

Relative Orientation of Prasat Hin Phanom Rung Temple to Spica on New Year's Day: The Chief Indicator for the Intercalary Year of the Luni-Solar Calendar

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Abstract. Prasat Hin Phanom Rung, located in Buriram Province of Thailand, is an ancient temple that had been built between the 10th and 13th century. The temple, which is off east-west orientation by 5.5° towards north, has unveiled the astonishing phenomena exhibiting both astronomical and architectural intellect of the ancient builders. The phenomena involve perfect quarterly-alignments of the sun through all the fifteen doorways of the temple. The phenomenal orientation of this ancient architecture has been elucidated by several scholars—including historians, archaeologists, and astronomers—that it might be related to solar or lunar events only. However, our studies have otherwise found a clue to this mystery that it may be based on how the ancient intelligence used stars in the zodiacal constellations to regulate agricultural calendars. In this study, we find that Phanom Rung was oriented with respect to Spica such that on the day Spica set on the west-side doorway at dawn, the sun was entering *Mesha Rashi* (Aries). This day has a direct connection to a New Year's Day of Saka calendar (Śaka Era), presently called *Thaloeng Sok Day*. Furthermore, we have found the relationship between Spica and the full moon of *Caitra* from which the intercalary month-year (*Adhikamas*) was detected.

Keywords. Phanom Rung, Temple Orientation, Spica, Intercalary Month-year, *Adhikamas*

1. Introduction

Prasat Hin Phanom Rung, a spectacular Khmer ancient sanctuary situated on extinct volcano in Buriram, is one of the most significant ancient monuments of Thailand. This temple had been built between the early 10th and 13th century. The oldest structures remaining in compound, which can be dated back to the 10th century during the King Rajendravarman (*r.* 944 – 968), are the two brick sanctuaries: one facing the east and another facing the south. The main sanctuary was built and dated back to the 11th – 12th century by Narendraditya. The last structures built are the two libraries and the pavilion during the King Jayavarman VII (*r.* 1181 – 1218) ([Fine Arts Department 2005](#)).

The Phanom Rung temple, which is off east-west orientation by 5.5° towards north, has unveiled the phenomena involving perfect quarterly-alignments of the Sun through all the fifteen doorways of the temple: during April 3rd – 5th and September 7th – 9th

for sunrises; and during March 5th – 7th and October 5th – 7th for sunsets. The significance of this phenomenal sunrise and sunset events has been previously studied by many scholars (Chunpongtong 2010; Komonjinda 2011; Mollerup 2007). Most of these studies explain such phenomena in relation to the Sun and/or the Moon. However, our studies of over a decade have otherwise proposed another answer to this mystery orientation that it may be based on how the ancient intelligence used stars in the zodiacal constellations to regulate agricultural calendars.

According to Yano (1986), the first step in the planning and construction of ancient Hindu temple is to determine cardinal directions by either observing fixed stars or observing the shadow of a vertical column or gnomon. Moreover, in ancient times, the risings or settings of stars, along with the Sun and the Moon, were used to determine the date of farming activities. Those stars including Spica, Regulus, Aldebaran, Antares, and Pleiades were marked by ancient Chinese (Chu 1947), Greek (Penrose 1893, 1901), Indian (Rajani & Kumar 2019; Rao 1992), Javanese (Magli 2020) and Khmer (Magli 2017). Therefore, we hypothesize that the orientation of the Prasat Hin Phanom Rung may be used as an astronomical instrument to observe the bright marked stars.

Ancient Khmer adopted the Saka Calendar (Śaka Era) in which a bright star had been used to mark the day the Sun entering *Mesha Rashi* (Aries) as the New Year's Day (NYD) this day is currently known as the *Thaloeng Sok* (TLS) Day of present *Culasakaraj* (CS) (Saelee *et al.* 2018). Based on Hipparchus First point of Aries, a marked star was Spica or Alpha Virginis (α Vir) (Saha & Lahiri 1992); therefore, in this study, we examine relative orientation of Phanom Rung to Spica by taken the precession of equinox in to account to reveal the dates and azimuths of Spica rising and setting at the temple as detailed in Section 2. Furthermore, we have investigated the relationship between Spica and the full moon of *Caitra* from which the intercalary month-year (*Adhikamas*) were detected as detailed in Section 3.

2. Relative Orientation of Prasat Hin Phanom Rung to Spica

In this section, we explore the relation between Spica and the Saka's NYD from the Hipparchus time (140 B.C.) to the present day (A.D. 2020) and propose that the off east-west orientation by 5.5° towards north is related to the position of Spica. When the First Point of Aries was introduced by Hipparchus, the ecliptic longitude of Spica was located almost 180° opposite to this point in 140 B.C., but it changes its position roughly 30° (the precessional cycle in a period of 26,000 years or 1° every 72 years) in A.D. 2020.

From the observer point of view, the star will rise or set earlier each day because the sidereal day is shorter than the mean solar day by about 4 minutes. The timings when Spica is rising and setting at Phanom Rung (14.53189° N, 102.94028° E; GMT+7) are investigated for the year 2020. There are four dates known as: (1) "heliacal rising"—the first day (18 Oct) at which Spica first becomes visible in the east at dawn; (2) "acronychal rising"—the last day (12 Apr) when Spica (after a period when it was visible at night) rises in the evening after sunset; (3) "cosmic setting"—the first day (15 Apr) at which Spica after becomes visible in the west at dawn; and (4) "heliacal setting"—the last day (15 Oct) when Spica (after a period when it was visible) sets after sunset. Among these four dates where both Spica and the Sun are seen on the horizon, only two dates are found related to the orientation of the temple, *i.e.*, the cosmic setting (Spica set south of west at dawn in April) and heliacal setting (Spica set in the evening in October). However, the cosmic setting is considered coinciding with the Saka NYD and the phenomenal sunrise.

Using the Stellarium 0.20.3, we obtain the dates and azimuths of Spica setting in the west while the Sun rising in the east at a horizon. From Fig. 1 (*left*), the orientation of

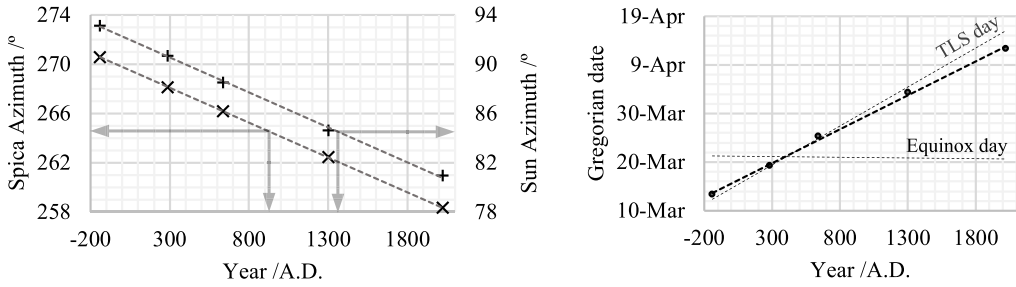


Figure 1. Left: The azimuth of Spica (×) when setting compared to the azimuth of the Sun (+) during rising. Right: The date when Spica sets as the Sun rises.

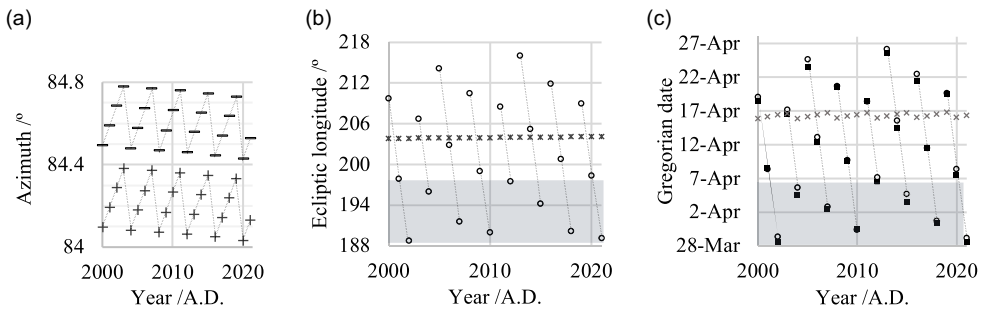


Figure 2. a) The azimuth of the Sun when rising on the 3rd (–) and the 4th (+) of April that the Sun can be seen through the 15 doors. The full moon of *Caitra* (o) in relation to b) Spica (*) and c) the TLS day (×). The full moon date on the Thai calendar is symbolized in solid square. The years in shaded areas are *Adhikamas*.

Phanom Rung (az. 84.5° and 264.5°) coincides with the azimuth of Spica around A.D. 930 which is matched with the first structure planning period (c. A.D. 900 – 1000) and the azimuth of the Sun about A.D. 1360 in which all the structures were already constructed. Fig. 1 (right) also shows that the shift on such dates, eventually due to the precession of equinox, is the same as the calendric TLS day of CS, but slightly different as a longer length of the sidereal year was used. Therefore, we postulate that the orientation of the temple is likely to aim at Spica around A.D. 930 and cosmic setting of Spica may have been used to mark the NYD of Saka Calendar.

3. Indicator for Intercalary Year of the Luni-Solar Calendar

The Prasat east-west line is oriented off the east towards the north by 5.5° or equivalently at the azimuth = 84.5° . We find that the dates in which the sun rises with azimuth closing to 84.5° are the 3rd and the 4th of April (Fig. 2a). The Sun’s azimuth of these two dates in each year differ by approximately $23.7'$ or 0.4° (decreasing or shifting towards north), whereas the azimuth of the Sun of the same date each year is shifted back approximately $5.7'$ except in the solar leap year.

We find that in 2000 – 2021, the full moon of *Caitra* exhibits the similar pattern of its longitude and date as shown in Fig. 2b – 2c. The pattern is repeated every 19 years (metonic cycle). In each year, the full moon of *Caitra* shifts backward 11° because ordinarily the lunar year is shorter than solar year by 11 days. As a result, in one solar year, the full moon date in *Caitra* shifts about 11 days. The *Adhikamas* years, which were assigned on the official Thai lunar calendar year 2002, 2004, 2007, 2010, 2012, 2015,

2018 and 2021, can be noticed by both moon's longitude and date on the full moon of *Caitra* as highlighted with the shaded area.

Fig. 2*b* shows the relationship between the actual full moon of *Caitra* and Spica from which the *Adhikamas* year were detected. Based on the intercalary month-year of the present CS calendar, if full moon's longitude of the year Y-1 is between $197^\circ - 208^\circ$ (the Spica's longitude of 204° is in this range), the year Y will be an *Adhikamas* year. It is to be noted that Saka and CS calendar based their TLS day calculation on the original *Surya Siddhanta*.

Fig. 2*c* shows the relationship of the calendar full moon date of *Caitra* and the TLS day. If the calendar full moon of *Caitra* year Y-1 occurs (April 7th – 16th) before the TLS day, the year Y will be an *Adhikamas* year. In other words, the full moon of *Caitra* occurring on/before the TLS day within a maximum of 10 days can be used to indicate that the next year is an *Adhikamas* year. It is important to note that the calendar full moon in the year 2011 is on April 18th, which is after the TLS day, and thus the year 2012 will not be an *Adhikamas* year. This result is conflicted with the official Thai lunar calendar and the detailed argument is already given in Saelee *et al.* (2018).

4. Concluding Remarks

We can conclude that Prasat Hin Phanom Rung may have been built as a religious monument and also as an astronomical instrument as follows:

- (1) The orientation of the Phanom Rung is believed to be used to observe Spica setting on the west-side doorway at dawn as the mark for the sun entering *Mesha Rashi* (Aries), and thus a direct connection to a New Year's Day of Saka calendar (Śaka Era). This day is presently called the *Thaloeng Sok Day*.
- (2) The orientation that is shifted away from east towards north by 5.5° could come from the observation of the chief Spica setting opposite to the rising sun (cosmic setting) at the azimuth 264.5° around A.D. 930, which coincided with the time the first temple layout was planned.
- (3) The case study during the year 2000 – 2021 reveals that if the full moon of *Chitra* occurs within 10 – 11 days before the New Year's Day, then the following year will be an *Adhikamas* year. It is possible that the ancient Khmer may used the full moon of *Chitra* in relation to the cosmic setting of Spica as an indicator for adding an intercalary month to an *Adhikamas* year.

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