History of Indian and European Calendars (Timekeeping): Difference in Definition of a Year

Anand M. Sharan

Abstract: This paper discuses Indian and European calendars used since ancient times. The paper shows that the Indian calendar included sidereal as well as tropical year information. On the other hand, the European (Julian) calendar did not include the processional motion of the earth's axis. This calendar was reformed in 1582 AD by Pope Gregory but this calendar changed from a sidereal to a tropical calendar which is about 20 seconds shorter than a sidereal calendar.

In India, Gregorian calendar was adopted during the British rule but its use remained amongst the educated masses in the cities. The students in schools and universities in India have not been taught accurately the difference between a sidereal and a tropical year.

***Keywords*: Calendar, Effect of precession, Tropical calendar, Sidereal calendar, Time period of a year**

I. INTRODUCTION

Humans have relied on agriculture for thousands of years. The planting of crops depended on seasons. This required them to look at the sky for regularity in the appearance of heavenly bodies as they could not rely merely on the position of the Sun in the sky. The Egyptians had established a link between the heliacal rising of Sirius and the beginning of the year [1]. Similarly, the Mayans also developed their own calendars as they needed to plant crops.

In India also, the agriculture was quite developed and there were many mathematicians who applied astronomy with a view to develop accurate calendar. Here, they calculated the positions of the Sun and planets which included the nodes of the Moon [2,3]. They refined their calculations to include precession of the earth's axis which takes place at an extremely slow rate of 50.287 angular seconds per year or it causes about a day's change in the calendar every 72 years. It required great mathematical accuracy, and minute observations in the sky to be made - to accurately chart the position of planets in the sky.

India was a leader in using trigonometry to calculate the position of planets. Aryabhatt I made very accurate calculations and was aware of the phenomenon called precession of the earth's axis in space. He came up with the idea that the earth spins around its axis in the 5th century AD [4].

II. MOTIONS OF EARTH AROUND THE SUN AND NAKSHATRAS (ASTERISMS)

In astrology and historical astronomy, the Nakshatras (asterisms) are distributed along a circle of 27 equal divisions each of 13.333° span of celestial longitude that are centered upon the ecliptic. When viewed from the earth it is the apparent path of the Sun or the trace of the Sun as we see during the day across the celestial sphere in the sky. The paths of the Moon and visible planets - also remain close to the ecliptic, within the belt of the zodiac, which extends 8-9° north or south of the ecliptic, as measured in celestial latitude. The earth goes in its orbit of almost a circular shape around the Sun in about 365.25636 days (Fig. 1). In this figure, the distance between the Sun and earth is far smaller than between the Sun and any of the Nakshatras in the zodiac belt

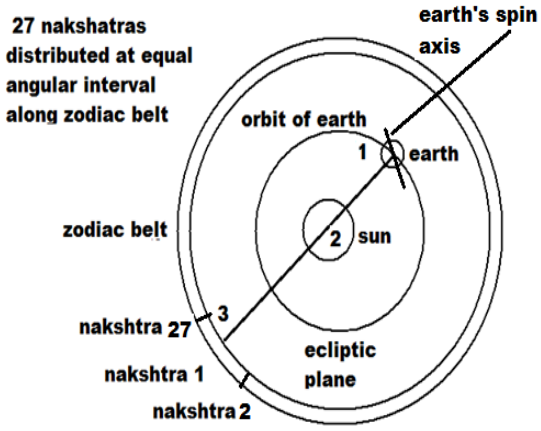

FIG. 1 DISTRIBUTION OF NAKSHATRAS ALONG THE ZODIAC BELT

During its (earth's) traverse, its north pole is oriented towards the Sun on June 21 and its south pole on December 21 which gives rise to summer and winter seasons respectively. The Moon goes around the zodiac belt in 27.322 days (sidereal) when viewed from the space but 29.531 days (synodic) when viewed from the earth.

The earth has a second motion which is spin around its own spin axis once in 24 hours which gives rise to day and night. Aryabhatt I was the first one who came up with the concept of spin of the earth in the 5th century AD in India. This concept was known in Europe only around 14th century AD.

The earth has a third motion which is called the precession of the earth's axis in the space as shown in Fig. 2.

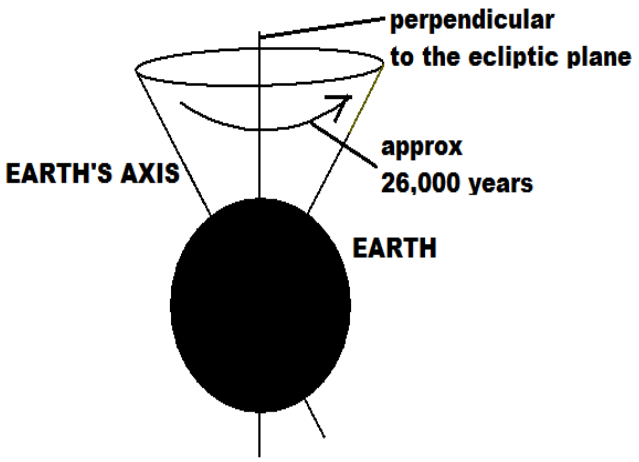

FIG. 2 PRECESSION OF EARTH'S AXIS

Here, this axis rotates as observed in the space along the conical surface once in around 26,000 years which is an extremely slow motion. Due to this motion, the earth's axis changes its orientation in space whereby the North Pole would face the Sun with same orientation on June 20 instead of June 21 after a lapse of about 72 years. Similarly, the equinox will take place on March 20 instead of March 21 after 72 years. In a nut shell, it affects the seasons on the earth by shifting the solstices and equinoxes one day earlier.

This motion was known in India in the Gupta period with great degree of accuracy (46. 2 angular seconds per year) which is determined as 50.287 angular seconds per year in modern times [2-4].

III. THE EUROPEAN (GREGORIAN) CALENDAR

The Europeans used Julian calendar prior to 1582 but it was a refinement in 1582 when the length of the year was reduced by about 20 seconds, and this type of year is called a tropical year [5-7]. It was Pope Gregory who refined the calendar and after 1582 it is called as Gregorian calendar. The reason for the reform was to bring the date for the celebration of Easter to the time of the year in which the First Council of Nicaea held - which was in 325 AD. As mentioned above, in Europe the third type of motion (precession) was not known and as a result, the seasons (equinoxes) drifted earlier by one day in every 72 years. In 325 AD the spring equinox took place on March 21. In 1582, it had shifted to March 10.

Because the celebration of Easter was tied to the spring equinox, the Roman Catholic Church considered this steady drift in the date of Easter undesirable. To stop this drift in the Julian calendar, Pope Gregory reformed the calendar by making the length of the year 20 seconds shorter than a sidereal year observed in the Julian calendar. The consequence of this reform was that the equinoxes after and including 325 AD would always occur on March 21. This shorter year is called a tropical year so that a season on a given day would always remain the same, year after year, but it was a deviation from a sidereal year used in other parts of the world including India.

This Gregorian calendar was first adopted in Europe and then, after many years –also in India during the British period. However, its use was confined mainly to those residing in the cities in India.

CALENDARS IN INDIA

Most lunar calendars in India are in fact luni-solar calendars. That is, months reflect the lunar cycle, but then intercalary months (adhika-masa) are added to bring the calendar year into synchronization with the solar year [8].

As seen from the earth, the Moon moves in its orbit around the earth (Fig. 3) and it takes about 29 and a half days where it has waxing (Shukla pasha) and waning phase (Krishna pasha) of equal duration.

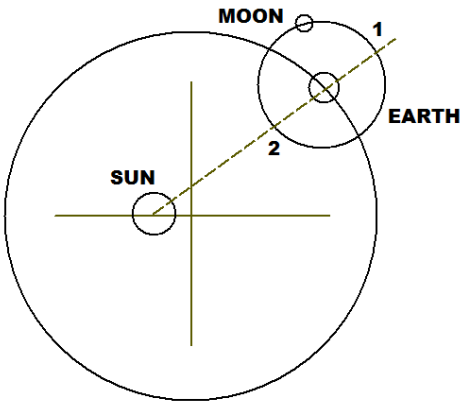

FIG. 3 FULL AND NEW MOON

During this orbital travel, the full moon takes place when the Moon and the Sun are on the opposite sides of the earth whereas on a new moon day, they are on the same side. On the new moon day, the Moon is not visible because its face which faces the earth is in shadow. During its orbital motion, its face which is visible from the earth is the same i.e. we never see the other face of the Moon from the earth. Since India had the knowledge about precession even in Aryabhata's time, its calendars (Penchants) took into account all the three motions shown in Figs 1 to 3. The entire India whether in cities or villages used these Panchangs in their daily lives.

In other words, planting of crops took place in accordance with the times shown in Panchangs. In recent times, there have been calls to modify Indian calendars (luni-solar) which have been in use as Saka Samvat (starting year 78 AD) and Vikram Samvat (starting year 57 BC) and make them similar to the Gregorian calendar which is solar.

Table 1 shows information about zodiac signs in the zodiac belt and corresponding Nakshatras.

TABLE 1: ZODIAC SIGNS AND CORRESPONDING NAKSHATRAS

Zodiac Sign	Abbrev	Angle, Zodiac Sign	Angle, Nakshatras (Degrees)	NAKSHATRAS (Asterisms)
Aries	Ar	0	13.3333	1. Aswini
(Mesha)			26.6666	2. Bharani
Taurus	Ta	30	40	3. Krittika
(Vrishaba)			53.3333	4. Rohini
Gemini	Ge	60	66.6666	5. Mrigasirsha
(Mithuna)			80	6. Ardra
Cancer	Ca	90	93.3333	7. Punarvasu
(Karkata)			106.666	8. Pushya
Leo	Le	120	120	9. Ashlesha
(Simha)			133.333	10. Magha
			146.666	11. Purva Phalguni
Virgo	Vi	150	160	12. Uttara Phalguni
(Kanya)			173.333	13. Hasta
Libra	Li	180	186.666	14. Chitra
(Tula)			200	15. Swathi
Scorpio	Sc	210	213.333	16. Vishaka
(Vrishchika)			226.666	17. Anuradha
Sagittarius	Sa	240	240	18. Jyeshitha
(Dhanu)			253.333	19. Moola
			266.666	20. Poorvashada
Capricorn	Cp	270	280	21. Uttarashada
(Makara)			293.333	22. Shravana
Aquarius	Aq	300	306.666	23. Dhanishtha
(Kumbha)			320	24. Shathabisha
Pisces	Pi	330	333.333	25. Poorva Bhadrapada
(Meena)			346.666	26. Uttara Bhadrapada
			360	27. Revati

Table 2 shows the names of various months in the luni-solar calendar. The name of the month is derived from the place of the Moon on the full moon day in a given Nakshatra which are 27 in total and are equal to the number of days in a sideral lunar month or period.

TABLE 2: THE MONTHS, AND SEASONS OF THE HINDU CALENDAR

	Hindu Month	Western Months	Name of the Hindu Season	Western Name of Season
1.	Chaitra	March-April	Vasanta	Spring
2.	Vaishakh	April-May	Vasanta	Spring
3.	Jyeshta	May-June	Greeshma	Summer
4.	Aashaadh	June-July	Greeshma	Summer
5.	Shraavan	July-August	Varsha	Monsoon
6.	Bhadrapad	August-September	Varsha	Monsoon

7.	Ashwin	September-October	Sharad	Autumn
8.	Kaartik	October-November	Sharad	Autumn
9.	Margasheersh	November-December	Hemanta	Winter
10.	Paush	December- January	Hemanta	Winter
11.	Maagh	January-February	Shishira	Dewey
12.	Phalgun	February-March	Shishira	Dewey

Indian farmers who outnumber the population in cities – still follow either the Saka or Vikram Samvats as shown in Tables 3 and 4 where the lack of timely rain is mentioned [9-11].

TABLE 3 ADAPTING TO CHANGING WEATHER CYCLE: OBSERVATIONS IN ORISSA [9]

NUMBER	NAKSHATRA	CALENDAR PERIOD	REMARKS
1	Ardra	22 June-5 July	Earlier start of sowing season (Rice)
2	Punarvasu	6 July-19 July	Now starting of sowing season
3	Pushya	20 July- 2 August	Now starting of sowing season
4	Aslesha	3 August-16 August	
5	Makha	17 August- 30 August	
6	Pubba	31 August-12 September	
7	Uttara	13 September-26 September	No Rain
8	Hasta	27 September-9 0ctober	No rain (Less Pulses Production)
Belief in Orissa	"Awat Adar Nahi Diyo Jat No Diyo hasta. Bina Khane Dona Gaye Pahuna aur Grihasta" (If there is no rain in Ardra (22 June–5 July) with the onset of the monsoon and No rain in Hasta (27 September–9 October) during the retreat, host And guest have to go without food		

TABLE 4 TIMELINESS OF RAIN IN MITHILA (BIHAR) , AND NEPAL TERAI (FOOTHILLS) [10,11]

NUMBER	SAYINGS IN MITHILA
1	"Aadi na bares aadra hasta na bares nidan Kahe Ghagh sun Bhaddari, bhaye kisan pishan." IF there is no rain in the beginning of Ardra nakkshtra and if there is also no rain in the Hasta nakshatra then Ghagh says to Bhaddari listen there will be no rain and the farmer's community will suffer a lot
2	" Adra gele tinigel, san ,sathi aur kapas Hathiya gele sab gel, Aagin pachhilnas." If there is no rain in the Ardra nakshtra then there will be no crop of jute, paddy and cotton. Likewise when in Hasta nakshtra if it does not rain then there will be no crop before and after.

Depending upon the convention, some places use the duration of a month as the time span between a full moon to full moon day and the other between the two new moon days.

VI. DOES INDIA NEED REFORM IN ITS CALENDAR (LUNI-SOLAR) TO A TROPICAL CALENDAR?

India is a vast country where the majority of its population still lives in villages and where largIe effort is needed to educate its population. The rural masses have historically, without break, followed fairly accurate calendar unlike in Europe. Therefore, in the view of the author, not much can be achieved by rushing through any changes. It would be a massive task. In U.S.A. ,they did not change to a metric system even when most of the countries in the world changed because its economy was too big and it would have been a massive task to make this change. Similar is the situation in India because the output from agriculture constitutes very significant part of India's GDP. Any tampering with agriculture can have serious consequences for the country.

Indians, to the surprise of many in the cities, have also used the concept of a tropical year since the ancient times. The proof is shown in various statements of Tables 3 and 4 where the Nakshatras mentioned show the positions of Sun as a function of time (similar to a solar calendar). Since Indian calendars always stated the position of the Sun amongst the Nakshatras, they knew the fact that the position of the Sun in the sky is the cause of seasons as has been made clear in Tables 3 and 4.

These statements have been arrived at after great deal of experience. Since these statements describe the positions of the Sun through various Nakshatras for planting crops which need rain , this means that India always followed equivalent of tropical calendar (change of seasons). Indians all along knew about the drift of seasons by continuously correcting their calendar year by year when Panchangs were issued. The Europeans, on the other hand, were not aware of the precession and corrected their calendar abruptly in 1582. Not only this, they changed the definition of the year itself by shortening it by 20 seconds.

It should be noted that the Panchangs must have shown different set of Nakshatras in 57 BC for monsoon rains as shown in Fig 4. Here, in 2013, the equinox takes place at F whereas in 57 BC it was at G. Corresponding to this difference, the set of Nakshatras during the monsoons are different.

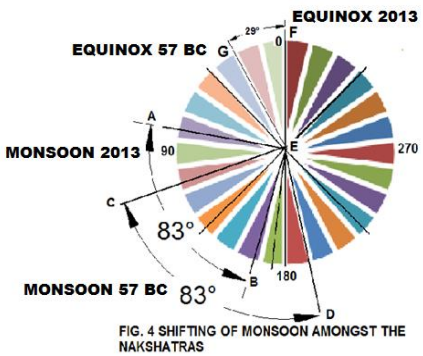

FIG. 4 SHIFTING OF MONSOON AMONGST THE NAKSHATRAS

Fig. 5 shows that the time period for a year taught in universities and schools in India; It is the time elapsed for the earth as goes around its orbit at point A but the tropical year requires the time travel between points A to B as the earth moves in the counter-clockwise direction . Schools, colleges and various offices use the Gregorian or the tropical calendar without the realization that what the people have studied or known as the definition of a year (a sideral year) - is not used in the Gregorian calendar that India has adopted now.

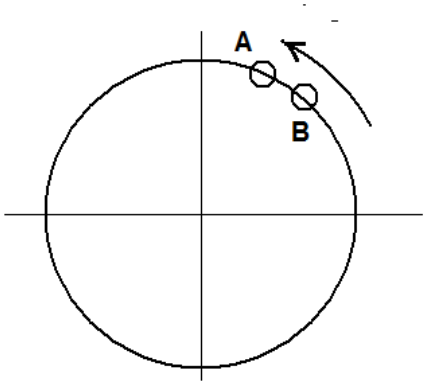

FIG. 5 DEFINITION OF A TROPICAL YEAR

It is imperative that the students in the schools and universities are imparted accurate information which is the concept of a tropical year.

VI. CONCLUSIONS

In this work, the motions of the earth were discussed and their corresponding effects on earth's seasons were described. This work also reviewed the calendars used in India as well as in Europe.

Based on the work, the following can be concluded:

1. Indians were aware of the earth's three motions since the ancient times whereas in Europe, this awareness came in the middle of the second millennium.
2. Indians followed tropical calendar for agriculture by continuously correcting their calendar for recessional motion of the earth but kept the definition of the year as sidereal year.
3. The Europeans changed their definition of the year and shortened the sidereal year by 20 seconds. They called this new type of year as a tropical year.
4. Indian schools and universities have not included in their syllabus the concept of a tropical year even though they follow a tropical year calendar.

VII. REFERENCES

[1] Egyptian calendar**,** http://en.wikipedia.org/wiki/Egyptian_calendar

[2] S. B, Rao, *Ancient Indian astronomy planetary positions, and eclipses* (B. R. Publishing Corp Corporation, Delhi,2000) Chs 1,2,4 and Appendix 1

[3] P.C.Naik and L. Satpathy, Samanta Chandra Shekhar: The Great Naked Eye Astronomer, Bull Astro Soc. of India, 1998, Vol 26 , pp 33-49

[4]A. Cunningham, Book of Indian Eras, (Indological Book House, Varanasi, India , 1970) , pp 47-50

[5] Gregorian Calendar, http://en.wikipedia.org/wiki/Gregorian_calendar

[6] Julian Calendar , http://en.wikipedia.org/wiki/Julian_calendar

[7]B. Snowden, The Curious History of the Gregorian Calendar Eleven Days That Never Were , ", http://www.infoplease.com/spot/gregorian1.html
[8] Panchang , http://en.wikipedia.org/wiki/Panchangam

[9] A. Panda, Adaptation to Climate Variability and Change Among Small and Marginal Farmers in Odhisha, India , http://www.cseindia.org/userfiles/architesh.pdf

[10] R. D. Rakesh, Panorma of Proverbs in Nepal Terai : Cultural Heritage of Nepal Terai, (Nirala Publications, New Delhi 1994)

[11] S. Parmar, Traditional Folk Media in India (GEKA Books, New Delhi , 1975)

Anand M. Sharan: Department of Mechanical Engineering, Memorial University of Newfoundland, Canada