

# Precession of Equinoxes and Sun's Transit in the Vṛddha-Gārgīya Jyotiṣa

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## Abstract

VGJ is a text of about 5000 verses, and some prose spread over 64 aṅga (sections). The text contains astral and other information, including the observed motion of the sun, moon, grahas, nakṣatras, and seasonal changes. Given the observations of the Sun's seasonal transit through nakṣatras in VGJ in Ādityacāra (11<sup>th</sup> aṅga) and Ṛtusvabhāva (59<sup>th</sup> aṅga), we present a method to statistically estimate the date of the observations in the text commensurate with the precession of the equinoxes. The same Ādityacāra information is also found in Parāśaratantra, which is in prose.

An observer, modern or ancient, would notice that the sun rises more in the southeast during winter and in the northeast during summer. There is daily progress between the two extremes, with the sun swinging from south to north and back. This swing is called a seasonal (tropical) year. The sun crosses the mid-point between the two extremes twice in one year. These four solar events in a year are the uttarāyaṇa (winter solstice), spring equinox, dakṣiṇāyaṇa (summer solstice), and autumn equinox, respectively.

The night sky is adorned with stars - as if in a celestial sphere. Stars seem to rotate east to west around a pivot position in the northern sky of this sphere as the night progresses. Stars closer to the pivot are always above the horizon even as they rotate around the pivot, while the further ones rise in the east and set in the west. The belt of stars on the celestial sphere, on the circle perpendicular to the pivot, is called nakṣatra maṇḍala - almost the same as the ecliptic. This maṇḍala is divided into 27 nakṣatras - each nakṣatra is a defined region with one or more stars. The motion of the celestials is constrained to this maṇḍala.

The nakṣatras last seen rising in the east before sunrise is an indicator of the season, apart from the felt experience. When the sun is at its southernmost, the nakṣatra before sunrise heralds the beginning of śiśira(winter) - considered the beginning of the year in ancient India. As the sun journeys north and then back to the south, covering the 27 nakṣatras, the start, and end of the six ṛtus (seasons), namely śiśira, vasanta, grīṣma, varṣā, śarat, and hemanta, are marked by different nakṣatra. Each season spans 4 ½ nakṣatras.

In Ādityacāra aṅga, winter is observed to start from the beginning of śraviṣṭhā while in the Ṛtusvabhāva aṅga the start is past śraviṣṭhā. It can be seen the seasonal nakṣatra markers between the two chapters have moved by around ½ nakṣatra. This movement indicates the observations in the two chapters are from different epochs - attributable to precession.

Each nakṣatra is a defined region with one or more stars around the ecliptic for a total of 83 stars. In our approach, we first gather the positions of nakṣatras for many past epochs using planetarium software. Then we compute an error metric that indicates how far these projected nakṣatra positions are from the expected season described in the text, for each epoch. The epoch with the least error is an estimate for the date of the observations in the text.

We determine that the two chapters have observations of two different epochs - Ādityacāra is placed around 1300 BCE and Ṛtusvabhāva 800 years later. This shows that the text is layered, assimilating later observations and insights as the text advances. Ṛtusvabhāva not only discusses the 12 months in addition to the six seasons of Ādityacāra. It also develops the notion of 12 solar months obviating the need for intercalary months needed in the earlier lunar reckoning.

## References

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