# INDIAN CALENDARS:

## COMPARING THE SURYA SIDDHANTA AND THE ASTRONOMICAL EPHEMERIS

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**Abstract**

## Introduction

The aim of this report is to give a brief overview of the workings of the Indian solar and lunisolar calendars, and to highlight the differences between the two methods of measuring the solar year from a fixed point on the ecliptic: the *tropical (sayana)* system and the *sidereal (nirayana)* system. In addition, I will also give an introduction of the two well-known astronomical treatises, the Surya Siddhanta and the Astronomical Ephemeris, from which most calendar-makers obtain all astronomical data. I will also explain and highlight the underlying differences between the two treatises in detail. Finally, this report aims to introduce computer codes written to produce true longitude values of the Sun and the Moon, calculated based on modern methods. They are modified from the computer codes originally written by Nachum Dershowitz and Edward M. Reingold in Lisp, but converted to Mathematica by Robert C. McNally. Their calculations are based on old Siddhantic methods**.**

## The Indian solar calendars and lunisolar calendars

The regional Indian solar calendars are generally grouped under four schools, known as the *Bengal*, *Orissa*, *Tamil* and *Malayali* School, and they are made to approximate the sidereal or nirayana year. The nirayana year is the time taken for the Sun to return to the same fixed point on the ecliptic which is directly opposite to a bright star called *Chitra*. The longitude of Chitra from this point is 180°. In order to assign a firm position to this initial point for astronomical purposes, this fixed initial point is taken to be the March equinox point of 285 A.D.. In other words, the starting point of the nirayana year coincided with the March equinox in the year 285 A.D.. This occurred on March 20, 285 A.D. at around 22 53 hrs, I.S.T.[1]. The celestial longitude of Chitra from the March equinox then was around 179°59'52'', which for all calendrical calculations is taken to be 180°.

The nirayana year comprises 12 solar months and they are directly linked with the 12 *rasi* divisions. A rasi is defined to be a division that covers 30° of arc on the ecliptic. The first rasi (*Mesha* rasi) starts from the same point that starts the nirayana year. The entrance of the Sun into the rasis is known as *samkranti*. A solar month is defined to be the time interval between two successive samkrantis. Most Indian solar calendars start with *Mesha* rasi and end with *Mina* rasi. However, samkranti can occur at any time of the day and hence it is not advisable to start a solar month at the concerned samkranti. Instead, the beginning of a solar month is chosen to be from a *sunrise*[2] that is *close to* its concerned samkranti.

The basic unit of the Indian lunisolar calendar is the lunar month, which is the time interval either from one *new moon* to the next or one *full moon* to the next. The lunisolar calendar based two successive new moons is called the *amanta* calendar. The lunisolar calendar based on two successive full moons is called the *purnimanta* lunisolar calendar. The lunar year consisting of 12 lunar months is shorter than the solar nirayana year, and hence leap months have to be added occasionally so that the calendar approximates the nirayana year. Such leap or intercalary months are called *adhika* months, and the occurrence of adhika months cannot be determined by arithmetical rules as in the Gregorian calendar. In addition, some lunar months in the amanta lunisolar calendar can have *skipped* days or *repeated* days, which makes the numbering of days in the month slightly more complicated than usual.

## The Surya Siddhanta and the Astronomical Ephemeris

The Indian solar and lunisolar calendars are based on common calendrical principles found mainly in an ancient and well-known astronomical treatise called the *Surya*

[1] Indian Standard Time. Ahead of Universal Time (U.T.) , or Greenwich mean time, by 5 h 30 min.
[2] The Hindu solar day starts with sunrise.

*Siddhanta*. The Surya Siddhanta is the first Indian astronomical treatise where rules were laid down to determine the *true* motions of the luminaries, which conforms to their actual positions in the sky. However, having written at around 400 A.D. when positional astronomy was not as advanced as now, astronomical values and true positions obtained by the *siddhantic* methods are not very accurate. For example, the modern mean length of the sidereal year is about 365.2564 days, but the *siddhantic* length of the sidereal year is 365.258756 days, longer than the correct mean length by about 3 minutes 27 seconds.

In contrast, the *Astronomical Ephemeris* is an astronomical treatise that contains accurate and modern astronomical information, calculated using advanced and more sophisticated methods.

## Computer codes based on ephemeric rules

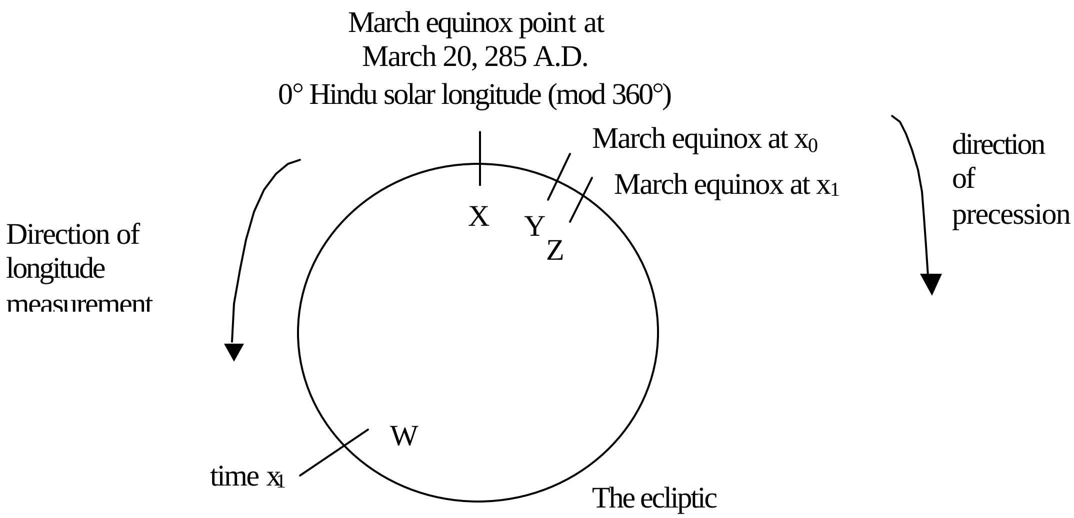
The computer codes written by Dershowitz and Reingold are based on old siddhantic methods, and hence it has caused their outputs to be different from those obtained if modern ephemeric methods were to be used. Their computer codes will be modified in this report using ephemeric rules, to obtain outputs that will more accurately determine present-day longitude values and other important astronomical information. To distinguish between their codes and mine, I will place an extra 'e', abbreviated for '*ephemeric*', in front of all codes written by them. The following are some examples:

| | |
|---|---|
| **HinduSiderealYear** | ***e*****HinduSiderealYear** |
| **HinduSolarLongitude** | ***e*****HinduSolarLongitude** |
| **HinduLunarLongitude** | ***e*****HinduLunarLongitude** |

In addition, we introduce computer codes like **ToFixed[date], JDStart**, **JDFromMoment[ToFixed[date]]** and **HinduEpoch** to facilitate understanding of the way the various computer algorithms are written.

The *solar longitude* measures the position of the Sun with respect to a reference point on the ecliptic from which all measurements are to be taken. For calendars following the tropical year, it will be March equinox point, which will undergo precession. The

Indian calendar approximates the sidereal year. Hence, they have a different point of reference from which *Hindu solar longitude* is to be measured. This point is the point on the ecliptic when the March equinox occurred on March 20, 285 A.D. Our aim is to calculate modern day Hindu solar longitude based on modern day solar longitude values.




We want to calculate the Hindu solar longitude at time $x_1$ as follows, given in simplified form

**eHinduSolarLongitude[$x_1$]**

**= ZW – YX – ZY**

**= SolarLongitude[$x_1$] - SolarLongitude[$x_0$] – PrecessionDistance**

of which we proceed to calculate the modern Hindu lunar longitudes in the same way.

## References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