THE KINEMATIC MOTION OF ASTRAL REAL AND COUNTER BODIES IN *TRILOKASĀRA*

L. C. JAIN

Professor of Mathematics,

Govt. Post Graduate College, Sehore, M.P.

(*Received 10 December 1973*)

Trilokasāra is a Prakrit text of eleventh century A.D., a condensed work of Nemicandrācārya, mainly from *Tiloya Paṇṇatti* (c. 500-800 A.D.) Observations of astral bodies seem to be based on Kinematics. The two mysterious facts are : (1) The existence of exactly similar moving astral bodies at diametrically opposite ends of a celestial sphere in small and great circles in Jambūdvīpa and other places. (2) The division of the celestial sphere into 109800 parts, the workable parts being 54900, for defining the average motions of the astral bodies. The meru worked as a celestial axis for the observed bodies, from which the stretch of the *Jodiciya Loga* (astro-universe) of different islands was defined. The mention of a Rāhu moving with an average velocity, slightly less than that of the Sun defines a mean solar year of 360 mean solar days, on the basis of which all other types of periods are defined. From the absolute kinematical average velocities of the astral bodies one can find relative motions and synodic periods and other calendrical data.

1. INTRODUCTION

There are a few published articles on the Jain School of Astronomy.[1] They have detailed the Jaina calendar, the source material and certain observations of the characteristic features of the school diversely distributed from the period of *Sūra Paṇṇatti* to the late Jesuit period. Their sources have been chiefly astrological. The author of the present article had published a work[2] on the Mathematics of *Tiloya Paṇṇatti* in 1958 in Hindi, and the translational difficulties went adverse in the way of its reviews abroad. In order to supplement some of its remaining study of the astronomical contents relating to the Jambūdvīpa, this article was envisaged, and prepared from the contents of *Trilokasāra*[3], a text of the eleventh century, which seems to be condensed from *Tiloyapaṇṇatti*[4] of *Yati Vṛṣabha* (c.500A.D.), and commented upon by Mādhava Candra Traividya (c.1200 A.D.) in Sanskrit.

Trilokasāra contains six chapters out of which the fourth is the chapter on *Jyotirloka* (astro-universe). The word *jyotiṣka* (astronomical) is *Jodisiya*[5] or *Joisiya* in Prakrit . This well reminds us of the word Zodiac. China[6] and India have much in common so far as the 'Lunar Zodiac' is concerned. One can also find linear relations in the Jaina School of Astronomy parallel to those in the Babylonian[7] astronomy of the contemporary period, though the Indian records are of much later dates. The astro-universe of *Trilokasāra* is rather a symmetrical mathematical structure, with a set-theoretic base, rounding the details of a non-summable stretch. For exomple, the total number of astral images are quoted to be the quotient set obtained by dividing the square of the universe-line set by the product of the set of the squared finger-width, and the square of two hundred fifty-six. The distribution of astral bodies are symmetrical and based on the five kinds of *joigaṇa* (astral groups) : The moon, the sun, the plant, the constellation (*nakṣatra*), and scattered stars (*prakīrṇaka tārā*).[9] The moon is the head of the family of eighty-eight planets, twenty-eight *nakṣatras*, and 66975000000000000000 stars.[10]

2. The Celestial Diagram

We shall concentrate upon the motion of the astral bodies in the Jambūdvīpa[11] alone, the motion of these bodies being either similar or else they being stationary for the far off islands and oceans. The circular island of Jambūdvīpa is one lac *yojana* in diameter, the subsequent alternate oceans and islands being double the preceding in diameter, forming a geometrical progression with one as first term and two as common ratio. In the centre of the Jambūdvīpa is supposed a type of celestial axis, Meru[12] mountain, perfectly symmetrical with a height of one lac yojana, in the form of a frustrum of a cone with lower base having a diameter of $10090\frac{10}{11}$ *yojanas* and with upper base having a diameter of 1000 *yojanas*. This picture gives an idea of illustrating the positions of the stationary and moving bodies through a celestial diagram.

Due to the assumption of the existence of two suns and two moons[13] along with the families of the moons in both the parts of the celestial sphere, one in each half, it appears as if the other symmetrical half with the same events and motions, was a fictitious display for some mathematical convenience, though not clear so far. The whole of the celestial path has been divided into 109800 parts,each known as '*Gagaṇa Khaṇḍa*'. But half the path is covered by one sun, one moon and its family in twenty-four hours or thirty *muhūrtas*. This half the path is 54900[14]

This path is covered by the constellations (*Nakṣatras*) celestial parts. of various stretch.[15] Starting from *Kṛttikā* (*Kittiya*), the celestial parts covered by each *nakṣatra* are respectively 2010, 3015, 2010, 1005, 3015, 2010, 1005, 2010, 2010, 3015, 2010, 2010, 1005, 3015, 2010, 1005, 2010, 2010, 3015, 630, 2010, 2010, 1005, 2010, 3015, 2010, 2010, 1005. The sum total is 54900 parts.[16] This much strip is needed for practically all purposes, because this path defines the motion during twenty-four hours. It is not understood why the necessity for having an additional strip of 54900 celestial parts with a perfect symmetry was felt by the authors of *Tiloyapaṇṇattī*, and Trilokasāra of the Jaina School.

Supposing the remaining strip of 54900 parts as fictitious (needed for some mathematical or observational purposes), and depending upon the 54900 celestial stretch one degree may be taken to be equal to such 152.5 or 152½ parts. One sign of the Zodiac is found to be of 4575 such celestial parts. 360 degress are thus equivalent to 54900 celestial parts.

The motions of the astral bodies per *muhūrta* or per forty-eight minutes are given as follows :[17]

The *nakṣatras*	1835 celestial parts
The sun	1830 ,, ,,
The moon	1768 ,, ,,
The *Rāhu*	$1829\frac{11}{12}$,, ,,

Thus the relative motions of the above astral bodies with respect to the *Nakṣatras* are respectively 0, 5, 67, and $5\frac{1}{12}$ celestial parts.[13] The *Rāhu* defined here is a fictitious body meant for a seasonal or *Sāyana* or *Ṛtu* or *Karma* year (*samvatsara*).[19] From the above fundamental information one can easily calculate the various types of periods in relation to the sidereal synodic or Kinematic motions of all the above types of astral bodies.

By the *True Rāhu* 61/12 celestialparts are traversed in 1/30 of a solar day, hence the stretch of 4575 celestial parts or a Zodiacal sign is covered in a month of 30 solar days. As such 360 degrees or 54900 celestial parts are traversed in 360 days or twelve months. The solar day, the basic unit for all periodic measures is defined 1830 celestial parts are traversed in a *muhūrta* or 1/30 of a day, hence 54900 celestial parts or 360 degrees are traversed in 1 day.[20] This is the solar day equivalent to 24 hours or 30 *muhūrtas*. This is a mean solar day, subject to the definition of a fictitious mean sun moving along a mean path with a uniform velocity or 1830 celestial parts per *muhūrta*. Here *muhūrta* is not defined but it has been defined by Mahāvīracārya[21] of the ninth century as follows :

"The time taken by an ultimate particle in moving from a point to the next point of space is called a *samaya* (instant). A set of non-summable number of *samayas* form an *āvali* (trail). Summable number of *āvalis* form an *ucchavāsa* (Breath). Seven *ucchavāsas* make a *stoka* and seven *stokas* make a *lava*. Thirty-eight and a half *lava* make a *ghatī* and two *ghatīs* make a *muhūrta*. However, this definition is also vague for our practical purposes. It appears, however, that the average period of a solar day was in practical view and defined on the basis of the period of a sun-rise and sun-set, and that it formed the basis of all time-measure in the ancient times. In the *tattvārtha sūtra* description is as follows : The astral bodies—the sun, the moon, the planets, the constellations and the scattered stars, in the human region (*nṛloka*), are characterized by incessant motion around Meru, and they cause the divisions of time.[22]

3. THE MOTION OF NAKṢATRAS

The diurnal motion of the *nakṣtatras* is defined as 1835 celestial parts or $12\frac{2}{61}$ degrees per 48 minutes.[23] Thus 54900 celestial parts or 360 degrees are traversed in $\frac{1830}{1835}$ part of a day. Thirty such revolutions make a *nakṣatra* month of $29\frac{1685}{1835}$ solar days. Three hundred and sixty such revolutions make a *nakṣatra* year of $359\frac{35}{1835}$ solar days. As compared with the three hundred and sixty-six revolutions of the sun the relative *nakṣatra* year will come out to be of $365\frac{5}{1835}$ days.[24] The *nakṣatra* day is calculated to be 23 hours 56 minutes and $4\frac{1060}{1835}$ seconds. This is a sidereal day.

When we consider the mean relative motions of the sun and that of the moon we find the following :

With respect to the *nakṣatras* the sun moves 5 celestial parts less per *muhūrta.* Thus 150 celestial parts are traversed in 1 day. Hence 54900 or 360 degrees are traversed in 366 days. Thus with relation to the fixed stars the sun takes 366 days to complete a strip of 54900 celestial parts or 360 degrees.[25] This motion of the sun defines a solar year of 366 days. The average solar month is therefore of $30\frac{1}{2}$ days This defines the conjunction of the sun and a fixed star or constellation.[26]

Regarding the relative motion of the moon with respect to that of the *nakṣatras*, the moon covers 67 celestial parts less than those covered by the *nakṣatras.* Thus 67×30 parts are covered in a solar day. Hence the strip of 54900 celestial parts is covered by the moon in $27\frac{21}{77}$ solar days. This lunar conjunction takes place in 27.313 days whereas the modern value for a lunar month is 27.32166 days. This is a mean lunar sidereal month. Regarding the relative motion of the moon with respect to that of the sun, the moon moves 62 celestial parts in 1/30 day,[27] hence it covers 549000 clestial parts in $29\frac{32}{62}$ days or 29.516 days, whereas the modern value for a lunar synodic months is 29.5305 days.[27]

The *Ṛtu Rāhu* moves $1829\frac{11}{12}$ celestial parts per 48 minutes, and describes the strip of 54900 celestial parts in a $\frac{21960}{22259}$ solar day. Relative to the *nakṣatras* the *Ṛtu Rāhu* moves 61/12 celestial parts in a *muhūrta.* Hence it covers a strip of 54900 celestial parts or 360 degrees in 360 solar days. This defines a *Ṛtu* or *Sāyana* year. This defines the sidereal motion of the *Ṛtu Rāhu.* Relative to the sun the *Ṛtu Rāhu* covers 1/12 celestial parts in a *muhūrta* or 1/30 of a solar day, hence it covers 54900 celestial parts or 360 degrees over the sun in 21960 days or 61 years. This appears to denote that the seasons will again appear in the same way after a lapse of 61 years. The annual motion of the *Ṛtu Rāhu* is 360 degrees in 360 days or 1 degree per day, whereas the sun moves diurnally 360 degrees in a day. Thus the *Ṛtu Rāhu* moves one degree per day along the ecliptic or the path of the sun and it appears that the division of the twelve months, twelve *Rāśis* of the *nakṣatras,* is based on motion of this *Ṛtu Rāhu.* This is due to the fact that this type of motion is relative to the fixed stars, seemingly moving diurnally due to the rotation of the earth. This basis was an essential epoch because the motion of the sun was in spiral orbits with respect to the *nakṣatras*. The sun covers 360 degrees or 54900 celestial parts in 366 days, hence the *Ṛtu Rāhu* was essentially established for a *Ṛtu* year of 360 days. The *Ṛtu* year was then divided into months, and in relation to it, the positions of the *Ṛtu Rāhu* were being marked with the help of separate type of sets of stars, which came to be known as the twelve rāśis in India. However, it is probable that this development might have been done in the Jaina School of Astronomy, perhaps much earlier than the actual records, signifying A.D. dates. Although the *Ṛtu Rāhu* defines a $\frac{21960}{22059}$ mean solar day by its kinematic motion, the month of 30 days is defined by it relative to the absolute motion with respect to the *nakṣatras*. One degree is set in equivalence with one day.[28]

Let us also calculate the motion of *Ṛtu Rāhu* with respect to that of the moon. The moon covers 743/12 celestial parts more in a *muhūrta* hence it covers 54900 celestial parts in $29\frac{413}{743}$ days or 29.555 days.[29] This may be treated as the Lunar synodic month with respect to the *Ṛtu Rāhu* or a fictitious mean sun.[30] The mean of the above two types of the Lunar synodic months works out to be 29.535,with an excess of .005 over the modern value of the lunar synodic month.[31]

In *Tiloyapaṇṇattī*, some additional information about the motion of various *nakṣatras* is given as follows :[32]

Name of the *nakṣatras*	Motion in *yojanas* per *muhūrta*
Śrāvaṇa etc. 8 and *Abhijit*, *Swāti*, *Uttarā* and *Pūrvā*	$5265\frac{18263}{21960}$
Punarvasu and *Maghā*	$5273\frac{11403}{21960}$
Kṛttikā	$5285\frac{37}{594}$
Citrā and *Rohiṇī*	$5288\frac{20377}{21960}$
Viśākhā	$5292\frac{16947}{21960}$
Anurādhā	$5300\frac{10454}{21960}$
Jyeṣṭhā	$5304\frac{7024}{21960}$
Puṣya, *Āśleṣā*, *Pūrvāṣāḍhā*, *Uttarāṣāḍhā*, *Hasta*, *Mṛgaśirṣa*, *Mūla*, and *Ārdrā*	$5319\frac{15998}{21960}$

As the above data give the arcual rate of description, on the basis of the already mentioned details of their angular coverage in celestial parts, the radial distances of the *nakṣatras* can be calculated and traced on the celestial diagram. The next three verses of *Tiloyapaṇṇatti* describe about the circular fields of motion, as well as directions of motion.[33]

The motion of the stars has been mentioned to be greater than that of the *nakaṣtras*.[34] The bodies with relative greater velocities in succession are the moon, the sun, the planets, the *nakṣatras*, and the stars.[35] The sun, the moon and the moving planets have their solstices (*ayanas*), but the *nakṣatras* and the stars have no laws for solstices.[36]

4. The motion of the sun

The motion of the sun at the rate of 1865 celestial parts per *muhūrta* defines a solar day of 30 *muhūrtas* or 24 hours. This is the mean motion of the sun. The vertical heights of the astral bodies are given as follows :[37]

The stars	790 *yojanas* to 900 *yojanas*
The sun	800 ,,
The moon	880 ,,
The *nakṣatras*	884 *yojanas*
The Mercury	888 ,,
The Venus	891 ,,
The Jupiter	894 ,,
The Mars	897 ,,
The Saturn	900 ,,

Thus the circular disc in which the astral bodies are found is between the height 110 *yojanas* of the disc.[38] The *Ketu*, invisible planet is described to move along with the sun under it at a depth of four standard fingers below, causing the eclipse at periodic intervals.[39] All the astral bodies including the sun are described to move at a distance of 1121 *yojanas* from the celestial axis (*Meru*) so far as we are describing the *Meru* of Jambūdvipa.[40] The lunar and the solar zodiac (*Cara kṣetra*) has a stretch of 51048 *yojanas*. Out of this 180 *yojanas* are covered in the Jambūdvīpa by the sun and the moon and the remaining stretch lies in the Lavaṇa has a stretch of $510\frac{48}{61}$ *yojanas*. Out of this 180 *yajanas* are covered in the Jambūdvīpa by the sun and the moon and the remaining strength lies in the Lavaṇa ocean.[42] The orbits of the sun are 184. In a single solstice of the sun there are 183 solar days.[43] The motion of the sun is in a winding and unwinding spiral of 183 revolutions in a solstice.[44] There are two solstices in a solar year of 366 days. Every such spiral orbit-revolution is at an interval of 2 *yojanas*.[45] Everyday the solar revolution-path shifts by a distance of 170/61 *yojanas*. The first internal orbit of the the orbit of the sun has a circumference of about 315089 *yojanas*. The last has a circumference of about $315106\frac{38}{61}$ *yojanas*.[47] Thus other orbits may also be calculated.[48] This is a kinematic description. When the sun is in the internal orbit, there is a day of 18 *muhūrtas* and a night of 12 muhūrtas.[49] Reverse is the case when the sun is in the external orbit.[50] These are respectively called the Cancer (*Karkaṭa*) and the Capricornus (*Makara*).[51] The reesulting bright and dark areas are then described in details.[52] The motion of the sun in the next spiral orbit-path is accelerated,[53] rather the sun is in accelerated motion every instant while moving from the inner paths to the outer paths, and is in retarded motion every instant while moving from the outer paths to the inner paths.[54] This also signifies the kinematic motion for covering of unequal distances in equal time, when the motion of the sun along different paths is defined with respect to a mean solar day.

Then the range of vision of the sun is described, and many calculations have been done.[55] The rise stations of the sun upto Niṣadha, Nīla mountain are 63 and those in the Lavaṇa ocean are 199, and those at Hari and Ramyaka are 2, totalling to 184 in all.[56] More mathematical details are available. Such progressive motion of the sun has also been anticipated in China[57] and Babylon,[58] where the sun, the moon and the planets had linear functional zigzag motion,but not described through such mathematical manipulation.

The calendrical details of the frequencies, *parva*, *tithis*, and *viṣupas* have also been described in mathematical and positional details in *Trilokasāra*[59] as well as in *Tiloyapaṇṇattī*.[60]

5. The Motion of The Moon

All the astral bodies have been regarded hemispherical, with spherical side towards the earth.[61] The diameter of the moon is 56/61 *yojanas*,[62] whereas that of the sun is 48/61 *yojanas*.[63] Similarly those of other astral bodies are described.[64] Two types of *Rāhus* for the moon are described to be below, four standard fingers.[65] They are *Dina Rāhu* and *Parva Rāhu*.[66] Some preceptors have described the phases of the Moon due to the *Dina Rāhu* and others have recognized on the basis of the motion of the moon.[67] The diameter of the *Rāhu* and *Ketu*, each is slightly less than one *yojana*.[68] The motion of the moon is also in spiral orbits, its Zodiac also being the stretch of 31158/61 *yojanas*. The roads or the orbits of the moon are defined to be 15 in number, with an interval of $35\frac{214}{427}$ *yojanas*, in the Jambūdvīpa and Lavaṇa ocean.[70]

Relative to the mean motion of the moon, the motion of the moon is accelerated in progressive paths and retarded in the regressive paths,[71]for covering unequal distances in equal time. The complete revolution of the moon, 54900 celestial parts, at the rate of 1768 per *muhūrta* is $31\frac{23}{442}$ *muhūrtas*[72] as per our convention. The mean motion of the moon is described on this basis for all the paths, keeping the time constant and varying the iterceptible distances.[73] This is a kinematic description.

Calculating the rises of the moon in the north and the south solstices on the Jambū island and the Lavaṇa ocean are found to be fourteen, in successive order of five and nine.[74] It may be remarked that the Chinese have also described nine roads of the moon with conventional diagrams.[75] The path of the moon, *muhūrta* to *muhūrta* can be traced in the form of a diagram from the data of the *Trilokasāra* and *Tiloyapaṇṇattī*.[77] The velocity of the moon has been given and the celestial parts as well as the positions of the *nakṣatras* are given. Yet the tracing on this basis can be an average diagram trace, kinematic in character.

On the basis of the above, one can easily derive the calendar. The *yuga* (era) of five years starts with the sun, the moon and the *Ṛtu Rāhu* on the *Abhijit nakṣatra* at the north solstice.[78] The *yuga* contains 67 *nakṣatra*-months, 63 lunar-months, 61 *Ṛtu*-months, and 60 solar months based on the following:[79]

Name of the year	*Days in the year*
Nakṣatra	$327\frac{51}{67}$
Moon	$354\frac{12}{62}$
Ṛtu Rāhu	360
Sun	366

As we have already observed that the above periods can be calculated from the relative velocities mentioned earlier, the days in the specific months can easily be derived. It is also obvious that a *yuga* of five years will consist of three lunar years of $354\frac{12}{62}$ days each and two intercalary lunar years of $383\frac{44}{62}$ days each.

The fifteen paths of the moon through the eight paths of the sets of *nakṣatras* are as follows :[80]

The innermost path is through *Abhijit, Śrāvaṇa, Dhaniṣṭha, Śatābhisā, Pūrvābhādrapada, Uttarābhādrapada, Rewatī, Aświnī, Bharaṇī,* and the set of *Swāti, Pūrvāphālgunī, Uttarāphālgunī.* Through the third path of the moon is the orbit of *Maghā* and *Punarvasu.* In the seventh path move *Rohiṇī* and *Citrā.* In the sixth path is *Kṛttikā.* In the eighth is *Viśākhā.* In the tenth path is *Anurādhā.* In the eleventh path is the *Jyeṣṭhā.* The outermost path is traversed by the remaining eight *nakṣatras : Hasta, Mūla, Pūrvāṣaḍhā, Uttarāṣāḍhā, Mṛgaśirṣa, Ārdra, Puṣya, Āṣleṣā.*

"The motion of planets is not available in the existing records" is mentioned in *Tiloyapaṇṇattī*.[81] This shows that the records were not available even at the time of *Yati Vṛṣabha,* or else at the time when this work was written by some scribe later on.

ACKNOWLEDGEMENT

The author is grateful to Smt. S. Mitra for her kind cooperation.

References and Notes

[1] The following articles are outstanding:

Das, S. R., The Jaina Calendar, *The JainaAntiquary*,Arrah, vol. 3, no. ii, sep.1973, pp. 31-36 Agrawala, M. B., Part III Jaina Jyotiṣa,Thesis on "*Gaṇita evam Jyotiṣa keVikāsa menJainā cāryon kā Yogadāna*", University of Agra, August, 1972, pp. 314-341.

Jaina, L. C., *Tiloyapaṇṇattī kā Gaṇita*, Jivaraja Granthamala, Sholapur, 1958, pp. 1-109. Nahata,A. C., *Jaina Jyotiṣa aura Vaidyaka Grantha*, Sri Jaina Siddhanta Bhasakara, Arrah, vol. 4, no. ii, sep. 1937, pp.110-118. Shastri, N. C., *Grīka-pūrva JainaJyotiṣa Vicāradhārā*, Br. Candabai Abhinandana Grantha, Arrah, 1954, pp. 462-466. Shastri,N.C., *BhārtīyaJyotiṣa kā poṣaka Jaina Jyotiṣa*, Varni Abhinandana Grantha, Sauger, 1962.

Jain, N. C., *Jaina Jyotiṣa Sāhitya*, Acarya Bhiksu Smriti Grantha, Calcutta, sec. ii, 1961, pp. 210-221.

[2] Cf. ref. 1 above.

[3] *Trilokasāraḥ*, Manikya Chandra Digambar Jaina Granthamala samiti, Bombay, V. N. 2444. A Hindi translated work on *Trilokasāra* is also available, with translation of Ṭoḍaramala, edited by Pt. Manoharlal Shastri, Hindi Jaina Sahitya Prasarak Karyalaya, Hirabagh, Bombay, 1918.

[4] *Tiloyapaṇṇatti of Yati Vṛṣabha, Bhāga* 2, edited by H. L. Jain and A. N. Upadhye, Jaina Samskriti Samraksaka Samgha, Sholapur, 1951. Cf. also *Jambūdiva paṇṇatti samgaho of Padmanandi (Paumanamdi)*, edited by A. N. Upadhye, H.L. Jain Jaina Samskriti Samraksaka Samgha, Sholapur, 1958.

[5] Cf. the following verses from *Ṣaṭkhanḍāgama* texts of the 2nd century A.D., edited in 23 volumes by various authors:

Bhavaṇavāsiya-vāṇaventara-jodiciya-sodhammīsāṇa kappavāsiya
devesu dcvagadibhaṅgo.—1, 9-9, 190.
Bhavaṇavāsiya-vānaventara-joisiyadevā devīo ca soodhammisāṇaka
kappavāsiya-devio ca asaṃjadasammāiṭṭhiṭṭhāne khaiyasammāiṭṭhī
ṇatthi, avasesā atthi avasesiyāo atthi.—1, 1, 169.

Dr. H. L. Jaina and various other authors have edited the above work of *Puṣpadanta* and *Bhūtabali*, and the first volume came out from Amaraoti in 1939 and the sixteenth from Vidisha in 1959. The Mahābandha part was independently published from Bharatiya Jnana Pitha Kashi, vol. 1-7, from 1947 to 1958, initiated by Pt. S. C. Diwakar.

[6] For a comparative study, the following work will be referred: Needham, J. and Wang, L., *Science and Civilization in China*, vol. 3, Cambridge, 1959.

[7] For comparison with Bobylonian, Greek, Egyptian & Hindu astronomy the following work is referred: Neugebauer, O., *The Exact Sciences in Antiquity*, Providence, 1957.

[8] *Āṇiya guṇasaṃkalidaṃ kiñcūṇa pañcaṭhāṇasaṃṭhaviyaṃ, Candādiguṇam milide joisabimbāṇi savvāṇi*. 361. Cf. *Trilokasāra*, op. cit., v. 361 ch. 4. Cf. also the following verses of *Tiloyapaṇṇatti*, op. cit., ch. 7:

Dugaigitiyatitiṇavayā ekkā thānesu navasu suṇṇānima,
Cauaṭṭhaekkatiyasattaṇavayagayaeṇkkaaṅkakame. 29.
Edehi guṇidasaṃkhejjarūvapadarangulehiṃ bhajidūnaṃ,
Seḍhikadī sattahade parisaṃkhā savvarikkhāṇaṃ 30.

Cf. also the following:

Besadacchappaṇṇaṅgulakadihidapadarassa saṃkhabhāgamide, Joisajinindagehe gaṇaṇātide namansāmi. Trilokasāra, op. cit. v. 302 ch. 4.

[9] *Candā puṇa āiccā gaha ṇakkhattā paiṇṇatārā ya,Pañcavihā joiganā loyantaghanodahim puṭṭhiā.* Cf. ibid., v. 303, ch. 4.

10 *Adasdīatthāvisā gaharikkhā tāra kodakodīnam, Chāvatthisahassāni ya navasayapannattarigi cande.* 362. *Trilokasāra,* 4. 362.

11 *Jambū joyanalakkhā vatto tadgunadugunavasehim, Lavanādihim parikhitto sayambhuramanu-vahiyamtehim.* 308. Ibid. 4. 308.

12 Cf. *Tiloyapannattī kā Ganita,* op. cit., vv. 4. 1780 et seg.

13 *Do ddovaggam bārasa bādāla bahattarimduinasamkhā, pukkharadalotti parado avatthiyā savva-joiganā.* 346. *Trilokasāra,* 4. 346.

14 *Do candānam milide atthasayam navasahassamigilakkham,*
Sagasagamuhuttagadinabhakhandahide paridhigamuhuttā. 401. *Trilokasāra,* 4. 401.
Dosasinakkhattānam parimanam bhanami gayanakhandesum,
Lakkham nava ya sahassā atthasaya kāhalāyārā. 474, *Tiloyapannattī,* 7. 474.

15 *Abhijissa gaganakhandā chassayatīsam ca avaramajjhavare,*
Chappannarase chakke igidutigunapanayutasahassā. 398. *Trilokasāra,*

16 *Avarāo jetthaddāsadabhisabharar sādiāsilessā,*
Honti a varāo punavvasāsu ti uttarā rohanivisāhāo,
Seasāo majjhimāo jahannabhe pañcauttarasahassam,
Tam ciya dugunam tīgunām majjhimavarabhesu nabhakhandā. 471.
Abhijissa chassayānim tisajuvanim huvanti nabhkhandā,
Evam nakkhattānam sīmavibhāgam viyānehi. 472.
Tiloyapannatti, 7. 471, and 7.472.
Ekkam joyanalakkham nava ya sahassaynni adasayānim pi,
Parihinam pattekkam kādavvā gayanakhardanim. 266., *Tiloyapannatī* 7.266. *Cf. also Trilokasāra,* 401, *cited above.*

17 *Atthatthī sattarasayamindū bāvatthi pañcahiyakamam,*
Gacchanti sūririkkhā nabhakhandānigimuhuttāna. 402.
Ravikhandāae bārasbhagūnam vajjade jado Rāhū,
Tamhā tatto rikkhā bārahidigisatthikhardahiyā. 405.
Cf. *Trilokasāra,*4.402 and 4.405. *Tiloyapannattī* does not mention about the motion of *Rāhu:*

11 *Sattarasatthatlhini hu cande sūre bisatthiahiyam ca,*
Satthatīhī vi ya bhaganā carai muhuttenī bhāgānam. 507.
Tiloyapannattī, 7.507.

19 For *Rtu* year cf. Das, S.R., op. cit., p.33 et For *Rāhu* as imaginary invisible planet, cf, Nee dham and Ling, op. cit., pp. 175, 228, 252(c), and 416. Here is a very important statement of the authors, "But as we shall seé the Chinese had themselves imagined from ancient times the existence of a 'counter Jupiter' which moved round diametrically opposite the planet, itself. There was a Greek parallel to this in the strange Pythagorian theory of the 'counter -earth',apparently due to Philolaus of Tarentum (late -5^{th} century),which was devised either to bring the number of planets upto a perfect number,10,or to explain lunar eclipses[m].Perhaps both originated from a more ancient Babylonian theory" Cf. ibid., p. 228. Similar to this is the following details of the *Tiloyapannattī* : ch. 7, vv. 504 and 505.
Cauvannam ca sahassā nava ya sayā honti sayala rikkhānam,
Biguniyagayanakkhandā docandānam pi nādavvam. 504.
Eyam ca sayasahassā atthānaudisāyā ya padipunnā,
Eso mandalachedo bhaganānam sīmavikkhambho. 505.
It therefore appears that the assumption of duplicate bodies at diametrically opposite end of their situations might have been the conventional method for calculating events like the eclipses.

20 *Gacchadi muhuttamekke tīsabbhahiyāni attharasayānim,*
nabhakhandānim ravine tammi hide savvagayankāhandanim. 267.

Tiloyapaṇṇattī, 7.267. Cf. also *Trilokasāra*, 4. 402. Here the motion of a counter sun is also mentioned in *Tiloyapaṇṇattī* : ch. 7, v. 268.
Abbhantaravīhīde duticadupahudīsu savvavihisuṁ,
Kamaso be ravibimbā bhamanti saṭṭhīmuhuttehim. 268.

21 *Aṇuraṇvantaram kāle vyatikrāmati yāvati, sakālaḥ saṃayos saṃkhyaiḥ samayairāvalirbhavet.* 32. *Saṃkhyā tāvalirucchavāsaḥ stokastūcchvāsa saptakaḥ, stokāḥ sapta lavasteṣām sārdhaṣṭātrinśatā ghaṭi.* 33.
Ghaṭṭīdvayam muhūrstotra muhūrtaistrinṣatā dinam, pancghanaistridinaiḥ pakṣab pakṣau dvau māsa iṣyate. 34. *Ṛturmāsadvyena Syāttribhistairayanam matam, taddvayam vatsare vakṣye dhānyamānamataḥ param.* 35.
Cf. *Mahavīrācārya's Gaṇita Sāra Saṃgraha, Sholapur,* 1963, 1. 32-35.

22 *Jyotiṣkāḥ sūryācandramasau grahanakṣatraprakīrnakatārakāṣca.* 12.
Merupradakṣiṇā nityagatayo nṛloke. 13. *Tatkṛtaḥ kālavibhāgaḥ.* 14.
Cf. *Tattvārthasūtra* of Umāsvāti, *Sarvārthasiddhi* commentary translated as Reality by S.A. Jain, Calcutta, 1960, ch. 4, vv. 12, 13, and 14.

23 Cf. *Trilokasāra*, 4. 402. The sidereal day thus turns out to be of 23 hours, 56 minutes, and $4\frac{1060}{1835}$ seconds on calculation. The bodies also take this period for such diurnal motion.

The modern value in mean solar units is 23 hours, 56 minutes, and 4.1 seconds.

24 The modern value for the *nakṣatra* year is 366 days, 6 hours, 9 minutes, and 8.97 seconds-

25 Cf. *Trilokasāra*, 4. 402.
Ravirikkhagamanakhaṇḍe aṇṇoṇṇam sohiūṇa jam sesam,
Eyamuhuttapamāṇam phalā paṇa iccha taha tisam. 511. *Tiloyapaṇṇattī*, 7. 511.
The present value of the tropical year is 365 days, 5 hours, 48 minutes, and 45.98 seconds. In the Jaina School the value is with respect to the mean solar velocity.

26 Cf. *Trilokasāra*, 4. 402. Cf. also *Tiloyapaṇṇattī*, 7.507. this is about 13.18° per day.

27 *Canderavigayan akhaṇḍe aṇṇoṇṇavisuddhasesabāsaṭṭhī,*
Eyamuhuttapamāūam bāsaṭṭhipahalicchiyā tisā. 508. *Tiloyapaṇṇattī*, 7.508. This is about 12.19 operday for comparison with Babilonian values cf. Neugebauer, 8., op. cit., pp. 118, 121, and 162. For details of the motions of the sun, the moon and the planets, cf. Needham and Ling, op.cit., pp. 392-401.

28 Such a *Rāhu* has been described only in *Trilokasāra* from 4.405 to 4.409. This fictitious sun moves at the rate of one degree per day relative to the *nakṣatras*. Such description is also found in China, as quoted by Needham and Ling : "The uniform and apparently circular rotation of the heavenly bodies is mentioned many times in texts which are probably much elder than Chang Hêng or even Lohsia Hung, for example the *Chi Ni Tzu*[4] book[e] and the *Wen Tzu*[5] book. The former (perhaps of–3rd or–4th century) speaks of the sun's path as a turning *ring* (*hsün huan*[6]) with limits but no starting point (*wei shih yu chi*[7]) ever rotating (*chou huri*[8] and never still, the sun moving 1° each day ." Cf. p. 218. Cf. also p. 219.

29 *Nakkhattasūrajogajamuhuttarāsim dubehi saṃguṇiya,*
Ekaṭṭhihide divasā havanti ṇakkhattarāhujogassa. 406. *Trilokasāra*, 4.406.

30 In China Ko Hung (c. 200 A.D.), writes as follows :
"The seven liminaries all fall back (lit. move) eastwards, the sun making 1° a day and the moon 13°."

31 Cf. *Trilokasāra*, 4.402 and 4.405. For comparison with Babylonian lunar velocity, cf. Neuge bauer, pp. 118, 119 and 121, the mean velocity being 13 ; 10, 35° per day. The mean synodic month these was a value close to 29 ; 31, 54 days. Cf. ibid., p. 122.

[32] *Savaṇādiahṭṭabhāṇim abhijissadīo uttaerā puvvā,*
Vaccanti muhutteṇam bāvaṇnsayāṇi adhiyapanasaṭṭhī. 478.
Adhiyappamāṇamansā aṭṭhārasahassadusayatesaṭṭhī,
Igivīsasahassāṇim ṇavasayasaṭṭhi have hāro. 479.
Vaccanti muhutteṇam puṇvvasumaghā tisattadugapañacā,
Aṅkakame joyaṇayū tiyaṇahhacauekkaekkakalā. 480.
Bāvaṇṇasayā paṇasīdiuttarā sattattīsa ansā ya,
Cauṇaudipaṇasayahidā jādi muhuttneṇa kittiyā rikkhā.
Pacasahassā dusayā aṭṭhāsidī ya joyaṇā adhiyā,
Cittao rohiṇio janti muhutteṇa pattekkam. 482.
Adirekassa pamāṇam kalāe sagasattatiṇahadugamettā,
Aṅkakame taha hāro khachakkaṇavaekkadugamāṇe. 483.
Bāvaṇṇasayā bāṇaudi joyaṇā vaccade visāhā ya,
Solasasahassaṇavasayasagadālakalā muhutteṇam. 484.
Tevannasayānim joyanāni vaccadi muhuttenam,
Cauvanna causayā dasasahassa ansā ya anurāhā. 485.
Tevaṇṇasayānim joyanāṇi cattārim vaccadi jeṭṭhā,
Aṅsā satta sahassā cauvīsā judā muhutteṇam. 486.
Pusso asilesāo puvvāsāḍha ya uttarāsāḍhā,
Hattho migasiramūlā addūo aṭṭha pattekkam. 487.
Tevannasayā unavīsajoyanā janti igimuhuttenam,
Aṭṭhānaudī ṇavasaya paṇṇarasasahassa ansā ya. 488.
Cf. *Tiloyapaṇṇattī*, vv. 478-488. The numerical notations have been left in the above. The above verses are not found in the *Trilokasāra.*
For details of *nakṣatras* in China, cf, Needham and Ling, pp. 252 ff. The following description is available : "The planispheres consist of 'three roads',[6] each marked with twelve stars, one for each of the months according to the times of their heliacal risings. Those of the central road, 'the equatorial belt, were known as the Stars of Anu ; those of the outer road were asterisms south of the equator (Stars of Ea)., while the inner road was travelled by the northern and circumpolar asterisms (Stars of Enlil)." Cf. ibid. p. 256. in the Jaina School, however, the three types of stars collections (*nakṣatras*) are known as the *jaghanya, madhyama* and *utkṛiṣṭa.* Their stretches have been defined as 1005 : 2010 : 3015. *Abhijit* is 635 in ratio of the celestial parts. The circular fields have been defined to be 30, 60, 90, 18. Cf. *Tiloyapaṇṇattī*, 7.471 ; 7.489, 7.490. The following remarks of Neugebauer about Babylon are also important : "It is difficult to say when and how the celestial omens developed. The existing tests are part of large series of texts, the most important one called "Enuma Anu Enlil" from its initial sentence, similar to papal bullae in the Middle Ages. "Cf. ibid., p. 101. "The first tablet is mostly concerned with the fixed stars which are arranged in three roads", the middle one being an equatorial belt of about 30° width.

[33] *Maṇḍalakhettapamāṇam jahannabhe tisa joyanā honti,*
Tam ciya duguṇam tiguṇam majjhimavarabhesu pattekkam. 489.
Aṭṭhārasa joyaṇayā havedi abhijissa maṇḍalakkhittam,
Satthiyanahamettae niyaniyatarāna maṇḍalakhidīo.
Uḍḍhādho dakkhināye uttaramajjhesu sādibharanio,
Mūlam abhijīkittiyarikkhāo caranti niyamagge. 491.
Edānim rikkhānim niyaniyamaggesu puvvabhanidesum,
ṇiccam caranti mandaraselassa padāhinakameṇam. 492.
Cf. *Tiloyapannattī*, vv. 7. 489-. 492.
The definition of the *Maṇḍala Kṣetra* as 30, 60, 90, 18 *yojanas* of the *jaghanya, madhyama, utkṛṣṭa* and *Abhijit nakṣtras* is not clear. This description is not found in *Trilokasāra.*

[34] *Rikkhagaminādu adhāyam gamiaṇam jāṇejja sayalatārāṇam,*
Tāṇam ṇāmappahud su uvaeso sampai paṇaṭṭho. 496. *Tiloyapaṇṇatti,* v. 7.896. The miscellaneous stars are of two kinds: moveable and immoveable (*Cara* and *Acara*). Cf. v. 7.494.

[35] *Candādo mattaṇḍo mattaṇḍāde gahā gahāhinto,*
Rikkhā rikkhahinto tārāe honti sigghagadi. 497. *Tiloyapaṇṇattī,* 7. 497.

[36] *Ayanān ya ravisan ṇo sagasagakhette gaha ya je cāri,*
Ṇatthi avanāna bhagane niyamā tārāna emeva,
Raviayane ekkekam tesidisayā havanti dinaratti,
Terasadivasā cande sattaṭṭhibhāgacaucālam. 499. *Tiloyapannattī,* vv. 7. 498 and 7.499.

[37] *Ṇauduttarasattasae dasa sīdī caduduge tiyacaukke,*
Tāriṇasasirikkhabuhā sukkaguruṇgāramandagadī. 332. *Trilokasāra,* v. 4. 332. Cf. also *Tiloyapannattī,* vv. 7. 36, 7.65, 7.82, 7.83, 7.89, 7.93, 7.99, 7.104, 7.108, 7.112.

[39] *Avasesāṇa gahāṇam ṇayarie uvari cittabhūmīdo,*
Gantūṇa buhasaniṇam viccāle honti ṇiccāo. 333.
Atthai saṇī ṇavasaye cittado tāragāvi tāvadie,
Joisapaḍalabahallam dasasahiyam joyaṇāṇa sayam. 334.
Tāramtaram jahaṇṇam terieche kosasattabhago du,
paṇṇāsam majjhimayam sahassamukkassayam hodi. 335.
Cf. *Trilokasāra,* vv. 4.333, 4.334, 4.335.

[39] *Rāhuariṭṭhavimāṇadhayaduvari pamāṇaaṅgṇlacaukkam,*
Gantūṇa sasivimāṇā sūravimānā kame honti. 340. *Trilokasāra,* 4.340.
Sasaharaṇayaratalādo cattāri pamaṅaangulāṅam pi,
Heṭṭhā gacchiaya honti hu rāhuvimāṇassa dhayadaṇḍā. 201.
Tiloyapaṇṇattī, 7.201.

[40] *Igivīseyārasayam vihāya merum caranti joigaṇā,*
Candatiyam vajjittā sesā hu caranti ekkapahe. 345. *Trilokasāra,* 4.345.

[41] *Do ddo candaravim paddi ekkekkam hodi cārakhettam tu,*
pañcasayam dasasahiyam ravihimbahiyam ca cāramahī. 374.
Trilokasāra, 4.374.
Pañcasayajoyaṇāṇim dasuttaraim huvedi vikkhambho,
Sasaharacāramahīe diṇayarabimbādirittāṇim. 117. *Tiloyapaṇṇattī,* 7.117.
Regarding the Zodiac in China, the following remarks of Needham and Ling are important: "Now in these texts there is never mention of any zodiac or of constellations lying along the ecliptic; the earliest documentary evidence of this conception occurs[e] just after–420. On the other hand, the Seleucid Babylonian cuneiform texts of the –3rd and –2nd centuries give great prominence to the zodiac, and use ecliptic coordinates exclusively. Finally, the thirty-six Old Babylonian asterisms were confused with the Egyptians decans and twelve of them ousted to make room for the zodiacal constellations. One might fairly surmise, therefore, that the equatorial moon-stations of East Asia originated from Old Babylonian astronomy before the middle of the –1st millennium and probably a long time before." Cf. p. 256. In *Tiloyapaṇṇattī,* the description of the fifteen roads of the mean and one hundred and eighty four paths of the sun are described in details of the velocities in *yojanas* through the asterisms zodiac (*Cāra Mahī*) from 7.117 to 7.271. Apart from the above the description of the length of day and night as well as that of bright and dark areas for different roads (*Pahas*) is given in vv. 7.276 to 7.455. The rise stations of the sun are also expressed.

[42] *Jamburabindū dīve caranti sīdim sadam ca avasesam,*
Lavane caranti sesā sagasagakhette va ya caranti, 375. *Trilokasāra,* 4.375.
Visūnabesayānim jambudīve caranti sīdakarā,

Ravimaṇḍalādhiyanim tīsuttaratiyasayāni lavaṇammi. 118. *Tiloyapaṇṇatti*, 7.118.
Jambūdīvammi duve diāyara tāṇa ekkacāramahī,
Ravibimbādhiyapanasayadahuttarā joyanāni tavvāso. 217.
Sīdijudamekkasayam jambūdīve caranti mattaṇḍā,
Tisuttaratisayaṇim diṇayarabimbadhiyāṇi lavaṇammi. 218. *Tiloyapaṇṇatti*, ch. 7. vv.217 and 218

[43] *Causīdiadhiyasayam diṇayaravihio honti edānam,*
Bimbasamānam vase ekkekkāoam tadaddhabahalattam. 219.
Tesīdīadhiyasayam diṇesavīhīṇa hodi viccālam,
Ekkapahammi carante doṇṇicciyabhānubimbāṇim. 220. *Tiloyapṇṇatti*, 7.219-. 220.
Paḍidivasamekkavīthim candāiccā caranti hu kameṇa,
Candassa ya paṇṇarasa iṇassa causīdisaya vīthī. 376.
Abhijādi tisīdisayam uttaraayanassa honti divasāṇi,
Adhikadiṇānam tiṇṇi ya gadadivasā honti igi ayaṇe. 407.
Cf. *Trilokasāra*, vv. 4.378 and 4.407. Needham and Ling remark, "Though the fact that the equinoxes are not placed at exactly equal intervals between the solstices may have been implicit in data available to the Han astronomers, and had already led Hipparchus in the –2nd century to his eccentric circle theory of the sun's motion, it was not recognised in China until the time of Chang Tzu-Hsin[1] and his pupil Chang Meng-Pin[2] (in the Northern Chhi dynasty, about +570)[a]."
Cf. ibid., pp. 393-394.

[44] Cf. *Trilokasāra*, 4.409.

[45] *Divasayarabimbarundam causīdīsamadhiyasaeṇam,*
Dhuvarāsissa ya majjhe sohejjasu tattha avasesam. 223.
Tesīdijudasadenam bhajidavvam tammi hodi jam laddham,
Vihim paḍi ṇādavvam taraṇiṇam langhaṇapamāṇam. 224.
Tammettam pahaviccam tam manam doṇṇi joyaṇā honti,
Tassim ravibimbajude pahasūcicae diṇiṃdassa. 225.
Cf. *Tiloyapaṇṇatti*, vv. 7. 223–7.225.
Pathavasapindahīṇā cārakkette ṇireyapathabhajide,
Vīthīnam viccālam sagabimbajudo du divasagadī. 377. *Trilokasāra*, 4.377.

[46] Cf. *Trilokasāra*, v. 4.377, commentary.

[47] *Suragiricandaraviṇam maggam paḍi antaram ca parihiṃ ca,*
Diṇagaditapparihīṇam khevādo sāhae kamaso. 378. *Trilokasāra*, 4.378.
Cf. also *Tiloyapaṇṇatti*, vv. 7.254 to 7.263.

[48] Cf. the above references in 47.

[49] *Sūrādo diṇarattī aṭṭhārasa bārasā muhuttāṇam,*
Abbhantaramhi edam vivarīyam bāhiramhi have. 379. *Trilokasāra*, 4. 379.
Paḍhamapahe diṇabaiṇo saṃṭhidakālammi savvaparihīsum,
Aṭṭharasamuhuttāṇim divaso bārasa nisā hodi. 277. *Tiloyapaṇṇatti*, 7.277.
For the length of daylight and its variation in Babylonian scheme, cf. Neugebauer, pp. 116, 159 and for that of Egypt, pp. 86, 94. His remarks regarding that for India are "This was fully in line with a discovery which had been made by Kugler in 1900, namely, that the ratio 3 : 2 of longest to shortest day used by both systems in columns C and D of the Babylonian lunar ephemerides also appears in Hindu astronomy, though this ratio is totally incorrect for the main parts of India." Cf. ibid., p. 162.

[50] Cf. *Trilokasāra*, 4.379. Cf. also, *Tiloyapaṇṇatti*, 7.278.

[51] *Kakkaḍamayare savvabbhantarabāhirapahaṭṭhio hodi,*
muhabhūmiṇa visese vīthīṇantarahide ya cayam. 380. *Trilokasāra*, 4.380.
In *Tiloyapaṇṇatti*, however, the words for the cancer and the capricorn *rāśis* are not available. In China a military expedition of +349 records an observation, showing that the Chinese found

what the Alexandrian Greeks had also known, namely, that south of the Tropic of Cancer (*which passes just north of Canton*) the sun will cast shadows at midday towards the south during part of the year. Cf. Needham and Ling, p. 292.

[52] Cf. *Trilokasāra*, 4.381 to 4.386. Cf. also *Tiloyapaṇṇattī*, 7.291 to 7.420.
For Chinese version cf. Needham and Ling, p. 211.

[53] *Niyantā sigghagadi pavisantā ravisasi du mandagadi,*
Visamāṇipariräyaṇi du sāhanti samāṇakālena. 387. *Trilokasāra*, 4.387.
Ravibimbā sigghagadi ṇiggacchantā huvanti pavisantō,
mandagadi asamāṇā parihi sāhanti samakāle. 265. *Tiloyapaṇṇattī*, 7.265.

[54] *Gayahayakesarigamaṇam paḍhame majjhantime ya sūrassa,*
paḍiparihim ravisasiṇo muhuttagadikhettamāṇijjo. 388. *Trilokasāra*, 4.388.

[55] Cf. *Trilokasāra*, 4.389 to 4.392. Cf. also *Tiloyapaṇṇatti*, 7.429 to 7.434.

[56] *Diṇagadimāṇam udayo te ṇisahe ṇilge ya tesaṭṭhi,*
Harirammagesu do ddo sūre ṇavadasasayam lavaṇe. 395.
Diubahicārakhitte vediye diṇagadihide udayā,
Dive cau candassa ya lavaṇasamuddamhi dasa udayā. 396.
Trilokasāra, 4.395 and 4.396.

[57] Cf. Needham and Ling, pp. 392-396.

[58] Cf. Neugebauer, pp. 110, 114, 116, 118. For the Greek theory, cf. pp. 156, 186, 192 and 204.

[59] Cf. *Trilokasāra*, 4.410 to 4. 438.

[60] Cf. *Tiloyapaṇṇattī*, 7.525 to 7.549. In accordance with the above, the *Prakṣepas* of the sun are infinite-infinite (*Anantānanta*).

[61] *Uttāṇaṭṭhiyagolagadalasarisā savvajoisavimāṇā,*
Uvārim suraṇagarāṇi ya jiṇabhavaṇajudāṇi rammāni. 336. *Trilokasāra*, 4.336.
Uttāṇavaṭṭhidagolagaddhasarisāṇi sasimaṇimayāṇim,
Tāṇam puha puha bārasasahassasisirayaramandakiraṇāṇim. 37. *Tiloyapaṇṇatti*, 7.37.

[62] *Joyaṇamekkaṭṭhikae chappaṇṇaṭhadāla canderavivāsam,*
Sukkaguridaratiyāṇam kosam kiñcūṇakosa kosaddham, 337. *Trilokasāra* 4.337.
Cf. *Tiloyapaṇṇattī*, 7.218.

[63] *Ekaṭṭhiyabhāgakade joyaṇae tāṇa hodi chappaṇṇā,*
Uvarimatalāṇaṇ rundam dalidaddhabahalam pi pattekkam. 39. *Tiloyapaṇṇattī*, 7.39. For the diameter of the sun in China cf. Needham and Ling, pp. 300, 332, 573(c). There is no description of the moon's diameter or that of stars. Similarly the records in Babylon, Egypt and Greek are not available.

[64] *Kosassa turiyamavaram turiyahiyakameṇa jāva kosotti,*
Tārāṇam rikkhāṇam kosam bahalam tu bāsaddham. 338.
Rāhuariṭṭhavimāṇā kiñcuṇam joyaṇam adhogantā,
Chammāse pavvante candaravi chādayanti kame. 339.
Cf. *Trilokasāra*, 338, 339 ch. 4. Cf. also *Tiloyapaṇṇatti*, 68, 85, 91, 95, 98, 100, ch. 7, for the diameters of the planets and the sun.
Cf. ibid., 7.108 for the constellations.

[65] *Rāhuariṭṭhavimāṇadhayāduvari pamāṇaṇagṇlacaukkam,*
Gantūṇa sasivimāṇā sūravimāṇā kame honti. 340. *Trilokasāra*, 4.340.
Te rāhussa vimāṇā añjaṇavaṇṇā ariṭṭharayaṇamayā,
Kiñcūṇam joyaṇayam vikkhambhajudā tadaddhabahalattam. 202.
Tiloyapaṇṇatti, 7.202. Another measure is given in the next verse 7.203, and it is 250 *Dhanuṣa.*

[66] *Cando ṇiyasolasamam kiṇho sukko ya paṇṇaradiṇotti,*
Heṭṭhilla ṇicca rāhūgamaṇavisesena vā hedi. 342. *Trilokasāra*, 4.342.
In *Tiloyapaṇṇatti*, the details of the motion of the *Dina Rāhu* and *Parva Rāhu* are given in the following verses ; 7.205 to 7.216.

[67] Cf. the above ref. 66.

[68] Cf. the above ref. 65.

[69] *Pathavāsapiṇḍahīnā cārakkhette ṇireyapathabhajide,*
Vīthīṭṭṇam viccālam sagabimbujudo du divasagadi. 377. *Trilokasāra,* 1.377.
Ekattisasahassā aṭṭhāvaṇṇuttaram sadam taha ya,
Igisaṭṭhaie bhajide dhuvarāsipamāṇamuddiṭṭham. 123. *Tiloyapaṇṇatti,* 7.123.
Lunar zodiac in the Chinese system was perhaps derived from Babylon as observed by Needham and Ling. Cf. ibid, p. 173.

[70] *Tam coddasapavihattam huvedi ekkekkavihiviccālan,*
Paṇutisajoyaṇāṇim adirekam tassa parimāṇam. 125.
Adirekassa pamāṇam coddasamadirittabiṇṇisadamansā,
sattāvisabbhahiyā cattāri sayā have hāre. 126. *Tiloyapaṇṇatti,* 7.125, 7.120.
Cf. *Trilokasāra,* 163, ch. 4. and v. 4.396, 4.377.

[71] Cf. *Trilokasāra,* 4.387, op. cit.

[72] Cf. *Trilokasāra,* 4.402, op. cit. Cf. also *Tiloyapaṇṇattī,* op. cit. 7.507.

[73] For the different paths the different velocities in *yojanas* per *muhūrta* are given successively from the first to the last as follows :5073 *Y*.3*K*., 5077 *Y*.1*K*., 5080 *Y*.3*K*., 5084 *Y*.2*K*., 5088*Y*. 1*K*., 5092 *Y*., 5095 *Y*. 3*K*., 5099 *Y*.2*K*., 5103*Y*., 5106*Y*. 3*K*., 5110*Y*. 2*K*., 5114*Y*. 1*K*., 5118*Y*., 5121*Y*. 3*K*., 5125*Y*. 2*K*., Cf. *Tiloyapaṇṇatti,* 7.186 to 7.200. Here *Y* stands for *Yojana* and *K* for *Kośa*. These details are not available in *Trilokasāra*.

[74] Cf. *Trilokasāra,* op. cit., 4.396 :
Diubahicārakhitte vedie diṇagadihide udayā,
Dive cau candassa ya lavaṇas muddamhi dasa udayā. 396.
In the verse the paths are respectively 4 and 10 for the rise of the moon. However in the *Uttarāyaṇa* the number changes to five and nine respectively for the island and ocean, as in *Dakṣiṇāyana* the same rise at othe ocean will not be counted. The total paths being 15, it is clear from the description of the distance between the moon and its counter in the verses of *Tiloyspaṇṇatti,* 7.143 to 7.159, that there are five paths in the land and the remaining in the ocean. The distance in the sixth path between the moon and its counter becomes $100004\frac{82}{427}$ *yojanas* which is greater than the diameter of the Jambūdvīpa by $4\frac{82}{427}$ *yojanas*.

[75] Cf. Needham and Ling, op. cit., p. 393.

[76] Cf. *Trilokasāra,* 4.377, 4.378.

[77] Cf. *Tiloyapaṇṇatti,* 7.186 to 7.200 ; 7.120 to 142 ; and 7.143 to 7.159.

[78] *Āsāḍhapuṇṇimie jugaṇippatti due savaṇe kiṇhe,*
Abbijimmi candajoge paḍivadivasammi pārambho. 530. *Tiloyapaṇṇattī,* 7.530.
Exactly the same verse is found in the *Trilokasāra,* 4.411. For the Augustus, Nabonassar, Parthian, Saka and Seleucid eras cf. Neugebaur, pp. 164, 187, 98, 101, 103, 174, 103, 110, 116, 229, op. cit.

[79] Cf. Das, op. cit. p. 31. He has, however, given the details of the Jaina Calendar without any references. Some relevant information may also be available in the *Bhāratiya Jyotiṣa* (Indian Astronomy) by Nemicandra Shastri, Varanasi, 1970.

[80] *Ṇava adhijippahudiṇim sādi puvvāo uttarāo vi,*
Iya bārasa rikkhāṇim candassa caranti paḍhamapahe. 460.
Tadie puṇavvasu magha sattamae rohiṇi ya cittāo.,
Chaṭṭhammi kittiyāo taha yo visāhāo aṭṭhamae. 461.
Dasame aṇurāhāo jeṭṭhā ekkārasammi paṇṇarase,
Hattho mūlāditiyam migaiseradugapussasilisā 462. *Tiloyappanṇṇttī,* 7.460 to 7.462. Cf. also *Trilokasāra,* 4.437 to 4.439. For the Chinese System, cf. Needham and Ling, op. cit., pp. 225

For details in Egypt and Babylon, cf. Neugebauer, op. cit., pp. 5, 81, 82, 89, 166 (India), 102, 140, 170, 188, 207. It may also be noted that in *Tiloyapaṇṇattī*, details of stars and the symbols of their collections are given in 7.463 to 7.467 in the chapter 7. Similarly in the chapter 4th *Trilokasāra* such details are available in 4.440 to 4.445.

[81] *Aṭṭhāsidigahāṇam ekkam ciya hedi jattha cārakkhidi,*
Tajjogo vihio padvihim hont parihio. 457.
Parihisu te carante tāṇam kaṇayācalassa viccālam,
Aṇṇam pi puvvabhanidam kālavasāde paṇaṭṭhamuvaesam. 458.
Cf. *Tiloyapannattī*, 7.457, 7.458. This statement is not aailable in *Trilokasāra*. The names of of the eighty-eight planets are given in vv. 15-22, ch. 7 of *Tiloyapaṇṇattī*, and in vv. 363-370, ch. 4 of *Trilokasāra*. The planets have solstices. Cf. *Tiloyapaṇṇatti* 7.498.