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A NOTE ON KALI ERA

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The present epoch of Kali era, which is generally taken as-3101 AD, February 17-18, midnight (Ujjain time), is not free from controversy. First mention of this era is found in Āryabhaṭiya where there is a cryptic statement of Āryabhaṭa, taken to have been made in 499 AD, that 3600 years of Kali era had elapsed when he just completed 23 years of his age. It has been mentioned that at the beginning of Kali yuga the Sun, the Moon, and five bright planets were grouped together at the 1st point of *Meṣa rāśi*, and also then the ascending node and the apogee of the Moon were respectively 180^0 and 90^0 away. The beginning of Kali era mentioned by Āryabhaṭa has been linked with the above unique astronomical phenomena, but the present epoch date of this era does not satisfy in any manner the aforesaid stipulations nor it is possible to find any other alternative date which would meet all the said astronomical requirements for this epoch. This note suggests several different dates for the start of the era in the calculated year of-3101 AD, that would be more rational and would satisfy in a better manner the astronomical requirements for the commencement of this era which begins from a very remote past.

Key Words : *Āryabhaṭa, Grouping of luminaries, Meṣa rāśi, Solar eclipse Vernal equinoctial point, Winter solstice.*

INTRODUCTION

1. Kali era is an unique era whose epoch, unlike all others in the world, is not linked with the birth or death of a founder of any religion, or the birth or coronation of any king, or the winning of a war by a monarch against a powerful opponent, but it is based on a secular astronomical event said to have happened at the start of the era. First reference of Kali Yuga era, or Kali era, is found in Āryabhaṭa I's Āryabhaṭīya[1] where the following cryptic statement made by Āryabhaṭa is mentioned 'When 3600 years had elapsed since the beginning of Kali era, then 23 years had passed since my birth'. Historians believe that the statement was made by Āryabhaṭa in 499 AD[2], and on this basis the epoch year of Kali era has been calculated as-3101 AD. It is, however, not mentioned in this book, or anywhere else, on which day of the year Āryabhaṭa made this statement. It is taken to have been made on 21

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March 499 AD, perhaps for the reason that the day was calculated to be the vernal equinox day of that year or the day following it, an important day from astronomical as well as other points of view. Now Āryabhaṭian 3600 years equal 1, 314, 931.25 days, and so on the presumption that Āryabhaṭa made the statement at sunrise time on 21 March 499 AD, Feb 17-18 midnight has been worked out to be the date of the epoch of Kali era. If it is presumed, that the statement was made at mid-day, the epoch time will be sunrise time of 18 February. But as ārdharātrika system was advocated by Āryabhaṭa, midnight of 17-18 February is generally taken as the epoch time. However, as per "Planetary Programs and Tables" by Pierre Bretagnon of Bureau des Longitudes, spring equinox occurred in 499 AD on 19 March at 18^h 46^m Ujjain time, and hence it appears that the date 20 March was the spring equinox day of that year and 21 March was the day following it. As the date of Āryabhaṭa making the statement is not firmly known, aim of this note is to propose some other more appropriate dates for the epoch of Kali era than the present one within the present epoch year-3101 AD, which should satisfy in a better manner the criteria for the start of the era.

2. It has been stated that at the start of Kali era a grand celestial event happened when the Sun, the Moon, and the five planets were in conjunction at the first point of the zodiac, which is taken as the 1st point of *Meṣa rāśi*. Also it is stated that the Moon's ascending node was 180^0 away and its apogee 90^0 away from this initial point[3]. Under the above presumed situation, a solar eclipse would have happened at that time. However, for the purpose of analysis, the conjunction of luminaries may be taken for practical purposes to be such that they were grouped or clustered with the Sun, that is, placed reasonably close to it. The aforementioned astronomical circumstances that are said to have existed at the epoch of Kali era may be expressed in order of importance as stated below. In this analysis, the position of apogee has been left out as it is thought not to be of much importance for our calendric purposes.

   a) The Sun should be on the 1st point of the zodiac from which the year is counted. If Sūrya siddhāntic system is to be followed, then it would be 1st point of *Meṣa rāśi,* which is taken to be the vernal equinoctial point of 285 AD[4].

b) The Moon should be with the Sun, that is the day should be *śukla pratipadā.*

c) Five bright planets should be grouped with the Sun. For practical purposes it can be said that these should be within a longitudinal distance of say about 12^0 from the Sun.

d) Moon's ascending node should be 180^0 away, or near to it, from the initial point where the sun and the moon are grouped together.

3. No epoch date has been found where all these conditions can be satisfied. When Āryabhaṭa mentioned about Kali era, it is likely that he based it on what was then the traditional belief, or mentioned in some folk lores, or in some ancient books not traceable at present.

4. He seems to have thought that our glorious ancient history which was traceable many milleniums back from his times, can be best described by using this era for calendrical purposes. But as there was no clearly laid down standard epoch for it, he fixed or standardised the epoch date by stating that it was 3600 years earlier than the anniversary date of his 23rd birthday which is taken as the spring equinox day of the year or the day following it, which is a very significant day from the astronomical point of view, and thus suitable for fixing the epoch with reference to this day. It may also be mentioned that 3600 years is 1/1200 part of planetary *yuga* period which is of 43,20,000 years as stated earlier, it was reckoned that at the start the luminaries were grouped together. The grand assembly of the luminaries at the initial point as mentioned, is said to have happened on the basis of their mean positions[5]. Perhaps this was so stated because astronomical knowledge was not then sufficiently advanced to back calculate correctly the true positions of the luminaries for many milleniums back. The grand event of conjunction, or say grouping or clustering of the luminaries at or around one point of the zodiac, which is the distinguishing feature of the epoch of Kali era compared to other epochs, will have importance or meaning if it actually happens, and this can only be by their true positions, and not by their mean positions. Hence the Tables that have been shown in this note showing the positions of luminaries for different suggested epochs, are on their actual positions. However, in Table I, placed under Para 6, which shows the position of the luminaries for the epoch time as in use at present, the information has been given for both mean and true positions for the purpose of perusal and comparison.

The true positions of the Sun and the planets shown in this Table (I) and in other Tables have been calculated on the basis of *Planetary Programs and Tables* by Pierre Bretagnon and Jean-Louis Simon (1986), and that of the Moon and its Node on the basis of *Lunar Tables and Programs* (1991) by Michelle Chapront Touze and Jean Chapront, all of Bureau des Longitudes, Paris.

5. Let us examine different timings of the Kali epoch in the calculated epoch year of -3101 AD to determine which would satisfy in as best manner as possible, the four criteria mentioned in para 2. It may be remembered that there are limitations in calculating correctly the co-ordinates of the luminaries for such distant epoch, more so because of the difficulty of determining the correct value of Δ.T. In trying to find out the plausible year and date for this epoch, it has been presumed, as already mentioned, that Āryabhaṭa made the statement about the Kali era years in 499 AD, and thus the epoch of this era will be in -3101 AD. But as it is not very certain on which month and date in 499 AD, he made the statement, several probable dates in different months of this year have been suggested which will satisfy some desirable astronomical features for the start of this era which has an ancient beginning.However, in one of the possibilities analysed, the epoch year has been suggested to be one year earlier that is, -3102 AD, as this is the closest year where both the Sun and the Moon were together at the 1st point of *Meṣa rāśi,* which is a very important feature needed to be satisfied for the start of the epoch.

6. Positions of the Sun, the Moon, five bright planets, and the ascending node of the Moon for different possible timings for the epoch of Kali era have been shown in different Tables in this and subsequent paragraphs. In Table I, placed below, both mean and true positions of the luminaries have been shown, and in other only true positions have been indicated. Tropical longitudes indicated in the Tables are with reference to the mean equinox and ecliptic of date, and the sidereal longitudes have been calculated as per present usage, from the vernal equinoctical point of 285 AD, which is the point opposite Citrā star. From this initial point the vernal equinoctial point of -3101 AD is placed at about 46.6^0 on the east, and as such this figure has been added to the tropical longitude to get the sidereal or *nirayaṇa* longitudes. Longitudes have been shown correct to one place of decimal as this accuracy is sufficient to demonstrate the purpose of this note.

EPOCH DATE AND TIME AS IN USE AT PRESENT

Table I: -3101 AD Feb 17-18 midnight, Ujjain time, or
Epoch I -3101 AD Feb 17, $18^h\ 57^m$ U T
JD 58 8465.2896 U T

	Object	Longitude (Tropical)**		Latitude	Longitude from VE pt. of 285 AD (+ 46°.6)	
		(True	(Mean)*		(True)	(Mean)
1.	Sun	304°.5	301°.7	—	351°.1	348°.3
2.	Mercury	289.6	268.4	-2°.1	336.2	315.0
3.	Venus	317.2	334.7	-1.2	3.8	381.3
4.	Mars	301.0	290.0	-1.0	347.6	336.6
5.	Jupiter	317.6	318.7	-1.3	4.2	5.3
6.	Saturn	276.6	282.4	-1.0	323.2	329.0
7.	Moon	316.0	305.6	0.9	2.6	352.2
8.	Node (Moon-Asd)	145.9	147.3	—	192.5	193.9

*(As given in Calendar Reform Committee's Report p.253)

** Reference frame for tropical longitudes shown in this and other tables is the mean ecliptic and equinox of date.

The Table I above shows tropical and sidereal longitudes both for mean and true positions of the Sun, the Moon, five bright planets, and the ascending node of the Moon. It will be observed that neither the mean nor the true Sun was on the 1st point of *Meṣa rāśi* which is the first requirement, as mentioned in para 2. Moon was close to the Sun in case of mean position, but not so in case of true position. Of the planets, only Mars may be said to have been grouped with the Sun, and so the present epoch time is not considered to be very satisfactory.

7. It has been mentioned that at the present epoch on the basis of true

positions, the Sun and the Moon were not together or close to each other, but this important requirement was satisfied a few hours earlier at the time as shown in Table II below.

Table II : -3101 AD Feb 17, 2^h 10^m, Ujjain time, or
-3101 AD Feb 16, 21^h 7^m U T
JD 58 8464. 3799 U T
(When new moon occurred at the time closest to the present epoch of Kali era.)

Object	Longitude (Tropical**)	Latitude	Longitude from VE pt. of 285 AD (+ $46^0.6$)
1. Sun	$303^0.6$	-	$350^0.2$
2. Mercury	288.2	-2.1	334.8
3. Venus	316.2	-1.2	2.8
4. Mars	300.2	-1.1	347.0
5. Jupiter	317.4	-1.3	4.0
6. Saturn	276.4	-1.0	323.1
7. Moon	303.6	2.0	350.2
8. Node (Moon-Asd)	145.9	-	192.5

Here apart from Mars, Venus may be said to be grouped with the Sun, being only 12.5^0 away and broadly also Mercury and Jupiter, which were only about 15^0 away. Saturn was about 27^0 away. Following the midnight principle, the epoch time will be :

Epoch-II : -3101 AD, Feb 16-17 midnight Ujjain time.
JD 588464. 2896 U T

This epoch is only one day earlier than the present one, and fits very well with the correct vernal equinox day of 499 AD which, as mentioned in para I, happened on 20 March, one day earlier than the assumed date of 21 March. It

would thus not be unreasonable to assume that Āryabhaṭa might have made the statement on the linking his birthday with Kali era years on this date, and in that case the epoch time shown above would be more reasonable than the present one.

8. Table III below shows the position of the luminaries and the ascending node when the Sun was at the 1st point of nirayaṇa siddhāntic Meṣa rāśi, which is an important requirement for the epoch of Kali era.

Table-III : -3101 AD Feb 27, 3^h 25^m Ujjain time, or
-3101 AD Feb 26, 22^h 22^m U.T.
JD 58 8474.4173 U.T.

	Object	Longitude (Tropical)	Latitude	Longitude from VE pt. of 285 AD (+ $46^0.6$)
1.	Sun	$313^0.4$	-	$360^0.0$
2.	Mercury	307.2	-1.8	353.8
3.	Venus	328.5	-1.1	15.1
4.	Mars	307.8	-1.1	354.4
5.	Jupiter	319.7	-1.3	6.3
6.	Saturn	277.6	-1.0	324.2
7.	Moon	67.6	4.7	114.2
8.	Node	145.9	-	192.5

It will be seen that Moon was not at the 1st point of *Meṣa rāśi,* being away by about 114^0, three planets namely Mercury, Mars, and Jupiter were grouped with the Sun. Following midnight principle, the epoch time will be :

Epoch III : -3101 AD, Feb 26-27 midnight Ujjain time
JD 58 8110. 2896 U.T.

This epoch time is closest to the present one when the Sun was on the 1st point of *Meṣa rāśi,* the first requirement mentioned in para 2, and hence may

be considered in the place of present epoch time. It may be presumed in this case that Āryabhaṭa made his statement in 499 AD when the Sun was on 1st point of *Meṣa rāśi* which was then on 23 March.

9. The desirable condition that both the Sun and the Moon should be on the 1st point of siddhantic *Meṣa rāśi*, or be very close to it, can get satisfied if we choose the epoch time one year earlier in -3102 AD, and in that case the epoch time will be as follows :

Epoch IV : -3102 AD, Feb 27-28 midnight (Ujjain time)
JD 58 8110. 2896 U T

Table IV below shows the position of the Sun, the Moon, the planets and the node of the Moon at this epoch time.

Table-IV : -3102 AD Feb 27-28 midnight, Ujjain time, or
-3102 AD Feb 27, 18^h 57^m U T
JD 58 8100.2896 U T

	Object	Longitude (Tropical)	Latitude	Longitude from VE pt. of 285 AD (+ $46^0.6$)
1.	Sun	$314^0.5$	—	$1^0.1$
2.	Mercury	294.4	$-2^0.3$	341.0
3.	Venus	329.1	-7.8	15.7
4.	Mars	61.9	-3.1	108.3
5.	Jupiter	292.6	-1.2	339.2
6.	Saturn	266.2	-0.6	312.8
7.	Moon	317.0	3.3	3.6
8.	Node (Moon-Asd)	164.5	—	211.1

Here for all purposes the Moon was with the Sun, and the *tithi* was *śukla pratipadā*. No planets were, however, within 12^0, but Venus was only 14^0 away, and Mercury and Venus were within 22^0. As already mentioned, this epoch time is the closest to the present one, that satisfies two most important requirements

of the Sun and the Moon being together at the 1st point of *Meṣa rāśi*, at the start of the epoch. But it has to be presumed that Āryabhaṭa made his statement in 498 AD, one year earlier. If there is no objection to it, this epoch time becomes very suitable.

10. In the previous paragraphs, various possibilities have been mentioned for selecting afresh the epoch of Kali era which would satisfy in a better manner the various astronomical factors that have been worked out on the basis of *Sūrya Siddhāntic* system of starting the year from the 1st point of *Meṣa rāśi* which is taken as the vernal equinoctial point of 285 AD. It is, however, to be considered that Āryabhaṭa was referring to an era whose epoch was 3600 years earlier than his time, and at that ancient time *rāśi* system of calendar keeping was not in vogue. It was brought into use round about his time in the *siddhāntic* period. The most ancient and the earliest systematic method of calendar keeping which was prevalent before *siddhāntic* time was the one that was prescribed in the book *Vedāṅga Jyotiṣa*, which was compiled c 1400 BC or so. It is likely that even prior to this date some methods similar to *Vedāṅga Jyotiṣa* system was in use, and the book was probably a compilation and standardisation of that system, and it laid down in some systematic manner the rules and methods to be followed for keeping the calendar. In *Vedāṅga Jyotiṣa* system, the year started from the new moon, that is, *śukla pratipadā*, occurring at *Uttarāyaṇa* day (day next to winter solstice day), or the day closest to it. At the time of compilation of the book, winter solstice was mentioned to have happened when the Sun was at the longitudinal position as that of *Dhaniṣṭhā (Śraviṣṭhā) nakṣatra* (α or β Delphini). but due to precessional motion of the earth, Sun's position at winter solstice could not remain at *Dhaniṣṭhā*, which was no doubt later observed, as found from reference given in *Mahābhārata*[6]. The main criterion that was followed was that the year started from *śukla pratipadā* that happened on or immediately after the *Uttarāyaṇa* day. It is likely that this was also the practice followed before the *Vedāṅga Jyotiṣa* book was compiled. Therefore, it is not unlikely that Kali era referred to by Āryabhaṭa which started from a very remote past, had also its epoch fixed on the above principle.

11. In consonance with the aforesaid exposition, an alternative epoch time has been worked out. Table V below shows the position of the luminaries and the ascending node of the Moon when the new moon occurred immediately after the winter solstice day in -3101 AD..

Table-V : -3101 AD Jan 18, 15^h 35^m Ujjain time or
-3101 AD Jan 18, 10^h 32^m U T
JD 58 8434.9389 U T

	Object	Longitude (Tropical)	Latitude	Longitude from VE pt. of 285 AD (+ $46^0.6$)
1.	Sun	$274^0.6$	—	$321^0.2$
2.	Mercury	247.3	$-0^0.6$	293.9
3.	Venus	279.7	-1.4	326.3
4.	Mars	278.1	-1.1	324.7
5.	Jupiter	310.8	-1.4	357.4
6.	Saturn	272.9	-1.0	319.5
7.	Moon	274.6	4.0	321.2
8.	Node (Moon-Asd)	147.2	—	193.8
9.	Apogee (Moon)	62.1	—	108.7

Following the midnight principle, the epoch time will be as follows :

Epoch V : -3101 AD, Jan 18-19 midnight, Ujjain time or
-3101 AD, Jan 18, 18^h 57^m, U T
JD 58 8435.2896 U T

It will be observed that five luminaries out of a total of seven, were grouped together, which is the maximum number possible in this epoch year. The luminaries that were grouped together were the Sun, the Moon, Venus, Mars, and Saturn. The other two planets, Mercury and Jupiter were not far away. They were respectively 27^0 and 36^0 away. There will not be any appreciable change in their positions for the epoch time, a difference of only 6 hours. This epoch time has very good merits for acceptance. However, the date of Āryabhaṭa's pronouncement has to be adjusted. This can be done in two ways. This epoch

date being 30 days earlier, it may be presumed that Āryabhaṭa spoke about Kali years earlier by the same number of days. Alternatively, the better way would be to presume that Āryabhaṭa made the statement on a day similar to the epoch date, namely on the first *śukla pratipadā* following winter solstice day of 498 AD (same 421 saka), which happened on 29 December.

12. It will be seen from para 2 that astronomical circumstances that have been stated to have existed at the beginning of Kali era were that all the luminaries were grouped together at the 1st point of the zodiac, and the ascending node of the Moon was 180° away, and also that apogee was 90° away which has so far not been considered. This meant that the circumstances were conducive to the happening of a solar eclipse at that time. Indeed, a solar eclipse has been calculated to have happened in March, -3101 AD, closest to the present epoch, and Table VI below shows the position of the luminaries and the ascending node at the time of occurrence of this eclipse.

Table-VI : -3101 AD March 18, $13^h\ 46^m$ Ujjain time, or
-3101 AD March 18, $18^h\ 43^m$ U T
JD 58 8493.8632 U T

	Object	Longitude (Tropical)	Latitude	Longitude from VE pt. of 285 AD (+ 46°.6)
1.	Sun	332°.1	—	18°.7
2.	Mercury	347.5	-1°.6	34.1
3.	Venus	352.4	-0.3	39.0
4.	Mars	322.0	-0.9	8.6
5.	Jupiter	324.4	-1.3	11.0
6.	Saturn	279.6	-1.1	326.2
7.	Moon	332.1	-0.6	18.7
8.	Node (Moon-Asd)	145.9*	—	192.5*
9.	Apogee (Moon)	58.6*	—	105.2*

* From the conjunction point of the Sun and the Moon, the ecliptic angular distance of (a) ascending node of the Moon is 173°.8, (b) the descending node is 353°.8, and (c) apogee of the Moon's orbit is 86°.5.

It will be observed that apart from the Moon, Mars and Jupiter were grouped with the Sun, and also Mercury was only about 15^0 away and Venus about 20^0 away. So excepting Saturn, all the four other planets were close to the Sun, which was in *Meṣa rāśi*, and in this case the ascending node of the Moon was away from the conjunction point of the Sun and the Moon by about 174^0, which is very close to the stipulated 180^0, and happily the apogee of the Moon's orbit was also away by about 87^0 from the same conjunction point which again is very close to the stipulated 90^0. This possible epoch is the only one which satisfies in as best manner as practically possible, all the astronomical circumstances that are said to have existed at the epoch of Kali era. In this case, the epoch time will be

Epoch VI :- 3101 AD, March 18-19, Midnight, Ujjain time or
- 3101 AD, March 18, $18^h\ 57^m$ U.T.
JD : 58 8494.2896 U.T.

However, as the proposed epoch date is 29 days later than the present date, here again the presumed date of Āryabhaṭa's statement may require adjustment. But instead of pushing the statement date later by the same number of days, is may be better done by choosing a date near about this period which has the best astronomical similarity as that of the date of the epoch, and this will be 19 February as has been explained in para 16.

13. There will be another very plausible alternative on reckoning the beginning of Kali era from the vernal equinox day or the day next to it, in the present epoch year of -3101 AD, because when Āryabhaṭa is said to have made the statement on 21 March 499 AD, saying that 3600 Kali years had expired and 3601st year had started, the day then was the vernal equinox day or the day following it. It will, therefore, not be unreasonable to think that he had in his mind of the Kali era also starting similarly from a vernal equinox day or immediately following it. *Siddhāntic* zodiac current at the time of Āryabhaṭa had its beginning from a vernal equinoctial point, and therefore there is a good possibility of Āryabhaṭa referring to the Kali era years also starting similarly from the vernal equinoctial point of -3101 AD. Accordingly, longitudinal position of the Sun, the Moon, the five planets, and the ascending node of -3101 AD is shown in Table VII. below.

Table-VII :-3101 AD April 16, $17^h\ 26^m$ Ujjain time, or
-3101 AD April 16, $12^h\ 23^m$ U T
JD 58 8523.0160 U T

	Object	Longitude	Latitude	Longitude from VE pt. of 285 AD
1.	Sun	0°.0	—	46°.6
2.	Mercury	16.1	0°.8	62.7
3.	Venus	27.6	1.0	74.2
4.	Mars	342.5	0.7	29.1
5.	Jupiter	331.0	1.4	17.6
6.	Saturn	281.8	1.2	328.4
7.	Moon	354.4	-2.8	41.0
8.	Node (Moon-Asd)	145.6	—	192.2

The epoch time in this case will be :

Epoch VII :-3101 AD, April 16-17, midnight, Ujjain time or
-3101 AD, April 16, 18^h 57^m U.T.
JD 58 8523.2896 U.T.

At the epoch time, which is midnight, the tropical longitude of the Sun will be approx 0°.3, and of the Moon will be approx 359°. which for such a distant epoch means that they are in conjunction. At sun-rise time on 17 April, the position of the Sun and the Moon respectively will be approximately 0°.5 and 1°.7, which means that the day is a *śukla pratipadā* day, and hence this epoch time satisfies a very important requirement. No planets, however, were grouped with the Sun, but all the bright planets except Saturn were within the range of 30° from the Sun, Mercury and Mars were, however, within 20°.

14. One striking feature for this aforementioned epoch is that the longitudinal position of the Sun was at or very near to the middle of Rohiṇī *nakṣatra* division, and also broadly it may be said to be close to the position of Rohiṇī star (∝ Tauri), a very important and prominent star in the zodiac belt. Just as the present initial point of the *nirayaṇa* zodiac for measuring the year, etc, is taken to be the point on the ecliptic opposite, that is, 180° away from Citrā star (∝ Virginis), and its firm position being taken as the

vernal equinoctial point of 285 AD, so similarly it may be said that the initial point of the Kali era epoch for measuring Kali years is the point on the ecliptic placed at nearly the same longitudinal position as that of the middle of Rohiṇī *nakṣatra* division, but its firm position is to be reckoned as the vernal equinoctial point of -3101 AD. It is, however, to be noted that if the date of statement made by Āryabhaṭa is taken as 21 March 499 AD, the length of the years will be that of tropical years, which will be a little shorter than Āryabhaṭian years, but one is not sure as to which type of year Āryabhaṭa had in mind when he linked 3600 Kali era years with his 23rd birthday. But as Āryabhaṭa is said to have pronounced the ending of 3600th year and the commencement of 3601st year of Kali era on a spring equinox day, or the day following it, it is highly probable that he was referring to an era which had also its epoch starting from a vernal equinox day or the day next to it, when happily the Moon was also at that point.This linking of the Kali epoch with a vernal equinox day is likely because the epoch of the ancient Kali era becomes then similar to the ancient vedic calendar comprising of the months of *Madhu, Mādhaba,* etc, where commencement of the year was linked with the spring equinox day. Further, this assumption will also be in line with the view of a school of scholars that in the beginning *Sūrya Siddhāntic* astronomers generally followed the tropical system of calendar keeping because it is found by studying the co-ordinates of junction stars recorded in *Sūrya Siddhānta* book, that these have been noted on the basis of their polar longitudes measured from vernal equinoctial points of different epochs as that of 285 AD, 500 AD, and 575 AD, and not from a fixed initial point[7], and as such the initial *rāśi, Meṣa,* started from the vernal equinoctial point. It may, therefore, not be irrational not to stick to Āryabhaṭian length of the year in deciding the epoch of Kali era. Thus in this proposal, Āryabhaṭa's date of statement of linking Kali years with his birth will not need any adjustment unlike other two preceding proposals.

15. Summarising, it may be said that it may not be reasonable, or easily possible, to change the epoch year -3101 AD of Kali era as it is based on the accepted year of birth of Āryabhaṭa, and now on its long usage. Hence the proposal made at para 9, and detailed in Table IV may be left out. Also the suggestion made at Para 7 as Epoch II is proposed to be left out from consideration, because the difference is only of one day, and this little change may not perhaps be acceptable. Suggestions made here is to change the epoch date within the accepted epoch year so that it becomes more reasonable than the present date. Accordingly, the different possible dates out of those elaborated in earlier paragraphs that may be considered

for selection, are noted below :

a) -3101 AD, February 26-27, midnight (Ujjain time), when the Sun was at or very near to *Meṣa rāśi* (Epoch III-Para 8).

b) -3101 AD, January 18-19, midnight (Ujjain time), midnight immediately following the occurrence of new moon next to the winter solstice day. (Epoch V-Para 11).

c) -3101 AD, March 18-19, midnight (Ujjain time), midnight immediately following the occurrence of new moon when a solar eclipse took place. (Epoch VI-Para 12).

d) -3101 AD, April 16-17 midnight (Ujjain time), midnight immediately following the time when the Sun was on the vernal equinoctial point. (Epoch VII-Para 13).

16. Concluding, it may be reiterated that it may not be prudent to attempt to change the epoch year -3101 AD for the reason that it is based on Āryabhaṭa's accepted year of birth, and language but consideration may be given for choosing a different possible date in the epoch year out of those mentioned in the preceding para 15, each of which has been worked out by following certain calendrical principle for determining the date for this ancient epoch. In making a choice, if preference is to be given to the first expressed principle of starting the Kali era from the first point of modern *Sūrya Siddhāntic nirayaṇa Meṣa rāśi*, then epoch at (a) has to be selected. However, if it is not deemed vital to stick to this criterion for the reason that the present *nirayaṇa rāśi* system came into use comparatively recently, composed to the epoch of Kali era which has a beginning many milleniums earlier, then any of the proposals at (b), (c), and (d) may be considered for selection. If it is felt that the era should start from an initial point linked with the vernal equinox day or the day following is, because Āryabhaṭa mentioned about the commencement of 3601st Kali year from a vernal equinox day, and also that at the time when Āryabhaṭa lived, the initial point of the *Siddhāntic* zodiac was linked with a vernal equinoctial point, then proposals at (d) should be preferred. However, if it is thought that the most ancient systematic method of calendar keeping has been as that is given in the book *Vedāṅga Jyotiṣa*, and also that as the era Kali era starts from a very remote past, then proposal at (b) may be chosen being based on the aforesaid system.

17. However, it is likely that when Āryabhaṭa pronounced about the Kali era years, he had in his mind of a calendric system similar to the most ancient yajur vedic one where the first month, *Madhu,* according to prominent scholars and *pañcāṅga* makers started 30 days ahead of vernal equinox day and was followed by the second month, *Mādhava,* so that these two months covered the true period of the spring season.[8] Taking this view, and also considering the circumstances mentioned in Para 12, the proposal at (c) may be given the highest preference. At this epoch, all luminaries, except Saturn, may be said to have been grouped with the Sun, or say placed close to it. Further the unique thing would be that the era will start just after a solar eclipse as was expected to happen as per astronomical circumstances said to have existed at the epoch time, and that the apogee as well as about 90° away. All these conditions are not simultaneously satisfied in any of the other possible times for the epoch and hence it is most preferred. This epoch being 29 days later than the present accepted date, it may be thought that the day of Āryabhaṭa's statement on Kali era should get pushed back by the same number of days if the length of 3600 years is calculated as per Āryabhaṭian years. But this adjustment may not be applied because the ancient vedic calendric year comprising of the months of *Madhu, Mādhava,* etc, was tropical in length, and the vernal equinox day of 499 AD being on 20 March, it may be presumed that Āryabhaṭa made the statement on 19th February of that year, which may be taken as the start of Madhu month, being 30 days earlier than the vernal equinox day including that day. As discussed earlier the tropical year principle also applies in the case of proposals at (b) and (d). Incidentlly 3600 tropical years is shorter than the same number of Āryabhaṭian years by slightly more than 59 days, and that 3600 sidereal years is shorter by slightly more than 8 days.

18. The other important feature that needs attention is the time when the day should start for Kali era year calendar. In the early *siddhāntic* days, the practice has been to indicate the start of the day, and consequently that of the epoch, from midnight in accordance with Ujjain time, that is, time as per the meridian of Ujjain. But due to fading out of Ujjain's importance, this system of time keeping has gone out of use many many years back, and the present practice of time keeping adopted all over India is to follow Indian Standard Time (IST), which is internationally recognised. It will, therefore, be logical and practical to adopt this standard system of time keeping for Kali era year calendar and for its epoch, replacing Ujjain time. The difference between the two systems is only of 27 minutes, and will not affect in any significant way the analysis made in the previous paragraphs on different possible epochs for Kali era. Further, many *pancāṅga* makers

start the Kali year on the basis of the mean Sun arriving at the 1st point of *Meṣa rāsi*. But as all solar years at present are calculated to start at the time when true Sun arrives at the 1st point of zodiac, this practice should also be followed for Kali years.

19. Another point that may be brought out while dealing with Kali era is that some scholars like Prof. P.C. Sengupta has opined that Kali yuga as mentioned in *Mahābhārata* started in January, 2454 BC, (or-2453 AD), the *Mahābhārata* battle having been fought in January 2449 BC, (or-2448 AD)[9]. Again Prof. R.V. Vaidya has contended after referring to various statements made in *Mahābhārata* that the correct date for the great battle should be in the second half of October 2786 BC (or-2785 AD) and the commencement of Kali yuga should be in November, 2749 BC) (or -2748 AD)[10]. Without entering into the controversy about the above dates, specially about the start of Kali yuga, it should be stressed that one should not mix up the start of calendric Kali era as referred by Āryabhaṭa in his book Āryabhaṭiya with the commencement of Kali yuga as mentioned in *Mahābhārata* and *Purāṇas* which apparently refers to the commencement of evil times or evil *yuga*, when evil motives and immoral actions started getting sway over right motives, honest, and moral actions. The *Āryabhaṭian* Kali era is calendrical, that is, mathematical and astronomical in nature, and is meant for counting the elapsed years from a presumed astronomical event. It is not intended to raise any controversy on this point but to say that this era is already in use and also that inscriptions bound of this era refers to Āryabhaṭian Kali era having its epoch in -3101 AD., and therefore it is an accepted calendrical era.

References and Notes

1. *Āryabhaṭiya's* Kālkriyā Section, Verse 10.

2. Kerala astronomer Haridatta (C. 683 AD) and Jyeṣthadeva think that Āryabhaṭa was born in Saka 421 (499 AD) and wrote Āryabhaṭiya in Saka 444 (522 AD), but Kupanna Sāstri and others think that it is a wrong interpretation of the Verse, vide Āryabhaṭiya of Āryabhaṭa edited by K.S. Shukla and K.V. Sarma (p.98), published by Indian National Science Academy.

3. Ancient Indian Chronology (1947), p.35, by Prof. P.C. Sengupta, Calcutta University; Repeated in the Report of the Calendar Reform Committee, p.253.

4. There have been several schools in the past on reckoning the initial point on the ecliptic of the *nirayana* zodiac from which *Meṣa rāsi* starts. At present most of the *pañchānga* makers follow Citrā school, which means, that the initial point is taken to be that point on the ecliptic which is opposite Citrā star (α Virginis), meaning that longitudinal position of

Citrā is 180° from this point. However, to assign this point correctly for astronomical purposes, the vernal equinoctial point of 285 AD is taken as the initial point of the *nirayana* zodiac from which *Meṣa rāsi* and so also *Aśvini nakṣhatra* division start. Citrā star was then almost opposite this point, its longitude that time from this point was 179° 59, 52''.2.

5. Ibid, para 3 above. Also *Sūrya Siddhānta*-English translation by Rev. Burgess, p. 19 (Indological Book House, 1977).

6. *Mahābhārata* : Aśvamedha Parva, Verse 2.

7. Calendar Reform Committee's Report, 1955, Page 265 & 266.

8. a) Ibid, page 219; *Taittiriya Saṁhita,* 4.4.11.
   b) *Rashtriya Pañchāng* (1918 Saka), page 91.
   c) Lahiri's Indian Ephemeris (1997 AD), page 8.

9. Bhārata-Battle Traditions by Prof. P.C. Sengupta-*Journal of Royal Asiatic Society Bengal,* Volume IV, 1938, Article No. 15, page 399 & 402.

10. Some controversial dates established by Prof. R.V. Vaidya-*The Astrological Magazine,* March, 1997, Vol. 86, No. 3 (Originally published in 1946 issue of Marathi Magazine *Sahyadri,* published in Poona).