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STANDARDIZATION OF TIME-UNIT *MUHŪRTA* THROUGH THE SCIENCE OF SCIATHERICS IN *ATHARVA VEDĀṄGA JYOTIṢA**

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In ancient Indian astronomy, there were three kinds of gnomonie experiments, viz. standardization of *muhūrta* (=48 minutes), measurement of the time of day and determination of seasons. The paper discusses that *Atharva Vedāṅga Jyotiṣa* gives shadow-lengths in *aṅgulas* (finger-widths) after every *muhūrta* from sunrise upto sunset and in moonlight during night. It is shown using method of least squares for the available sciatheric data that the data relate to the experiment on equinoctial day and the day is divided into fifteen equal *muhūrtas*. The shadow-length has been measured as a function of time and thus *muhūrta* has been standardized as the fundamental unit of time.

INTRODUCTION

1 Gnomon was an important tool of observational astronomy in ancient times. This was the simplest device used by ancients as Sarton remarks :[1]

"Any intelligent person, having driven his spear into sand, might have noticed that its shadow turned around during the day and that it varied in length as it turned. The gnomon in its simplest form was the systematization of that casual experiment."

Sarton also mentions[2] that Anaximander (*c.* 610-545 B. C.) of Miletus, a junior contemporary of Thales, was the earliest Lonian philosopher who used the gnomon in Greater Greece. In ancient China also Sun's shadow at noon used to be observed for meridian passage whereas upper and lower transits across the meridian of the various circumpolar stars were observed at night[3]. In India also, by measurnig the length and direction of the

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shadow of the gnomon, the ancients determined the length of the year and the time of the day so as to perform their religious rites at proper time. Though we have no Papyrus Prisse to prove our age, no Pyramids of Gizah, nor mummies of Akhnaton and Tutankhamen, no town dug up like Ur and Babylon to speak for us, yet Vedas are our inheritance as the knowledge of the mode of producion and the way of life of the great Brahman, the commune of Vedic Aryan man. This is the way Aryan Hindu tradition puts history on record[4]. We find, the earliest use of gnomon in ancient India in connection with the observation of solstices in *Aitareya Brāhmaṇa.* The Vedic Hindus had determined at that time that the Sun remained stationary for seven days at the Summer solstice.[5]

2. The ancients reckoned the length of day in a great variety of ways. The Babylonians and the Athenians reckoned the day from sunset to sunset, the Umbarians from noon to noon, the Egyptians and Hipparchus from sunrise to sunrise and the Roman priests from midnight to midnight.[6] In ancient India the length of an *ahorātra* (day and night) was reckoned from sunrise to sunrise. Like Babylonian hours (equal hours counted from sunrise to sunrise) and Italian or Bohemian hours (equal hours counted from sueset to sunset)[7], the Jainas (belonging to post-*Vedāṅga* pre-*Siddhāntic* period) had also divided an *ahorātra* (day and night) into thirty equal *muhūrtas* (1 *muhūrta* = 48 minutes) counted from sunrise to sunrise.[8] In *Brāhmaṇic* period, there were different names for 15 *muhūrtas* in the day and the night in the dark and bright lunar halves[9] But the earliest gnomonic record of the division of day in fifteen *muhūrtas* is first found in *Atharva Veda Jyotiṣa* (=*AVJ*).[10] Here it is exposed that the *AVJ* data relate to a gnomonic experiment designed to standardize *muhūrta* as the unit of time.

Theory

Regarding the length of *muhūrta* in terms of its sub-divisions, *AVJ* (vv. 4-5) states :[11]

"Twelve *nimeṣas* (or the time required for twelve times blinking an eye) is known as *lava*. Thirty *lavas* make a *kalā*. Thirty *kalās* make *truṭi*. Thirty *truṭis* make a *muhūrta* which is determined by the shadow) of a twelve-*aṅgulas* upward portion of a stick vertically driven into the earth."

These data can be shown in the following Table 1.

TABLE 1

(*Time-units in AVJ*)

12 *nimeṣas*	=	1 *lava*
30 *lavas*	=	1 *kalā*
30 *kalas*	=	1 *truṭi*
30 *truṭis*	=	1 *muhūrta* (=48 minutes)

Here a *muhūrta* has been defined in terms of its sub-divisons and a *muhūrta* equals 324000 *nimeṣas*. Therefore :

$$1 \text{ nimeṣa (blinking of an eye)} = \frac{1}{324000} \text{ muhūrta}$$

$$= \frac{48 \times 60}{324000} = \frac{2}{225} \text{ second.}$$

However, there exists a great diversity of magnitude of a *nimeṣa* in ancient Indian astronomical literature. A more detailed discussion is out of scope of this paper. (An interested reader may be referred to relevant portion of Dr. S. S. Lishk's doctoral thesis entitled, "Mathematical Analysis of Post-*Vedāṅga* Pre-*Siddhāntic* Data in Jaina Astronomy," Punjabi University Library, Patiala).

According to the given text (*AVJ*, vv. 4-5), the length of a *muhūrta* is ascertained with the length of a shadow of a twelve-*aṅgulas* upward portion of a stick vertically driven into the earth. This indicates that the *AVJ* gnomonic experiment was purposefully designed to standardize *muhūrta*, in terms of shadow-lengths. Here a complicated question arises as to how they measured one-fifteenth portion of an equinoctial day in order to mark the shadow-length at the end of a *muhūrta*. Did they use water clepsydra ? Did a man begin to count the blinkings of an eye ? Or did they use any hit and trial method ? As a matter of fact, a standard measure of time is essentially required to graduate the shadow-clock. It may be conjectured that according to the text, a *muhūrta* has been defined in terms of its sub-divisions *nimeṣas* (blinkings of an eye) and not in terms of water-clepsydric details. Therefore, they might have employed the counting of blinkings of an eye in one way or the other for this purpose, but what was the exaet technique, it is not conceived as yet. But on the other hand *Jalaghaṭī* (water-clepsydra) was an old instrument and it is mentioned in *Vedāṅga Jyotiṣa*[12] and *Viṣṇu Purāṇa*.[13] However, it is interesting to note that in *Jyotiṣa Karaṇḍaka*[14] (*gāthās* 10-24, 30-3), *muhūrta* is defined as the interval of time during which four *adhakas* or 200 *palas* of water inflow in *Magadha Jalaghaṭi*. The *Jyotiṣa Karaṇḍaka* is a Jaina non-canonical work of about fifth century A.D, chronologically not earlier than *AVJ* period. Its mention is only intended to expose the one-time tradition of measuring the duration of a *muhūrta* with the help of a *Jalaghaṭī* Thus, it may also be speculated that the shadow clock might have been graduated with the help of a water-clepsydra which had surely come into existence earlier than gnomonic shadow-clock.

Now we attempt to analyse the *AVJ* data. *AVJ* (vv. 6-10) states as :

At the time of sunrise when the shadow-langth is 96 *aṅgulas* from east to west, that is called *Raudra muhūrta* (6).

"(When the shadow length is) 60 (*aṅgulas*), that is called *Śveta* (*muhūrta*) ; 12 *aṅgulas*, *Maitra* (*muhūrta*) : 6 *aṅgulas*, *Sārabhaṭa* (*muhūrta*) may be called ; 5 (*aṅgulas*), *Sāvitra* (*muhūrta*) may be understood (7).

(When the shadow length) is 4 *aṅgulas* (that is called) *Vairāja* (*muhūrta*) ; 3 (*aṅgulas*), *Viśvāvasu muhūrta*. At noon there is *Abhijit* (*muhūrta*) in which the shadow-length remains constant (8).

On changing direction towards east, when the shadow length is 3 *aṅgulas*, that is called *Rohiṇī* (*muhūrta*) 4 (*aṅgulas*), *Bala* (*muhūrta*) is known 5 *aṅgulas*, *Vijaya* (*muhūrta*) may be understood (9).

(When the shadow-length is) 6 *aṅgulas* (that is called) *Nairta muhūrta* ; 12 *aṅgulas*, *Varuṇa* (*muhūrta*) ; 60 (*aṅgulas*), *Saumya* (*muhūrta*) ; (That is called) *Bhaga muhūrta* when the shadow length is maximum."

These data can be easily shown in Table 2.

TABLE 2

Shadow-lengths at different muhūrtas in AVJ

Muhūrta	Shadow-length (in *aṅgulas*)	*Muhūrta*	Shadow-length (in *aṅgulas*)
1. *Raudra*	96 (max)	5. *Sāvitra*	5
2. *Śveta*	60	6. *Vairāja*	4
3. *Maitra*	12	7. *Viśvāvasu*	3
4. *Sārabhaṭa*	6	8. *Abhijit*	Shadow remains constant

Abhijit is the *muhūrta* in which the shadow does not alter in length. The lengths of shadows associated with *muhūrtas* coming afternoon increase in the reverse order. It cannot be said that the shadow-length at meridian transit of the Sun is three *aṅgulas*, but it must be shorter than 3 *aṅgulas*.[16] Because the duration of a day or a night differs on every degree of latitude, so Albīrūnī was led to think that the length of a *muhūrta* during the day is different from its length during the night. A day and a night consist of 15 *muhūrtas* each. Albīrūnī thinks that here the *muhūrtas* are treated like the horae oblique temporales (twelve equal parts of the day and twelve equal parts of the night, which differ as the day and the night differ). Albīrūnī further thinks that the digits like 96, 60, 12, etc. represent the excess of shadow-length over the noon-shadow length at different *muhūrtas* respectively as shown in Table 3.

TABLE 3

Shadow-lengths as given in Albīrūnī's India

The *muhūrtas* which have elapsed before noon	1	2	3	4	5	6	7
How many digits the shadow length in question is larger than the noon-shadow length	96	60	12	6	5	3	20
The *muhūrtas* which have elapsed after noon	14	13	12	11	10	9	8

The digits 4 and 3 of *AVJ* (See Table 2) have been replaced by 3 and 2 respectively. Albīrūnī has not mentioned the exact source but referred to only some metrical compositions.[17]. Here it is worth mentioning that a similar gnomonic record is also found in *Śrutasthāvirasūtritam*[18] with the difference that the digit 3 of *AVJ* text is replaced by 2. So the diversity of record of 6th and 7th *muhūrtas* where the velocity of shadow is slower than that in *Abhijit* (eighth *muhūrta*) leads us to think that the experiment might have been performed over different latitudes not varying much.

Now let us mathematically check up the Albīrūnī's view that the digits like 96, 60, 12 etc. represent the excess of shadow lengths over the noon shadow length at different *muhūrtas* respectively. Vide Table 3, the decrease of shadow-length in the second *muhūrta* is 36 (=96—60 *aṅgulas* whereas in the third *muhūrta* it is 48 (=60−12) *aṅgulas*. But this is contrary to the fact that the rate of decrease of shadow-length goes on diminishing as the shadow-length decreases from its maximum value at sunrise to its minimum value at noon time. Thus, the third *muhūrta* would be longer than the second *muhūrta* and it leads to a system of unequal *muhūrtas* which Albīrūnī has himself discarded. Thus, Albīrūnī's views are refuted.

Besides, in ancient Indian astronomy, we find that the day, that is the period between sunrise and sunset, is divided into 2, 3, 4, 5 and 15 parts. The two divisions of the day are the *pūrvāhṇa* (the former half) and the *aparāhṇa* (the latter half) ; the three divisions are *pūrvāhaṇa*, *madhyāhaṇa* (noon) and *aparāhṇa*. In the four-fold division each part is equal to a *prahara* (a period of three hours) and they are successively called *pūrvāhṇa madhyāhṇa*, *aparāhṇa*, and *sāyāhṇa* (evening). The five parts are named *prātaḥ*, *saṅgava*, *madhyāhṇa aparāhṇa*, and *sāyāhṇa*, and lastly the day is divided into fifteen parts called *muhūrtas*.[19] There are different names of different fifteen *muhūrtas* of the day and the night each in the bright and the dark lunar halves respectively ; and the *muhūrtas* are further sub-divivided into sub-divisions called *pratimuhūrtas*, their names being *idānīm*, *tadānīm* and others as given in *Taittirīya Brāhmaṇa*[20] (3.10). Such a minute division could not possibly be made without the help of a water clock or the clepsydra ; and it certainly implies the use of a standard yardstick of time. Here we cannot deny that primarily the division of a day into different folds was just like the two-fold or three-fold approximate divisions as mentioned earlier which are commonly used in India in these days also. We see that ancient Sumerians (original dwellers of Babylon) also divided the day into three unequal watches which continued down to medieval times.[21] It was quite natural that the need for measurement of equal intervals of time was felt. The ancient Babylonians divided the nychthemeron into twelve hours of thirty *gesh* each, *gesh* being *equal* to four minutes. The Egyptians divided the day into twelve hours and also the night into twelve hours, Later in medieval times, the twenty-four hour division for the whole day (day and night) has been adopted. Similarly, firstly the day and the night might have been divided into fifteen *muhūrtas* each ; and then due to the concept of an *ahorātra* (day and night), the thirty-fold division for the whole day (from sunrise to sunrise) might have been adopted. *Manusmṛti* also gives thirty *muhūrtas* as the duration of an *ahorātra*.[22] Thus, it seems convincing that the *AVJ* text does not imply any system of uneqal *muhūrtas*.

Now for an equal *muhūrtas* system, when the day and the night each being equal to fifteen *muhūrtas*, two cases arises :

1. Either the observer is situated over the equator where the day and the night remain equal throughout the year. This does not seem plausible due to geographical conditions.

2. Or the experiment was performed on the equinoctial day. Because the exponents of *AVJ* had developed the concept of *muhūrta* being equal to 324000 *nimeṣas* and thirty of which make an *ahorātra* (day and night), they might have obviously thought of concretely defining the length of a *muhūrta* with the help of gnomonic techniques. As a matter of fact those who could note the lenghths of shadow at intervals of time could not be so foolish that they might have not noted that the lengths of shadow are not

the same throughout the year, the reason upon which Dixit had discarded the problem as not worth attempting.[23] Therefore, the gnomonic experiment implied in the *AVJ* text refers to only a particular day of the year, obviously the equinoctial day when the day and the night are equal everywhere.

Here it is worthwhile to give a short account of an everlasting effect of standardisation of *muhūrta* as a unit of time. It is quite natural that some particular deeds like daily morning prayer etc. must have been attached to certain *muhūrtas*. With the repeated use of *muhūrta* as the unit of time, the word *muhūrta* began to be used for an interval of time other than the unit of time for astrological prognostications. Thus might have been born an important branch of astrology called *muhūrta* astrology, i.e. the astrology dealing with the election of an auspicious time for a particular deed to be done. Even these days the time of meridian passage of the Sun is called *Abhijit muhūrta* after the name of eighth *muhūrta* in *AVJ* text. But this type of astrological application of the word *muhūrta* does not in any way tell upon astronomical dimensions of *muhūrta* as a unit of time. This point may be illustrated with an example. According to Rāma Daivajña,[24] for election of an auspicious time for commencing a journey, a day (total time from sunrise to sunset) is divided into eight parts. Each part is called as *caturghaṭikā*, i. e. the time equal to four *ghaṭīs* (one *ghaṭī*=24 minutes). Duration of the astrological *caturghaṭikā* changes with the variation in the length of the day and it hardly affects the time-unit *ghaṭī* being equal to 24 minutes. It is worth mentioning that astrology had played an important role in the development of early astronomy.[25] Therefore, one can not overlook the astrological implications in early astronomical concepts in order to make their deeper meanings out. In the present context, it seems however convincing that at one time the length of the day might have been divided into fifteen astrological *muhūrtas* meant for the liturgical purposes. This is very evident from *AVJ* (verse 11) which states:

"As these fifteen *muhūrtas* have been described in day (from sunrise to sunrise), they may be understood as such at night also." (11).

This indicates that the night was also divided into fifteen *muhūrtas* and they were ascertained through gnomonic shadow length of the moon. Since the Moon does not always rise in the beginning of the night and the night does not end with the setting of the Moon, the parallel set of fifteen *muhūrtas* at night seems to have no astronomical significance except astrological implications. Or could there occur a full-moon night on an equinoctial day?

We again come to the astronomical implication of the *AVJ* gnomonic text. As the noon shadow-length changes considerably as the Sun moves from Summer solstice to Winter solstice, the given data cannot suit for all days of the year. Thus, it seems plausible that the *AVJ* text relates to a specific attempt to mark the exact length of a *muhūrta* (=48 minutes) through gnomonic shadow-lengths on an equinoctial day.

Now let us compute the latitude of the observer.

1. Firstly we have already refuted Albīrūnī's view that the digits 96, 60, 12 etc. represent the excess of shadow-lengths over the noon-shadow length respectively as shown in Table 3.

2. Secondly, let us presume that the digits 96, 60, 12 etc. represent the variation in shadow-length in the given *muhūrtas* respectively. Thus, zero will be the change in the eighth *muhūrta*.

Suppose, latitude of the observer $=\phi$, length of the gnomon $=12$ *aṅgulas*, declination of the sun $=0^{\circ}$.

$$\therefore \text{ Noon shadow length, } S=12 \tan \phi \qquad (1)$$

Let S_n be the shadow at the end of nth *muhūrta*

$$\begin{array}{lllllll}
\therefore S_8 & = & S_7 & = S+0 & = & S \\
S_9 & = & S_6 & = S_7+3 & = & S+3 \\
S_{10} & = & S_5 & = S_6+4 & = & S+7 \\
S_{11} & = & S_4 & = S_5+5 & = & S+12 \\
S_{12} & = & S_3 & = S_4+6 & = & S+18 \\
S_{13} & = & S_2 & = S_3+12 & = & S+30 \\
S_{14} & = & S_1 & = S_2+60 & = & S+90 \\
S_{15} & = & S_0 & = S_1+96 & = & S+186
\end{array}$$

Let H_n = hour angle of the Sun at the end of nth *muhūrta*

Z_n = zenith distance of the Sun at the end of the nth *muhūrta*.

Now according to spherical astronomy, on the equinoctial day (declination of the Sun being zero), we have :

$$S_n=12 \tan Z_n \qquad (2)$$

and

$$\text{Cos } Z_n=\text{Cos } \phi \text{ Cos } H_n. \qquad (3)$$

from (2) and (3) we get

$$144=(144+S_n^2) \text{ Cos}^2 \phi \text{ Cos}^2 H_n. \qquad (4)$$

As we know that on the equinoctial day the H (hour angle of the Sun) varies uniformly from 90° east to 90° west at the rate of 12° per *muhūrta*. Thus, $H_0=90^{\circ}$, $H_1=78^{\circ}$, $H_2=60^{\circ}$ and so on. Now we know S_n and H_n, so the value of ϕ can be easily computed from equation No. (4).

But on actual calculations, we find that (4) does not give any real value of ϕ. Thus, our supposition is wroug.

3. Thirdly, we presume that the digits 96, 60, 12 etc. represent actual shadow-lengths (S_n) at the end of different *muhūrtas* respectively. Therefore using equation No. (4), we obtain the following results as shown in Table No. 4.

TABLE 4

Latitude of the observer

Shadow length S_n	Hour-angle H_n	Latitude of the observer	Actual noon-shadow length (*aṅgulas*)
S_1	78°..	53°.38....	16.14
S_2	66°..	61°.17....	21.80
S_3	54°..		
S_4	42°..	No real value	
S_5	30°..		
S_6	18°..	4.05	0.85
S_7	6°..	12.71....	2.71

We have argued earlier that the rate of change of shadow-length is maximum in the morning, and there the shadow-length approaches infinity. Moreover, due to the faintness of the shadow and the penumbral effects, the digit 96 denoting the length of shadow one *muhūrta* or 48 minutes after sunrise cannot be much depended upon. Secondly, the digits 96 and 60 correspond to very high latitudes (See Table 4), where the actual noon-shadow length is considerably larger than the length of the gnomon also. In this mannar it violates the *AVJ* text in the sense that in the *Abhijit* (eighth) *muhūrta*, the shadow length remains almost unchanged and it will be about three *aṅgulas* or so. Therefore, these values may be easily discarded.

The digits 3 and 4 give latitudes near the equator. The rate of change of shadow-length is very small near the meridian transit of the Sun. Therefore, the digits 3, 4 and 5 (shadow length changing one *aṅgula* per *muhūrta*) also imply some error in their measurements. Besides, there may be some error in the length of the upward portion of the gnomonic stick vertically driven into the earth. There may also be some error in the inclination of the gnomon. Thus, it seems convincing that several errors might have crept in the given data. Still one cannot deny that it was a unique attempt to standardize the time-unit *muhūrta* through the science of sciatherics. In the light of our present findings the latitude of the observer ranges from 4°.05 to 12°.71 north (See Table 4). By applying statistical method, the best fit latitude comes out to be 9°.49 north.

After the *muhūrta* was standardized as a time-unit, later gnomonic texts as extant in *Sūrya Prajñapti*,[27] fifth *upāṅga* (sub-limb) of the Jaina canonical literature, refer to more different types of gnomonic experiments. In *AVJ*, the shadow-langth has been measured as a function of time but in *Sūrya Prajñapti*, the smaller intervals of time were measured as a function of shadow-length[28] and seasons were also determined.[29] We are still probing deeper into the ancient gnomonic texts.

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11 *AVJ* states as :

द्वादशाक्षि निमेषस्तु लवो नामाभिधीयते ॥
लवात्रिंशत् कलाज्ञेया कलात्रिंशत् त्रुटिर्भवेत् ॥ 4 ॥
त्रुटीनांतु भवेत् त्रिंशं मूहूर्तस्य प्रयोजनम् ॥
द्वादशांगुल मूछेषं तस्य छाया प्रमाणतः ॥ 5 ॥

For more details about time-units in ancient India, see our paper 'Time-Units in Ancient Indian Astronomy : *Tulsi Prajña*, Vol. 2, Nos. 7-8, pp. 100-108,

12 Dvivedi, S. (1906) *Vedāṅga Jyotiṣa*. Skt. commentary. Prabhakari and Co., Benaras.

13 See Gupta, M. L. *Viṣṇu Purāṇa* (edition with Hindi tr.) p. 514., Gita Press, Gorakhpur. 1957.

14 *Jyotiṣa Karaṇḍaka* (=*JK*), *gāthās* 10-24, 30-31, Skt. commentary by Malayagiri. Jain Bandhu Yantralaya, Pipli Bazar, Indore.

15 *AVJ* (vv. 6-10) states as :

नर्वात पञ्गूलारचैव प्रतीचीं तां प्रकाशयेत् ॥
पुरस्तात् सन्धि वेलायां मुहूर्तं रौद्रउच्यते ॥ 6 ॥

श्वेतः षष्टि समाख्यतो मैत्रोवै द्वादशांगुल ॥
षट् सुसारभटोजेयः सावितः पञ्चसुस्मृतः ॥ 7 ॥
चतुर्षु चैव वैराजस्त्रिषु विश्वावसुस्तथा ॥
मध्याह्ने चाभिजिन्नाम यस्मिन् छाया प्रतिष्ठति ॥ 8 ॥
प्राचीं वैगामिनीं छायां रौहिकस्तिषु वर्तते ॥
बलश्चतुर्षु बिरत्यातो विजयः पञ्चसु सस्मृतः ॥ 9 ॥
नैऋतस्तु पञ्गुल्यो वारूणो द्वादशांगुलः ॥
सौम्यः षण्टिः समादव्याते भगस्तु परमस्तथा ॥ 10 ॥

It is worth noting that the same numerical data are found in *Śārdūlakaraṇāvadāna* (See *Śārdūlakaraṇāvadāna* edited by S. K. Mukhopadhyaya, Visvabharati, Shantiniketan. 1964, pp. 54-55). The nomenclature of *muhūrtas* differs.

16 Dixit, S. B. ***Bhāratīya Jyotiṣa Śāstra.*** Eng. tr. by R. V. Vaidya (1968), pp. 97-98.

17 ***Albirūnī's India.*** Eng. tr. by E. Sachau. S. Chand and Co., New Delhi.

18 ***Śrutasthāvirasūtritam.*** Skt. Commentary Agamoday Samiti, 114-116, Javeri bazar, Bombay 1927.

19 Dixit S. B. op. cit., p. 41.

20 Ibid., pp. 42-43.

21 Sarton, G. ***Introduction to the History of Science***, Vol. III, part I; p. 716. Washington.

22 *Manusmṛti.* Hindi commentary by Keshav Prashad. Sri Venkateshwar Press, Bombay. 1898.

23 Dixit, S. B. ***op. cit,.*** p. 98.

24 ***Mārtaṇḍa Pañcāṅgam*** edited by S D. Sharma. Martand Bhawan, P. O. Kurali (Pb.) 1979.

25 Pannekock. A. Astrology and its influence upon the development of Astronomy. ***Journal of the Royal Astronomical Society of Canada,*** Vol. XXIV, No. 4, pp. 159-176. 1930.

26 *AVJ* (Verse 11) states as :

एते मुहूर्ता व्यास्वाता दशद्वौच तथा त्रयः ॥
अहन्येव तु विज्ञेया रात्राबपि न संशयः ॥ 11 ॥

27 ***Sūrya Prajñapti (=SP)*** belongs to post-***Vedāṅga*** Pre-***Siddhāntic*** period in the history of ancient Indian astronomy. Fore more details, see Lishk and Sharma, Sources of Jaina Astronomy. ***The Jaina Antiquary*** Vol. 29, No. 1-2 pp. 19-32.

Now mathematical commentaries of ***Sūrya Prajñapti*** in Sanskrit and English are being prepared by the authors under the principal investigator S. D. Sharma under the patronage of Jaina Muni Abhaysagar Ji of Vardhamana Kendra. Ahmedabad.

28 Lishk, S. S. and Sharma, S. D. The Time of Day measured through Shadow-lengthes in ***Sūrya Prajñapti. The Mathematics Education***, Vol. 10, No. 4, pp. 83-89.

29 ——————————Seasons Determination through the Science of Sciatherics in Jaina school of Astronomy. ***Indian J. Hist. Sci.*** 12, No. 1, pp. 33-44.