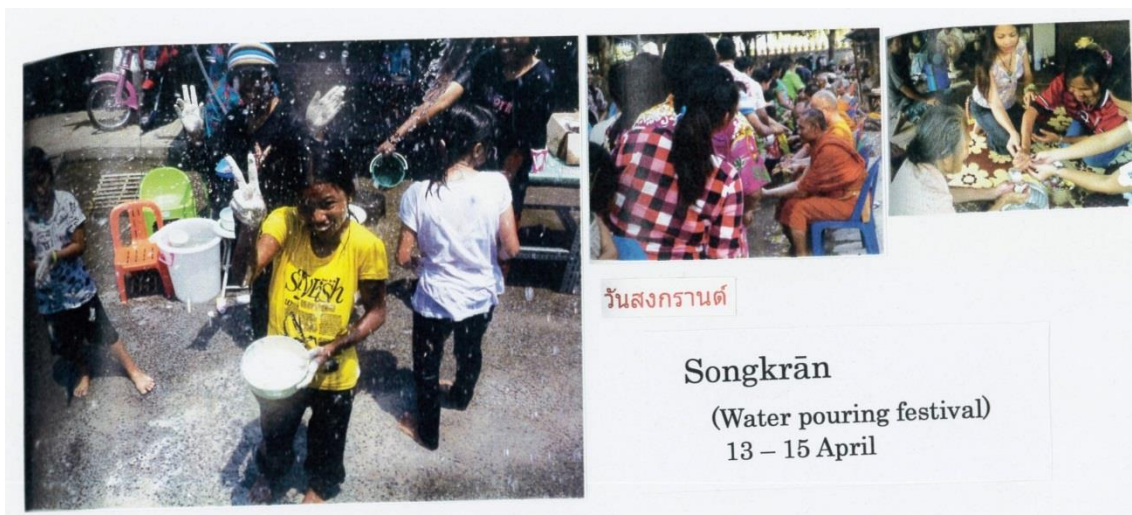
6

There are several traditional festivals in Southeast Asia.

For example, let us see two festivals of Thailand:

Songkrān and Lōy Krathong

..... (The following pictures are from a Japanese book (Kajiwara, 2013).)



“Songkrān” ... Sun’s entrance to a sign of the zodiac.

The famous Thai festival “Songkrān”

... Sun’s entrance to Aries

... that is the vernal equinox.

Why 13 – 15 April? Indian sidereal year is used.



Lōy Krathong song:

วันเพ็ญเดือนสิบสอง น้ำนองเต็มตลิ่ง

Wan-phen duan sipsong nam nong tem taling

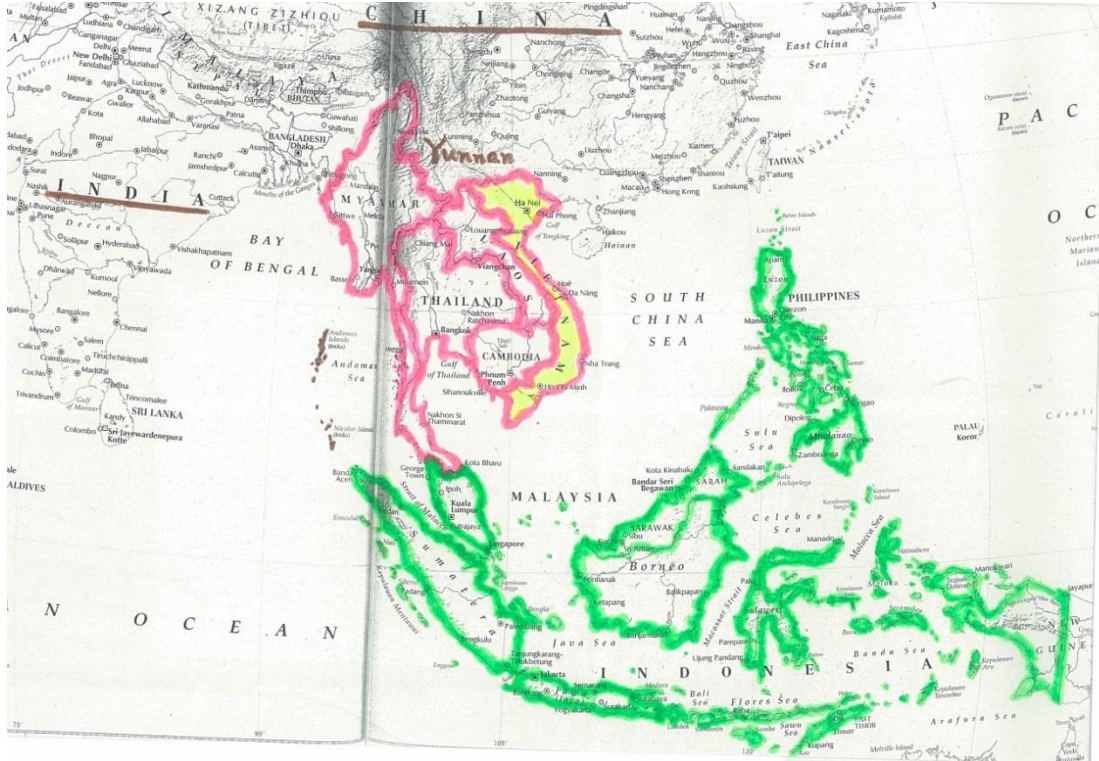
(The full-moon day) (the 12th month) (water fills to the banks)

This is based on the luni-solar calendar.

Thai traditional calendars:



(II) Geographical Overview



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Mainland Southeast Asia:

Vietnam:

Local original astronomical knowledge

+ Chinese influence

Myanmar (Burma), Thailand, Laos and Cambodia:

Local original astronomical knowledge

+ Chinese influence

+ Indian influence

Island Southeast Asia:

Local original astronomical knowledge

+ Indian influence

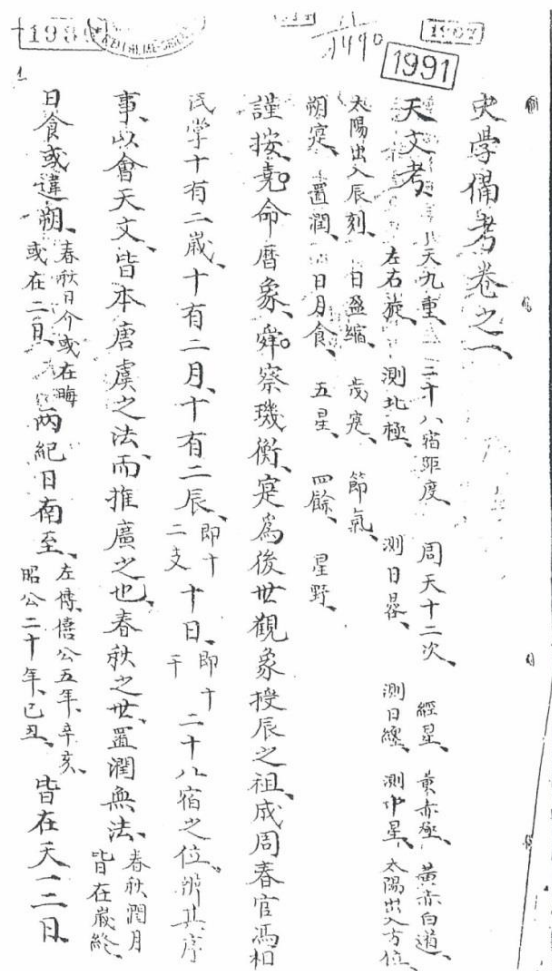
+ Islamic influence

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Some examples:

Vietnam is close to East Asia, and historical records were written in Classical Chinese.

An example of an astronomical work in Vietnam written in Classical Chinese:



Vietnamese Mathematics

The history of mathematics in Vietnam is now extensively studied by Alexei Volkov. (See Volkov (2009).)

According to Volkov, there are at least 22 mathematical works in Vietnam, mainly written in Classical Chinese. Some of them are partially written in Chu Nom (字喃) (special characters to express Vietnamese language). Most of them were written from the 18th century to the beginning of 20th century. They were largely influenced by Chinese mathematical works such as the *Sunzi-suanjing* (孫子算經), *Suanfa-tongzong* (算法統宗) of Cheng Dawei (程大位) etc, but there are Vietnamese originalities also.

For calculations, counting rods were first used, and later Chinese abacus was also used. The both seem to have been used until the early 19th century or so.

There are records that state examinations of mathematics were done from the 11th century to the end of 18th century. Traditional education of mathematics was done until the beginning of 19th century.

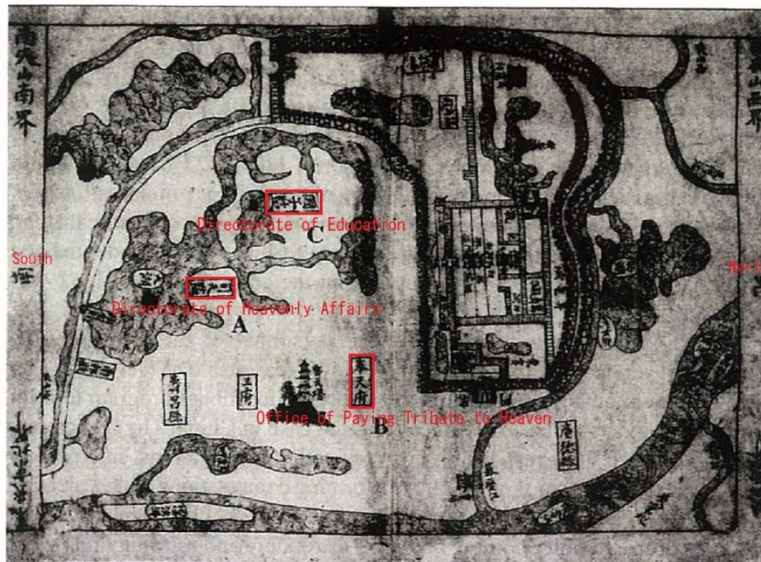
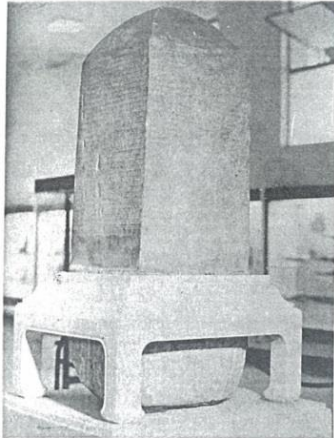


Fig. 1. The map of Hanoi from the *Hồng Đức Bản Đồ* 洪德版圖 (the West is at the top) showing the locations of the “Directorate of Heavenly Affairs” *Ti Thiên Giám* 司天監 (A), the “Office of Paying Tribute to Heaven” *Phụng Thiên Phủ* 奉天府 (B), and the “Directorate of Education” *Quốc tử giám* 國子監 (C).

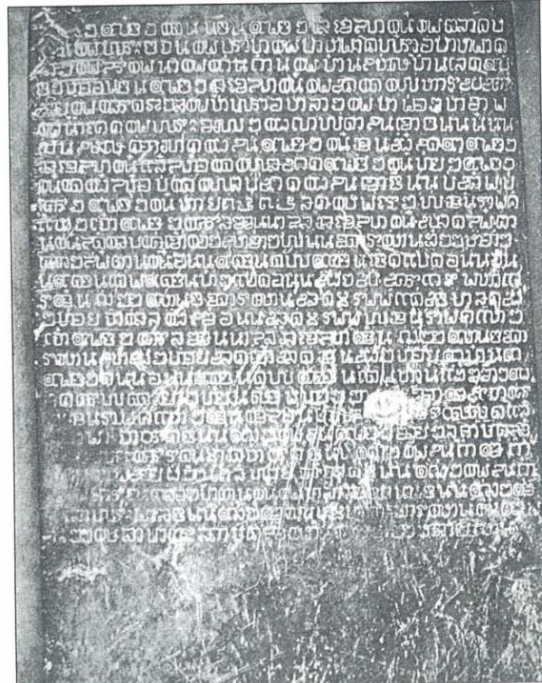
A Map of Hanoi (1490) (From Volkov (2013), p.119)

The earliest Thai inscription:

The Inscription of Ram Khamhaeng



The Inscription of King Ram Khamhaeng



Face 3



๑๐ เภส ขแมง ๑๒๑๔ สก นพ โศก พงพราหมณ์

In the above inscription, it is seen that the year is mentioned as “In 1214 Śaka, year of the Dragon” (corresponding to AD 1292), both Indian year and Chinese year.

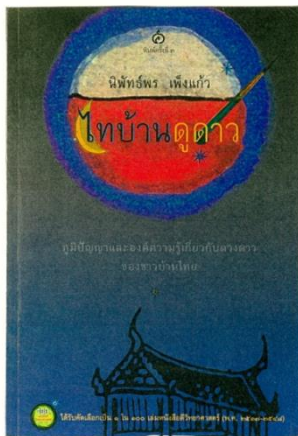
The Śaka Era is an Indian era. The “year of the Dragon” is one of the Chinese 12-year cycle.

(III) Local Original Astronomy:

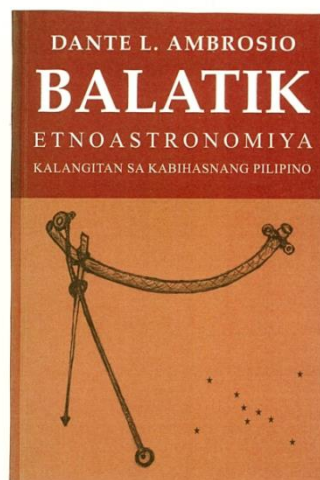
(A) Local names and folklore of the stars and constellations

There are some works on the Asian folk-astronomy.

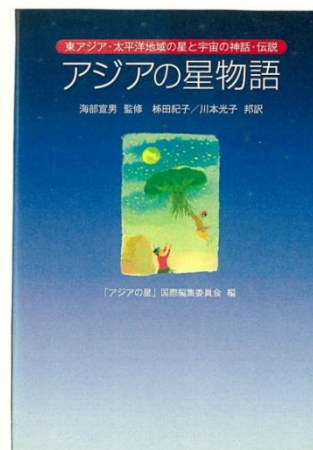
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Phengkaew (2009)



Ambrosio (2010)



Kaifu (2014)



Saibejra (2012)



Maison (2013)

Burmese star maps:

In Myanmar, there are some star maps, among which the most famous interesting maps are the three star maps (two circular star maps and one rectangular star map) drawn on the ceilings of corridors of the Kyauktawgyi Pagoda (built in 1847 by King Pagan of the Konbaung Dynasty) at Amarapura (near Mandalay, Myanmar). There described several Burmese original constellations which cannot be found in other areas.



The entrance (southern side) of Kyauktawgyi Pagoda, Amarapura
(taken by the author in 2017).

In these star maps, Indian 27 lunar mansions and Burmese original constellations are drawn. Among the Burmese constellations, 9 northern constellations are important.

My identification of 27 lunar mansions and 9 northern constellations in the Burmese star maps:

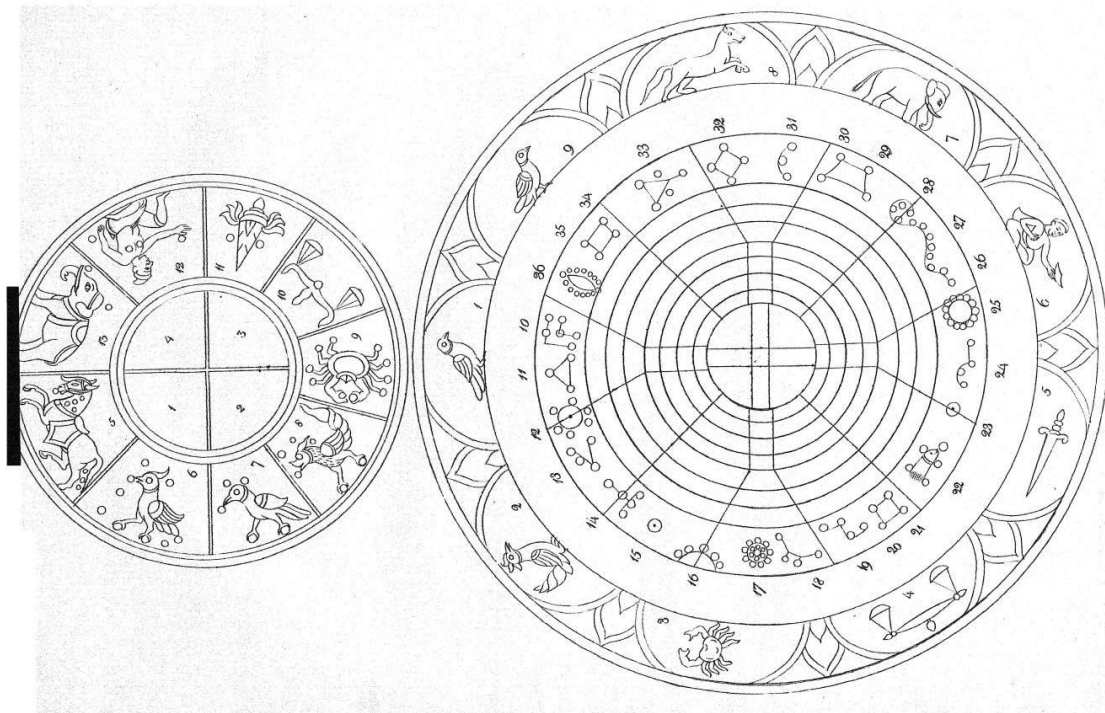
Indian 27 lunar mansions:

1. Āśvinī (α, β, γ Ari)
2. Bharanī (35, 39, 41 Ari)
3. Kṛttikā (Pleiades)
4. Rohiṇī (Hyades)
5. Mṛgaśīras (λ, ϕ^1, ϕ^2 Ori)
6. Ārdrā (Orion)
7. Punarvasu (Gemini)
8. Puṣya (Cancer)
9. Āśleṣā (Western part ($\kappa, \lambda, \epsilon, \mu$) of Leo ?)
10. Maghā ($\alpha, \eta, \gamma, \zeta$ Leo)
11. Pūrva-Phālgunī (δ, θ Leo)
12. Uttara-Phālgunī ($\beta, 93$ Leo)
13. Hasta (Northwestern part of Virgo ?)
14. Citrā (Spica)
15. Svātī (Arcturus)
16. Viśākhā (Corona Borealis)
17. Anurādhā (Northwestern part (β, δ, π) of Scorpius)
18. Jyeṣṭhā (α, σ, τ Sco)
19. Mūla (Southeastern part of Scorpius)
20. Pūrva-Āṣāḍhā (δ, ϵ (and γ, η ?) Sgr)
21. Uttara-Āṣāḍhā (ζ, σ (and τ, ϕ ?) Sgr)
- (* Abhijit (Disused in Burma))
22. Śravaṇa (α, β, γ Aql)
23. Dhaniṣṭhā ($\alpha, \beta, \gamma, \delta$ Del)
24. Śatabhiṣaj (Western part of Aquarius)
25. Pūrva-Bhādrapadā (α, β Peg)
26. Uttara-Bhādrapadā (γ Peg, α And)
27. Revatī (Northeastern part of Pisces)

Burmese 9 northern constellations:

- I. Byain “Heron”, (Cassiopeia).
- II. Kyi “Crow”, (Perseus).
- III. Hindha “Ruddy Sheldrake (duck)”, (Auriga).
- IV. Puzun “Crab”, (Head and forelimbs of Ursa Major).
- V. Khyein “Balance (scales)”, (Hindlimbs of Ursa Major).
- VI. Hsankyin “Hairpin”, (Coma Berenices).
- VII. Tanga “Fisherman”, (Hercules).
- VIII. Hsin “Elephant”, (Cygnus).
- IX. Myin “Horse”, (Cepheus).

There is a record of Burmese constellations already in 1799. (Buchanan, Francis, 1799: “On the Religion and Literature of the Burmas”, *Asiatick Researches*, 6, pp.163 – 308.)

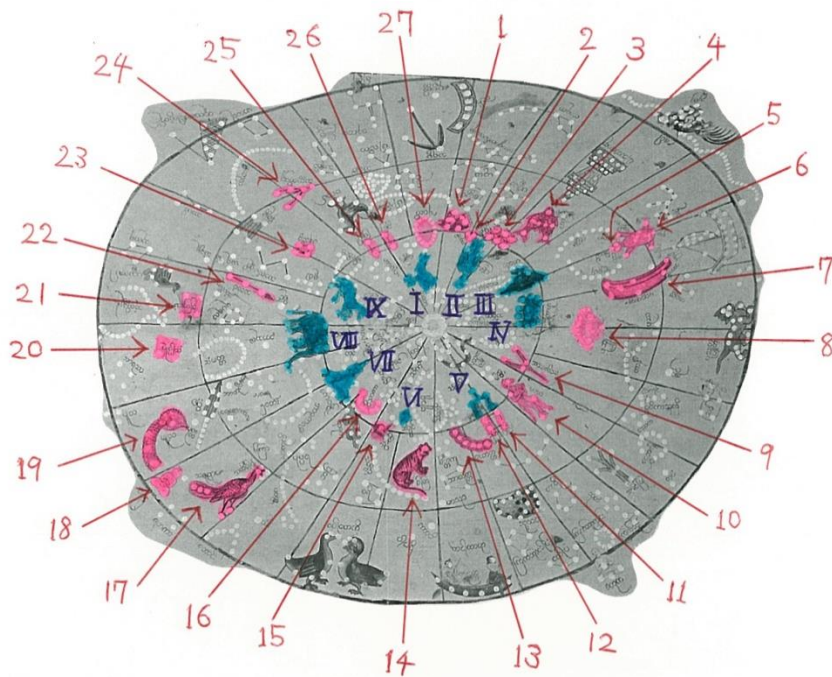


Nine Burmese constellations (left); and nine Burmese constellations (outer ring) and 27 Indian lunar mansions (inner circle) (right). (From Buchanan (1799))

The followings are pictures of the star maps in Kyauktawgyi Pagoda taken by me in 2017.

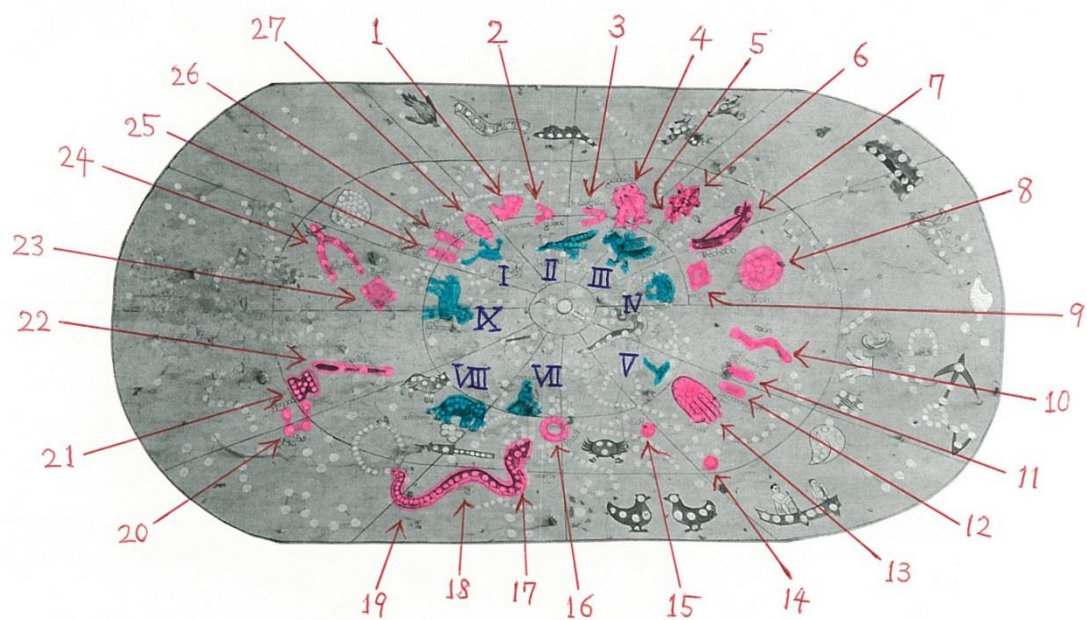


The star map in the southern corridor of Kyauktawgyi Pagoda, Amarapura



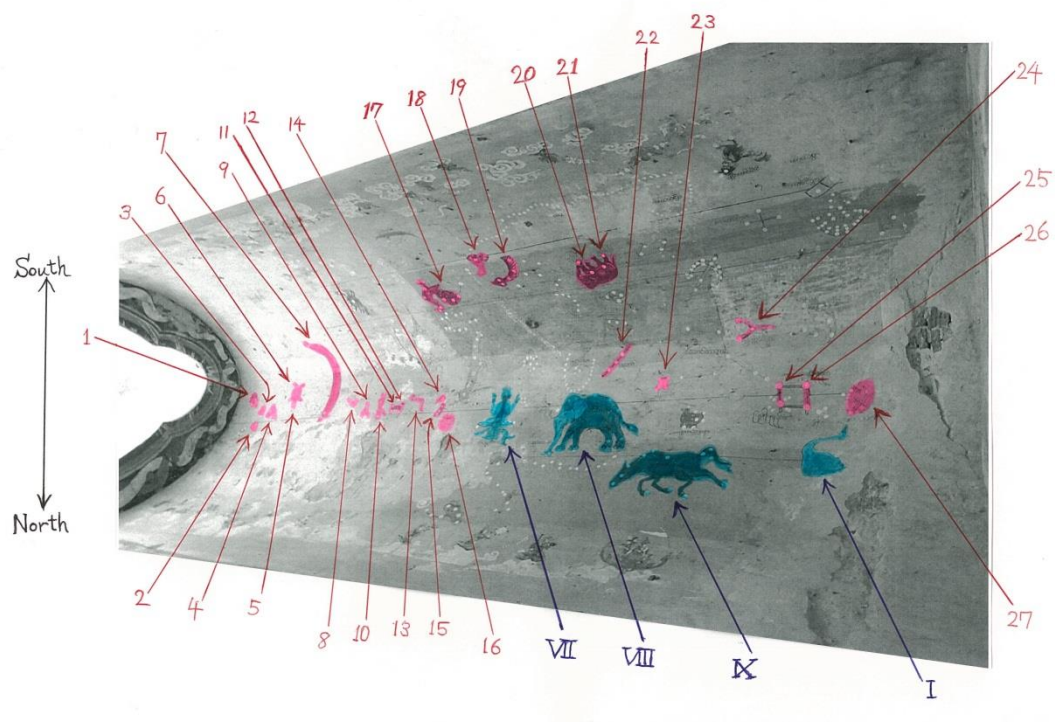


The star map in the northern corridor of Kyauktawgyi Pagoda, Amarapura



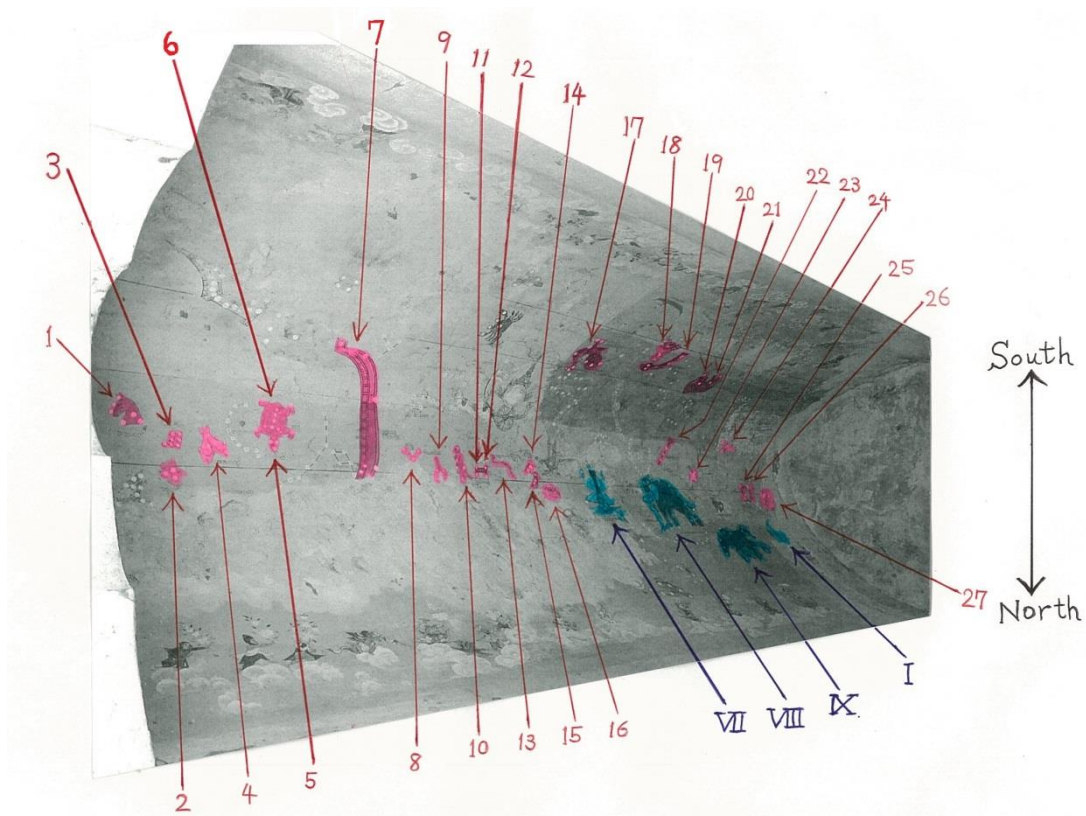


The star map in the western corridor of Kyauktawgyi Pagoda, Amarapura (looking from its inner side)

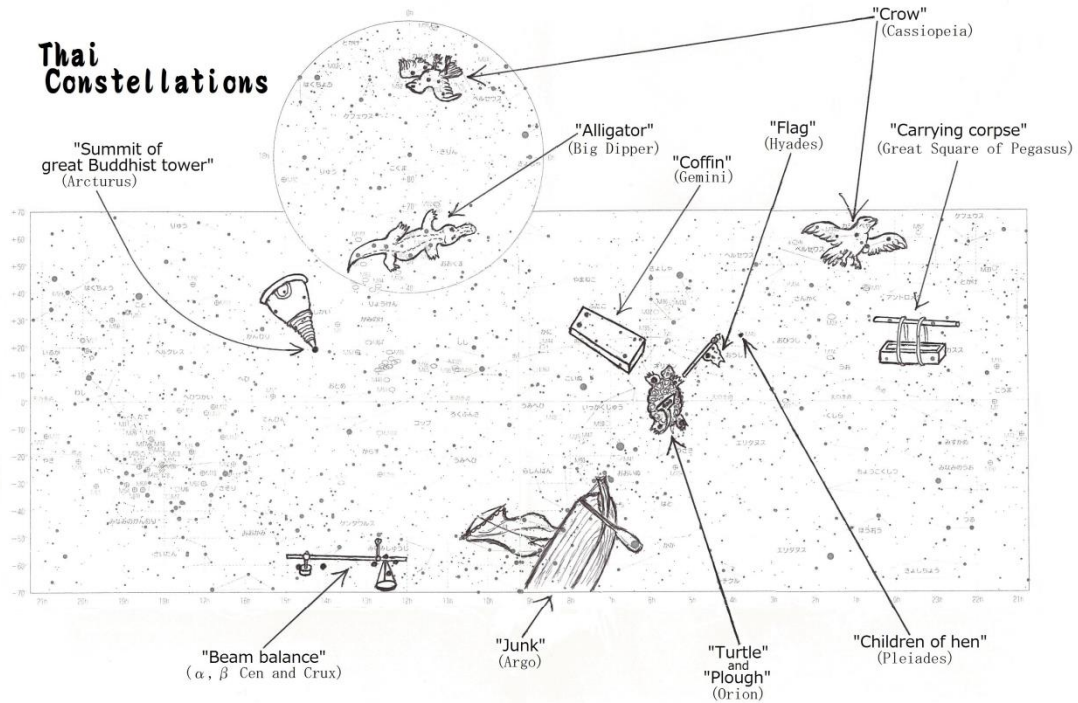




The star map in the western corridor of Kyauktawgyi Pagoda, Amarapura (looking from its outer side)



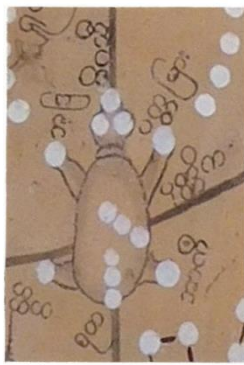
Thai constellations:



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Thai constellations, drawn by the author basing on Saibejra (2012)

There are some similar constellations in Southeast Asia. The following figures show Southeast Asian constellations corresponding to Orion. In the figure, A and B are from the Burmese star maps of Kyauktawgyi Pagoda which are pictures of "turtle", C is the Thai constellation based on Saibejra (2012) which is a combination of "turtle" and "plough", and D is the Javanese constellation based on Ammarell (1996) which is a "plough".

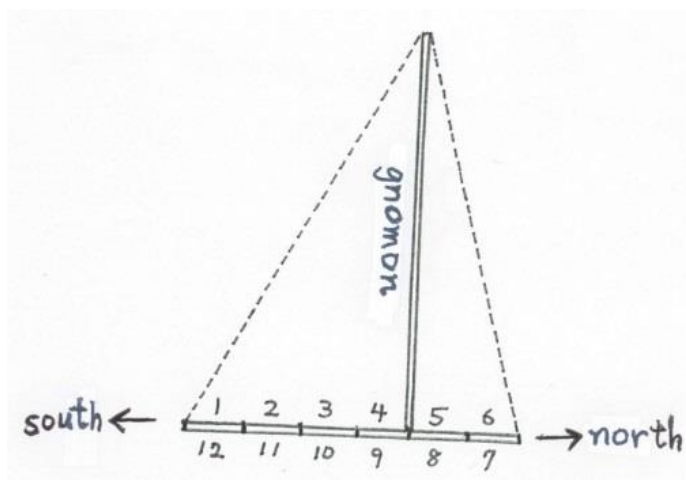


(B) Timekeeping

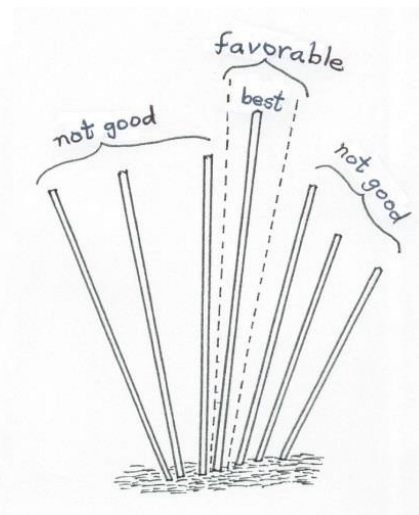
The gnomon (vertical rod) and some other instruments were used for timekeeping. The followings are instruments to know seasons for agriculture etc. As they depend on local latitude, they are indigenous.

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Gnomon in Java:



Gnomon in Borneo:



(C) Calendars

There are several different regional calendars in Southeast Asia.

The followings are calendars of Thailand and Myanmar.



Modern Thai traditional calendars (author's collection).



Modern Burmese calendars (author's collection).

(D) Determination of directions and navigation

Astronomical knowledge is used in local traditional navigation etc.

It will be interesting to compare with traditional navigation in Pacific islands.

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(IV) Chinese influence

(A) 12 animal names of the years and Chinese 60-year cycle

The Chinese 12-year cycle of animals (rat, ox, tiger, rabbit, dragon, snake, horse, goat, monkey, cock, dog and pig) is very popular in several parts of Asia with some variations in some areas.

It is very popular in Thailand. In Vietnam, usually ox is replaced by buffalo, and rabbit is replaced by cat. The Chinese 60-year cycle (combination of 10-year cycle and 12-year cycle) was used in Vietnamese traditional calendar, and also by Thai people outside the Central region.

As there are Indian Jovian 12-year cycle and 60-year cycle, which are independent of the Chinese cycle, we should distinguish them carefully.



(Above:) Figures of 12-year animal cycle in modern Vietnamese postage stamps.



(Above:) Figures of 12-year animal cycle in modern Thai postage stamps]

(B) Chinese luni-solar calendar

Serial numbers to denote luni-solar months may be Chinese influence. (In Hindu calendar, the name of lunar mansions is used to denote luni-solar months.)

19-year cycle for intercalation may also be Chinese origin.

There are 7 intercalary months in 19 years in ancient Chinese calendar. This is the same as Greek Metonic cycle.

19 years

$= 12 \times 19 + 7$ months

$= 235$ months

(V) Indian influence

(A) The signs of the zodiac

The 12-sign zodiac originate in Mesopotamia, and widely used in the Hellenistic World. Then, it was introduced to India, the Islamic World, the West etc.

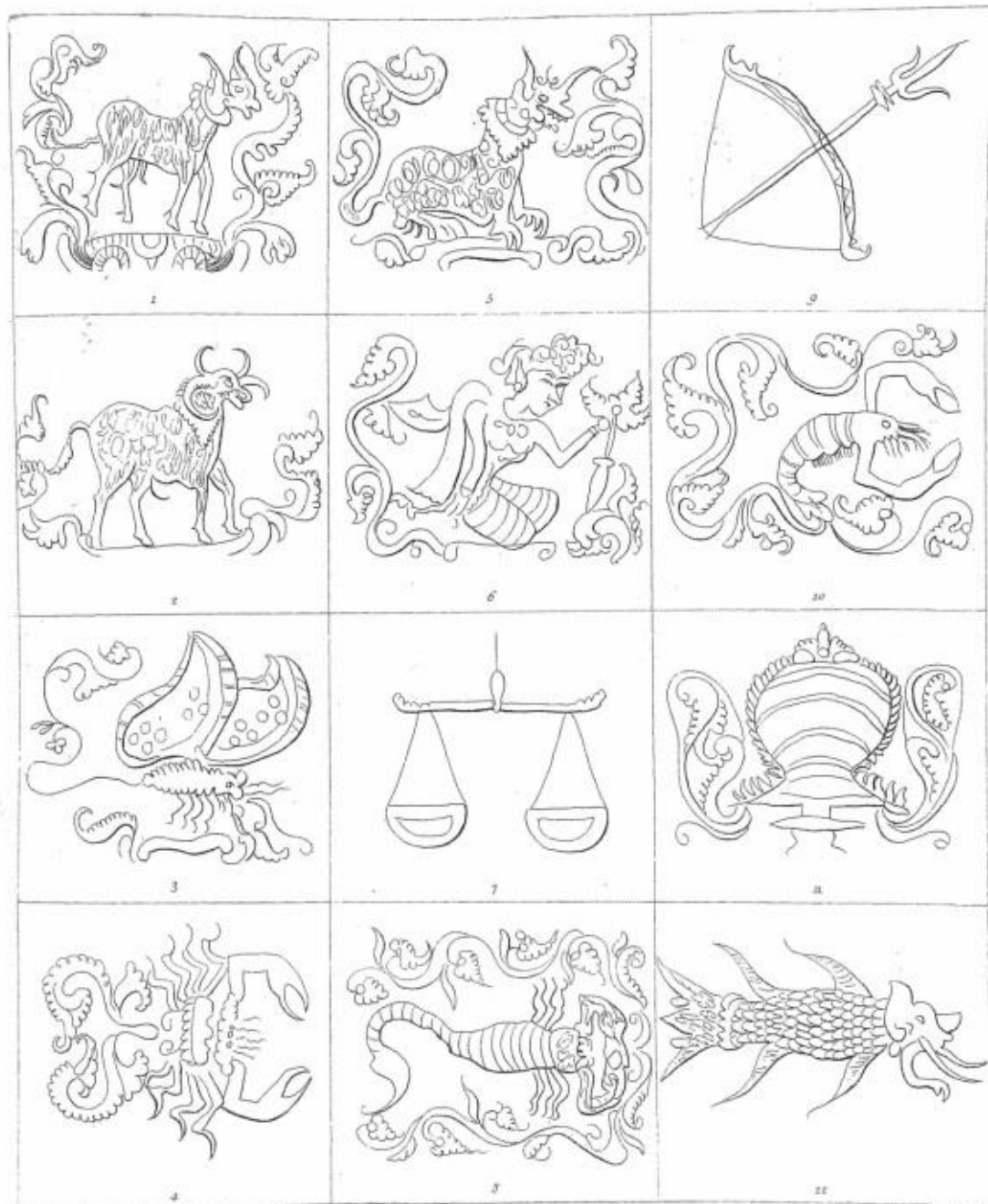
The 12 zodiacal signs were introduced into India in around 3rd century AD from the Hellenistic World, and then introduced into Southeast Asia as well as East Asia from India. As the zodiac is used in Islamic World also, the name of the signs of zodiac originates with Arabic in some areas, while the name originates with Sanskrit in other areas of Southeast Asia.

In India, the zodiacal signs are usually fixed to their sidereal position around the second half of the 6th century AD or so.

This Indianized zodiacal signs are used to regulate some Southeast Asian calendars. For example, the Thai festival “Songkrān” is the Sun’s entrance to the sign Aries. As the signs are fixed to their sidereal position, the Sun’s entrance to the sign Aries, which corresponds to the vernal equinox, is now different from the usual (Western tropical) vernal equinox due to the effect of precession of the equinoxes. So, the Thai “Songkrān” is celebrated in 13-15 April now.

In present Thailand, name of the 12 months of Gregorian calendar are named by Sanskrit name of zodiacal signs.

The signs of the zodiac in Java:

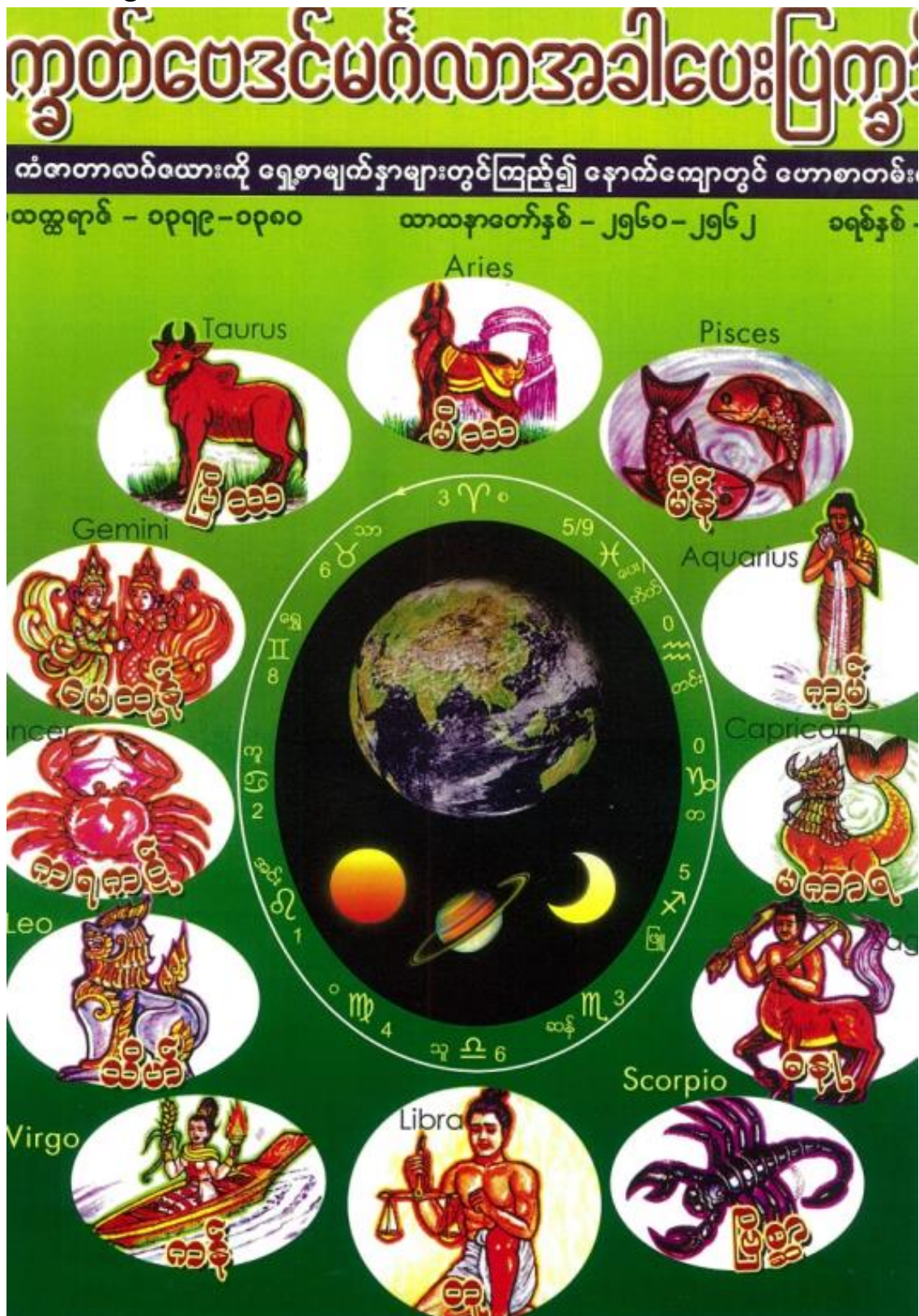


*Fac Simile of the Signs of the Zodiac as represented
in an ancient M.S. in possession of the
Tumenggong of Telaga in Cheribon.*

London, Published by Messrs. Murray, 1817, Strand, near St. Dunstons.

Signs of the zodiac in a manuscript found in Cheribon, Java, Indonesia (from Raffles (1817)).

The signs of the zodiac in the front cover of a Burmese calendar:

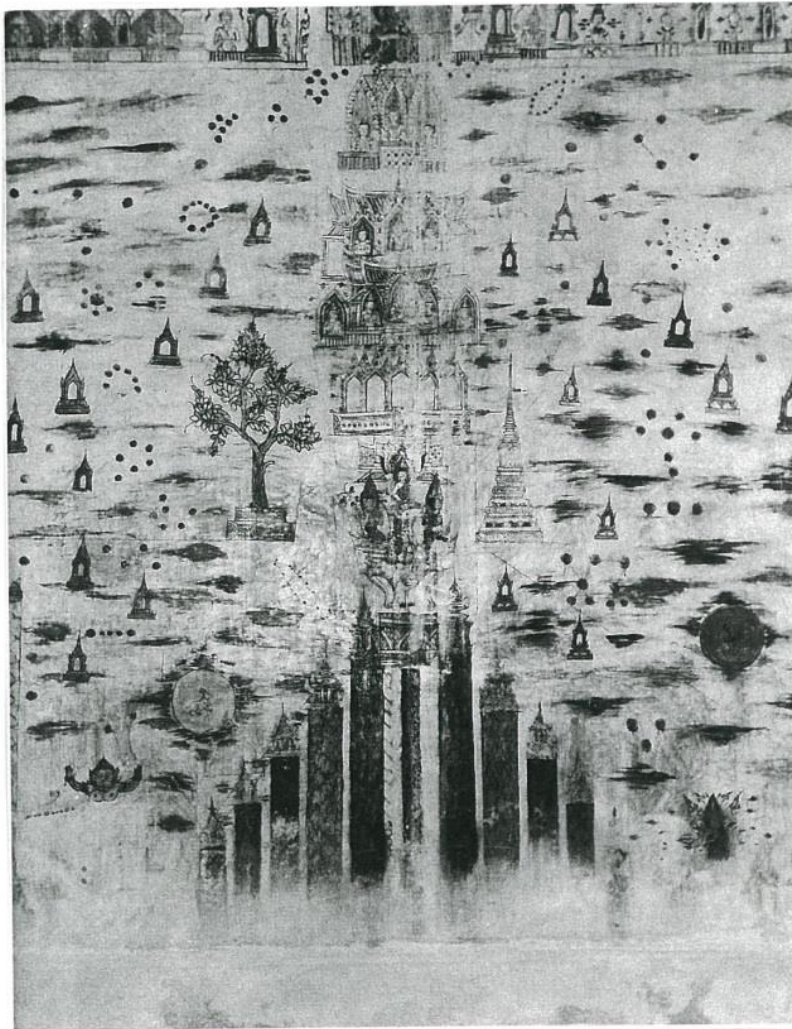


(B) Lunar mansion

India has 27 or 28 lunar mansions, and China has 28 lunar mansions. They are probably originally independent. The 27 lunar mansions are used in the Thai and Burmese traditional calendars. In the Thai traditional calendars, the position of the moon is indicated by the Indian 27 lunar mansions besides the 12 zodiacal signs. And also, the Indian 27 lunar mansions are shown in the star maps of the Kyauktawgyi Pagoda in Amarapura, etc.

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Lunar mansions drawn in a Thai painting:



Trai Phum or The Three Worlds of Buddhist Cosmology
(Wat Ko Kaeo Suttharam, Amphoe Muang Phetchaburi,
Changwat Phetchaburi)

(From: Intralib, Sonthiwan: *Thai Traditional Paintings*, Bangkok, 1994)

(C) Seven-day week

The 7-day week originates in Hellenistic world, and introduced to India, the Islamic World, the West etc.

The 7-day week was introduced into India in around 3rd century AD from the Hellenistic World.

And then it was introduced into Southeast Asia and East Asia from India. In Thailand and Myanmar, the day of the week of one's birth is considered to be very important. As the 7-day week is used in Islamic calendar also, the name of the days of the week originates with Arabic in some areas, while the name originates with Sanskrit in other areas.

In Thailand, there are symbolic colours of the days of the week. Sunday is red, Monday is yellow, Tuesday is pink, Wednesday is green, Thursday is orange, Friday is blue, and Saturday is purple. In Thai astrology, Wednesday is divided into daytime and nighttime (after 6PM), and nighttime corresponds to Rāhu. Sometimes, the symbolic colour of the night of Wednesday is considered to be black.

(D) Indian eras (Śaka Era tec.)

There are several eras in India. Indian Śaka Era was used in Thailand, Cambodia, Burma, Indonesia, etc.

And also, Buddhist Era is used in some regions of Mainland Southeast Asia. In Thailand, Buddhist Era ("Phuttha-sakkarāt" in Thai) is usually used (Buddhist Era = AD + 543). It should be noted that the 0th year of Buddhist Era begins from 544 BC in Thailand, Laos and Cambodia, while the 1st year of Buddhist Era begins from 544 BC in Burma and Sri Lanka.

(E) Sidereal year

Traditional calendars of Mainland Southeast Asia (except for Vietnam) use sidereal year. It is Indian origin. The use of sidereal year corresponds to the use of the zodiacal signs which are fixed to their sidereal position around the second half of the 6th century AD or so as we have seen in the section of “zodiac”. Therefore, one calendrical year is the sun’s revolution around the fixed stars, that is a sidereal year.

1 tropical year = 365.24219 days,

1 sidereal year = 365.25636 days.

(F) Indian luni-solar calendar

Hindu traditional calendars are mostly luni-solar calendars, and this system was introduced into Southeast Asia. As Chinese traditional calendar is also a luni-solar calendars, it is sometimes difficult to distinguish Indian influence and Chinese influence in this respect.

One Indian specialty is that Hindu method divide one synodic month into a white half month (from new moon to full moon) and a black half month (from full moon to new moon). This method is used in some Southeast Asian calendars. This division is absent in Chinese luni-solar calendars. Another Indian specialty is to use Sanskrit names of lunar mansions to name lunar months.

And also, one synodic month is divided into 30 *tithis* in Hindu calendars. (In usual Hindu calendars, one *tithi* (lunar day) is a period during which longitudinal difference between the sun and moon changes by 12°.) This kind of lunar days are used in some Southeast Asian calendars.

The Indian Jovian 12-year cycle, which is independent of the Chinese 12-year cycle of animals, was used in Burmese inscriptions.

The following is an example of a Thai traditional astronomical calendar. Here, we can see that the positions of the sun, moon, planets and the ascending node of the lunar orbit at the end of the day (24:00) are given in sidereal signs, degrees and minutes.

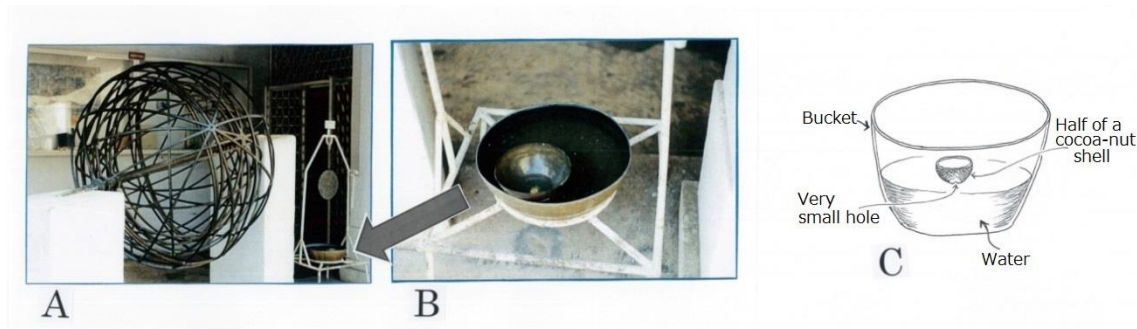
We can see that the sun enters sidereal Aries in 14, April, 1999, which is the day of Songkrān.

The “Ketu” usually means the descending node of the lunar orbit or, sometimes, comets or meteors in Hindu astronomy, and usually means Neptune in Thai astrology, but the position of the “Ketu” in this calendar is different from them, and its meaning is not clear to me at present.

We can see that Thai traditional luni-solar date is maximum 15th, because one sidereal month is divided into two half months. This is Indian stile.

(G) Time keeping

The famous naturalist Wallace (Wallace, Alfred Russel: *The Malay Archipelago*, London, Macmillan, 1869; resetted edition: London, Penguin Books, 2014, Chapter 28) recorded a water clock used in a local vessel of Makassar (In the following figure, C is my drawing based on Wallace's description.). This floating type of water clock was used in India since the end of the 5th century or so, and was very popular (A and B are the photographs of the water clock in Rao Madho Singh Museum, Kota, Rajasthan, India, taken by the author.).



Picture of water clock based on the description of Wallace, and photographs of the water clock in Rao Madho Singh Museum, Kota, Rajasthan, India, taken by the author.

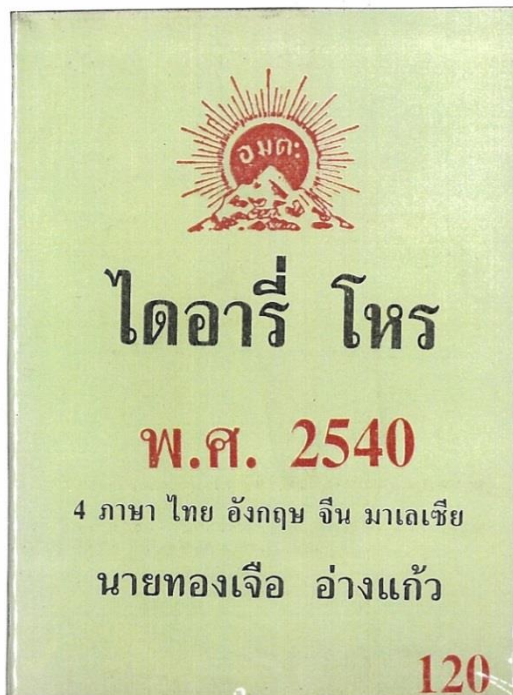
(H) Horoscope

A horoscope is a diagram to indicate the position of the sun, moon and planets in the zodiacal signs. It is used for astrology.

Horoscopes are found in inscriptions of Southeast Asia. There are several examples of the horoscope which are popular till now. A horoscope is shown in Burmese traditional birth certificate called “zata” as follows.



Burmese birth certificate (author's collection)



พุธ 1 มกราคม 8 ค 1

丙子 8 17 4 乙
5 17 27 丁
5 5 50 未
11 7 29 20 申
9 2 41 酉
22 7 23 10 戌
11 1 41 亥
5 8 33 子
7 7 23 丑
3 9 6 27 寅

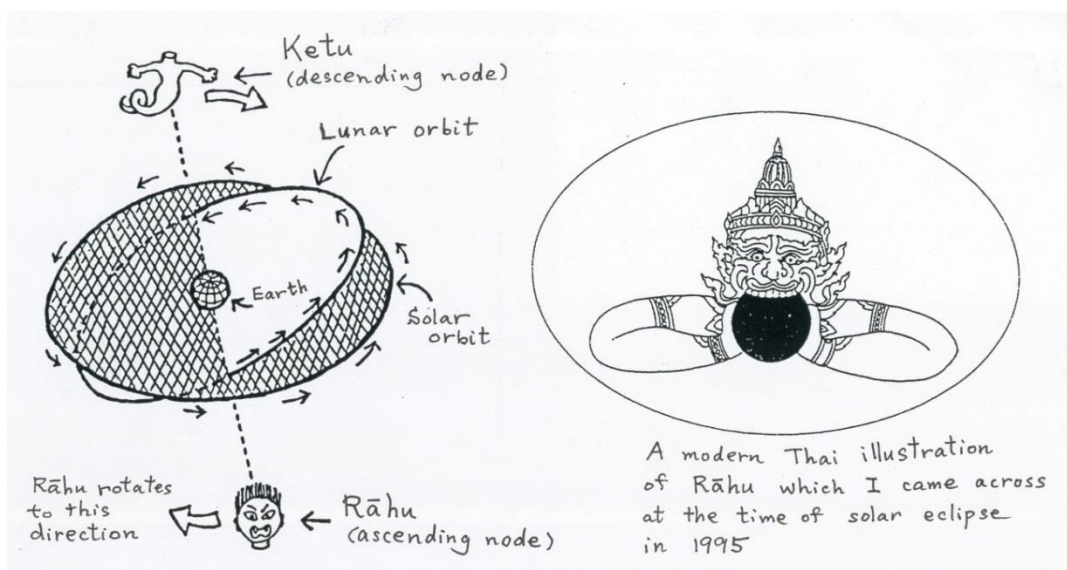
ฤกษ์ 12.34 ไล่ ← 10.42 → คุมป่าไผ่
คฤ 7.31 มรณะ ← 11.54 → ลาภะ
Wednesday 1 January 1997
1417 8 8 22 8 22 8 22 8 22
๗ ๗ 00.07 ๗ ๗ 06.42 ๗ ๗ 12.22 ๗ ๗ 18.01

07.12

From a Thai astrological diary.

(I) Rahu ----- a demon who produces eclipses

In Indian astronomy, the ascending node and descending node are called Rāhu and Ketu. The legend of Rāhu is widely found in Southeast Asia. Solar and lunar eclipses occur around them.

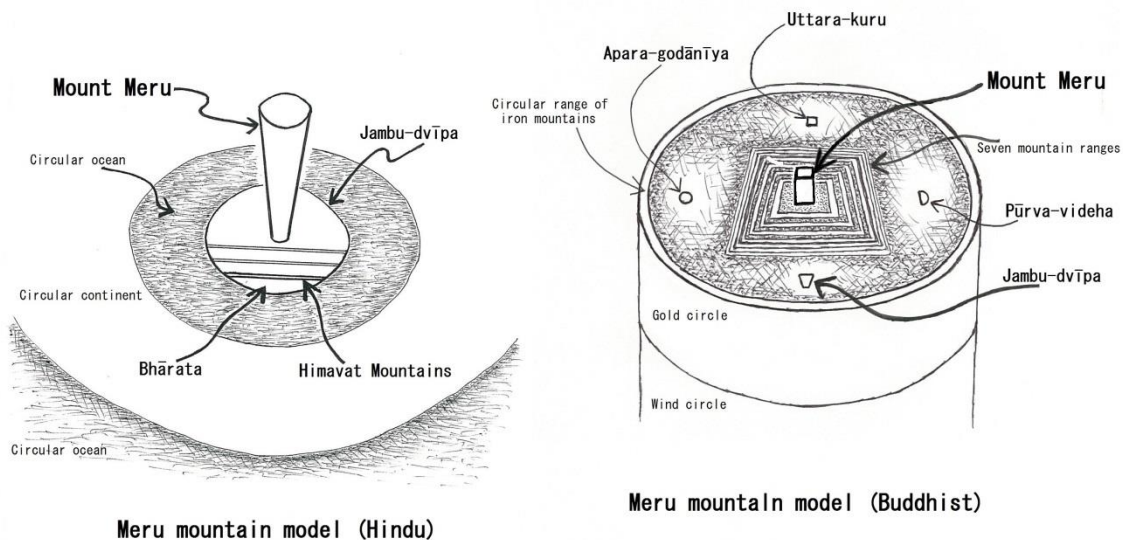


(J) Cosmology ----- Mount Meru model

The Mount Meru (or Mount Sumeru) model is an ancient Indian cosmology. (It is called “須彌山” (“Xumi-shan” in Chinese, and “Shumi-sen” in Japanese) in East Asia.)

According to this model the Mount Meru is at the centre of the flat earth.

There are some differences between Hindu, Buddhist and Jaina models.



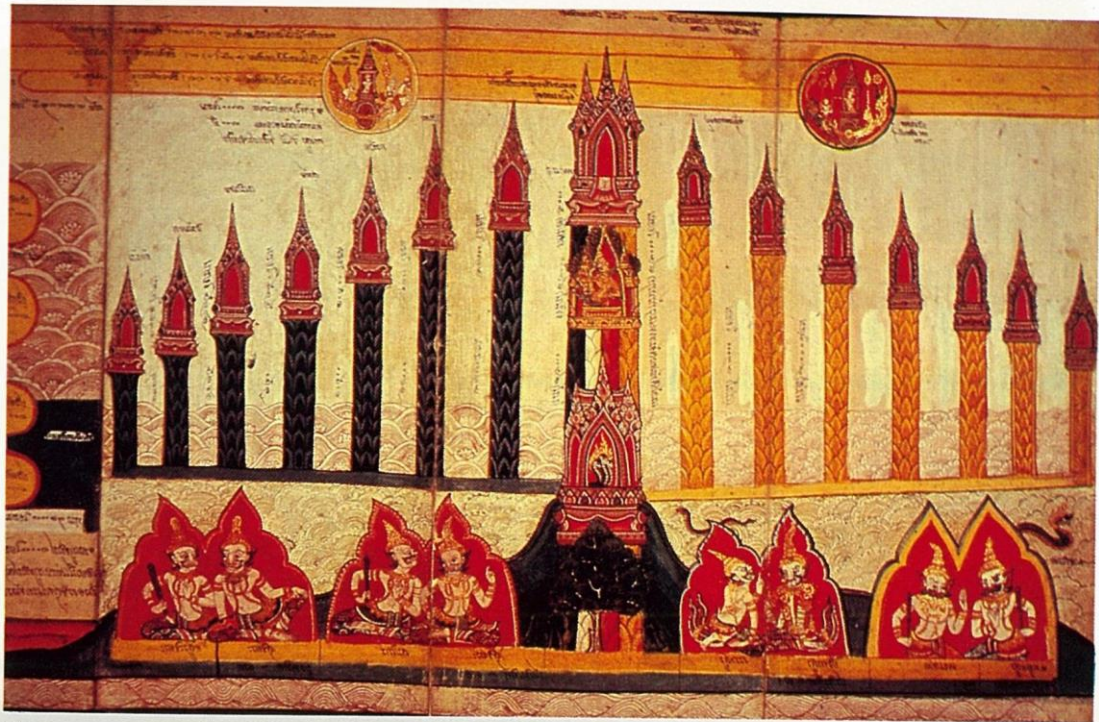
In the Hindu model, the human world is “Bhārata” (which now means India), on the south side of “Himavat Mountains” (which symbolize the Himalayas) at the south of the “Jambu-dvīpa” continent. In the Buddhist model, the human world “Jambu-dvīpa” is a south island. The Meru mountain model in Thailand etc. is based on the Buddhist model.

King Lithai of the Sukhothai dynasty of Thailand wrote the *Trai-phūm* (Three Worlds) in the mid-14th century. This is a celebrated text of traditional Thai cosmology, and some information about traditional astronomy is also found there.

There are several paintings of Mount Meru model in Thailand.



The seven mountains and seas of the Cakkavāḷa viewed from above, with the four continents depicted in the four corners.



The seven mountains of the Cakkavala, with the sun and moon above and a lower segment depicting the eight asura kings.

(From Reynolds, Frank E., and Reynolds, Mani B. (tr.): *Three Worlds according to King Ruang*, Berkeley, University of California, 1982)

It is supposed that the central tower of Angkor Vat etc. symbolizes Mount Meru.



Angkor Vat
(12th century)



Miniature (1922)
of Angkor Vat

(From ブリュノ・ダジャンス (中島訳) 『アンコール・ワット』、(「知の再発見」双書)、創元社, 1995))

(VI) Islamic influence

(A) Islamic lunar calendar

1 year = 12 lunar months (without intercalation)

Basically, when new crescent moon is observed in the western sky in the evening, a new Islamic lunar-month begins from the sunset. So, the length of a month (29.530589 days) is exact. One year is 12 lunar months regardless seasons.

There are some simplified methods to predict lunar visibility.

One method is trigesimal calendars using 30-year cycle (360 months), which has 11 leap years. It means that one lunar-month is $“(30 \times 6 \times (29 + 30) + 11) / (30 \times 12)” = 29.530556$ days.

A simpler method is octaval calendars using 8-year cycle (96 months), which has 3 leap years. It means that one lunar-month is $“(8 \times 6 \times (29 + 30) + 3) / (8 \times 12)” = 29.53125$ days. This octaval calendar was widely used in pre-nineteenth century Southeast Asia.

At present, the visibility of the crescent moon is still very important, and the crescent moon at the beginning and the end of the month Ramadhan (month of fasting) etc. are carefully observed.

(B) Time keeping and Qibla--- the direction of the Ka'ba in Mecca

There are five prayers called “ṣalāt” daily, and time keeping is very important for muslims.

The direction of the Ka'ba in Mecca is called “Qibla”. The prayers should be done towards this direction. It is indicated in mosques.

As the direction of Mecca is approximately the west, some people in Indonesia considered that the rising three stars of Orion (which approximately rise from the west) indicate Qibla.



Istiqlal Mosque (Indonesia)



Masjid Istiqlal (Istiqlal Mosque) in Jakarta, Indonesia.

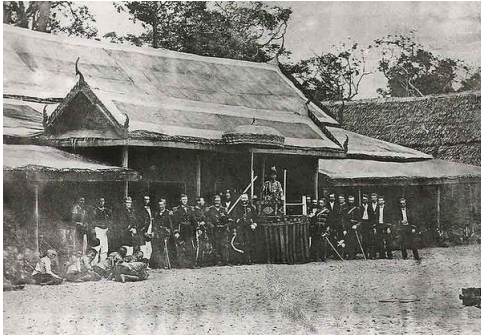
(VII) Western influence:

Let us see one example.

King Mongkut (Rama IV) of Thailand predicted a total solar eclipse on 18 August 1868



Western astronomy textbooks that King Mongkut used to learn astronomy



This photograph shows King Mongkut and his eclipse expedition party. The King is seated in the center of the pavilion and the British group stands around; to left are royal officials who are kneeling.

[Pictures are from the web page of NARIT \(National Astronomical Research Institute of Thailand\).](#)

(VIII) Conclusion

Several different astronomical traditions are found in Southeast Asia, which have regional originality.

For example, the Thai traditional astronomy and some other Mainland Southeast Asian astronomy are created as a kind of combination of local astronomical knowledge, Chinese influence and Indian influence, and their astronomy have Southeast Asian specialty.

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References of Vietnamese mathematics and astronomy:

- Volkov, Alexei: “Mathematics and mathematical education in traditional Vietnam”, in Robson and Stedall (eds.): *The Oxford Handbook of The History of Mathematics*, Oxford, Oxford University Press, 2009, pp.153 – 176, (Japanese translation: アレクセイ・ヴォルコフ (小川東訳): 「伝統的ベトナムにおける数学と数学教育」、斎藤、三浦、三宅 (監訳)、『Oxford 数学史』、共立出版、2014, pp.135 – 155).
- Volkov, Alexei: “Astrology and Hemerology in Traditional Vietnam”, in *Les Astres et le Destin, (Extreme-Orient, Extreme-Occident, 35)*, Saint Denis, Presses Universitaires de Vincenne, 2013, p.113 – 140.

For references of Southeast Asian astronomy, see “Additional readings” (Southeast Asia 1).

Additional readings

- (Tibet 1): Ôhashi, Yukio: “Remarks on the Origin of Indo-Tibetan Astronomy”, in Selin, Helaine (ed.): *Astronomy across Cultures*, Dordrecht, Kluwer Academic Publishers, 2000, pp.341 – 369.
- (Tibet 2): Ôhashi: 大橋由紀夫: 「チベット数学・天文学の話」、『数学史研究』、通巻 232 号、2018-19, pp.22 – 28.
- (Vietnam 1): Ôhashi, Yukio: “On the History of Vietnamese Mathematics and Astronomy”, in Li, Zhaohua (李兆华) (ed.): *Hanzi-wenhuaquan Shuxue-chuantong yu Shuxue-jiaoyu* (汉字文化圈数学传统与数学教育), Beijing (北京), Kexue-chubanshe (科学出版社), 2004, pp.112 – 123.

(Vietnam 2): Ôhashi: 大橋由紀夫: 「江戸時代の「安南国漂流物語」と、ベトナム・日本・中国の暦法」, in 『平成 27 年度、黎明期日本天文学史研究会集録』, 国立科学博物館, 2016, pp.39 – 43.

(Southeast Asia 1): Ôhashi, Yukio: “Southeast Asian Traditional Astronomy at the Crossroads: Local Original Astronomy and the influence of China, India, the Islamic World and the West”, (to be included in a forthcoming proceedings), 2018.

(Southeast Asia 2): Ôhashi: 大橋由紀夫: Tōnan Ajia tenmongaku-shi ni mukete (「東南アジア天文学史に向けて」, in 相馬、谷川 (eds.): 『第 5 回天文学史研究会』集録』, 国立天文台, 2016, pp.87 – 103.

(Southeast Asia 3): Ôhashi, Yukio: Tōnan Ajia dentō tenmongaku no jūsō-kōzō (「東南アジア伝統天文学の重層構造」, in 相馬、谷川 (eds.): 『第 5 回「歴史的記録と現代科学」研究会集録』, 2018, pp.208 – 238. (Its oriented version is black-and white, and its Web version, which is reproduced here, in coloured.)

Errata:

Lecture Note 4:

P.48, line 2: For “Southern (南宋)”, read “Southern Song (南宋)”.

P.49, line 3 of the main text: For “Yelu Chucai (耶律楚材)”, read Yelü Chucai (耶律楚材).

An additional reference:

Lecture Note 5:

Reference of the history of Japanese astronomy:

Hayashi: 林淳 『渋川春海』、(日本史リブレット人 050)、山川出版社, 2018.