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A Comparative Analysis of Different Types of *Ayanāṃśa* in Ancient Indian Astronomical Computations

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Abstract: Ayanāṃśa is a fundamental concept in Indian astronomical calculations that accounts for the precession of the equinoxes, ensuring accurate computation of planetary positions. This paper compares major types of Ayanāṃśa, such as Lahiri, Raman, and Krishnamurti, analysing their origins, computational methodologies, and their implications for astronomical models. By examining their historical foundations and evaluating their precision against observational data, this study highlights the strengths and limitations of each approach. The research further explores the cultural and regional preferences for specific Ayanāṃśa types, offering insights into their impact on traditional and modern Indian astronomical practices.

Key words: Tropical and Sideral Constellations, Ephemeris (Pañcāṅga), *Ayanāṃśa*, cusp of Aries**,** Mesham 0°

1. INTRODUCTION

Ayanāṃśa refers to the angular difference between the tropical zodiac, i.e., constellations that lie on the Ecliptic Band (used in Western astronomical calculation), and the sidereal zodiac (used in ancient Indian astronomy). This difference arises due to the precession of the Earth's equinoxes, a phenomenon where the Earth's rotational axis wobbles over millennia, shifting the apparent position of the fixed stars.

The ancient Indian computation (*Pañcāṅga*) is thus based on the sidereal (*Nirayana*) system only. "*Nirayana*" means "Ni + Ayana, meaning without Ayana (*Ayanāṃśa* is not included), i.e., the system uses the fixed zodiac reference. But modern astronomy is based on the tropical (*Sayana*) system only. "*Sayana*" means "Sa + Ayana, with Ayana (*Ayanāṃśa* is included), i.e., the system uses a moving zodiac reference.

In modern astronomy, consider the March equinox point (March 21) as their reference point (i.e., the first **point of Aries**, also known as the **cusp of Aries**) for the measurement of celestial coordinate systems. In ancient astronomy, astronomers used Mesham 0° on the ecliptic as the reference point for their reference systems for the measurement of celestial coordinate systems. Once upon a time, in ancient times, the March equinox used to coincide with Mesham 0° on the ecliptic (as per the data available, we don't know the exact time period in which it occurs, the biggest controversy to date). The ancient astronomers were able to discern this small difference when they compared the position of the March equinox and 0° of Mesham against a distant star in the stellar background ("sidereal position). This phenomenon is called precession of the equinoxes [1]. This westward drift is cumulative, and the extent of deviation from the original point of time in the past when the March equinox exactly coincided with the 0 of Mesham in the celestial zodiac to the current time is termed "*Ayanmasa*." The shift is reluctant; one can never experience it in his lifetime. It required a long period of observations. We can say the first **point of Aries** in modern astronomy is not the same as **Mesham 0°; it** is not the same point.

$$\boldsymbol{Mesham}\,\mathbf{0}^{\circ} + Ayanmasa = \boldsymbol{first\ point\ of\ Aries}$$

i. e.,

$$\boldsymbol{Sideral\ Longitude}\ (Nirayana) + \boldsymbol{Ayanmasa}\ (\boldsymbol{Precession\ correction}) = \boldsymbol{Tropical\ Longitude}\ (\boldsymbol{Sayana})$$

For the calculation of *Ayanāṃśa*, it is very important to know in which year or time period *Ayanāṃśa* is 0, i.e., the March equinox used to coincide with Mesham 0° on the ecliptic. But unfortunately, it is not known at which point in time in the past these two were exactly coinciding. Due to this uncertainty, there are many *Aynamsas* being used by different practitioners of the *Nirayana* system. The different values adopted for *Ayanāṃśa* are the main cause for the birth of different types of Indian ephemerides (*Pañcāṅgas*). So, the term "*Ayanāṃśa*" is the most important factor for our timekeeping method. To ensure accurate astronomical computations, the choice of *Ayanāṃśa* significantly influences computational accuracy, making its precision a topic of ongoing research.

At present in our country, Pañcāṅga Karthas adopt *Ayanāṃśa* values varying between 19° to 24°. This paper aims to provide a comparative analysis of the most commonly used *Ayanāṃśa* types—Lahiri, Raman, and Krishnamurti. We will explore their historical origins, computational methods, and implications for Indian astronomical studies, providing a comprehensive understanding of their respective advantages and limitations.

2. HISTORICAL BACKGROUND

2.1 The Concept of *Ayanāṃśa* in Vedic Astronomy

The use of *Ayanāṃśa* dates back to ancient Vedic texts, where scholars observed the gradual shift in the celestial sphere over time. The *Surya Siddhanta*, a foundational astronomical treatise, contains early references to the precession of the equinoxes and provides methods for calculating the sidereal positions of planets.

2.2 Evolution of Different Ayanāṃśa Types in ancient Indian computational method

Over the centuries, Indian astronomers developed different *Ayanāṃśa* systems based on their interpretations of astronomical observations and ancient scriptures. These variations reflect differences in the chosen reference points, such as fixed stars or other celestial markers. The modern era saw the formalization of several prominent *Ayanāṃśa* types (Here we consider only three of them):

- **Lahiri Ayanāṃśa** (Chitrapaksha): Popularized by N.C. Lahiri in 1955 and officially adopted by the Government of India for astronomical calendars.
- **Raman Ayanāṃśa**: Introduced by Dr. B.V. Raman, emphasizing alignment with traditional Indian astronomical principles.
- **Krishnamurti Ayanāṃśa**: Developed by K.S. Krishnamurti, specifically designed for the Krishnamurti Paddhati system of precise astronomical predictions.

2.3. Evolution of Different Ayanāṃśa Types in Modern computational method

IAU 1976 Precession model IAU, announced a Precession formula in the year 1976 (which is referred to as "IAU 1976 model' based on the research papers of J.H.Lieske. Further, the Besselian epoch system Which was in existence till then, was replaced by Julian Epoch, with year J2000, as reference epoch. (J stands for Julian) and time duration in Julian centuries.[2]

As per their recommendation the equation for Precession (IAU 1976 modal) for any year would be as follows:

$$P = C + (5029.0966 \times T) + (1.11113 \times T^2) - (0.000006 \times T^3)$$

wherein P = *Ayanāṃśa* (Precession) for any required Year (date/time)

C = *Ayanāṃśa* value for J 2000 (01-01-2000, 12.00 hr UT) in sec.

T = the time interval between J 2000 and the year for which *Ayanāṃśa* is required, in Julian centuries.

American Ephemeris & Nautical Almanac (AENA) have adopted the precession value mentioned above (IAU 1986 model) from year1984 onwards, in the preparation of their Almanac. [3] Additional information Incidentally, J.H. Lieske has provided an updated version of Newcomb precession, in his research paper, using which, the formula to find *Ayanāṃśa* for any year would work out as below.

$$P = C + (5029.0966 \times T) + (1.11161 \times T^2) - (0.000113 \times T^3)$$

C = Precession value for J 2000 in sec.

T = interval between required year and J 2000 in Julian centuries.

It is reliably learnt that Indian Astronomical Ephemeris (IAE) have adopted the above formula from year 1985 onwards (omitting the third component i.e.: $0.000113 \times T^3$, the value being insignificant) for calculating mean Ayanāṃśa, for use in their Ephemeris, taking C value as 85885.53192 seconds. [4,5]

I intend to defer further elaboration on IAU 1976 model, as it has been superseded by IAU 2006 model.

IAU 2006 Precession Model: IAU announced a Precession formula (update to its 1976 model) in the year 2006, which remains the latest as on date.

The formula is given below.

$$P = C + (5028.796195 \times T) + (1.1054348 \times T\text{^}2) + (0.000079640 \times T\text{^}3) - 5\,(0.000023857 \times T\text{^}4) - (0.000000038300 \times T\text{^}5)$$

In which P = Precession (Mean Ayanāṃśa) for any required year (time) in second

C = *Ayanāṃśa* for J 2000 (As on 01-01-2000,12.00 UT (05-30 pm IST) in seconds.

T = interval between the date for which P is required and J 2000, in Julian centuries. (value will be minus for years before J2000 and plus for years after J2000) [3].

3. COMPUTATIONAL METHODOLOGIES

3.1 KP Ayanāṃśa (Krishnamurti Paddhati Ayanāṃśa)

The formula for KP Ayanāṃśa is [6]:

$$KP\ Ayanams = (Fixed\ Value\ at\ Epoch\ Year) + (Precession\ Rate\ per\ Year \times Years\ Since\ Epoch)$$

Fixed Values

- The fixed Ayanāṃśa at epoch 1900 is **22° 27' 37"[7]**.
- The annual precession rate is approximately **50.2388475 seconds per year** [8,9].

Example: Calculate KP Ayanāṃśa for 2025

Step 1: Years Since Epoch

Years Since 1900=2025−1900=125 years.

Step 2: Calculate Precession Contribution

Precession per year is **50.2388475 seconds**.

Total Precession=125×50.2388475 seconds.

Convert to degrees (1 degree = 3600 seconds):

Total Precession = (125×50.23884753600) / 3600 ≈1.742°

Step 3: Add to Fixed *Ayanāṃśa*

Fixed *Ayanāṃśa* (epoch 1900) = **22° 27' 37"**.

Convert to decimal degrees:

22°27′37"=22+27*60+37*3600 ≈ 22.4603°

Now, add the precession contribution:

KP *Ayanāṃśa* for 2025=22.4603+1.742 ≈ 24.2023°

Step 4: Convert Back to DMS

24.2023°=24°12′8.28"

3.2. B.V. Raman *Ayanāṃśa*:

1. **Know the Year of Calculation**: The *Ayanāṃśa* changes over time due to the precession.
2. **Reference Year and Value**: B.V. Raman used 285 A.D. as the reference year with a starting Ayanāṃśa of 0°.[9]
3. **Rate of Precession**: Typically assumed to be 50.29 seconds of arc per year.
4. **Formula**: $Ayanamsa\,(degrees) = (Current\,Year - 285) \times 50.29\,seconds/year \div 3600$[9]
5. **Add or Subtract Ayanāṃśa**:
    - To convert tropical positions to sidereal, subtract the Ayanāṃśa.
    - To convert sidereal positions to tropical, add the Ayanāṃśa.

Example Calculation for 2025:

1. **Current Year**: 2025
2. **Reference Year**: 285
3. **Years Elapsed**: 2025−285=17402025 - 285 = 17402025−285=1740
4. **Total Precession in Seconds**: 1740×50.29=87,504.6
5. **Convert to Degrees**: 87,504.6÷3600=24.3068°

Thus, the *Ayanāṃśa* for 2025 using B.V. Raman's method is approximately **24.31°**.

3.3 Lahiri *Ayanāṃśa*

It is officially recognized by the Indian government and is based on a specific starting point known as the *Chaitra Paksha*, marking the vernal equinox alignment with the star Spica (Chitra Nakshatra).

Key Concepts in Lahiri Ayanāṃśa:

1. **Reference Year**: 285 A.D. is the reference year with an Ayanāṃśa value of 0° [12].
2. **Precession Rate**: Similar to B.V. Raman, Lahiri Ayanāṃśa assumes a precession rate of **50.29 arcseconds per year**.
3. **Formula for Lahiri Ayanāṃśa**: $Ayanamsa\,(degrees) = (Current\,Year - 285) \times 50.29\,seconds/year) \div 3600$ [12,13]

Example Calculation for 2025:

1. **Current Year**: 2025
2. **Reference Year**: 285
3. **Years Elapsed**: 2025−285=17402025 - 285 = 17402025−285=1740
4. **Precession in Arcseconds**: $1740 \times 50.29 = 87{,}504.61740 \times 50.29 = 87{,}504.61740 \times 50.29 = 87{,}504.6\,arcseconds$
5. **Convert to Degrees**: $87{,}504.6 \div 3600 = 24.3068°87{,}504.6 \div 3600 = 24.3068°87{,}504.6 \div 3600 = 24.3068°$

Thus, the **Lahiri Ayanāṃśa for 2025** is approximately **24.31°**.

3.4 IAU Precession Model

Formula for Precession (Generalized):

The precession angle can be calculated using polynomial approximations:

$$P(T) = P0 + P1 \times T + P2 \times T\text{^}2 + P3 \times T\text{^}3 + \cdots$$

P(T): Precession angle (arcseconds)

- T: Julian centuries from J2000.0 (t=Julian Date−2451545.036525) [5]

Key Constants for IAU 2006:

1. **Precession of the Ecliptic (ϵ_A)**:
$\epsilon_A = 84381.406 - 46.836769 \times T - 0.0001831 \times T\text{^}2 + 0.00200340 \times T\text{^}3 - 0.000000576 \times T\text{^}4 - 0.0000000434 \times T\text{^}5$ [3]

Precession Rate: Approximate rate of 50.29 arcseconds per year (historically consistent).

Precession Value for 2025 (Using IAU 2006 Model)

Steps:

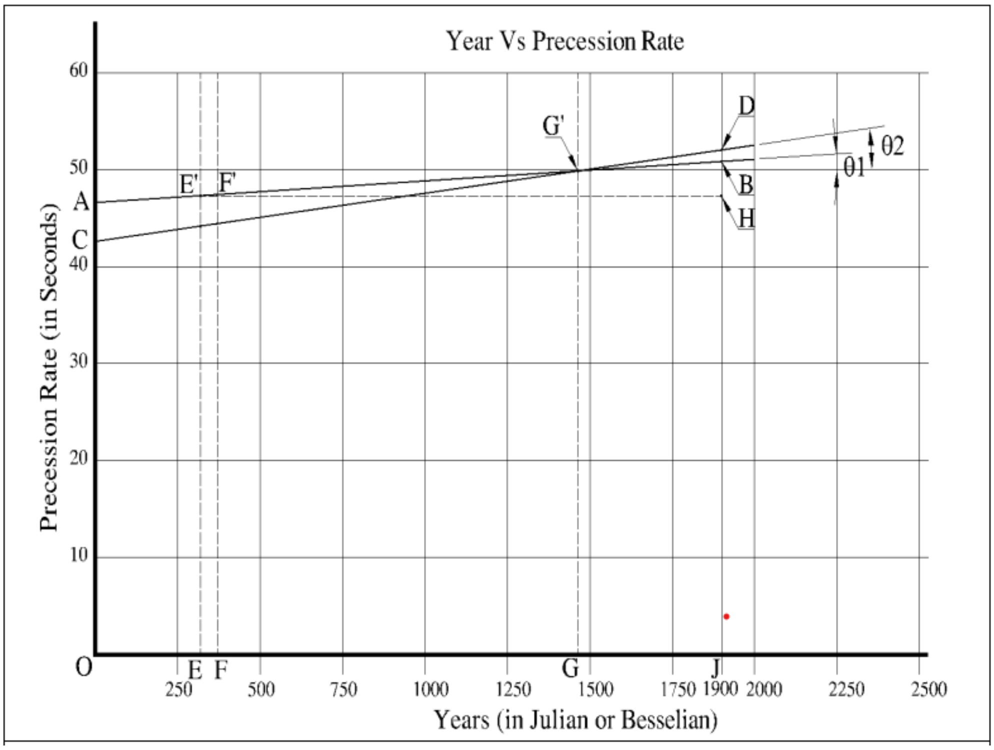
1. **Julian Date for 2025**:
   - Calculate t relative to J2000.0.
   - For mid-2025 (e.g., June 1, 2025): Julian Date ≈ 2460440.0.

T=2460440.0−2451545.036525=0.2437

Precession Angle (ϵ_A): Substitute T=0.2437 into the formula:

$$\epsilon_A = 84381.406 - (46.836769 \times 0.2437) - (0.0001831 \times 0.2437\text{^}2) + (0.0020034 \times 0.2437\text{^}3) - (0.000000576 \times 0.2437\text{^}4) - (0.0000000434 \times 0.24372\text{^}5)$$

Calculation yields **24.3°** as the approximate precession value.



Graphical representation of Precession rate and Aynamasa using IAU2006 Precession Model along with latest Nutation Model IAU20004

4. RESULTS AND DISCUSSION

4.1 From the above we reach in two conclusions:

1. To calculate accurate values of Precession Rate and Ayanāṃśa (Precession), we shall find the basic parameter 'T.' So that 'T' can be used in the selected precession, the nutation model is based on which they were developed/derived.

2. Hence, for our Indian Ephemeris calculation, it is recommended to adopt the IAU2006 Precession Model along with the latest Nutation Model, IAU20004, to obtain True Ayanāṃśa and True Obliquity so that a more accurate Nirayana position of Cusps and Planets can be obtained.

The epoch years differ in various Ayanāṃśa calculations because different astrologers and traditions use distinct reference points for the alignment of the tropical and sidereal zodiacs. These reference points are tied to specific astronomical phenomena or interpretations of ancient texts, and they reflect varying assumptions about the precise position of the celestial equinox at a given time in history.

The words of KSK from his article “Which Pañcāńga to use?” published in December 1963 [7].

“Our ancient astronomers had clearly mentioned in their treatises that the astronomers in the future have to revise the calculation from time to time, if and when found necessary. They have expressed that the results arrived at should agree with the scientific and ocular verification. They are of the opinion that if the position of planets is arrived at by using a calculation inconsistent with observational precession, then the result is only approximate and rough.”

The above words are from the authority and self-explanatory. Hence our Pañcāńga Kartha (Indian ancient ephemeris makers) are recommended to use the True Ayanāṃśa and True Obliquity, calculated based on the latest Precession/Nutation Model for calculating accurate Nirayana longitude for the planets and cusps.

4.2 Implications for Astronomical Computation

- **Lahiri Ayanāṃśa**: Suitable for general astronomical predictions and universally accepted for computational calendars.
- **Raman Ayanāṃśa**: Preferred by those who value alignment with ancient texts and traditions.

- **Krishnamurti Ayanāṃśa**: Ideal for astronomers focusing on detailed, event-based computations.

4.3 Cultural and Regional Preferences

The choice of *Ayanāṃśa* often reflects regional and cultural influences. Lahiri is the standard across India, while Raman and Krishnamurti systems have strong followings among specific schools of astronomy.

5. Conclusion

The debate over the “correct” Ayanāṃśa underscores the dynamic interplay between tradition and modernity in Indian astronomical studies. Each system offers unique strengths and serves different purposes within astronomical computations. While the Lahiri Ayanāṃśa remains the most widely used, the Raman and Krishnamurti Ayanāṃśa types cater to specialised needs, highlighting the diversity and adaptability of Indian astronomical traditions. To make our Indian astronomical computational technique (ephemeris or panchang) more accurate, it is recommended to adopt the IAU2006 precession model along with the latest nutation model, IAU20004, to obtain true Ayanāṃśa and true obliquity.

Future research should focus on refining computational techniques and exploring ways to harmonise traditional wisdom with advancements in astronomy, ensuring the continued relevance of Indian astronomical practices in the modern era.

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