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Using Stellarium in Educating the Young Generation on Ancient Lanna Astronomy

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Abstract: The orientation of the ancient *Lanna* religious buildings was related to the calendar system. It included designing and using traditional *Lanna* style Architecture, houses, temples, and city planning to observe times and positions of the Sun, the Moon, and stars for timekeeping, intercalation, and regularly checking the season to prescribe calendar for agriculture or accurate rice-planting time. This knowledge was transferred to the young generation and embedded in the curriculum in the Religious Place Module, SCiUS CMU. One of the astronomy wisdoms called the "13-dark moon impending 13-full moon" (13DMFM) phenomenon involved using the temple and the celestial stars for synchronizing the lunar calendar with the solar calendar or seasonality so that rice could be planted according to the rainy season. This was selected as the case study in this paper. The Stellarium Software, a helpful tool for education through archaeoastronomy, is used to simulate a celestial sphere and visualizing the astronomical phenomenon. It helps young learners to unveil the ancient *Lanna*'s astronomical knowledge in predicting an *Adhikamas* year (leap month-year).

Keywords: Stellarium, *Adhikamas* year, *Lanna* astronomy, Chet Yot Temple, temple orientation

1. Introduction

For more than ten years, the holistic learning concept is embedded in the Religious Place Module curriculum for The Science Classrooms in University-Affiliated School Project under supervision of Chiang Mai University (SCiUS CMU) at Chiang Mai University Demonstration School. The module emphasizes astronomical context related to the orientation of religious sites and archaeological sites such as vihara, ubosot, cathedral, pagoda, etc., and includes history, architecture, mathematics, physics, social science, etc. This is done by exploring the old and important temples in the northern province of Thailand, e.g., Chiangman Temple, Chet Yot (Photharam) Temple, Ton Kwen (Intharawat) Temple, and Chedi Luang Temple in Chiang Mai, Phra That Hariphunchai Temple, Phra Yuen Temple, and Chamadevi Temple in Lamphun, and Phra That Lampang Luang Temple in Lampang.

After a survey at temples, the class reviewed the local knowledge of *Lanna* (Northern Thais) astronomy so that the students could learn about how the orientation of the temple related to the calendar. In ancient times, the monks and local philosophers for each temple or village had to know about astronomy, astrology, and seasonality. The Temple buildings use as a reference in observing times and positions of the Sun, the Moon, and stars for timekeeping and intercalation, for regularly checking the season to prescribe calendar for agriculture and accurate time for rice planting, in comparing to occasion and zodiac to indicate the date, month, and year according to the solar and lunar calendar concerning the season (Yodintra, 2007). Although at that time, there was no instant calendar, monks could still date annual Buddhist Lent Day precisely during the rainy season, and farmers could plan correct seasonal rice planting and even postpone planting for one lunar month in the *Adhikamas* (leap-month) year (Yodintra, 2011; p.95-129).

One of the old pieces of the literature reveals that ancient *Lanna* investigated *Adhikamas* year from the "13-dark moon impending 13-full moon" (*13 Dub bang cub 13 Pen*) phenomenon, in which students has been greatly interested. This wisdom related to positioning of the entrance of the vihara or the ubosot (Ordination Hall), pillars in the old *Lanna* vihara and including the floor plan within the boundary stone makers. This phenomenon is a local *Lanna*'s astronomical knowledge on the brink of

extinction. It is influenced by the Kalachakra Tantra, one of the Mahayana Buddhism. Astronomy is employed exoterically in the Kalachakra (wheel of time) which is the science of calculating planetary and stellar movement providing a measurement of time through the medium of calendars (Gyatso, 2004) in the early *Lanna* period. The ancient knowledge about monument orientations, temple, and city planning, related to astronomy (Kramrisch, 1976) and especially the marked stars such as the Pleiades, Spica, Aldebaran, or Antares. Moreover, the *Lanna* Viharas tradition such as the Prasart or the Sa-Pao Kham (Golden ship) Vihara, always created the front pillars (left, middle, and right) corresponding to the Sunrise azimuth on the summer solstice, the equinoxes, and winter solstice (Saelee et al., 2021). This knowledge created the "13-dark moon impending 13-full moon" (13DMFM), the local knowledge used for adjusting the lunar calendar to be in line with the solar calendar so that rice could be planted according to the season. Later, *Lanna* King had adopted Theravada Buddhism, and this knowledge had almost been extinct. However, the wisdom of *Lanna* ancestors and local knowledge about checking seasonality has been transferred from generation to generation, and prevented *Lanna* people from famine, providing peaceful and well-being livelihoods, so that they could create beautiful and unique handicrafts, fine art, painting, architecture, and temples that still exist for many hundred years.

The 13DMFM wisdom illustrated the good knowledge of the ancients about the vernal equinox, summer solstice, autumnal equinox, and winter solstice. They knew that if there was a dark moon (New Moon) before winter solstice (the day that the Sun moved southernmost) no longer than 11 days, this dark moon day would be the 13th, signaling that the following year would be an *Adhikamas* year with 13 full moons. The 13th full moon would occur after the summer solstice (the day that the Sun moved northernmost) no longer than 11 days (Saelee et al., 2018). How the ancient people marvelously designed architecture related to astronomy is worth thoroughly investigating, especially in the aspects of astronomical phenomena and the positions of the Sun, the Moon, and the related stars. Therefore, the objective of this study was to understand local *Lanna* knowledge in checking the *Adhikamas* year, how the ancient *Lanna* observed, what their visions were, and how the position of the Sun, the moon, and the involved stars related to the 13DMFM phenomenon. All these questions from students would not be answered without the help of the Stellarium software.

Stellarium software might be the key tool giving new insight into the astronomical phenomenon in the ancient time. This is because this software is a modern astronomical tool using a precise calculation to provide accurate, unbiased, with standard results, as well as the ability for real-time presentation of many data such as sphere shape of the observed sky, sunrise and sunset time, and the moon phase compared with asterism backdrop. Nowadays, not many old *Lanna* viharas built before AD 1857 has survived, the remaining are such as the Great Vihara of Pa Daeng Maha Vihara Temple and Prasart Vihara of Prasart Temple in Chiangmai, Khom Kham Vihara of Phathard Sadet Temple, the Great, Buddhist, and Namtham Vihara of Phra That Lampang Luang Temple, and Jamadevi Vihara of Pong Yang Khok Temple in Lampang (Boonyasurat, 2001). In this paper, *Sema* (the temple boundary stones) pillars at Ubosot (Ordination Hall), located on *Lan Sao Kean Chan* at Chet Yot Temple, were selected to be this case study as Yodintra (2011; p.165-176) confirmed its pillars positioning has been similar to the old *Lanna* vihara and synchronized with the 13DMFM phenomenon.

2. Materials and Methods

Yodintra (2011) previously found that positions of the *Sema* pillars at *Lan Sao Kean Chan* (*see Figure 1*) related to prediction of an *Adhikamas* year. To understand ancient *Lanna* methodology, we searched for a relationship between the13DMFM phenomenon and astronomical aspects including the positions of the Sun, the Moon, and the stars, by collecting data such as Azimuth (the angle measuring clockwise from the North along the horizon) and astronomical simulation using Stellarium software.

Note: The study of *Lanna* calendar, later also called *Culasakaraj* calendar, is based on the *Surya Siddhanta of Varaha Mihira* with the mean sidereal year length of 365.25875 days. There are 354 days in Regular years, 355 days in an *Adhikavara* (Leap-day) year and 384 days in an *Adhikamas* (Leap-month) year. There are 7 *Adhikama*s years in a 19-year cycle with a pattern as 3332 332 (Saelee et al., 2018).

According to the ancient *Lanna* data based on the record from palm leaf scripture of the Chiangman Temple mentioned the year 1871 and 1874 were the *Adhikamas* year (Inchan, 2020), and based on the *Chiangmai Chronicle* stated that the years 1815 and 1817 were the *Adhikamas* year

(Wichienkaeo & Wyatt, 1995; p.192-193). The 13DMFM phenomena around those years had been investigated and confirmed it occurred within 11 days from the new moon of the signal-year and the full moon in the *Adhikamas* year as per Yodintra (2011). Although the dates are not enough to view the pattern of the 19-year cycle, it's fortunate that the used *Lanna* calendar is the same as the present Thai lunar calendar (*Culasakaraj*). The *Adhikamas* year pattern in the present-day period from AD 2000 – 2021 is in the examination.

The two objectives of this study with the methodology are as follows:

1. To investigate the relationship between the azimuth of Sunrise/Moonrise and the positions of the *Sema* pillars. We compared the azimuths on the full moon day after the summer solstice and the new moon day before the winter solstice as the following procedures: a) setting the Stellarium software with the location of observation at Chet Yot Temple (18°48′18″N, 98°58′09″E); b) selecting the desired dates; and c) finding the azimuth of the Sun or the Moon when it is rising with altitude just zero.
2. To visualize the Sun/Moon and the asterism on the new moon day before the winter solstice, for instance, to unveil how the ancient *Lanna* observed the celestial objects in the signal-year and knew that the successive year would be an *Adhikamas* year. We set an appropriate background in Stellarium software by adjusting the ecliptic line to be a straight line; then collected all the sky maps on the desired dates for AD 2001 – 2021.

3. Results and Discussion

3.1 Positioning Lanna Ubosot Floor Plan Related the Two Solstices

In *Figure 1,* the layout for the floor plan of *Lan Sao Kean Chan*, Chet Yot Temple, Muang district, Chiang Mai Province, was sketched. The *Sema* pillars, labeled as S1, S2, S3 and S4, were compared with solstice events, S1 and S2 to the summer solstice, and S3 and S4 to the winter solstice. The angle direction of *Sema* pillars were measured using a compass and tape measure and the data was collected.

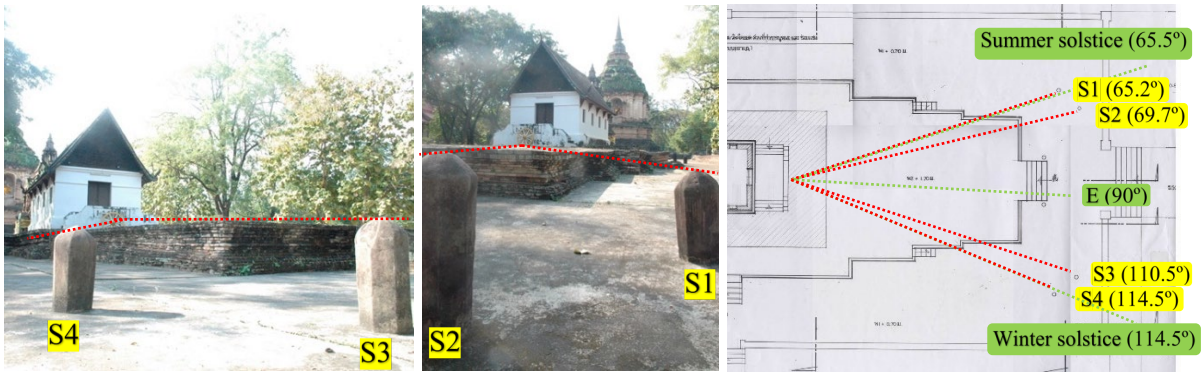

Figure 1. Sema pillars at *Lan Sao Kean Chan* of Chet Yot Temple. Right: Layout of the *Sema* pillars identified by the azimuth (given in parenthesis) measuring from observed point in front of the ubosot.

3.2 Azimuth of the Sun, the Moon and the Sema Pillars

The 13DMFM phenomenon stated that if a new moon occurred during the Sun and the Moon rising between the two southeast pillars (S3 and S4) no more than 11 days before the day the Sun moved southernmost (winter solstice), that new moon was the 13th new moon, signaling that one more lunar month would be added in the next year. The 13th full moon would occur after the day the Sun moves northernmost (summer solstice) no more than 11 days, and the Sun would rise between the two northeast pillars (S1 and S2).

The relationship between the Sun and the Moon position, at the new moon (*Lanna* called dark moon) days before the winter solstice and the first full moons day after the summer solstice was investigated. This was done by comparing the azimuth of the rising sun and moon on those dark moons' days and full moons day in with the space between each pair of the four pillars from AD 2001 to 2021. Stellarium was used to rectify all year's azimuth of the Sun and the Moon on the related dates.

Figure 2: Right shows that if the full moon days occurred between 11 days after the summer solstices, between 22 June and 1 July (or 23 June – 2 July in the leap year), thus the years (2002, 2005, 2007, 2010, 2013, 2015, 2018, and 2021) as highlighted in the shaded area would be *Adhikamas* years. Similarly, the last new moon day before the winter solstice in *Figure 2: Left* shows that if such new moon days occurred between 11 days before the winter solstices, between 11 and 21 December (or 12 – 22 December in the leap year), then the following years will be the *Adhikamas* year. The Sun's azimuth was closed to the S1 on the first full moon day after the summer solstice in the *Adhikamas* year and was closed to the S4 on the last new moon before the winter solstice in the year before. Note that all the azimuths were close to S1 or S4 within about 3º. In contrast, *Figure 3* shows no relationship between the Moon positions and the *Sema* pillars (S3 and S4) in both those full moon days and those new moon days for identifying an *Adhikamas* year, however, it shows an interesting *sine*-liked pattern around the S3-S4 pair. Consequently, there are coincided with the 13DMFM phenomenon focused on the summer solstice and the winter solstice relating to the azimuth of sunrise but not the moonrise.

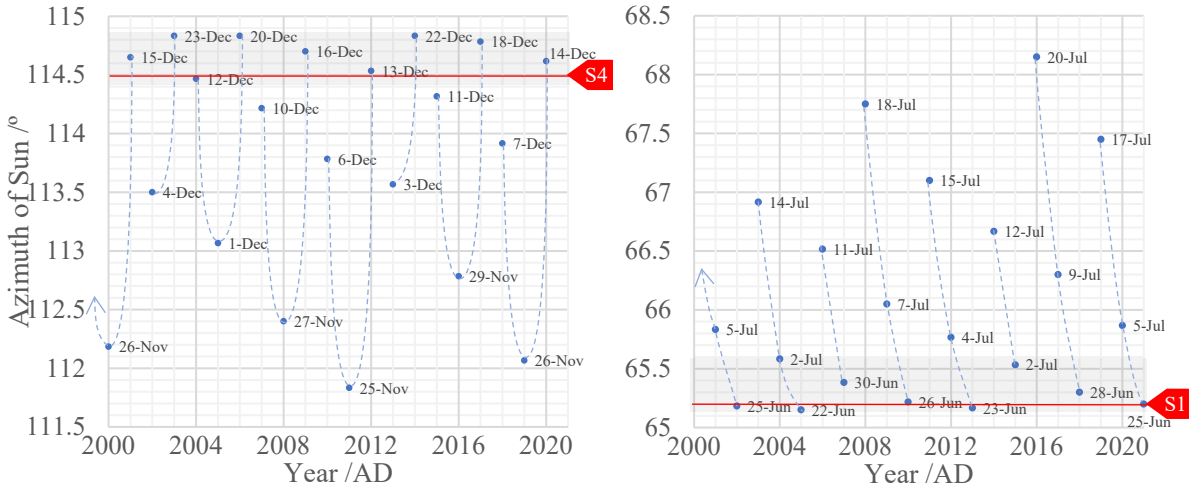

Figure 2. The azimuth of the rising sun. *Left:* on the last new moon day before the winter solstice. The years in shading area are signaled years indicated that the next year would be an *Adhikamas* year. *Right:* on the 1st full moon days after the summer solstice. The years in the shading area are *Adhikamas* years and are in the ending of the dashed lines.

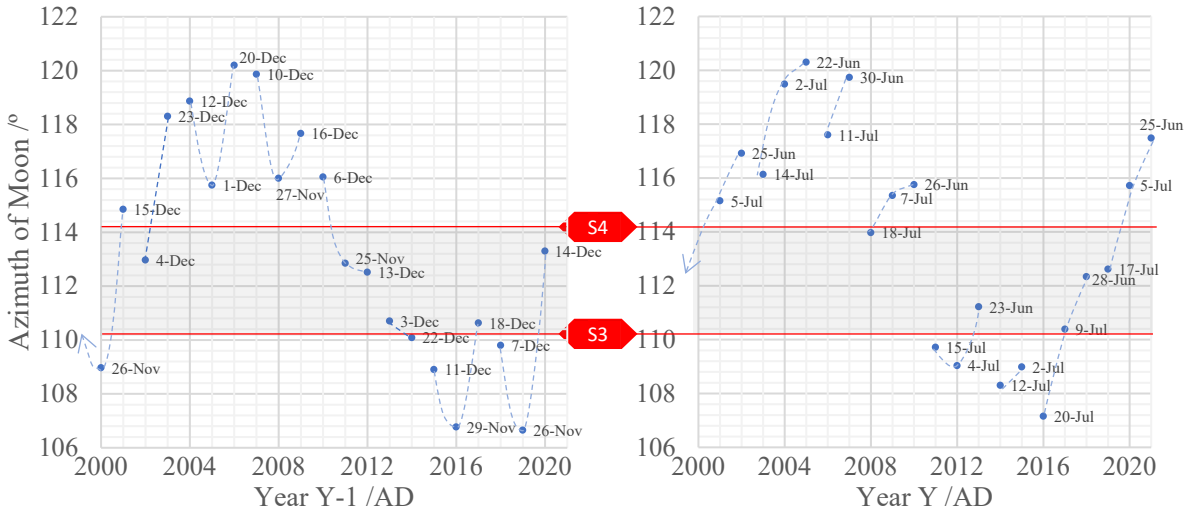

Figure 3. The azimuth of the rising moon. *Left:* on the last new moon day before the winter solstice. *Right:* on the 1st full moon day after the summer solstice. The shading area indicates the azimuth between the *Sema* S3 and S4

3.3 Celestial Position of the Sun on the New Moon Before Winter Solstice

According to the *Lanna* calendar, its year is based on a sidereal year and its month on a lunation, then, it is worth studying the relation between the Sun/Moon with the asterism in the sky on that new moon. To visualize the sky, Stellarium was used to simulate the sequent image of the sky maps as shown in *Figure 4* that to help understanding how the ancient *Lanna* observed the celestial objects and knew the sign of adding one more lunar month in the *Adhikamas* year.

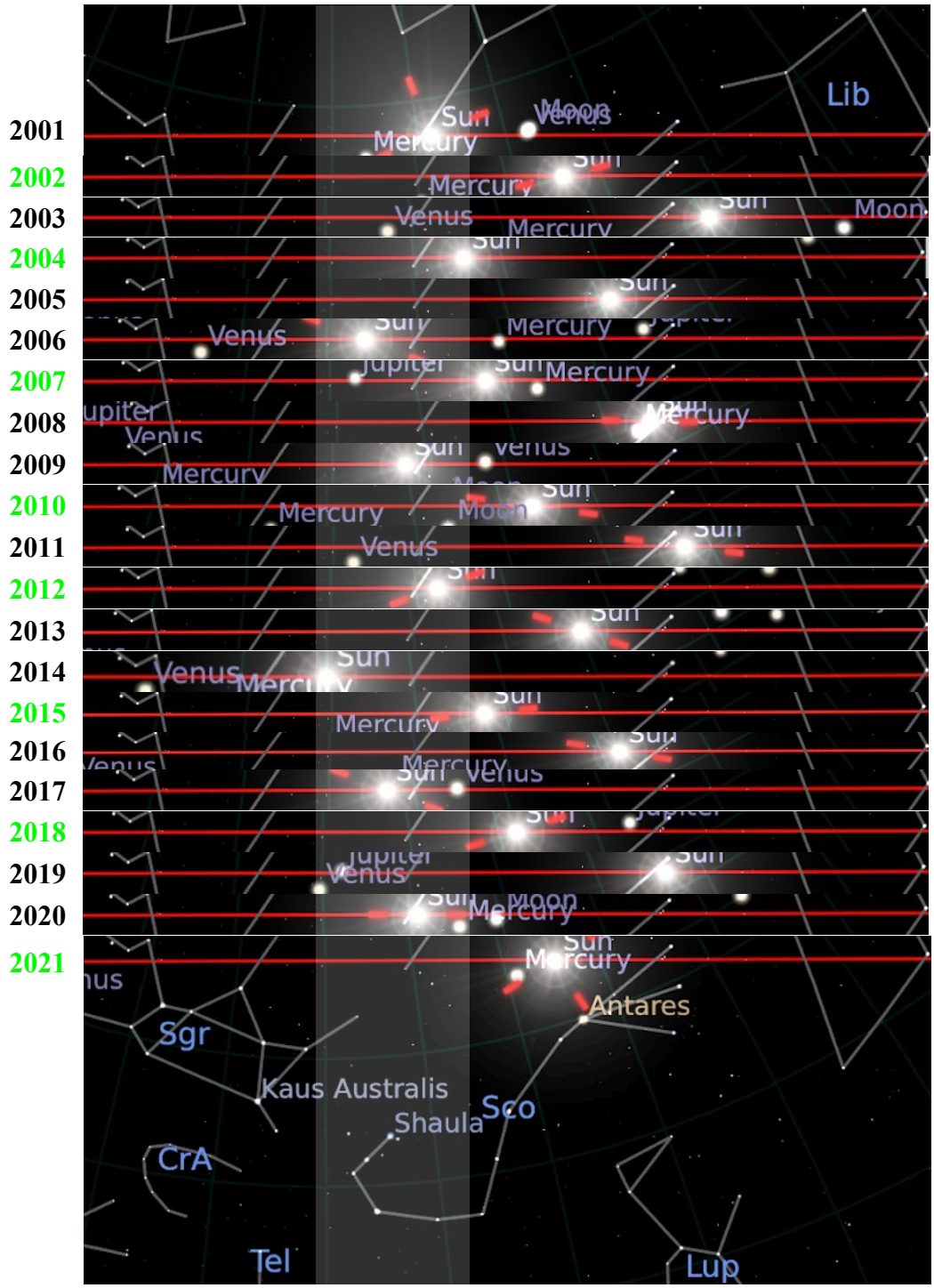

Figure 4. Sequent event on the new moon days before the winter solstice showing the different positions of the Sun in each year from 2001 to 2021, labeled in green for the *Adhikamas* years according to the official Thai Lunar Calendar. The shedding strip indicates the signal-year that the successive year would be an *Adhikamas* year and the red lines are the ecliptics.

Figure 4 was collected from 21 sky map images, visualizing the ecliptic position of the Sun on such new moon days in each year from AD 2001 to 2021. Those images were kept with the same background in order to compare the Sun positions with the asterism. To unveil how ancient observed the celestial objects in the signal-year and knew that the successive year will be an *Adhikamas* year, we focused on those last new moon day on the years before the *Adhikamas* year (the signal-year) which are 2001, 2003, 2006, 2009, 2011, 2014, 2017, and 2020. Stellarium had reviewed a relationship between the position of the Sun and the asterism that might have signaled to add one more month in the successive year. In those signal-years, the Sun stayed in the tail of Scorpion that was closer to Sagittarius than Antares. After adding one more lunar month in the *Adhikamas* year, the Sun located back close to Antares. In the regular year that was not the signal year, the Sun stayed on the right side of the Antares or just entered *Vrishchika Rashi* (Scorpio sign).

These studies indicated that using Stellarium software is an important step not only for better visual and understanding astronomy, but also adaptable for teaching other subjects such as history, architecture, religion, art, and culture etc., as well as applicable to study many ancient religious buildings all over the country.

4. Concluding Remarks

In the Religious Place Module at SCiUS CMU, Stellarium was the advantage tool that help the younger generation visualizing how ancient *Lanna* astronomy predicted an *Adhikamas* year. From Stellarium software, students have learnt that:

1. The *Lanna* local knowledge "13-dark moon impending 13-full moon" illustrated that *a)* on the first full moon after the summer solstice, the Sun rises in between the *Sema* pair S1 and S2 in the normal year, but rises close to S1 if the year is an *Adhikamas* year; *b)* on the new moon days before the winter solstice, the Sun rises between the *Sema* pair S3 and S4 in the normal year, but rises close to S4 if the year is a signal-year.
2. The Sun and the asterism on the new moon days before the winter solstice are related. The ancients have known the signal of adding one more lunar month. Those signal-years—the Sun stayed closer to Sagittarius than Antares—suggesting that the successive year would be an *Adhikamas* year.

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