ZODIACAL CIRCUMFERENCE AS GRADUATED IN JAINA ASTRONOMY*

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Lunar zodiac of the *Rg*-Vedic Hindus consisted of 27 *nakṣatras*[1] (asterisms); Jainas first measured zodiacal stretches of *nakṣatras* (asterisms) into time degrees and included *Abhijit* (α Lyrae) *nakṣatra* (asterism) to account for the discrepancy in lunar motion. A simple probe is rendered into a series of developments of graduating zodiacal circumference into $27\frac{21}{67}$ days (time degrees)[2] of a *nakṣatra* month (lunar sidereal revolution) and subsequently into $819\frac{27}{67}$ *muhūrtas* (1 *muhūrta* = 48 minutes) of a *nakṣatra* month, 54900 *muhūrtas* of a 5-year cycle and 360 *saura* days (one *saura* day equals the time taken by Sun to move on 360th part of zodiacal circle) finally leading to the development of equal amplitude system of *nakṣatras* when *Abhijit* (α Lyrae) was again dropped with the advent of *Siddhāntic* Astronomy.

INTRODUCTION

Here it would be worthy of Introduction that Jainas had a peculiar theory[3] of two Suns and two Moons and two sets of *nakṣatras* (asterisms). Here we need not enter into whatever may be the mystery of the real and counter bodies existent in Jaina Prakrit texts, China, Greece. and ancient Babylon[4] but one will find that actually a singte set of *nakṣatras* (asterisms) constituted the lunar zodiac of Jainas[5].

THEORY

1. Zodiacal stretch (=ZS) of every *nakṣatra* (asterism) has been expressed in time-units called *muhūrtas* (1 *muhūrta* = 48 minutes). In this context *Jambūdvīpa Prajñapti*[6] (=*JP*) 9.8 states as :

"*Abhijit* combines with Moon for $9\frac{27}{67}$ *muhūrtas* (1). *Śatabhiṣā, Bharaṇi, Ārdrā, Aśleṣā, Svāti,* aud *Jyeṣṭhā* (6 *nakṣatras*) combine (with Moon) for 15 *muhūrtas* each (2). Three *Uttarās, Punarvasu. Rohiṇī* and *Viśākhā* (6 *nakṣatras*) combine (with Moon) for 45 *muhūrtas* each (3). The rest of the 15 *naksatras* (asterisms) combine (with Moon) for 30 *muhūrtas* each (4)."

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A conspicuous view is presented in the following Table 1 :

TABLE I

Table of *Nakṣatras* (asterisms) and their Zodiacal Stretches (= ZS) in time units called *muhūrtas* (1 *muhūrta* = 48 minutes).

Sr. No.	*Nakṣatras*	ZS in *muhūrtas*	Sr. No.	*Nakṣatras*	ZS in *muhūrtas*
1.	*Abhijit* (α Lyrae)	$9\frac{7}{7}$	15.	*Puṣya* (δ Cancri)	30
2.	*Śravaṇa* (α Aquilae)	30	16.	*Aśleṣā* (ϵ Hydrae)	15
3.	*Dhaniṣṭhā* (β Delphini)	30	17.	*Maghā* (α Leonis)	30
4.	*Śatabhiṣā* (λ Aquarii)	15	18.	*Pūrvāphālguṇī* (δ Leonis)	30
5.	*Pūrvābhādrapada* (α Pagasi)	30	19.	*Uttarāphālguṇī* (β Leonis)	45
6.	*Uttarābhādrapada* (γ Pagasi)	45	20.	*Hasta* (δ Corvi)	30
7.	*Revatī* (ζ Piscium)	30	21.	*Citrā* (α Virginis)	30
8.	*Aśvinī* (β Arietis)	15	22.	*Svāti* (α Bootis)	15
9.	*Bharaṇī* (41 Arietis)	15	23.	*Viśākhā* (α Libra)	45
10.	*Kṛttikā* (η Tauri)	30	24.	*Anurādhā* (δ Scorpii)	30
11.	*Rohiṇī* (α Tauri)	45	25.	*Jyeṣṭhā* (α Scorpii)	15
12.	*Mṛgaśīrṣa* (λ Orionis)	30	26.	*Mūla* (λ Scorpii)	30
13.	*Ārdrā* (α Orionis)	15	27.	*Pūrvāṣāḍhā* (δ Sagittarii)	30
14.	*Punarvasu* (β Geminorum)	45	28.	*Uttarāṣāḍhā* (σ Sagittarii)	45

It can be easily computed that

$\sum_{n=1}^{28} (ZS)_n = 819\frac{27}{67}$ *muhūrtas*, where *n* denotes the serial number of a *nakṣatra* (*see* Table 1)

= length of a *nakṣatra* month (sidereal revolution of Moon)

[$\because$ 67 *nakṣatras* months = 1 *yuga* (5-year cycle) of 1830 days of 30 *muhūrtas* each][7]

This suggests that lunar zodiacal circumference was graduated in $819\frac{27}{67}$ *muhūrtas* of a *nakṣatra* month (sidereal revolution of Moon). This view is strengthened by the fact that the zodiacal positions of Moon and Sun at syzygies were also defined in terms of balance of *muhūrtas* of *nakṣatras* (asterisms) occupied by them respectively. For instance, *Sūrya Prajñapti*[8] (*SP.* 10.22.15) states as :

"At the ending moments of the last 62nd *pūrṇimā* (full-moon day) of the 5-year-cycle, which *nakṣatra* (asterism) is occulted by Moon ?

(The answer is *Uttarāṣāḍhā* (σ Sagittarii) ; the ending moments of *Uttarāṣāḍhā* (σ Sagittarii).

Which *nakṣatra* (asterism) is occulted by Sun at that time ?

(The answer is) *Puṣya* (δ Cancri) *nakṣatra* (asterism) with balance of $19\frac{43}{62} + \left(\frac{1}{62} \times \frac{1}{67} \times \frac{33}{1}\right)$ *muhūrtas*.".

These data can easily be generated. Thus we know that on the full-moon day,

$L_s - L_m$ = half the zodiacal circumference,

where L_s and L_m denote the longitudes of Sun and Moon respectively on a full-moon day.

$\therefore L_s - L_m = \frac{1}{2} \times 819\frac{27}{67}$ *muhūrtas* ($\because$ zodiacal circle $= 819\frac{27}{67}$ *muhūrtas*

$= 409\frac{47}{67}$ *muhūrtas*

In the present case,

$L_m = 0$, because zero of the scale graduating the zodiacal circumference in *muhūrtas* coincides with ending moments of *Uttarāṣāḍha* (σ Sagittarii) or beginning of *Abhijit* (α Lyrae) *nakṣatra* (asterism) where the Moon is posited at the end of 62nd *purṇimā* (full-moon day) or the beginning of the 5-year cycle.

$\therefore$ At the ending moments of the 62nd *purṇimā* (full-moon day)

$L_s = 409\frac{47}{67}$ *muhūrtas*

$= \left(429\frac{27}{67} = 19\frac{47}{67}\right)$ *muhūrtas*

= Ending moments of *Puṣya* $- 19\frac{47}{67}$ *muhūrtas* (using Table No. 1)

$= 19\frac{43}{62} + \left(\frac{1}{62} \times \frac{1}{67} \times \frac{33}{1}\right)$ *muhūrtas* of Balance of *Puṣya* (δ Cancri).

Similarly the positions of Moon and Sun can also be generated at other syzygies. This shows that the zodiacal circumference was graduated in *muhūrtas* of a *nakṣatra* month (sidereal revolution of Moon).

The time for which a *nakṣatra* (asterism) combines with Sun can be easily computed by applying ratio and proportion as follows :

$x : y ::$ sidereal revolution of sun : sidereal revolution of moon.

where x = the period for which the Sun in its sidereal revolution combines with a *nakṣatra*

y = zodiacal stretch of the *nakṣatra* (asterism) in *muhūrtas* or the period for which the Moon in one sidereal revolution combines with it.

∵ Sidereal revolution of Sun = 366 days of 30 *muhūrtas* each
= 10980 *muhūrtas*

and sidereal revolution of Moon = $819\frac{27}{67}$ *muhūrtas*.

$$\therefore \quad x : y :: 10980 : 819\frac{27}{67}$$

$$\text{or } x = \frac{67}{5}y. \tag{1}$$

∴ If $y = 9\frac{27}{67}$ *muhūrtas*, $x = 4$ days and 6 *muhūrtas*,

$y = 15$ *muhūrtas*, $x = 6$ days and 21 *muhūrtas*

$y = 30$ *muhūrtas*, $x = 13$ days and 12 *muhūrtas*,

and $y = 45$ *muhūrtas*, $x = 20$ days and 3 *muhūrtas*.

The values of x as derived above are also stated in *JP.* 9.8 as :

"*Abhijit* (α Lyrae) combines with Sun for 4 days 6 *muhūrtas* only (1). *Śatabhiṣā* (λ Aquarii), *Bharaṇī* (41 Arietis), *Ārdrā* (α Orionis), *Aśleṣā* (ε Hydrae), *Svāti* (α Bootis) and *Jyeṣṭhā* (α Scorpii) (6 *nakṣatras*) combine (with Sun) for 6 days and 21 *muhūrtas* each (2). Three *Uttarās* (viz. *Uttarābhādrapada*, i. e. γ Pegasi, *Uttaraphālguṇī* i. e. β Leonis, and *Uttarāṣāḍhā* i. e. σ Sagittarii), *Punarvasu* (β Geminorum), *Rohiṇī* (α Tauri), *Viśākhā* (α Libra) (6 *nakṣatras*) combine (with Sun) for 20 days 3 *muhūrtas* each (3).

The rest of the 15 *nakṣatras* (asterisms) combine (with the Sun) for 13 days 12 *muhūrtas* each".

This suggests that zodiacal circumference was graduated in 366 days of a solar year. But this seems to be of theoretical interest only.

2. Later, we find still a minute division of zodiacal circumference. The actual velocities of Sun and Moon are depicted with 54900 celestial parts (abbreviated, C. P.) equivalent to the 360° of the modern celestial sphere. *SP.* **15**.2-3 states :

"How many parts does Moon move in one *muhūrta* (48 minutes) ?

(Moon) moves 1768 parts of the *maṇḍala* (durinal circle) on which (Moon) moves, whereas the *maṇḍala* (dirunal circle) is divided into 109800 parts.

How many parts does Sun move in one *muhūrta* ?

(The Sun) moves 1830 parts of the *maṇḍala* (diurnal circle) on which (Sun) moves, whereas the *maṇḍala* (diurnal circle) is divided into 109800 parts ".

The rationale of this expression is easily discernible.

∵ The two Moons describe a *maṇḍala* (diurnal circle) of 109800 parts in one lunar *sāvaṇa* day (moonrise to moonrise).

$\therefore$ Velocity of either Moon $= \frac{109800}{2}$ parts/lunar *sāvaṇa* day

$= 54900$ parts/lunar *sāvaṇa* day.

$\because$ Again 1768 lunar *sāvaṇa* days equal 1830 days of 30 *muhūrta*s each.[9]

1 lunar *sāvaṇa* day $= \frac{1830 \times 30}{1768} = \frac{54900}{1768}$ *muhūrta*s

$\therefore$ Velocity of either Moon $= 1768$ parts/*muhūrta*

Similarly,

Velocity of either Sun $= \frac{109800}{2}$ parts/day of 30 *muhūrtas*

$= 1830$ parts/*muhūrta*.

This indicates that the zodiacal circumference was graduated into 54900 celestial parts (*gagana khaṇḍas*).

It may be seen that this number 54900 is the same as the number of *muhūrtas* in a 5-year cycle, for

one 5-year-cycle $=$ 1830 days $=$ 54900 *muhūrtas*

($\because$ 1 day $=$ 30 *muhūrtas*)

Numerically,

54900 C. P. $=$ 54900 *muhūrtas* in a five-year cycle.

Thus the earlier concept of dividing zodiacal circle in the ratio of *muhūrtas* of the 28 *nakṣatras* (asterisms) in a *nakṣatra* month (sidereal revolution of Moon) was further developed into dividing zodiacal circle in the ratio of respective sums of *muhūrtas* of the 28 *nakṣatras* (asterisms) in a 5-year cycle.

$\because$ One 5-year cycle $=$ 67 *nakṣatra* months[10] (sidereal revolutions of Moon).

Numerically,

54900 C. P. $=$ 67 $\times$ length of a *nakṣatra* month in *muhūrtas*

or

$$\sum_{n=1}^{28} (\text{C. P. of a } nakṣatra)_n = 67 \sum_{n=1}^{28} (ZS)_n$$

where n is the serial number of a *nakṣatra* (asterism) starting form *Abhijit* (α Lyrae) as the first one (See Table 1)

$\therefore$ C. P. of a *nakṣatra* (asterism) $= 67\ ZS$ .. (2)

$\therefore$ From eq. No. (2), zodiacal stretch in C. P. of every *nakṣatra* can be easily computed. Jain has compared the celestial parts of *nakṣatras* (asterisms) with the modern degrees of arc.

A typical Table is reproduced below[11].

TABLE 2

Nakṣatras (asterisms) and their zodiacal stretches in C. P.

Sr. No.	Name of asterism	Stretch in C. P.	Remarks, stretch from and upto
1.	*Aśvini*	2010 C. P. from O. C. P.	Aries from 0 onwards
2.	*Bharaṇi*	1005 C. P.	Aries
3.	*Kṛttikā*	2010 C.P.	Aries upto 4575 and Taurus 450 C. P.
4.	*Rohiṇi*	3015 C. P.	Taurus
5.	*Mṛgaśirṣa*	2010 C. P.	Taurus upto 4575 and Gemini 900 C. P.
6.	*Arḍrā*	1005 C. P.	Gemini
7.	*Punarvasu*	3015 C. P.	Gemini 4575 and Cancer 345 C.P.
8.	*Puṣya*	2010 C. P.	Cancer
9.	*Aśleṣā*	1005 C. P.	Cancer
10.	*Maghā*	2010 C. P.	Cancer 4575 and Leo 795 C. P.
11.	*Pūrvāphālguṇi*	2010 C. P.	Leo
12.	*Uttaraphālguṇī*	3015 C. P.	Leo 4575 and Virgo 1245 C. P,
13.	*Hasta*	2010 C. P.	Virgo
14.	*Citrā*	2010 C. P.	Virgo 4575 and Libra 690 C. P.
15.	*Svāti*	1005 C. P.	Libra
16.	*Viśākhā*	3015 C. P,	Libra 4575 and Scorpio 135 C. P.
17.	*Anurādhā*	2010 C. P.	Scorpio
18.	*Jyeṣṭhā*	1005 C, P.	Scorpio
19.	*Mūla*	2010 C. P.	Scorpio 4575 and Sagittarius 585 C. P.
20.	*Purvāṣāḍhā*	2010 C. P.	Sagittarius
21.	*Uttarāṣāḍhā*	3015 C. P.	Sagittarius 4575 and Capricorn 1035 C. P.
22.	*Abhijit*	630 C. P.	Capricorn
23.	*Śravaṇa*	2010 C. P,	Capricorn
24.	*Dhaniṣṭhā*	2010 C. P.	Capricorn 4575 and Aquarius 1110 C. P.
25.	*Śatabhiṣā*	1005 C. P.	Aquarius
26.	*Purvābhādrapada*	2010 C. P.	Aquarius
27.	*Uttarābhādrapada*	3015 C. P.	Aquarius 4575 and Pisces 2565 C.P.
28.	*Revati*	2010 C, P.	Pisces 4575 and Aries 0 C, P.

Incidentally it may be seen that the motion of Sun (1830 C. P. per *muhūrta*) relative to that of the Moon (1768 C. P. per *muhūrta* is (1830—1768)=62 C. P. per *muhūrta*. Thus there is a conjunction of Sun and Moon after $\frac{54900}{62}$ *muhūrtas* or 29.516 days whereas the modern value is 29.5305 days.[12].

3. A new mode of graduating the zodiacal circumference is also found implied in the notion of *Sīmāviṣkambha*, literally 'lock of the limits' or the demarcation of the limits. The *Sīmāviṣkambhas* of all the *nakṣatras* (asterisms) have been stated in *SP.* **10.** 22. 5 as :

i. e. "Out of these 56 *nakṣatras* (asterisms)"

(*i*) There are two *Abhijits* (α Lyrae) *nakṣatras* of $\frac{630}{30\times67}$ *Sīmāviṣkambha* each.

(*ii*) There are 12 *nakṣatras* of $\frac{1005}{30\times67}$ *Sīmāviṣkambha* each, viz. 2 *Śatabhiṣās* (λ Aquarii)... upto 2 *Jyeṣṭhās* (α Scropii).

(*iii*) There are 30 *nakṣatras* of $\frac{2010}{30\times67}$ *Sīmāviskambha* each, viz. 2 *Śravaṇas* (α Aquilae)... upto 2 *Pūrvāṣāḍhās* (δ Sagittarii).

(*iv*) There are 12 *nakṣatras* of $\frac{3015}{30\times67}$ *Sīmāviṣkambha* each, viz. 2 *Uttarābhādrapadas* (γ Pegasi)... upto (two) *Uttarāṣāḍhās* (σ Sagittarii)."

It is evident by inspection that *Sīmāviṣkambha* of any *nakṣatra* (asterism) is

$$\frac{630}{30\times67}\ ,\quad \frac{1005}{30\times67}\ ,\quad \frac{2010}{30\times67}\ \text{or}\ \frac{3015}{30\times67}$$

corresponding to its zodiacal stretch in *muhūrtas*, i. e. $9\frac{27}{67}$, 15, 30 or 45 *muhūrtas*, resppectively (see Table 1). If the zodiacal stretches in *muhūrtas* are converted into zodiacal stretches in days of 30 *muhūrtas* eaeh, we have

$$\text{Zodiacal stretch in days} = \frac{\text{Zodiacal stretch in } muhūrtas}{30}\ . \qquad (3)$$

Using this relation, *ZS* in days of any *nakṣatra* may be easily computed. Thus the following table of *nakṣatras* and their zodiacal stretches in days may be easily obtained (See Table 3).

TABLE 3

Nakṣatras and their Zodiacal Stretchcs (=*ZS*) in days

Total number of *nakṣatras* (Asterisme)	ZS in *muhūrtas*	ZS in days	ZS in days with the same denominator 30×67
1	$9\frac{27}{67}$	$\frac{630}{30\times67}$	$\frac{630}{30\times67}$
6	15	$\frac{15}{30}$	$\frac{15}{30}\times\frac{67}{67}=\frac{1005}{30\times67}$
15	30	$\frac{30}{30}$	$\frac{30}{30}\times\frac{67}{67}=\frac{2010}{30\times67}$
6	45	$\frac{45}{30}$	$\frac{45}{30}\times\frac{67}{67}=\frac{3015}{30\times67}$

In the light of the foregoing discussion this shows that *Sīmāviṣkambhas* of *nakṣatras* (asterisms) represent their zodiacal stretches in days expressed as fractions having the same denominator probably for a better comparison. Thus the zodiacal circumference was graduated in days of a *nakṣatra* month, i. e. $\frac{54900}{30\times67}$ days. The correspondence between days of *nakṣatras* and the modern degrees of arc works out as follows :

$$\frac{54900}{30\times67} \text{ days (time degrees)} = 360°$$

$$\frac{630}{30\times67} \text{ days} = 4° \frac{8}{61}$$

$$\frac{1005}{30\times67} \text{ days} = 6° \frac{36}{61}$$

$$\frac{2010}{30\times67} \text{ days} = 13° \frac{11}{61}$$

$$\frac{3015}{30\times67} \text{days} = 19° \frac{47}{61}$$

4. Later still a grand scheme of graduating the zodiacal circumference was evolved. This is based on the fact that 360 *saura* days (one *sarua* day equals the time taken by Sun to move on 1/360th part of zodiacal circle) make 3 seasons of 4 *saura* months (a *saura* month consists of 30 *saura* days) each. In this context, *JP.* 9. 17-19 states as:

(1) "How many *nakṣatras* (asterisms) are completed in the first month of *Varṣā* (rainy season) ? (The answer is) *Uttaraṣāḍhā* (σ Sagittarii) remains for 14 *ahorātras* (days and nights), *Abhijit* (α Lyrae) for 7 *ahorātras*, *Dhaniṣṭhā* (β Delphini) for one *ahorātra.*

Second month of *Varṣā*...*Dhaniṣṭhā* (β Delphini) for 14 *ahorātras* (days and nights), *Śatabhiṣā* (λ Aquarii) for 7 *ahorātras*, *Pūrvābhādrapada* (α *Pegasi*) for 8 *ahorātras*, and *Uttarābhādrapada* (γ Pegasi) for one *ahorātra.*

Third month of *Varṣā*...*Uttarābhādrapada* (γ Pegasi) for 14 *ahorātras*, *Revatī* (ζ Piscium) for 15 (*ahorātras*) and *Aśvinī* (β Arieties) for one (*ahorātra*).

Fourth month of *Varṣā*...*Aśvinī* (β Arietis) 14, *Bharaṇī* (41 Arietis) 15 and *Kṛttikā* (η Tauri) for one (*ahorātra*).

(2) First month of *Hemanta* (Winter)...*Kṛttikā* (η Tauri) 14, *Rohiṇī* (α Tauri) 15 and *Mṛgaśīrṣa* (λ Orionis) for one *ahorātra* (day and night).

Second month of *Hemanta* . *Mṛgaśirṣa* (λ Orionis) for 14, *Ārdrā* (∝ Orionis) 8, *Punarvasu* (β Geminorum) 7 and *Puṣya* (δ Cancri) for one *ahorātra.*

Third month of *Hemanta* .. *Puṣya* (δ Cancri) for 14 *ahorātras, Aśleṣā* (ϵ Hydrae) 15 and *Maghā* (∝ Leonis) for one *ahorātra.*

Fourth month of *Hemanta* ..*Maghā* (∝ Leonis) for 14 *ahorātras, Pūrvaphālguṇī* (δ Leonis) 15 *ahorātras* and *Uttaraphālguṇī* (β Leonis) for one *ahorātra.*

(3) First month of *Grīṣma* (Summer)... *Uttaraphālguṇī* (β Leonis) for 14 *ahorātras, Hastā* (δ Corvi) 15 *ahorātras* and *Citrā* (∝ Virginis) for one *ahorātra.*

Second month of *Grīṣma*... *Citrā* (∝ Virginis) for 14 *ahorātras, Svāti* (∝ Bootis) for 15 *ahorātras, Viśākhā* (∝ Libra) for one *ahorātra.*

Third month of *Grīṣma* ..*Viśākhā* (∝ Libra) for 14 *ahorātras, Anurādhā* (δ Scorpii) for 8 *ahorātras, Jyeṣṭhā* (∝ Scorpii) for 7 *ahorātras* and *Mūla* (λ Scorpii) for one *ahorātra.*

Fourth month of *Grīṣma*... *Mūla* (λ Scorpii) for 14 *ahorātras, Pūrvāṣāḍhā* (δ Sagittarii) for 15 *ahorātras* and *Uttarāṣāḍhā* (σ Sagittarii) for one *ahorātra.*"

These data may be seen at a glance in Table 4.

TABLE 4

Table of *Nakṣatras* (asterisms) and their numbers of *ahorātras* (days and nights) associated with different months of the year.

Season	Sr. No. of month	*Nakṣatras* and their numbers of *ahorātras* (days and nights)
Varṣā (Rainy)	1	*Uttarāṣāḍhā* 14, *Abhijit* 1 *Śravaṇa* 8, *Dhaniṣṭhā* 1.
	2	*Dhaniṣṭhā* 14, *Śatabhiṣā* 7, *Pūrvābhādrapada* 8, *Uttarābhādrapada* 1.
	3	*Uttarābhādrapada* 14, *Revatī* 15, *Aśvinī* 1.
	4	*Aśvinī* 14, *Bharaṇī* 15, *Kṛttikā* 1.
Hemanta (Winter)	1	*Kṛttikā* 14, *Rohiṇī* 15, *Mṛgaśirṣa* 1.
	2	*Mṛgaśirṣa* 14, *Ārdrā* 8, *Punarvasu* 7, *Puṣya* 1
	3	*Puṣya* 14, *Aśleṣā* 15, *Maghā* 1.
	4	*Maghā* 14, *Pūrvāphālguṇī* 15. *Uttarāphālguṇī* 1.
Grīṣma (Summer)	1	*Uttarāphālguṇī* 14. *Hasta* 15, *Citrā* 1
	2	*Citrā* 14, *Svāti* 15, *Viśākhā* 1
	3	*Viśākhā* 14, *Anurādhā* 8, *Jyeṣṭhā* 7, *Mūla* 1
	4	*Mūla* 14, *Purvāṣāḍhā* 15, *Uttarāṣāḍhā* 1.

This shows that twenty individual *nakṣatras* (asterisms) plus four pairs of *nakṣatras* (asterisms), i.e. *Abhijit* ($\varkappa$ Lyrae) and *Śravaṇa* (α Aquilae), *Śatabhiṣā* (λ Aquarii) and *Pūrvābhādrapada* (α Pegasi), *Ārdrā* (α Orionis) and *Punarvasu* (β Geminorum) and *Anurādhā* (σ Scorpii) and *Jyeṣṭhā* ($\varkappa$ Scorpii) have been allocated 15 *saura* days each. This hints upon a 24-fold division of the zodiacal circumference comprised of 360 *saura* days (one *saura* day equals the time taken by the Sun to move on 1/360th part of zodiacal circle).

Besides, we find that *Uttarāṣāḍhā* (σ Sagittarii) lying near the winter solstice is associated with last *saura* day of the fourth *saura* month of *Grīṣma* (Summer) when the Sun is in the neighbourhood of Summer solstice. This shows that the number of *saura* days associated with any *nakṣatra* (asterism) represents its number of acronical risings in the eastern horizon after sunset. In this context, King[13] also refers to the use of dekanal system, a kind of clock calendar of the stars, constellations and parts of constellations based on a year of 360 days, used by priests in some parts of the east. With the observed disposition of dekan stars, both the time and the direction could be found out. Ipso facto the Jainian approach may be contemplated as a sign of graduating the zodiacal circumference into 360 *saura* days.

Besides, if Summer ends with Sun at Summer solstice, Winter solstice coincides with one *saura* day of *Uttarāṣāḍhā* (σ Sagittarii), i.e. 14 *saura* days (time degrees) preceding Winter solstice coincided with *Abhijit* ($\varkappa$ Lyrae) *nakṣatra* (See Table No. 4). Taking 72 years for 1° (=one *saura* day) of precession, we have

14° (*saura* days) of precession $= 72 \times 14 = 1008$ years.

Thus this observation dates about 1008 years after Winter solstice coincided with the beginning of *Abhijit* ($\varkappa$ Lyrae) *nakṣatra*. So the event might have occurred in about 3rd/4th century A.D., i.e. just the transition period between pre-*Siddhāntic* and *Siddhāntic* astronomical systems.

Be it mentioned that the method of season determination as implied in the given data (vide Table 4) has been exhaustively dealt with in a separate paper.[14] However a passing reference may be made that allotment of equal numbers of *saura* days to the seasons is an indication that some inequalities of the Sun were not at all conceived contrary to the notion of stop function, in Babylonian astronomy.

5. Discussion

In Vedic period, days were called after the names of *nakṣatras* (asterisms)[15] That was the first attempt to graduate zodiacal circumference in 27 days

of a lunar sidereal revolution. Moon travels by definition through 27 *nakṣatras* (asterisms) in each sidereal revolution.[16] Pingree[17] points out from the Rk. recension, verse 18, that 27 *nakṣatras* (asterisms) have been interpreted as equal arcs of 13° 20′ each. It is, of course, true that from verse 18 of the Rk. recension, we find that the Moon travels through a *nakṣatra* (asterism) in 1 day and 7 *kālas* such that it completes 67 lunar cycles or covers 1809 (= 67 × 27) *nakṣatras* (asterisms) in a 5-year cycle of 1830 days. But this is the average motion of Moon. An estimate of the mean position of Moon could be easily made on this basis and the position of Moon in the neighbourhood of any bright star could help determine the name of day. In this way the conjunction stars of *nakṣatras* (asterisms) must have been identified. Distance between conjuction stars of any consecutive *nakṣatras* is not constant. So a *nakṣatra* (asterism) cannot be easily corresponded to an arc of 13°20′. Similarly Biot guessed that Hindu *nakṣatras* (asterisms) were theoretically generated corresponding to 27 days for which the Moon remains visible in a lunar month.[18] In the light of this discussion, Biot's views are easily refutable. The ancient Hindus were aware of lunar stations among the stars. A remarkable advancement in this regard was made by exponents of Jaina School of astronomy who measured the longitudinal stretches of *nakṣatras* (asterisms) in days of a *nakṣatra* month (sidereal revolution of Moon). A naked eye observer rounded off the zodiacal stretches of *nakṣatras* (asterisms) to the nearest whole number of half-days. 15 *nakṣatras* (asterisms) obtained 2 half-days each, 6 *nakṣatras* one half-day each and naturally the rest of the 6 *naksatras* three half-days each so as to correspond the 27 *nakṣatras* (asterisms) with 27 days. But the length of a *nakṣatra* month (sidereal revolution of Moon) is $9\frac{7}{67}$ *muhūrtas* or $\frac{7}{67}$ days (30 *muhūrtas* = 1 day) more than 27 days. Thus the inclusion of *Abhijit* (α Lyrae) *nakṣatra* (asterism) with zodiacal stretch $9\frac{7}{67}$ *muhūrtas* or $\frac{630}{30\times67}$ days was necessitated. Kaye mentions that *Abhijit* (α Lyrae) is the extra *nakṣatra* and their is a legend (*Maitraiya Brāhmaṇa iii*, 230.11) that it dropped out, but *Taittirīya Brāhmaṇa* (I.5.2.3) marks it as a new comer,[19] This fact hints that Jaina system of astronomical thought had established its identity in the *Brāhmāṇic* period also and zodiacal circumference was graduated in 28 *nakṣatras* (asterisms) corresponding to $27\frac{7}{67}$ days of a *nakṣatra* month (sidereal revolution of Moon). It is worthy to note that $27\frac{7}{67}$ or 27.313 days is the length of *nakṣatra* month (sidereal revolution of Moon) correct upto one place of decimal fraction. (The correct value is 27.3216615 days).[20] Thus the arguments of Jones *et al.*[21] that perfect exactness being either not attained or not required by Hindus, they fixed on the number 27 and inserted *Abhijit* (α Lyrae) for some astrological purpose for their nuptial ceremonies, are altogether

questionable. Zodiacal stretch of a *nakṣatra* (asterism) in days was called its *Sīmāviṣkambha*.

Later on *Sīmāviṣkambhas* of all the *nakṣatras* (asterisms) were converted into *muhūrtas* and thus the zodiacal circumference was graduated in $819\frac{37}{67}$ *muhūrtas* of a *nakṣatra* month (sidereal revolution of Moon). Then still a minute division was evolved. *A muhūrta* (time degrees) was sub-divided into 67 parts known as celestial parts (*gagana khaṇḍas*) such that the zodiacal circumference was graduated into 54900 C. P.

It is worth-mentioning here that unequal division in *muhūrtas* can provide a standard scale for weeding out the actual identifying stars of the *nakṣatras* because this unequal division in *muhūrtas* permits all *yagatārās* (identifying stars) of *nakṣatras* in their respective divisions. Although these divisions are not sensitively dependent on the velocity of the Moon (which may be of any magnitude between maximum to minimum dependent on the position of Ucha with period of order of $9\frac{1}{2}$ years) but they are certainly dependent upon the stretches of the Moon's passages at least to cover the extremities of the respective lunar asterismic patterns. Astronomically this zodiacal division is more important as regards naked eye amatuer observation than the simplified equal amplitude division for some practical usage. It is however worth mentioning here that in the study of syzygies in the 5-year cycle of fixed Jain calendar, this unequal division in *muhūrtas* did not exactly conform to the observation. Thus the amatuer astronomer divided the *nakṣatras* into three categories, i. e. *kula, upakula* and *kulopakula*. This simply reflects upon the degree of keenness possessed by amatuer Jaina astronomers in their studies in the division of zodiacal circle. (For more details, see S. S. Lishk's thesis, see ref. No. 5).

About a thousand years after Winter solstice coincided with beginning of *Abhijit* (α Lyrae) *nakṣatra* (asterism), i.e. in near about 3rd/4th century A. D., they switched from the lunar motion over to the solar motion and divided the zodiacal circle into 24 equal parts, each part representing a *nakṣatra* (asterism) except 4 parts which represented a pair of *nakṣatras* (asterisms) each. The zodiacal circumference was clearly graduated in 360 *saura* days of a *saura year*. (In ancient Chinese astronomy, too, a zodiacal circumference was graduated in the number of days in a year).[22] This led to the division of zodiacal circle in 360° and the equal amplitude system of *nakṣatras* (asterisms) was developed when *Abhijit* (α Lyrae) was again dropped with the advent of *Siddhāntic* astronomy. It is worthy of note that the use of 27 *nakṣatras* (asterisms) only is also hinted upon in *Samavāyāṅga Sūtra*[23] (=*SVS*). *SVS*27.2 states as :

"Leaving aside *Abhijit* (α Lyrae) only 27 *nakṣatras* (asterisms) are used in *Jambūdvīpa* (isle of *Jambu* tree)."

The role of Jaina School of Astronomy in allocating the number of *muhūrtas* (asterisms) has left an everlasting impact on Indian astrological thought so much so that every *Saṅkrānti* (solar ingress) etc. is termed as 15,30 or 45 *muhūrti* (pertaining to *muhūrtas*) corresponding to the zodiacal stretch in *muhūrtas* of the *nakṣatra* (asterism) occupied by Sun at that time.[24] No such series of developments is found in any Babylonian tablets of remote antiquity. Zodiac as known to Babylonians appears, however, for the first time in texts of the year 419 B. C.[25] The evolutionary series of developments of graduating the zodiacal circumference suggests the Hindu origin of its division into modern degrees of Arc.

It may be worth mentioning here that the solar division of zodiac in India is the same in substance as that used in Greece. Jones[26] remarks that both Greeks and Hindus owe it to an older nation who first gave names to the luminaries of heaven. Need it be emphasized that the hitherto unexplored Jaina contribution in the history of division of zodiacal circle is unique in character of its Hindu origination.

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REFERENCES AND NOTES

1 Cf. Dvivedi, Sudhakara (1906) *Jyotiṣa Vedāṅga*, V. 18, p. 14. (Varanasi).

2 For units of time, see Sharma, S. D, and Lishk, S. S. (1976) Time Units in Ancient Indian Astronomy. *Tulsi Prajña*, Vol. 2 No. 7-8, pp. 100-108 (JVB, Ladnun).

3 See Bose, D. M., Sen, S. N, and Subarayappa, B. V. (1971) *A Concise History of Science in India*, p. 80 (INSA, New Delhi).

4 Cf. Needham, J. and Wang, L. (1959) *Science and Civilisation in China*, Vol. 3, p. 228.

5 See Jain, L. C. (1975) Kinematics of the Sun and the Moon in *Tiloya Paṇṇatti*. *Tulsi Prajña*. Vol. 1 No. 1, pp. 60-67 (JVB, Ladnun).

For more details, see Lishk, S. S. (1977) Mathematical Analysis of Post-*Vedāṅga* Pre-*Siddhāntic* Data in Jaina Astronomy. Ph. D. thesis, Punjabi University, Patiala (India).

6 *Jambūdvīpa Prajñapti* (=*JP*). Hindi translation by Amolak Rishi (*Vira* era 2446). Jaina Shastrodhara Mudralaya, Sikandrabad.

The *J. P.* is the Sixth *upāṅga* (sub-limb) of Jaina canon of sacred literature. The present recension of the Jaina canonical literature is generally ascribed to the council of Valabhi under the presidency of Devardhi Ganin which met during fifth or sixth century A. D. For more details see our paper 'Sources of Jaina Astronomy'. *The Jaina Antiquary*, Vol. 29, Nos. 1-2, pp. 19-32.

As regards original quotations whose English translations have been given here, reference may be made to respective works by Amolak Rishi as referred to here or Lishk's Ph. D. thesis (See ref. No. 5).

7 See Jaina Nemichandra (1955) *Jaina Pañcāṅga* (in Hindi). *Jaina Siddhanta Bhaskara*, Vol. 8, No. 2 (Arrah).

See also Lal, Sohan. *Jaina Jyotiṣa Tithi Patrikā* (from 1972 B. S. upto 2007 B. S,) (in Hindi). Lala Niranjan Das Ram Lal Sravaka, Dabbi Bazar, Lahore.

See also Vijay, D. (1937) *Jaina Pañcāṅga Paddhati* (in Gujarati) (Viramgam)
See also Jaini, Veli Ram (1917) *Jaina Jyotiṣa Tithi Patram Samikṣā* (in Hindi) Ranvir Prakash Yantralaya, Lahore.

8 *Sūrya Prajñapti* (*SP*) Hindi translation by Amolak Rishi (Vīra era 2445). Jaina Shastrodhara Mudralrya, Sikandrabad.

The *S. P.* is the fifth *upāṅga* (sub-limb) of Jaina cannon of sacred literature. For more details, see ref. No. 6.

9 *See* ref. No. 7.

10 Ibid.

11 See ref. No. 5.

12 Ibid.

13 King, Henry C. (1957) *The Background of Astronomy*, pp. 23-24.

14 See Lishk, Sajjan Singh and Sharma, S. D. (1977) Season Determination Through the Science of Sciatherics in Jaina School of Astronomy. *Indian Journal of History of Science*, 12, No. 1, pp. 33-44.

15 *See* Dixit, S. B. *Bhārtiya Jyotiṣa Śāstra*, vol. 1, part 1. Eng. tr. by Vaidya, R. V. (1969), pp. 44-45.

See also Lishk, S. S. and Sharma, S. D. (1975). Hindu *Nakṣatras*. *The Astro. Mag*, vol. 64. No. 8, pp. 619-622.

16 See Dixit, S. B. op. cit. p. 79.

17 Pingree, D. (1973) Mesopotamian Origin of Ancient Indian Mathematical Astronomy. *JHA*. 4. pp. 1-12.

18 Biot, J, B. (1862) *Etudes Sur L'Astronomie Indienne et Sur L'Astronomie Chinoise*, p. 391 (Paris),

See also our paper 'Hindu *Nakṣatras*' op. cit.

19 Cf. Kaye. G. R. (1924) Memoirs of Archaeological Survey of India. No. 18 *Hindu Astronomy*, p. 22.

20 Cf. Lahiri, N. C. (1973) *Indian Ephemeris*, p. 7 (Calcutta).

[21] Jones, Sir W. *et al.* (1792) ***Dissertations and Miscellaneous Pieces Relating to the History and Antiquities, the Arts, Science and Literature of India.*** (*Ch. Antiquity of Indian Zodiac*), pp. 369-390.

[22] Yabuuti, Kiyosi (1974) The Calendar Reforms in the Han dynasties and Ideas in their Background. ***Archives Internationales D'Historie Des Sciences, 24,*** No. 94, pp. 51-65.

[23] ***Samvāyāṅga Sūtra*** (=***SVS***). Hindi translation by Amolak Rishi (***Vīra*** era 2446). Jaina Shastrodhara Mudralaya, Sikandrabad.
Tke ***SVS*** is the fourth ***aṅga*** (limb) of ***Jaina Cannon of Sacred Literature.***
For more details, see ref. No. 6

[24] ***See*** Jha, Sitaram (1960). ***Muhūrta Cintāmaṇi*** (Hindi commentary). p. 77

[25] Cf. Neugebauer, Otto (1952) ***The Exact Sciences in Antiquity.*** p. 97

[26] ***See*** Jones, Sir W. (1790) Antiquity of the Hindu Zodiac. ***Asiatic Researches,*** Vol. II, p. 289

(We have used the subject matter as contained in Centenary Review of the Asiatic Society of Bengal from 1783 to 1886 A. D. (1885) part III, p. 22)