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XXIV. Dhanisht'ha, the twenty-fourth asterism, is represented by a drum or tabor. It comprises four stars, one of which (the westernmost) is placed in 36° N., and according to the Súrya siddhánta, BRAHMEGUPTA and the Śirómańi, in 290° E., though the Graha lághava state 286° only. This longitude of the circle of declination, and the distance of the star on it from the ecliptic, indicate the Dolphin; and the four stars probably are.  $\alpha \beta \gamma$  and  $\delta$  Delphini. The same constellation is mentioned by the Jesuit missionaries as corresponding to Dhanisht'hd ;\* and there can be little doubt that the ascertainment is correct. The longitude stated by MUNISWARA, (viz. 294° 12) supports the conclusion, though his latitude (26° 25') be too small. To determine accurately the position of this nacshatra is important, as the solistitial colure, according to the ancient astronomers, passed through the extremity of it, and through the middle of Aslesha.

The twenty-fourth mansion, called by the Arabs Stand, comprises two stars in Aquarius ( $\beta$  and  $\xi$  Aquarii); totally disagreeing with the Hindu division.

XXV. Satabhishá, the twenty-fifth nacshatra, is a cluster of a hundred stars figured by a circle. The principal one, or brightest, has no latitude; or only a third, or at the utmost half, a degree of south latitude; and all the tables concur in placing it in long.  $320^{\circ}$ . This will suit best with  $\lambda$  Aquarii. These hundred stars may be sought in the stream from the Jar, where Sir WILLIAM JONES places the nacshatra; and in the right leg of Aquarius.

Akhbiyah, the twenty-fifth lunar mansion, is stated to consist of three stars only, which seem to be the three in the wrist of the right hand of Aquarius.<sup>†</sup> However, it appears from ULUGH BEG'S tables, as well as from MU-

\* COSTARD, p. SI.

HAMMED of *Tizin's*, that four stars are assigned to this mansion.\*

The Hindu and Arabian asterisms differ here less widely than in the instances lately noticed : and a passage, cited by HYDE from FIRÓZÁBÁDÍ, even intimates the circular figure of the constellation.

XXVI. The twenty-sixth of the Indian asterisms, called the preceding *Bhádrapada*, consists of two stars represented by a couch or bed, or else by a double-headed figure; one of which is placed by Hindu astronomers in  $24^{\circ}$  N., and  $325^{\circ}$  or  $326^{\circ}$  E. The only conspicuous star, nearly in that situation, is the bright star in Pegasus (a Pegasi); and the other may be the nearest considerable star in the same constellation ( $\zeta$  Pegasi). I should have considered  $\beta$  Pegasi to be the second star of this *nacshatra*, were not its yóga or chief star expressly said to be the most northerly. *Mukaddim*, the twenty-sixth lunar mansion, consists of the two brightest stars in Pegasus ( $\alpha$  and  $\beta_{+}^{+}$ ); and thus the two divisions of the zodiac nearly concur.

XXVII. Two other stars constitute the twenty-seventh lunar mansion named the subsequent *Bhádrapada*. They are figured as a twin, or person with a double face, or else as a couch. The position of one of them (the most northerly) is stated in 26° or 27° N., and 337° E. I suppose the bright star in the head of Andromeda to be meant; and the other star to be the one in the extremity of the wing of Pegasus ( $\gamma$  Pegasi). This agrees exactly with the twentyseventh lunar mansion of the Arabians, called *Muakkher*. For ULUGH BEG assigns those stars to it.§

XXVIII. The last of the twenty-eight asterisms is named *Révati*, and comprises thirty-two stars figured as

<sup>\*</sup> HYDE, p. 99, and Com., p. 95. † Com., p. 10.

HYDE'S ULUGH BEG, p. 53, and Com., p. 34.

<sup>§</sup> Hyde, p. 53, and Com., p. 34 and 35.

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a tabor. All authorities agree that the principal star, which should be the southernmost, has no latitude, and two of them assert no longitude; but some make it ten minutes short of the origin of the ecliptic, viz.  $359^{\circ}$  50'. This clearly marks the star on the ecliptic in the string of the Fishes ( $\zeta$  Piscium); and the ascertainment of it is important in regard to the adjustment of the Hindu sphere.

The Arabic name of the 28th mansion, Rishd, signifying a cord, seems to indicate a star nearly in the same position. But the constellation, as described by JAUHARI cited by GOLIUS, consists of a multitude of stars in the shape of a fish, and termed Betnu'lhút; in the navel of which is the lunar mansion: and MUHAMMED of Tizin, with some others, also makes this lunar mansion to be the same with Betnu'lhút, which appears, however, to be the bright star in the girdle of Andromeda ( $\beta$  Andromedæ); though others describe it as the northern Fish, extending, however, to the horns of the Ram.\* The lunar mansion and Indian asterism are, therefore, not reconcileable in this last instance.

The result of the comparison shows, I hope satisfactorily, that the Indian asterisms, which mark the divisions of the ecliptic, generally consist of nearly the same stars, which constitute the lunar mansions of the Arabians: but, in a few instances, they essentially differ. The Hindus have likewise adopted the division of the ecliptic and zodiac into twelve signs or constellations, agreeing in figure and designation with those of the Greeks; and differing merely in the place of the constellations, which are carried on the Indian sphere a few degrees further west than on the Greeian. That the Hindus took the hint of this mode of dividing the ecliptic from the Greeks, is not perhaps altogether improbable; but, if such be the origin of it they

\* Hype's Com., p. 10, 35, and 96.



have not implicitly received the arrangement suggested to them, but have reconciled and adapted it to their own ancient distribution of the ecliptic into twenty-seven parts.\*

In like manner, they may have either received or given the hint of an armillary sphere as an instrument for astronomical observation: but certainly they have not copied the instrument which was described by PTOLEMY, for the construction differs considerably.

In the Arabic epitome of the Almagest entitled Tahriru'lmejesti, the armillary sphere (Zát ul halk) is thus described. "Two equal circles are placed at right angles ; the one representing the ecliptic, the other the solstitial colure. Two pins pass through the poles of the ecliptic; and two other pins are placed on the poles of the equator. On the first two pins are suspended a couple of circles. moving the one within, the other without, the first mentioned circles, and representing two secondaries of the ecliptic. On the two other pins a circle is placed, which encompasses the whole instrument, and within which the different circles turn ; it represents the meridian. Within the inner secondary of the ecliptic a circle is fitted to it, in the same plane, and turning in it. This is adapted to measure latitudes. To this internal circle, two apertures, or sights, opposite to each other, and without its plane are adapted, like the sights of an instrument for altitudes The armillary sphere is complete when consisting of these six circles. The ecliptic and secondaries are to be gra-

\* According to the longitude of the three brightest stars of Aries, as stated by Pronemy, viz. 10° 40', 7° 40', and 6° 40', (I quote from an Arabic epitome of the Almagest); the origin of the ecliptic, in the Greek book which is most likely to have become known in India, is 6° 20' from the star which the Hindus have selected to mark the commencement of the ecliptic.

† By the celebrated NASÍRUDDÍN TÚSÍ; from the Arabic version of Is'HAR BEN HONAIN, which was revised by THÁBIT. x 2

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duated as minutely as may be practicable. It is best to place both secondaries, as by some directed, within the ecliptic (instead of placing one of them without it), that the complete revolution of the outer secondary may not be obstructed by the pins at the poles of the equator. The Meridian, likewise, should be doubled, or made to consist of two circles; the external one graduated, and the internal one moving within it. Thus the pole may be adjusted at its proper elevation above the horizon of any place. The instrument so constructed consists of seven circles.

"It is remarked, that when the circle representing the meridian, is placed in the plane of the true meridian, so that it cuts the plane of the horizon at right angles, and one of the poles of the equator is elevated above the horizon conformably with the latitude of the place; then the motions of all the circles round the poles represent the motions of the universe.

" After rectifying the meridian, if it be wished to observe the sun and moon together, the outer secondary of the ecliptic must be made to intersect the ecliptic at the sun's place for that time: and the solstitial colure must be moved until the place of intersection be opposite to the sun. Both circles are thus adjusted to their true places; or if any other object but the sun, be observed, the colure is turned, until the object be seen in its proper place, on that secondary referred to the ecliptic : the circle representing the ecliptic being at the same time in the plane of the true ecliptic and in its proper situation. Afterwards, the inner secondary is turned towards the moon (or to any star intended to be observed), and the smaller circle within it, bearing the two sights, is turned, until the moon, (or to any star intended to be observed), and the smaller circle within it, bearing the two sights, is turned, until the moon be seen in the line of the apertures. The intersection of the



secondary circle and ecliptic is the place of the moon in longitude; and the arc of the secondary, between the aperture and the ecliptic, is the latitude of the moon on either side (north or south)."

The same instrument, as described by MONTUCLA from the text of PTOLEMY (1. 3. c. 2.\*), consists of six circles : first, a large circle representing the meridian; next, four circles united together, representing the equator, ecliptic and two colures, and turning within the first circle on the poles of the equator; lastly, a circle turning on the poles of the ecliptic, furnished with sights and nearly touching, on its concave side, the circumference of the ecliptic.

The armillary sphere, described by the Arabian epitomiser, differs, therefore, from PTOLEMX'S, in omitting the equator and equinoctial colure, and adding an inner secondary of the ecliptic, which, as well as the meridian, is doubled.

According to LALANDE, the astrolabe of PTOLEMY, from which TYCHO BRAHE derived his equatorial armillary, consisted only of four circles: two placed at right angles to represent the ecliptic and solstitial colure; a third turning on the poles of the ecliptic and serving to mark longitudes; and a fourth, within the other three, furnished with sights to observe celestial objects and measure their latitudes and longitudes.<sup>+</sup>

Whether the ancient Greeks had any more complicated instrument formed on similar principles, and applicable to astronomical observations, is perhaps uncertain. We have no detailed description of the instrument which ARCHI-MEDES is said to have devised to represent the phenomena and motions of the heavenly bodies; nor any sufficient

<sup>\*</sup> Hist. des Mathém., i. p. 301.

<sup>†</sup> LALANDE Astron., i. 13. (§ 2279.)

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hint of its construction;\* nor does CICERO'S account of the sphere exhibited by POSIDONIUS; suggest a distinct notion of its structure.

Among the Arabs, no addition is at present known to have been made to the armillary sphere, between the period when the Almagest was translated,<sup>†</sup> and the time of AL-HAZEN, who wrote a treatise of optics, in which a more complicated instrument than that of PTOLEMY, is described. ALHAZEN'S armillary sphere is stated to have been the prototype of TYCHO BRAHE'S; S but neither the

\* If CLAUDIAN's epigram on the subject of it was founded upon any authority, the instrument must have been a sort of orrery, enclosed in glass.

Vide CLAUD epigr. 18. Cic. Tusc. Quæst. i. 25. De Nat. Deor. ii. 35. + Cic. De Nat. Deor. ii. 34.

I In the Hejira year 212, or A. D. 827, by ALHAZEN BEN YUSEF with the aid of SERGIUS (MONTUCLA, ii. p. 304); or rather by Is' HAK BEN HONAIN, whose death is placed about the Hejira year 260 (D'HERBELOT, "p. 456). According to the Cashf ul zunún, Is'HAR'S version was epitomised by HAJAJ BEN YUSEF, by THABIT BEN KOR-RAH, and by NASIRUDDIN Tosi. Other versions, however, are mentioned: particularly, one by HAJAJ, said to have been corrected first by HONAIN BEN IS'HAR, and afterwards by THABIT; another by THABIT himself; and a third by MUHI BEN YAHYA. A different account is likewise given of the earliest translation of the Almagest, which is ascribed to ABU HISAN and SALMAN, who are said to have completed it, after the failure of other learned men. who had previously attempted the translation. Mention is also made of a version by IBRAHIM BEN SALAT, revised by HONAIN. But none of these translations are anterior to the ninth century of the Christian era.

§ Adhibuit (Tycho) armillare quoddam instrumentum, quod tamencomperi ego positum et adhibitum olim fuisse ante Tychonem ab Alhazeno, lib. 7. opt. C. 1. prop. 15. et a Vitell. lib. 10. propos. 49. cujus instrumenti astronomice collocati ope atque usu, (vide instrumentum multiplex armillare apud Tycho. in Mechanicis Astronomize), candem elevationem falsam 9 scrupulorum invenit, quam per alia duo diversa instrumenta compererat.—BETTINI Apiaria, vol. ii. p. 41.



original treatise, nor the Latin translation of it, are here procurable; and I am therefore unable to ascertain whether the sphere, mentioned by the Arabian author, resembled that described by Indian astronomers. At all events, he is more modern<sup>\*</sup> than the oldest of the Hindu writers whom I shall proceed to quote.

The construction of the armillary sphere is briefly and rather obscurely taught in the *Súrya siddhánta*. The following is a literal translation.

"Let the astronomer frame the surprising structure of the terrestial and celestial spheres.

"Having caused a wooden globe to be made [of such size] as he pleases, to represent the earth : with a staff for the axis passing through the centre, and exceeding the globe at both ends; let him place the supporting hoops, as also the equinoctial circle.

"Three circles must be prepared, (divided for signs and degrees,) the radius of which must agree with the respective diurnal circles, in proportion to the equinoctial: the three circles should be placed for the Ram and following signs, respectively, at the proper declination in degrees, N. or S.; the same answer contrariwise for the Crab and other signs. In like manner, three circles are placed in the southern hemisphere, for the Balance and the rest, and contrariwise for Capricorn and the remaining signs. Circles are similarly placed on both hoops for the asterisms in both hemispheres, as also for Abhijit; and for the seven Rishis, Agastya, Brahme, and other stars.

\* He wrote his treatise on optics and other works about the year 1100.-Biogr. Dict.

† BRASCARA flourished in the middle of the twelfth century; being born, as he himself informs us, in the Sáca year 1036, answering to A. D. 1114. But the Súrya siddhánsa is more ancient.

‡ They are the colures.

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"In the middle of all these circles is placed the equinoctial. At the intersection of that and the supporting hoops, and distant from each other half the signs, the two equinoxes should be determined; and the two solstices, at the degrees of obliquity from the equinoctial; and the places of the Ram and the rest, in the order of the signs, should be adjusted by the strings of the curve. Another circle, thus passing from equinox to equinox, is named the ecliptic; and by this path, the sun, illuminating worlds, for ever travels. The moon and the other planets are seen deviating from their nodes in the ecliptic, to the extent of their respective greatest latitudes [within the zodiac]."

The author proceeds to notice the relation of the great circles before mentioned to the horizon; and observes, that, whatever place be assumed for the apex of the sphere, the middle of the heavens for that place is its horizon. He concludes by showing, that the instrument may be made to revolve with regularity, by means of a current of water; and hints, that the appearance of spontaneous motion may be given, by a concealed mechanism, for which quicksilver is to be employed. The manner of using this instrument for astronomical observations has been already explained (p. 324, &c.)

More ample instructions for framing an armillary sphere are delivered in the *Siddhanta* [sirómuni. The passage is too long for insertion in this place; and I reserve it for a separate article, on account of the explanations which it requires, and because it leads to the consideration of other topics,\* which cannot be sufficiently discussed in the pre-

\* Among others, that of the precession of the equinoxes; respecting which different opinions are stated by BHASCARA. It appears. from what is said by him, that the notion of a libration of the equinoxes has not universally prevailed among Hindu astronomers. The correcter opinion of a revolution of the equinoctial points was ad-

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sent essay. A brief abstract of BHASCARA's description may here suffice. In the centre he places a small globe to represent the earth encompassed with circles for the orbits of the planets arranged like the curved lines in a spider's web. On an axis passing through the poles of the earth, and prolonged on both sides, a sphere, or assemblage of circles, is suspended, by means of rings or tubes adapted to the axis, so that the sphere may move freely on it. This assemblage of circles comprises a horizon and equator adjusted for the place, with a prime vertical and meridian, and two intermediate verticals (intersecting the horizon at the N. E. and S. W. and N. W. and S. E. points); as also the equinoctial colure. Another circle is suspended within this sphere on the poles of the horizon, apparently intended to measure the altitude and amplitude of an object.

Another sphere or assemblage of circles is in like manner suspended on the pole of the equator. It consists of both colures, and the equinoctial with the ecliptic adjusted to it; and six circles for the planetary orbits duly adjusted to the ecliptic; as also six diurnal circles parallel to the equinoctial, and passing through the extremities of the several signs.

This, though not a complete description of BHASCARA'S armillary sphere, will convey a sufficient notion of the instrument for the purpose of the present comparison; and will justify the remark, that its construction differs greatly from that of the instrument specified by PTOLEMY.

In the description of the armillary sphere cited from the Súrya siddhanta, mention is made of several stars not included in the asterisms which mark the divisions of the ecliptic. The following table exhibits the positions of

vanced by some authors, but has not obtained the general suffrage of Hindu writers on astronomy.

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those, and of the few other stars which have been particularly noticed by Hindu astronomers.

	Brah siddhán śiró m	me 1tā Ş ani.	Gra lá gha	ha va.	S. sárvabh	Súrya siddhánta,		
Agastya	Lat. 77° S.	Long. 87°	Lat. 76° S.	Long. 80°	Lat. 77°16'S.	Long. 85° 5'	Lat. 80° S.	Long 90°
Lubdhaca, or ) the hunter.	40° S.	86°	40° S.	81°	40° 4' S.	84°36'	40° S.	80°
Agni	<u></u>		8° N.	53°	8°14' N.	57° 4'	8° N.	52°
Brahmehridaya		-	31° N.	56°	30°49' N	58°36'	30° N.	52°†
Projápati, or Brahmá			39 N.	61°	38°38'N.	56°53/	38° N.	57°
Apámva tsa			3° N.	183°	3° N.	183°	3° N.	1800
Ápas	-	-					9° N.	180°

According to the

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Sácalya sanhitá.

·特别的"新"的"自己"							Lat.		
CRATU				TUNN			$55^{\circ}$	N.	
PULAHA							50°	N.	
PULASTYA	-		-				50°	N.	
ATRI.				-			56°	N.	
ANGIRAS			1.			-	57°	N.	
VASISHT'HA							60°	N.	
MARICHI		1					60°	N.	

Here Agastya is evidently Canopus; as Lubdhaca is Sirius. Brahmehridaya seems to be Capella, which was shown, under that Indian name, to Dr. HUNTER at Ujja-

† The Súcalya sanhitá and Tatwa vivéca agree with the Súrya siddhánta as to the positions of the first four stars. They omit the other three.

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yint. Agni may be the bright star in the northern horn of the Bull ( $\beta$  Tauri): *Prajapati* is perhaps the star on the head of the Waggoner ( $\delta$  Aurige). The distances of the three last mentioned stars from the ecliptic do not exactly agree with the places stated: but no conspicuous stars are found nearer to the assigned positions: and it may be remarked, that they are all nearly in the longitude of the nacshatra Mrigasiras, corresponding to the head of Orion; and that the latitude, assigned to them by Hindu astronomiers, is as much too small, as that of Mrigasiras is too great.

The star, mentioned in the Súrya siddhánta under the name of Ápas or water, is doubtless  $\delta$  Virginis; and Apámvatsa comprises the nebulous stars in the same constellation, marked b. 1. 2. 3.

Astronomers give rules for computing the heliacal rising and setting of the star Agastya, on account of certain religious ceremonies to be performed when that star appears. VARAHA MIHIRA says, 'Agastya is visible at Ujjayint, when the sun is 7° short of the sign Virgo.' But he afterwards adds, that 'the star becomes visible, when the sun reaches Hasta, and disappears when the sun arrives at Róhińi.' His commentator remarks, that the author has here followed earlier writers; and quotes PARÁSARA, saying, 'When the sun is in Hasta, the star rises; and it sets when the sun is in Róhińi.'\* BHAŤŤÓTPALA cites from the five Siddhántas† a rule of computation, analogous to that which will be forthwith quoted from the Bhdswati; and remarks, that three periods of Agastya's heliacal rising

# \* दृम्यते स किल इस्तगते ऽर्के रोहिणी मुपगते

### ऽस्तम्पति ।

† Pancha siddhánta, a treatise by VARÁHA MIHIRA. VOL. II Y 353

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are observed, viz. 8th and 15th of Aswina and 8th of Cártica.

The Bhdswati directs the day of Agastya's rising for any particular latitude to be found by the following rule. 'The length of the shadow of a gnomon<sup>\*</sup> at a particular latitude, on the day of the equinox, is multiplied by 25; and to the product 900 are added; the sum, divided by 225, gives in signs and degrees the place of the sun, on the day when Agastya rises or appears in the south, at the close of night.' The commentator adds, that ' the day of the star's setting may be computed by deducting the sum found as above, from 1350; the difference reduced to signs and degrees, is the place of the sun, on the day when Agastya sets in the southwest.' According to these rules, Agastya in latitude 26° 34', rises when the sun is in 4° 20° and sets when the sun is in 1° 10°.

The Graha lághava teaches another method of calculation. The length of the shadow of the gnomon is multiplied by 8, and the product is added to 98 for the sun's place in degrees, on the day when Agastya rises; or is deducted from 78, to find the sun's place when that star sets. By this rule, the star should rise, in latitude  $26^{\circ}$  34', when the sun is at the 26th degree of the Lion, and should set when the sun quits the Ram. Accordingly, the Bhavishya and the Brahmevaivarta puránas ordain oblations for Agastya three days before the sun reaches the zodiacal sign Virgo; though the inhabitants of the province of Gaura, as observed in the last-mentioned purcina, perform this ceremony three days earlier.

In regard to the passages above quoted, it may be remarked, that the rule, stated in the *Bháswati*, implies the distance of three signs, from the beginning of Aries, to

\* In duodecimal parts.

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Agastya, and supposes the star to become visible when distant one sign from the sun. But the rule delivered in the Garha lághava places the star at the distance of 88º from the beginning of Mesha, and supposes it visible in the right sphere, when 10° distant from the sun. According to the quotation from PARASARA, the right ascension of the star must have been, in his time, not less than 100. reckoned from the beginning of Mesha; and the star, rising cosmically, became visible in the oblique sphere, at the distance of 60° from the sun ; and disappeared, setting acronychally, when within that distance. Making allowance, therefore, for the star's proper motion, and change of declination and right ascension, it remains probable, that PARASARA'S rule was framed for the north of India, at a period when the solstitial points were, as stated by that author, in the middle of Asleshá and beginning of Dhanisht ha.\*

I have purposely reserved for separate consideration the seven *Rishis*, who give name to seven stars in Ursa major; not only because their positions are not stated by BRAH-MEGUPTA, BHASCARA, and the *Súrya siddhánta*, but also because the authors, who give their positions, ascribe to them a particular motion, or variation of longitude, different from other stars, and apparently unconnected with the precession of the equinoxes.

VARAHA MIHIRA has a chapter in the Váráhá sanhitá expressly on the subject of this supposed motion of the *Rishis.* He begins by announcing the intention of stating their revolution conformably with the doctrine of VRÍDDHA GARGA, and proceeds as follows: 'When king YU-DHISHŤ'HIRA ruled the earth, the *Munis* were in *Magha*, and the period of the era of that king is 2526 years. They

\* As. Res., vol. ii. p. 393.

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remain for a hundred years in each asterism, being connected with that particular *nacshatra*, to which, when it rises in the east, the line of their rising is directed.'\*

The commentator, BHATTÓTPALA, supports the text of his author by quotations from VRIDDHA GARGA and CASYAPA. 'At the junction of the *Cali* and *Dwapara* ages,' says GARGA, 'the virtuous sages, who delight in protecting the people, stood at the asterism, over which the *Pitres* preside.' That is at *Maghá*. 'The mighty sages,' says CASYAPA, 'abide during a hundred years in each asterism, attended by the virtuous ARUNDHATL'

The author next states the relative situation of the seven *Rishis*, with <u>ARUNDHATI</u> near her husband VASISHT'HA; and the remainder of the chapter is devoted to astrology.

The revolution of the seven *Rishis*, and its periods, are noticed in *puránas*. The following passage is from the Śri Bhágavata.+

From your birth (PARICSHIT is addressed by SUCA) to the inauguration of NANDA, 1115 years will elapse.

# \* आसक्षघासु सुनयः ग्रासतिष्टव्यींयुधिष्टिरे नृपती । षड्दिकपंचदियुतः ग्रक्ता जस्तस्य राज्यस्य । एकैकस्मिन्च्चचेग्रतंग्रतंतेचरन्तिवर्षाणां । प्रागुद्यतोऽस्तविवराट् जूदयंतचसयुक्ताः ॥

According to a different reading noticed by the commentator, the concluding hemistich signifies "they constantly rise in the north-cast; together with ARUNDHATL"

## प्रागुत्तरतचैतेसदीद्यंतेससाध्वीकाः ।

1 Book xii. c. 2.

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Of the seven Rishis, two are first perceived, rising in the sky; and the asterism, which is observed to be at nighteven with the middle of those two stars, is that, with which the Rishis are united, and they remain so during a hundred years of men. In your time, and at this moment, they are situated in Maghd.

'When the splendour of VISHNU, named CRISHNA, departed for heaven, then did the *Cali* age, during which men delight in sin, invade the world. So long as he continued to touch the earth with his holy feet, so long the *Cali* age was unable to subdue the world.

"When the seven Rtshis were in Magha, the Cali age comprising 1200 [divine] years" began; and when, from Magha, they shall reach Purváshádha, then will this Cali age attain its growth under NANDA and his successors."

The commentator SRIDHARA SWAMI remarks, that the constellation, consisting of seven stars, is in the form of a wheeled carriage. MARICHI, he observes, is at the extremity; and next to him. VASISHT'HA in the arched part of the yoke; and beyond him ANGIRAS: next to whom are four stars in a quadrangle: ATRI at the north-east corner; south of him PULASTYA; next to whom is PULAHA; and CRATU is north of the last. Such being their relative position, the two stars, which rise first, are PULAHA and CRATU; and whichever asterism is in a line south from the middle of those stars, is that with which the seven *Rishis* are united; and they so remain for 100 years.

A similar passage is found in the Vishitu purdia, † and a similar exposition of it is given by the commentator RAT-NAGARBHA: but the period, there stated to elapse between the birth of PARICSHIT and the inauguration of NANDA, 1015 years only.

\* 432,000 common years.

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The Matsya purdia contains a passage to the like effect; but allows 1050 years from the birth of PARICSIHT to the inauguration of MAHAPADMA; and the seven Rishis are stated as being in a line with the constellation sacred to fire (that is *Critticd*), 836 years later, in the time of the Andhra kings.

In the Brahme siddhanta of SACALYA, denominated from its reputed author Sacalya sanhita, the supposed motion of the seven Rishis is thus noticed:" 'At the commencement of the yuga, CRATU was near the star sacred to VISHNU (Śravańa), at the beginning of the asterism. Three degrees east of him, was PULAHA; and PULASTYA, at ten degrees from this; ATRI followed at three degrees from the last; and ANGIRAS, at eight degrees from him; next came VASISHT'HA, at the distance of seven degrees; and lastly, MARICHI at ten. Their motion is eight liptas (minutes) in a year. Their distances from the ecliptic, north, were respectively 55°, 50°, 50°, 56°, 57°, 60°, and 60°. For, moving in the north into different positions, the sages employ 2700 years in revolving through the assemblage of asterisms; and hence their positions may be easily known at any particular time.'

LALLA cited by MUNISWARA in his gloss on the Širómańi, says, 'If the number of years of the Cali age, less fourteen, be divided by 100, the quotient, as the wise declare, shows the asterisms traversed by MARICHI and other celestial sages, beginning from the asterism of Viranchi (BRAHMÁ).'

Here LALLA is generally understood to mean *Rohińi*, which is sacred to PRAJÁPATI (or BRAHMÁ). But MU-NIŚWARA has remarked, in another place, that LALLA may intend *Abhijit*, which is sacred to VIDHI or BRAHMÁ;

· Prasna 2. ch. ii.

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and consequently may mean Sravahá, of which Abhijit forms a part: and thus LALLA and SACALYA may be reconciled.

Most of the commentators of the Súrya siddhanta and Sirómańi are silent on the subject of the seven Rishis. But NRISINHA, in his várticá to the Vásaná bháshya, or gloss on the Śirómańi, quotes and expounds the Sácalya sanhita, and rejects VARÁHA's rule of computation, as disagreeing with puráňas. MUNISWARA, in his commentary on the Śirómańi, cites some of the passages above noticed, and remarks, that BHÁSCARA has omitted this topic on account of contradictory opinions concerning it, and because it is of no great use.

The same author, in his own compilation entitled Siddhanta sarvabhauma has entered more fully into this subject. He observes, that the seven Rishis are not. like other stars, attached by spikes to the solid ring of the ecliptic, but revolve in small circles round the northern pole of the ecliptic, moving by their own power in the etherial sphere above Saturn, but below the sphere of the stars. He places the Rishis in the same relative positions, which SACALVA had assigned to them; states in other terms the same distances from the ecliptic, and the same annual motion ; and directs their place to be computed by deducting 600 from the years of the Cali age, doubling the remainder and dividing by fifteen: the quotient, in degrees, is divided by 30, to reduce it into signs. MUNISWARA supports this mode of calculation on the authority of SA-CALYA, against VARAHA MIHIRA and LALLA; and affirms, that it agrees with the phenomena, as observable at the period of his compilation. It appears, however, to be a correction of SACALYA'S rule.

CAMALÁCARA, in the Tatwavivéca, notices the opinion delivered in the Siddhánta sárvabhauma; but observes,

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that no such motion of the stars is perceptible. Remarking, however, that the authority of the *purdias* and *sanhitás*, which affirm their revolution, is incontrovertible, he reconciles faith and experience by saying, that the stars themselves are fixed; but the seven *Rishis* are invisible deities, who perform the stated revolution in the period specified.

If CAMALACARA'S notion be adopted, no difficulty remains: yet it can hardly be supposed, that VARAHA MIHIRA and LALLA intended to describe revolutions of invisible beings. If then it be allowed, that they have attributed to the stars themselves an imaginary revolution grounded on an erroneous theory, a probable inference may be thence drawn as to the period when those authors lived, provided one position be conceded; namely, that the rules, stated by them, gave a result not grossly wrong at the respective periods when they wrote. Indeed it can scarcely be supposed, that authors, who, like the celebrated astronomers in question, were not mere compilers and transcribers, should have exhibited rules of computation, which did not approach to the truth, at the very period when they were proposed.

If this reasoning be admitted, it would follow, that VARAHA MIHTRA composed the Váráhí sanhitá about 2800 years after the period assigned by him to the commencement of the reign of YUDHISHTHIRA, or near the close of the third century after the expiration of YUDHISH-T'HTRA's era as defined by him. For the circle of declination passing between CRATO and PULAHA (the two first of the seven Rishis), and cutting the ecliptic only 2° short of the beginning of Maghá, was the solstitial colure, when the equinox was near the beginning of Crittica; and such probably was the reason of that line being noticed by ancient Hindu astronomers. It agrees with the solstitial

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colure on the sphere of EUDOXUS, as described by HIP-PARCHUS.\* A similar circle of declination, passing between the same stars, intersected the ecliptic at the beginning of Magha when the solstitial colure was at the middle of Aslesha ; and a like circle passed through the next asterism, when the equinox corresponded with the first point of Mesha. An astronomer of that period, if he were apprised of the position assigned to the same stars by GARGA, reputed to have been the priest of CRISHNA and the Pandus, might conclude with VARAHA MIHIRA, that one revolution had been completed, and that the stars had passed through one nacshatra of the second revolution. In corroboration of this inference respecting the age of VARÁHA MIHIRA's astrological treatise, it may be added, that he is cited by name in the Pancha tantra, the original of the fables of Pilpay, which were translated for N ÚSHÍRVÁN more than 1200 years ago.+

The theory being wholly unfounded, VARÁHA MIHIRA'S rule of computation soon ceased to agree with the phenomena, and other rules have been successively introduced by different authors, as LALLA, SACALYA, and lastly,

\* "HIPPARCHUS tells us, that EUDOXUS drew the colure of the solstices, through the middle of the Great Bear; and the middle of Cancer; and the neck of Hydrus; and the star between the poop and mast of Argo; and the tail of the South Fish; and through the middle of Capricorn, and of Sagitta; and through the neck and right wing of the Swan; and the left hand of Cepheus; and that he drew the equinoctial colure through the left-hand of Arctophylax; and along the middle of his body; and cross the middle of Chebay; and through the right-hand and fore-knce of the Centaur; and through the flexure of Eridanus and head of Cetas; and the back of Ariea across, and through the head and right-hand of Perseus." Sir, I. NEWTON'S Chronology; § 29. HIPPARCH. ad Phanom. in PETAVIE Uranologia, p. 207, 208. BALLLY, Astr. Anc. p. 506. COSTARD, p. 136.

† PREFACE to the Sanscrit edition of the Hitspadeia, p. xi. [page 173 of the present volume.]

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MUNIŚWARA; whose rule, devised less than two hundred years ago, does not yet grossly betray its insufficiency.

This pretended revolution of the stars of Ursa Major is connected with two remarkable epochas in Indian chronology; the commencement of the *Cali yuga*, or sinful age, in the reign of Y UDHISHt'HIRA; and its prevalence, on the failure of the succession of *Cshatriya* princes, and establishment of a different dynasty, 1015 years after the birth of PARICSHIT, according to the *Vishiru puraina*; or 1115 years, according to the *Bhágavata*; but 1498 years, if a correction, which has been proposed by SRIDHARAswámí and some other commentators, be admitted. This subject has been already noticed by Capt. WILFORD in his Essay on VICRAMÁDITYA;<sup>\*</sup> and it is, therefore, unnecessary to enlarge upon it in this place.

It has been noticed, towards the beginning of the present essay, that the principal star of each nacshatra, is denominated Yógatárá. Perhaps it may not be superfluous to caution the reader against confounding these yóga stars with the yógas, of which a list is inserted in Sir WILLIAM JONES'S Treatise on the Indian Zodiac.<sup>†</sup> They are mentioned by him as divisions of the ecliptic : but it will presently appear, that they cannot in strictness be so denominated. Their principal purpose regards astrology; but they are also employed in regulating certain moveable feasts; and they are of such frequent use, that every Indian almanae contains a column specifying the yóga for each day, with the hour of its termination.

The yóga is nothing else than a mode of indicating the sum of the longitudes of the sun and moon. The rule for its computation, as given in the Súrya siddhánta, Bháswatí and Graha lághava, directs, that the longitude of the

<sup>a</sup> As. Res., vol. ix. p. 117, &c. + As. Res., vol. ii. p. 302.



sun be added to the longitude of the moon; and the sun, reduced to minutes, is to be divided by 800 (the number of minutes in  $13^{\circ} 20'$ ): the qotient exhibits the elapsed yógas, counted from Vishcumbha.\* It is obvious, therefore, that the yógas are twenty-seven divisions of  $360^{\circ}$  of a great circle, measured upon the ecliptic. But, if they be represented on a circle, it must be a moveable one in the plane of the ecliptic.

Astrologers also reckon twenty-eight yógas, which correspond to the twenty-eight nacshatras or divisions of the moon's path; varying, however, according to the day of the week. As the Indian almanacs sometimes appropriate a column to the moon's yóga for each day, I shall insert in a note a list of these yógas, with the rule by which they are determined.<sup>†</sup>

\* 1. Vishcumbha. 2. Priti. 3. Áyushmat. 4. Soubhágya. 5. Sóbhana. 6. Atigańda. 7. Sucarman. 8. Dhriti. 9. Súla. 10. Gańda. 11. Vriddhi. 12. Dhruva. 13. Vyágháta. 14. Hershańa. 15. Vajra. 16. Siddhi. 17. Vyatópáta. 18. Variyas. 19. Parigha. 20. Siva. 21. Siddha. 22. Súdhya. 23. Subha. 24. Sucla. 25. Brahman. 26. Aindra. 27. Vaidhriti.

† 1. Ánauda. 2. Cáladanda. 3. Dhúmra. 4. Prajápati, 5. Saumya.
6. Dhuáncsha, 7. Dhuaja, 8. Śrivatsa. 9. Vajra, 10. Mudgara,
11. Ch'hatra. 12. Maitra. 13. Mánasa. 14. Padma. 15. Lambuca.
16. Utpáta. 17. Mrityu. 18. Cána. 19. Siddhi. 20. Śubha. 21.
Amrita. 22. Musula. 23. Gada. 24. Mátanga. 25. Rácshasa. 26.
Chara. 27. St'hira. 28. Pravardha.

The foregoing list is extracted from the Ratnamild of ŠnípATI. He adds the rule by which the ydgas are regulated. On a Sunday, the nacshatras answer to the ydgas, in their natural order; via. Aswini to Ananda, Bharani to Cdlandanda, &c. But, on a Monday, the first ydga, (Ananda) corresponds to Mrīgadiras, the second to Árdrá, and so forth. On a Tuesday, the nacshatra, which answers to the first ydga, is Aileshá; on Wednesday, Hasta; on Thursday, Anurádha; on Friday, Uttaráshádha; and on Saturday, Satabishá.

Almanacs usually contain another set of astrological divisions of the lunar month, which it may be proper to explain. They are de364



Another topic, relative to the zodiac, and connected with astrology, remains to be noticed. I allude to the *Dréshedmas* answering to the Decani of European astrologers. The Hindus, like the Egyptians and Babylonians, from whom that vain science passed to the Greeks and Romans, divide each sign into three parts, and allot to every such part a regent exercising planetary influence under the particular planet whom he there represents.

The description of the thirty-six Dréshcáńas is given towards the close of VARAHA MIHIRA's treatise on the casting of nativities, entitled Vrěhat játaca. It is here translated conformably with the gloss of BHAFTÓTPALA: omitting, however, some variations in the reading of the text, which are noticed by him; but which can be of no use, unless occasion should arise for reference to them in comparing the description of the dréshcáňas with some amulet or ancient monument in which the Decani may be supposed to be figured. Even for that purpose, the following description will probably suffice.

1. [MARS] A man with red eyes, girt round the waist

Variable	Carañas.	Invariable Caranas.
1.	Bava.	1. Sacuai.
2	Bálava.	2. Chatushpad.
3.	Caulava.	3. Nága.
4.	Taitila.	4. Cintughna.
5.	Gara.	· · · · · · · · · · · · · · · · · · ·
6.	Van'ij.	CARLENDER CONTRACTOR OF THE PARTY OF
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They answer successively to half a tit'hi or lunar day; Cintughna being always assigned to the first half of the first tit'hi; and the variable caradas afterwards succeeding each other regularly, through eight repetitions: they are followed by the three remaining invariable caradas, which conclude the month; Chatushpid and Nága appertaining to Amivisyd or the new moon, and Sacuni being appropriated to the latter half of the preceding tit'hi.

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with a white cloth, of a black complexion, as formidable as able to protect, holds a raised battle-axe.

2. [The SUN] A female, clad in red apparel, with her mind fixed on wearing ornaments, having a mare's head, and a belly like a jar, thirsty and resting on one foot, is exhibited by YAVANA as the figure of the dréshcana in the middle of Mésha.\*

3. [JUPITER] A fierce and wrathful man, conversant with arts, of a tawny complexion, solicitous of action, but unsteady in his resolves; holds in his hands a raised stick, and wears red clothes. He is the third in the tripartite division of *Mésha*.

4. [VENUS] A woman with hair clipped and curled, a body shaped like a jar, her clothes burnt, herself thirsty, disposed to eat, and fond of ornaments : such is the figure of the first in Vrishabha.

5. [MERCORY] A man with the head of a goat, and a shoulder like a bull, clothed in dirty apparel, skilful in regard to the plough and the cart, acquainted with field, grain, house, and kine, conversant with arts; and in disposition, voracious.

6. [SATURN] A man with a body vast as an elephant's, and feet great as a Sarabha's,<sup>+</sup> with white teeth and a tawny body, his mind busied upon the wool of wild sheep, occupies the extremity of the sign Taurus.

7. [MERCURY] Such as are conversant with the subject, declare the first in the tripartite partition of the third sign, to be a woman fond of working with the needle, beautiful, delighting in ornaments, childless, amorous, and with her arms elevated.

 "Méshamadhyé dréshcánarápam yapanópadishéam." BHATTÓr-PALA expounds this "declared by YAVANÁCHÁRYA," "Yapanácháryaih cat'hitam."

† A monster with eight legs, who destroys elephants.



8. [VENUS] In the middle of the sign Gemini is a man, with the face of a garuda,\* standing in a grove: he is an archer clad in armour, and holds a bow; he meditates on sport, his children, ornaments, and wealth.

9. [SATURN] At the end of the sign Gemini is a man decorated with ornaments, having as many gems as the ocean contains; elad in armour and furnished with bow and quiver; skilled in dance, music, and song, and practising poetry.

10. [The Moox] The wise declare the first in Cancer to be an animal with the body of an elephant, the feet of a *Sarabha*, a boar's head and horse's neck, standing in a grove under a sandal-wood tree,<sup>+</sup> and upholding leaves, root, and fruit.

11. [MARS] In the middle of the sign Cancer, a woman, in prime of youth, with blossoms of lotus on her head, attended by a serpent, cries while standing in a forest, resting against the branch of a *palása*<sup>†</sup> tree.

12. [JUPITER] Last in Cancer is a man with his head inclined; he is decorated with golden ornaments, and, embarking on a vessel and encompassed by serpents [twined round him,] he traverses the ocean to seek ornaments for his wife.

13. [The SUN] A vulture and shakal stand on a cotton tree: § a dog is near: and a man, in a squalid dress, laments for his father and mother. This representation is pronounced to be the first of the Lion.

14. [JUPITER] A man formed like a horse, bearing on his head a garland of yellowish white flowers, wears a leather dress: unconquered like a lion; armed with a bow, and

- \* An eagle : or else a gigantic crane. Perhaps a vulture.
  - † Santalum album sive Sirium myrtifolium.
  - ‡ Butea frondosa. § Bombax heptaphyllum.

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distinguished by a hooked nose; he is placed in the middle of Leo:

15. [MARS] The third in the tripartite division of Leo, is a man having the head of a bear, with a long beard and curled hair; in disposition similar to an ape; and holding a staff, fruits, and flesh.

16. [MERCURY] A damsel, bearing a jar filled with blossoms, (her person clothed in apparel soiled with dirt,) solicitous for the union of dress with opulence, is going towards the family of her spiritual parent: such is the first of Virgo.

17. [SATURN] A man of a dark complexion, with a cloth on his head, holds a pen, and is casting up accounts of receipts and disbursements: he bears a large bow, and his body is covered with hair: he is placed in the middle of the sign.

18. [VENUS] A woman of a fair complexion, dressed in bleached silk, tall, holding in her hand a jar and ladle; is devoutly going towards a temple of the gods. The wise pronounce this to be the last of Virgo.

19. [VENUS] A man is proceeding along the middle of a highway; holding a balance, and having weights in his hand; he is skilled in measuring and meting, and meditates on commodities and their prices. The Yavanas declare this form to be first of Libra.\*

20. [SATURN] A man with the head of a vulture, carrying a water-pot, is anxious to proceed, being hungry and thirsty; in thought, he visits his wife and son. He is middlemost of the balance-bearer (Libra.)

\* "Tadrúpam vadanti Yavanáh praťhamam tuláyáh." This might signify "YAVANA declares;" for the plural is used in Sanscrit respectfully: and BHATTÓTPALA has before expounded Yavana as intending YAVANÁCHÁRXÁ: but a different explanation occurs a little lower. [MERCURY] A man, in figure like an ape, adorned with gems, bearing a golden quiver and armour, and carrying fruits and flesh, is scaring deer, in a forest: such is the figure exhibited by the Yavanas.\*

22. [MARS] A woman, without clothes or ornaments, comes from the great ocean, to the shore; she has fallen from her place; round her feet are serpents entwined; but she is pleasing: such is the first of the sign Scorpio.

23. [JUPITER] A woman, with a body like a tortoise and a jar, and with serpents entwined round her person; is solicitous to prepare local comforts for her husband. This figure the wise pronounce to be the middle one of Scorpio.

24. [The MOON] The last of the Scorpion is a lion with a large and stooping head resembling that of a tortoise; he guards the place where sandal-wood grows, terrifying dogs, deer, boars, and shakals.

25. [JUPITER] An animal with the body of a horse and head of a man, holding a large bow, stands near a hermitage and devoutly guards the implements of sacrifice; such is the first of the three divisions of the bow (Sagittarius.)

26. [MARS] A pleasing female, of golden complexion like the *champaca*,<sup>†</sup> moderately handsome, sits on a throne, distributing marine gems. This is described as the middle division of the bow.

27. [The SUN] A man with a long beard, of a complexion yellow like the *champaca*, is sitting on a throne with a staff in his hand: he wears silk raiment and a deer's skin: such is the third figure of the ninth sign.

28. [SATURN] A man, of a terrible aspect, with the

• " Yavanair udihritah," which BHATIOTFALA expounds " declated by the ancient Yavanas," " purchayavanaih."

+ Michelia Champaca.

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body of a hog, hairy, having tusks like a Macara,\* holds a yoke, a net, and fetters. He is first of Capricorn.

29. [VENUS] In the middle of *Macara* is a woman skilled in music, with eyes large like the petals of the lotos, and with a dark complexion. She seeks various things; she is decorated with jewels; and wears metallic ornaments in her ears.

30. [MERCURY], A man shaped like a Cinnara,+ clothed in a woollen cloth, and furnished with quiver, bow, and armour, bears on his shoulder a jar adorned with gems: he is last of the sign Macara.

31. [The SUN] The first of the jar (Aquarius) is a man with the head of a vulture, clothed in silk and wearing an antelope's hide with a woollen cloth : his mind is busied in obtaining oil, ardent spirits, water, and food.

32. [MERCURY] In a burnt carriage, a woman clad in soiled apparel, bearing vessels on her head, is collecting metals in a forest containing cotton trees.

33. [VENUS] A man of a dark complexion, with hairy ears, adorned with a diadem, carries and transports vases with articles of metal, and with bark, leaves, gum, and fruit. He is last of *Cumbha*.

34. [JUPITER] The first of the fish (Pisces) navigates the sea in search of ornaments for his wife: he has jewels, and his hands are full of vessels used in sacrifice, together with pearls, gems, and shells.

35. [The Moon] A woman, surpassing in complexion the blossom of the *champaca*, ascends a ship with lofty masts and flags; and approaches the shore of the sea, accompanied by her retinue. This is declared by sages to be the second in the tripartite division of *Mina*.

- \* A sea monster. Perhaps the Narwhal may be intended.
- † A human figure with the head of a horse. VOL. II



36. [MARS] Near a cavern, in a forest, a naked man, with serpents entwined round his body, and tormented by robbers and fire, laments. He is the last of the fish.

Arabian astronomers in like manner divide each sign of the Zodiac into three parts, denominated  $Wajeh((z_{rac}))$  or in the plural  $Wajuh((z_{rac}))$ , which severally belong to the different planets\* thence called Rab al wajeh. The proper import of the term  $(z_{rac})$  is face or countenance; agreeing with the Greek  $\pi\rho\delta\sigma\sigma\sigma\sigma\sigma\nu$ , which is similarly employed in this acceptation.<sup>4</sup>

The near correspondence of the *dréshcoinas* with the Decani of Roman authors and *Assavol* of Grecian writers will be evident from the following passage of MANILIUS, supported by quotations from other authors, which I shall insert on the faith of SAUMAISE; the original works, from which they are taken, not being here procurable.

MANILIUS says§

Quam partem deciman dixere Decania gentes ; A numero nomen positum est, quod partibus astra Condita tricenis propria sub sorte feruntur, Et tribuunt denas in se cocuntibus astris, Inque vicem terris habitantur sidera Signis.

HEPHESTION expressly declares, || that "each sign of the zodiac is divided into three Decani comprising ten

\* In the following order, beginning from Aries : viz. Mars, the Sun, Venus, Mercury, the Moon, Saturn, Jupiter, Mars, the San, &c. Ikhwdnu'l Safd.

+ FIRMICI Mathesis seu Astron., vide infra.

t SALMASII Pliniance Exercitationes, p. 460, &c.

§ Lib. iv. 298-302.

|| Kai έstiv ό μέν πρώτος χονταρέ, ό δε δεύτερος χονταχοέ, ό τρίτος σικέτ.

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degrees each: the first division of Aries is named Chontare; the second Chontachre, and the third Sicet."

FIRMICUS differs in the names, and does not allow ten complete degrees to each Decanus. Thus, in the sign Aries, the three first degrees are, according to him, unappropriated; the five next belong to the first Decanus Asitan; the next nine are vacant; and the four following appertain to the second Decanus Senacher; five degrees are again unoccupied; and the four last belong to the third Decanus Sentacher.\*

We learn from PSELLUS† that the several Decani were figured with different attributes and dresses; and, from DEMOPHILUS and FIRMICUS‡ that they represent the planets. The first appertained to Mars: the second to the Sun; and the third to Venus (the Hindu author says, Jupiter).

This astrological notion was confessedly received from foreign nations. The doctrine seems to be ascribed by FIRMICUS to NEREPSO, king of Egypt:§ and PSELLUS cites a Babylonian author, whom he calls TEUCER; and who is also noticed by PORPHYRIUS: besides, the names of

#### \* SALMASII Plin. Exerc. p. 460.

+ Εἰσὶ γάο ἐν ἐκάςτῷ τῶν ζωδίων τρεῖς κατειλεγμένοι Δεκανοὶ ποικιλόμορφοι, ὁ μὲν κατέχων πέλεκυν, ὁ ở εἰς ἄλλο τι ἐσχηματισμένος εἰκασμα. ῶν εἰ τὰ εἰδη καὶ τὰ σχήματα δακτυλίων ἐγγλύψεις σφενδόναις, ἀποτρόπαια δεινῶν φανήσεται. ταῦτα μὲν οὖν ὁ Τεῦκρος καὶ οἱ κατ' ἐκεῖνον περιττοὶ τὰ μετέωρα.

<sup>‡</sup> " Primum πρόσωπον est is planeta cujus signum est : secundum πρόσωπον planeta sequens, et sic deinceps. Aries est Martis primum πρόσωπον, secundum Solis, tertium Veneris, juxta seriem errantium." This agrees precisely with the Arabian  $\overset{\sim}{\sim}$ .

§ Sic et Nekepso, Ægypti justissimus imperator, et astrologus valde honus, per ipsos Decanos omnia vitia valetudinesque collegit, ostendens quam valetudinem quis Decanus efficeret, &c.

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the Decani, stated by HEPHESTION and FIRMICUS, are decidedly barbarous. It was not, therefore, without reason, that SAUMAISE and KIRCHER sought a derivation of the word Decanus itself from a foreign language. It cannot be deduced, as SCALIGER proposes, from the similar term for an inferior officer commanding ten men;\* since this office and its designation were first introduced later than the time of MANILLUS, by whom the astrological term is employed; and PORPHYRIUS expressly affirms that the word was used by those whom he denominates 'ancients.'t HUET, not concurring in either of the opinions above-mentioned, supposes the term to have been corruptly formed by the astrologers of Alexandria from the Greek numeral with a Latin termination.† If this be admitted, it still remains not improbable that some affinity of sound, in the Egyptian or in the Chaldaic name, may have suggested the formation of this corrupt word.

The Sanscrit name apparently comes from the same source. I do not suppose it to be originally Sanscrit; since, in that language, it bears, no etymological signification. For the same reason, it is likely, that the astrological doctrine itself may be exotic in India. One branch of divination, entitled *Tajaca*, has been confessedly borrowed from the Arabians: and the technical terms used in it, are, as I am informed by Hindu astrologers, Arabic. The casting of nativities, though its practice is of more ancient date in India, may also have been received from Western astrologers: Egyptians, Chaldeans, or even Greeks. If so, it is likely that the Hindus may have received astronomical hints at the same time.

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<sup>\*</sup> Erant Decani denis militibus propositi. VEGET. 2. 8.

<sup>+</sup> Ούς τινας εκάλεσαν δεκαιούς οί παλαιοί.

I HUBTH animadversiones ad Manilium. Lib. iv. v. 298.

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By their own acknowledgment,\* they have cultivated astronomy for the sake of astrology; and they may have done so with the aid of hints received from the same quarter, from which their astrology is derived. In the present instance VARAHA MIHIRA himself, as interpreted by his commentator, quotes the *Yavanas* (meaning perhaps Grecian authors), in a manner which indicates, that the description of the *dréshedmas* is borrowed from them.

The name of YAVANACHARYA, who is cited by BHAT-TÓTPALA, would not be alone decisive. He is frequently quoted by Hindu astronomers: and it is possible, though by no means certain, that, under this name, a Grecian or an Arabian author may be intended. To determine that point, it will be requisite (unless the work attributed to him be recovered) to collect all the passages, in which Y AVANACHARYA is cited by *Sanscrit* authors; and to compare the doctrines ascribed to him with those of the Grecian and Arabian writers on astronomy. Not being prepared for such a disquisition, I shall dismiss this subject for the present, without offering any positive opinion on the question, which has been here proposed.

• BHÁSCARA expressly says, "By ancient astronomers, the purpose of the science is declared to be judicial astrology; and that, indeed, depends on the influence of configurations; and these, on the apparent places of the planets."—G/lddhydya, 1. v. 6.



XV.

On the Notion of the Hindu Astronomers concerning the PRECESSION of the Equinoxes and Motions of the PLANETS.

> [From the Asiatic Researches, vol. xii. p. 209-250. Calcutta, 1816, 410.]

IN an essay on the Indian and Arabian divisions of the zodiac, inserted in the ninth volume of the Asiatic Researches, I adverted to a passage of BHASCARA, on the precession of the equinoxes, and intimated an intention of further noticing this subject in a separate essay.\* The passage which I had then in view, occurs in BHASCARA's description of the armillary sphere.† It appears to me deserving of distinct examination for the information which it contains, the difficulties which it presents, and the variety of topics which it suggests. I shall here quote the original, and add a verbal translation.

विषुवल्कान्तिवखययोस्सम्पातः कान्तिपातः स्थात् । तद्वगणाः सौरोका व्यस्ता त्रयुतत्रयं करूपे ॥१७॥ त्रयनचलनं यदुकं मुझाखाद्यैः स एवायं । तत्पचे तद्वगणाकल्पे गोङ्गर्तुनन्दगोचन्द्राः ॥१८॥

'The intersection of the ecliptic and equinoctial circles in the *Crántipáta*, or intersecting point of the sun's path.

\* As. Res., vol. is. p. 353. [p. 350 of the present volume.]

† Golddhydya, c. 6. v. 17 and 18.

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Its revolutions, as declared on the authority of Súava (Sauróctáh), are retrogade three myriads in a calpa. This is the same with the motion of the solstice, as affirmed by  $M \cup N J \land L A$ , and others. But, according to their doctrine, its revolutions are 199, 669 in a calpa.

This is the very passage to which the commentator on the Sárya siddhánta, cited by Mr. DAVIS,\* alludes, where he says, 'the meaning of BHASCARA ACHARYA was not that SÚRYA [in the Sárya siddhánta,] gave 30,000 as the revolutions of the places of the colures, in a calpa; the name he used being Saura not Sárya, and applied to some other book.'

It is certainly true, as here observed by this commentator, that BHASCARA'S quotation does not agree with the text of the Súrya siddhánta, which expresses, 'The circle of the asterisms moves eastward thirty scores in a guga. Multiplying the number of elapsed days by that, and dividing by the terrestrial days, [which compose the cycle,] the quantity obtained is an arc, which, multiplied by three, and divided by ten,† gives degrees (ansa) termed ayana, [or the place of the colure.]'

# चिंग्राकत्यी. युगे भानां चंत्रं प्राक्परिसम्बते । तहुणाद्भदिनैर्भकाद्युगणाद्यदवाप्यते । तद्दीस्तिज्ञा दग्राप्तांग्रा विज्ञेया अयनाभिधा ॥

Here the number of revolutions is 600 in a yuga, answering to 600,000 in a calpa; and not, as stated by BHÁSCARA, 30,000. But the commentator's mode of reconciling the contradiction, by supposing a different book from the Súrya siddhánta to have been intended, is incom-

\* As. Res., vol. ii. p. 267.

+ Ratio of 27° to 90°.

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patible with BHASCARA'S own explanation of his text in the Vásaná bháshya, containing annotations by himself on his own treatise. He there says in express words, 'the revolutions of the intersecting point of the sun's path are stated in the Súrya siddhánta, as amounting to 30,000 in a calpa.'\*

# त्रतोऽख क्रान्तिपातख भगणाः कल्पे ऽयुतचयं तावसूर्यसिद्धान्तीकाः ॥

His commentator,  $M \cup N f \le WARA$ , has therefore recourse to other expedients for reconciling the contradiction between  $B H \le CARA's$  quotation and the text of the Súrya siddhánta. Some, he observes, have proposed to read niyuta 'a hundred thousand,' for ayuta 'a myriad.'† Others have supposed the calpa to be a twentieth part only of the period usually so denominated. The commentator further 'suggests the resolution of the term vyastdh, translated 'retrograde,' into vi for vinsati 'twenty,' and astdh, which he makes to signify 'multiplied,' and expounds the phrase, 'thirty thousand multiplied by twenty.' But, dissatisfied with this and with another exposition, by which trayam 'three' is construed into 'sixty,' he gives the

• BHASCARA'S Vásand bháshya on the astronomy and spherics of his Siddhánta tirómani. This volume of annotations is commented, with the Śirómani, by Naïsinna in the Vásaná eártica, as proceeding from the same writer; and is expressly acknowledged to be a work of the author of the text (as it actually purports) by the scholiast Muniśwana, in this very place, where he is endeavouring to support his own interpretation of the text, against the apparent and natural sense of a passage in the author's notes.

† He alludes either to the *Visand vartica*, in which that emendation of the text is actually suggested by the annotator NRISINHA, or to some earlier commentary in which the same conjectural emendation may have been originally proposed.



preference to an equally strained interpretation, which divides the sentence into two members: 'its revolutions are declared by SúRVA, and [according to a different authority] are retrograde three myriads in a calpa.'

However unsatisfactory these explanations of the text may be, they prove the concurrence of the commentators of both works, in the received interpretation of the obscure passage of the Súrya siddhdnta, which is the subject of their discussion. That interpretation is supported by corresponding passages of the Soma siddhanta, Laghu vasishtha, and Sácalya sanhitá, in which the number of six hundred revolutions is explicitly stated:\* as well as by other quotations, which clearly demonstrate, that a libration of the equinoxes, at the rate of six hundred in a guga, was there meant. For, in all the passages quoted, the revolution, as it is termed, of the equinoctial points, consists in a libration of them within the limits of twenty-seven degrees east, and as many west, of the beginnings of Aries and Libra: and that such is the meaning conveyed in the text of the Súrya siddhanta, is distinctly shown by the

## \* खुगे षट्शतकत्वादि भचकं प्राग्निखंबते । तहुणे सदिनैर्भकी खुगुणे ऽयनखेचरः ॥ Sóme siddhénta

तत्पञ्चाचचितं चक्रम् इत्येतदेवं प्राक्चजनं चुगे तानि च षट्ग्रातं ॥

Sacalya sanhita, i. 286-291.

# अब्दाः खखर्त्तुभिर्भाज्यास्तद्ोस्तिन्ना दशाहता॥

Laghu vasish? ha siddhanta, cited by DADARNAI and Nalsınna, on the Surya siddhanta. Z 2



commentator cited by Mr. DAVIS,\* as well as by the other commentators on that work.

The same doctrine is taught in the *Párásara siddhánta*, as quoted by MUNIŚWARA; and, if we may rely on the authority of a quotation by this author from the works of ÅRYABHAŤTA, it was also maintained by that ancient astronomer: but, according to the first-mentioned treatise, the number of librations amounts to 581,709, and, according to the latter, 578,159 in a *calpa*, instead of 600,000; and ÁRVABHAŤTA has stated the limits of the libration at 24° instead of 27°.1

BRÁSCARA himself, adopting the doctrine for which he quotes the authority of MUNJÁLA, in the passage above cited, mentions a complete revolution of the places of the colures through the twelve signs of the zodiac, at the rate of 59 54 2 31 12 per annum, or 199,669 complete revolutions in a calpa. Having computed upon the same principle, the quantity of the precession in his own time  $\frac{10}{10}$   $\frac{10}{10}$   $\frac{54}{35}$  23 55 40 48, he thences for the sake of facility in calculation, assumes in his practical treatise, named *Carana catúnala*, the actual precession in whole numbers at eleven degrees, and allows the annual motion to be taken at one minute.<sup>†</sup> The time for which this

· As. Res., vol. ii. p. 267. The commentator is Nafsinna.

### † चतुर्विग्रत्यंग्रेशकम्भयतागच्छेत् ॥

ARYABHATTA, in the Arydshiasata; quoted by Monféwara. It is especially necessary to distinguish the particular work of this author, to which reference is made: for BRAHMEGUERA reproaches him for his inconsistency in affirming revolutions of the nodes in the Arydshlasata, which he denied in the Dasa gitaca. It is therefore probable, that the libration of the equinoxes (considered as nodes) for which the first-mentioned work is quoted, may not be stated in the other.

I MUNISWARA, in his commentary on the Siromani.

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computation was made, is the same with the epocha of the Carana cutuhala;\* which is the year 1105 Śdea,† thirtythree years after the Śirómańi was completed.‡

\* BHÁSARA'S authority, supporting that of MUNJÁLA, and countenanced by VISHŇU CHANDRA'S,§ has not availed with Indian astronomers. Even his commentator MUNISWARA rejects the notion of a complete revolution; and, in his own treatise entitled Siddhánta sárvabhaama, asserts the doctrine of libration, and attempts to refute the other opinion, not indeed by argument, but in deference to the Sárya siddhánta and other authorities to which it is opposed. Upon the same ground, CAMALÁCARA in the Siddhánta tatwavivéca says, 'The degrees of the colures, as stated by MUNJÁLA, and taught in the Širómańi, contrary to what is declared by ARCA (SúRVA) and others, from not rightly understanding what was by them declared

\* The Graha Ughava, written in 1442 Śaca, deducts 444 from the expired years of the Śaca, and divides by sixty, reckoning the precession at a minute a year. This agrees nearly with the Caraña cutáhala; for, if the same number (444) be deducted from the years expired (1105 Śaca), the remainder gives but one minute above 11°, the quantity there assumed by BHÁSCARA.

RAMACHANDRA, who in the Cála nirńaya states the quantity of precession as amounting to  $12^{\circ}$ , and reckons the precession at a minute of a degree, a year, seems also to have followed the same authority. He may therefore have written about sixty years subsequent to the date of the Carańa cutúhala; or Śáca, 1165. This ascertainment of the age of Rámachanbna áchiana is a step towards investigating the age of writers in other branches of science who have quoted this author, or who are cited by him. They are numerous.

+ FAIZI, in his translation of BHASCARA'S Likivati.

<sup>†</sup> For it was finished when the author was thirty-six years of age; and he was born in 1036 *Saca*: as he informs us.

§ Author of the Vasishi'ha siddhánta, a distinct work from the Laghu pasishi'ha cited by DADABHAÏ and (under the title of Vasishi'ha siddhánta) by NEÏSINHA.

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must be rejected by the wise.' He certainly here expresses the prevalent opinion of the Hindu astronomers, which is decidedly in favour of a libration of the places of the colures.

Besides MUNJÁLA mentioned by BHÁSCARA, the only other ancient author, whose name I find quoted for a complete revolution of the equinoctial and solstitial points, is VISHŇU CHANDBA, from whose works a passage is cited by PRĬT'HÚDACASWAMÍ, declaratory of a solstitial *yuga*, or period of the *ayana*. The text is corrupt in respect of the lowest digits of the number; and, having found no other quotation of it, I shall not attempt to state the period from a conjectural emendation of this passage.

It is necessary to observe, that some of the ancient writers on astronomy have not admitted a periodical motion of the equinoxes. This is adverted to by BHASCARA himself,\* who instances BRAHMEGUPTA. The reason of that omission or denial is supposed by  $BHASCARA^+$  to have been the inconsiderable quantity of the deviation or precession, not then remarkable, and consequently unheeded by BRAHMEGUPTA; since whose time it is become sensible, and therefore it is now taken into account.<sup>+</sup> BHASCARA next inquires ' why BRAHMEGUPTA and the rest did Lot

\* In the Vásand bhishya. + Ibid.

ः तत्कयंत्रद्वागुप्तादिभिनिंपुणैरपिनेकदतिचेत् तदाखल्पत्वात्तैर्नोपचअः ददानीं वज्जत्वात्धांप्र -नैरूपचअःश्रत एवाख गतिरस्तीत्यवगतं ॥

"Why has it not been stated by BRAHMEGUPTA and other skilful astronomers? It was not perceived by them, because it was then inconsiderable. But it is perceived by the moderns, because it is now considerable. Accordingly it is concluded, that there is motion, [of the solstice.'] BRASCARA in the Vásand bháshya.

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nevertheless state it on the strength of authority, since it had been declared in the *Saura siddhánta*; in like manner as the numbers of revolutions, the periphery of epicycles, &c.?\*

He replies: 'In mathematical science holy tradition is authority, so far only as it agrees with demonstration.' He goes on to say, 'Such motion, as results from the assigned revolutions, by which, places being calculated agree with those which are observed, must be admitted, whether taught by a holy sage or by a temporal teacher. If then the same places are deducible from other revolutions, which of the assigned motions is the true one? The answer is, whichever agrees with present observation must be admitted. But, if in process of time, the difference become great, then men of genius, like BRAHMEGUPTA, will arise, who will acknowledge such motions as agree with present observation, and compose books (*Sástras*) conformable thereto. Accordingly this mathematical science has no end in eternal time.'

But BRAHMEGUPTA's commentator, expounding a passage of this author,<sup>†</sup> which he considers to be levelled against those who affirmed a periodical revolution of the solstitial points, and which does deny such a revolution, and declares the solstice to be invariable, because the longest day and shortest night occur constantly at the end of *Mithuna* or Gemini, adverts, in the course of his exposition of the text, to passages which place the southern and northern solstice respectively in the middle of *Aslishd*, and beginning of *Dhanishthd*, and proceeds to remark 'this

# \* वद्येवसनुपज्ञ स्रोऽपि सीर्सिद्दान्तो कत्वादा -

गमप्रासाख्वेनभगषपरिष्यादिवत्कधंतैनीकः ॥

† Ch. ii.

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only proves a shifting of the solstice, not numerous revolutions of it through the ecliptic.' His notion appears then to have been, that his author was aware of the fact of a change in the positions of the solstitial and equinoctial points, but did not admit the inference that the motion must be periodical.

From all that has been said, it appears, that some of the most celebrated astronomers, as BRAHMEGUPTA, have been silent on the subject of a change in the places of the colures, or have denied their regular periodical motion. That others, as MUNJÁLA and BHÁSCARA (we may add VISHNU CHANDRA) have asserted a periodical revolution of the places of the colures. But that the greater number of celebrated writers, and all the modern Hindu astronomers, have affirmed a libration of the equinoctial points.

The earliest known author who is cited for the support of this doctrine, as far as present research has gone, is A EYABHATTA, who is undoubtedly more ancient than BRAHMEGUPTA; for he is repeatedly quoted in the Brahme sphuta siddhanta which is ascribed to BRAHMEGUPTA, and which there is every reason to consider genuine, since the text of the book accords with the quotations from that celebrated astronomer to be found in treatises of various dates.

I purposely omit in this place the Súrya siddhánta, Sóma, Sácalya, Vasisht'ha and Párásara, because their authenticity and age are subjects of question or of controversy.

Relying then upon the quotation from the work of ÁRYA-BHATTA, and on the tendency of BHÁSCARA'S observations both in his text and notes, it may be inferred, that the notion of a libration of the equinoxes is of some antiquity in India: since BRAMHEGUPTA, by whom ÁRYA-BHATTA is repeatedly mentioned, is either author or

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republisher of an astronomical system which was copied by BUASCARA in 1150 A. D., but which is adapted to a much earlier age.

The doctrine in question found advocates formerly among the astronomers of Europe and of Arabia. ARZAEL, a Spaniard, and a mathematician of the eleventh century,\* author of a treatise, entitled observations on the obliquity of the zodiac, affirmed a libration or trepidation in longitude within the limits of 10° E. and W. at the rate of a degree in seventy-five years.† Two centuries after him: THABIT BENKORRAH, an astrologer,‡ assigned to this supposed trepidation the limits of 22 E. and W.§ To the same astrologer, by some supposed to have lived as much earlier, as he is here stated to have been later, a different doctrine is ascribed, affirming a motion of the intersected points of the ecliptic and equinoctial in a small circle described with the radius 4° 18′ 43″.∥

They were led to that hypothesis (according to a remark quoted by the authors who have refuted the notion¶) by considering that 'HERMES had found some of the fixed stars more distant from the beginning of Aries, than PTO-LEMY subsequently did: for instance the bright star of Hydra in 7° of Leo, placed by PTOLEMY in 30° of Cancer; and the star named Vultur Cadens, in 24° of Sagittarius, but by PTOLEMY in 17°.

• He observed the quantity of the obliquity of the ecliptic about the year 1070; and is named by ABBAHAM BEN EZEA, who wrote in the twelfth century (A.D.1144 or 1150), as anterior to him by seventyone years. RECEDIN, Almag. nov.

† RICCIOLI, Almagestum novum, 3, 28, 6.

I MORERI, Dict.

nl

§ BRASMUS REINHOLD ON PURBACH; RICC. Almag. nov. 3, 28, 6. MONTUCLA Hist. des Math., vol. i. p. 346.

AUGUSTINUS RECCEUS, de motu octavæ sphæræ. REGIOMONTA-NUS, lib. 7. Epitomes Almagesti. Ricc. Alm. nov. 3, 28, 6.

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The notion of a trepidation in longitude, but at a rate not equable, had been entertained by the astronomers, who compiled the Alphonsine Tables, though ALPHONSUS himself was subsequently led to the adoption of a correcter opinion, and to the consequent alteration of the tables first published by him.\*

The earliest mention of a libration in longitude, which has been found in any Arabic writer, is in the work of MUHAMMEDBENJABER, surnamed ALBATANT, and by us called ALBATEGNIUS. This celebrated astronomer, an Arabian by birth and Sabian by religion, flourished at the end of the ninth century; or, to speak with precision, about the year of Christ 879; and from him we learn, that certain astronomers whom he does not appear to have any where named, had before him affirmed a libration of the fixed stars within the limits of 8° E. and W. at the rate of a degree in eighty or eighty-four years. He himself maintained the doctrine of a uniform motion at the rate of a degree in sixty-six years.

I have dwelt the longer upon the history of this opinion, because it appears to me deserving of attention on more than one account. ALBATANI is the earliest of the Arabian astronomers who improved upon PTOLEMY; (for ALFARGANI, who was a century earlier, is not cited as correcting the Greek astronomer on this point.) It was he then, who first, among the astronomers of the west of Asia, computed the motion of the stars at a degree in sixty-six years; which is almost the same with the rate of the motion of trepi-

\* ABRAMAM ZACUTHUS, cited, like the preceding authorities, in Records Almagest. 3, 28, 6.

+ D'HERBELOT, Bibl. Orient.

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t He himself furnishes the date, being the year I627 of the era of NABONABSAB. ALDATEON. c. 51, cited in Riccipli's Almagest. 6, 16, 2.

<sup>§</sup> ALBATEGNIUS, c. 52. as cited by RICCIOLI. || Ibid, c. 51.

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dation according to the Súrya siddhánta, and the herd of Hindu astronomers, who reckon a degree and a-half in a century.\* He is the first also, as far as can be discovered, in whose works mention is made of a motion of trepidation and we may be permitted to conjecture, that the earlier astronomers alluded to by him were Indian; since we find  $A_{RYABHATTA}$ , an author seemingly of an earlier age, quoted for a libration of the equinoctial points within the limits of twenty-four degrees, at the rate of one in seventyeight years; and since we know that an Arabian astronomer, anterior by nearly a century to  $A_{LBATANI}$ , had compiled tables in conformity to rules of astronomy apparently Indian.†

We may then safely conclude, that, on the subject of the precession of the equinoxes, the Hindus had a theory, which, though erroneous, was their own; and which, at a subsequent time, found advocates among the astronomers of the west. That they had a knowledge of the true doctrine of an uniform motion in antecedentia, at least seven hundred years ago,<sup>±</sup> when the astronomers of Europe also were divided on the question. That they had approximated

• This is the rate resulting from the quantity of the motion in trepidation stated in the Surya siddhánta: and the same results from the rules of calculation given in the *Bháswati caraña* of SATÁNANDA and in the *Játacárňava* improperly ascribed to VARÁMA MIMIRA. They both direct the number 421 to be deducted from the expired years of *Sáca*: and the one deducts a tenth and reduces the remainder into degrees; the other adds half and divides by a hundred. Another rule, producing the same result, is mentioned in BAILLY'S *Astr.Ind.* p. 76.

+ 'Ad regulas Send Hend.' (Siddhant?) ABULFARAG. Hist. Dynast. p. 114 and 161. COSTARD'S Astronomy, p. 157, and MONTUCLA Hist. des Math., vol. i. p. 344.

<sup>‡</sup> BRÁSCARA, who quotes MUNJÁLA, completed the Sirómani in 1072 Sáca, or A. D. 1150.

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to the true rate of that motion much nearer than PTOLEMY. before the Arabian astronomers, and as near the truth as these have ever done since. From this we may perhaps be led to a further conclusion, that the astronomy of the Hindus merits a more particular examination than it has vet obtained, not indeed with any expectation of advancing the science of astronomy, which needs not such aid, and can derive none from the labours of astronomers who have recorded no observations; but for the history of the science, and ascertainment of the progress which was here made: and that, with this view, the works of Hindu astronomers, whose age is precisely known, and in particular, those of BHÁSCARA, which contain a complete course of astronomy and of sciences connected with it, should be carefully perused ; as well as those of BRAHMEGUPTA, which are full of quotations from earlier astronomers, as ÁRVABHATTA,\* VARÁHAMIHIRA,† ŚRÍSHÉŇA,† VISH-NUCHANDRAS and some others, who are cited by him for the purpose of exposing and correcting their errors.

In regard to VARAHAMIHIRA and the Súrya siddhánta, both separately quoted in the Bráhme spihuťa siddhánta of BRAHMEGUPTA, I may here remark that a book entitled Súrya siddhánta is mentioned by VARAHAMIHIRA himself, in his most undoubted work, the treatise on Astrology, entitled Váráhi sanhitá, where, describing the qualifications requisite to form an accomplished astrologer, he says, 'the astrologer should be conversant with divisions of time and geometrical figures, as taught in the five Siddhántas, or

<sup>\*</sup> Anthor of the Dasagitica and Aryishia sata.

<sup>†</sup> Named with censure by BRAHMEGUPTA.

f Author of the Rómaca siddhánta.

<sup>§</sup> Mentioned as the author of the Vasishi'ha siddhanta.



systems of astronomy, called Paulisa, Rómaca, Vásishíha, Saura and Paitámaha.'\*

VARAHAMIHIRA, as appears from the quotations of his own commentator BHATTÓTPALA and many other astronomical writers, is likewise author of a treatise entitled *Pancha siddhánticá*, in which the five systems above mentioned are compared; and, as far as can be gathered from quotations, their agreements and disagreements noticed. A passage of this treatise as cited by BHATTÓTPALA, is sufficiently remarkable to be here inserted, since it bears relation to the subject of this paper. It corresponds in import to a passage quoted by Mr. DAVIS, and Sir WILLIAM JONES;<sup>†</sup> from the third chapter of the Váráhí sanhitá; but refers the actual position of the colures to the asterisms instead of the signs of the zodiac.

### श्रसेषाईादासीचदा निष्टत्तिः किलोष्णकिरणस्य ।

### यक्तमयनं तदासीत्सांप्रतमयनं पुनर्वस्तः ॥

'When the return of the sun took place from the middle of Asléshá, the tropic was then right. It now takes place from *Punarvasy*.'

The same five systems of astronomy from which VARA-HAMIHIRA is understood to have compiled the astronomical treatise just now quoted, and which are named by him in

\* तच ग्रहगणिते पौलिसरोमकवासिष्ठसौरपे -तामछेषु पञ्चस्वेतेषु सिद्धान्तेषु युगवर्षायनर्तुमा -सपचाहोराचयामसुह्नर्तनाडीविनाडीप्राणचुटिनु -घाद्यवयवस्य कालस्य चेवस्य च वेत्ता ॥ † As. Res., vol. ii. p. 391.

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the passage of his astrology before cited, are mentioned by BRAHMEGUPTA also as standard authorities, and enumerated by him in the same order: and his names, which are precisely the same with those in VARAHAMIHIRA's enumeration,\* are explained by BHATTÓTPALA, as intending the Pulisa siddhánta, Rómaca siddhánta, Vasishtha siddhánta, Súrya siddhánta, and Bráhme siddhánta.

All these books are frequently cited in astronomical compilations, and are occasionally referred to their real or supposed authors. The first is every where assigned to PULISA, whose name it bears. The Rómaca siddhánta is ascribed by the scholiast of BRAHMEGUPTA, and by a commentator of the Súrya siddhánta, to SRISENA or SRISHÉNA (for the name is variously written). The Vásisht'ha siddhánta is by the same authority given to VISHÍUCHANDRA. Both these authors are repeatedly mentioned with censure by BRAHMEGUPTA; and it is acknowledged that they are entitled to no particular deference.

# \* पौलिषरोमकवाशिष्ठसीरपैतामहेषु यत्प्रोक्तं तन्न -चचानधनं नार्यभद्दीक्तं तद्क्तिरतः ॥

This passage, in which the Paulisha, Rómaca, Vásishi'ha, Saura, and Paitámaha are specified, is introductory to a division of the lunar asterisms (for astrological purposes, it should seem), in unequal portions, by allotting to fifteen of them a quantity equivalent to the mean diurnal motion of the moon in minutes of a degree (790'35''), and half as much more to six of those asterisms (1185'52''), and so much less to the like number of nacshatras (395'17'') and assigning the complement of the circle (254' 18'') to the supplementary nacshatra called Abhiyit.

(CT The numbers here set down are copied from the scholiast BHATTOTFALA, and from BHASCARA'S commentators; being stated by them at the nearest second: for the moon's mean daily motion according to BRAHMEGUPTA and BHASCARA is a little less than 790'35".) The Brdhme siddhanta, which is the basis of BRAHME-GUPTA'S work, is not any where attributed to a known author; but referred in all quotations of it which have fallen under observation, either to the Vishinu dharmottara purdina, of which it is considered as forming a part, or to BRAHME (also called PITAMAHA), who is introduced into it as the speaker in a dialogue with BHRIGU; or it is acknowledged to be the work of some unknown person.\* The true author it may be now impracticable to discover, and would be vain to conjecture.

The Súrya siddhánta (if the same which we now possess) is in like manner ascribed to no certain author, unless in the passage cited by our colleague Mr. BENTLEY, two says, that 'in the commentary on the Bháswati, it is declared, that VARAHA was the author of the Súryasiddhánta;' and who adds, that 'SATÁNANDA, the author of the Bháswati, was a pupil of VARAHA under whose directions he himself acknowledges he wrote that work.'

The concluding remark alludes to the following verse of the Bháswatí caraña.

## अध प्रवच्छे निहिरीपदेशात् तत्पूर्यसिद्धान्तसमं समासात् ॥

'Next I will propound succinctly, from MIHIRA'S instruction, [the system] equal to the Súrya siddhánta.'

· DADABHAT, in his commentary on the Súrya siddhanta says so.

# पैतामहमपि केनचित्त्रिवद्वं तस्रोपरि ब्रह्मगुप्तेन पैता-महीभायं निवद्वं तदपि पौरूषं ॥

4 As. Res., vol. vi. p. 572.



It is preceded by an introductory couplet which will be found quoted at the foot of the page,\* or is omitted in some copies: but the correct reading, as appears from collation of text and scholia, retains both.

Admitting then its authenticity, and supposing, with most of the commentators, that VARAHAMIHIRA is here intended by the single word *Mihira*, which, however, is a name of the sun, and may here allude to the fabled dialogue of SÚRYA with MEYA, as is observed by the scholiast BALABHADRA;† still the passage is not unambiguous. It does not necessarily imply oral tuition, and may refer to instruction derived from the works of VARAHA; especially from the *Pancha siddhánticá* of that author, in which the Súrya siddhánta was explained concurrently with four other treatises termed Siddhánta.

To return from this digression. It appears from what had been before said, that a work bearing the title of Surya siddhinta is named as authority by VARAHAMIHIRA, in whose time, according to his assertion, the place of the

## \* नत्वा मुरारेखरणारविन्दं श्रीमान् वतानन्द इति प्रसिद्धः । तां भास्वतीं णिखहितार्धमाइ णाके विद्यीने प्राधिपचिलेके ॥

'Having bowed to the foot of the foe of MURA, the fortunate SA-TANANDA propounds, for the benefit of students, the *Bháswati*, in the Sáca year 1021.'

The author SATÁNANDA, as he himself informs us in the close of the book, was an inhabitant of *Purushóttama* (the site of the temple of *Jagannáť ha*): and date his work there in 4200 of the *Cali yuga*. In the body of the work he directs the difference of longitade to be reckoned from the meridian of *Purushóttama cshétra*.

† His commentary is dated in 1465 of VICRAMADITYA; more than 400 years ago.



Summer solstice was at the beginning of the sign Carcata, and in the asterism Punarvasu. A treatise under the same title is similarly mentioned by BRAHMEGUPTA, who has likewise noticed VARÁHAMIHIRA himself, and who is supposed by BHÁSCARA to have lived when the colures had not sensibly deviated from that position.

It may be questioned whether this testimony be not overthrown by proofs of a more modern date (between seven and eight hundred years ago), drawn from internal evidence, as set forth by Mr. BENTLEY, in his ingenious essays inserted in the sixth and eighth volumes of our Researches.\*

Without entering at present into any disquisition on this subject, or discussing the accuracy of the premises; but acceding generally to the position, that the date of a set of astronomical tables, or of a system for the computation of the places of planets, is deducible from the ascertainment of a time when that system or set of tables gave results nearest to the truth; and granting that the date abovementioned approximates within certain limits to such an ascertainment; I shall merely observe, that supposing the dates otherwise irreconcileable, still the book which we now have under the name of Súrya, or Saura, siddhanta. may have been, and probably was, modernized from a more ancient treatise of the same name, the later work borrowing its title from an earlier performance of a different author. We have an instance of this practice in the kindred case of the Brahme siddhanta; for we are acquainted with no less than three astronomical treatises bearing this title; one extracted from the Vishnu dharmóttara; another termed the Sácalya; and the third the Sp'huta siddhánta of BRAHMEGUPTA: and an equal number of tracts entitled Vasisht'ha siddhanta may be

\* As. Res., vol. vi. p. 572, and vol. viii. p. 206.

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traced in the quotations of authors; one by VISHNU-CEANDRA; another termed Laghu vasishtha, which from its name should be an abridgment; and the third, apparently an ample treatise, distinguished as the Vriddha vasishtha. This solution of the objection also is entirely compatible with the tenor of the references to the Saura, which have been yet remarked in the works of BRAHME-GUPTA and VARAHAMIHIRA; none of them being relative to points that furnish arguments for concluding the age of the book from internal evidence.

At all events, whatever may be thought of the Súrya siddhánta, we have the authority of a quotation from ÁRYABHATTA, to show, that the Hindus had ascertained the quantity of the precession more correctly than PTO-LEMY; and had accounted for it by a motion in libration or trepidation, before this notion was adopted by any other astronomer whose labours are known to us.

It appears also from a passage of BRAHMEGUPTA's refutation of the supposed errors of that author, and from his commentator's quotation of ÁRYABHATTA'S text, that this ancient astronomer maintained the doctrine of the earth's diurnal revolution round its axis. 'The sphere of the stars,' he affirms 'is stationary; and the earth, making a revolution, produces the daily rising and setting of stars and planets.'\* BRAHMEGUPTA answers, 'If the earth move a minute in a *praina*, then whence and what route does it proceed? If it revolve, why do not lofty objects fall ?'† But his commentator, PRIT'H & DACA SWAMI, re-

## \* भपचरः स्थिरी अरेवावत्याचत्य प्रातिदेवसिकी

### उदयास्तमयी संपादयति नचनयहाणां।

ARYABHATTA cited by PRIT'HUDACA.

+ प्राणेनैति कलां अर्थदि तत्कुती वजेत्कमध्वानं भ

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plies, 'ARVABHATTA'S opinion appears nevertheless satisfactory; since planets cannot have two motions at once: and the objection, that lofty things would fall, is contradicted; for, every way, the under part of the earth is also the upper; since, wherever the spectator stands on the earth's surface, even that spot is the uppermost point.'

We here find both an ancient astronomer and later commentator\* maintaining, against the sense of their countrymen, the rational doctrine which HERACLIDES of Pontus, the Pythagorean ECPHANTUS, and a few others among the Greeks, had affirmed of old, but which was abandoned by the astronomers both of the cast and of the west, until revived and demonstrated in comparatively modern times.

BRAHMEGUPTA is more fortunate in his reasoning where he refutes another theory of the alternation of day and night imagined by the Jainas, who account for the diurnal change by the passage of two suns, and as many moons, and a double set of stars and minor planets, round a pyramidical mountain, at the foot of which is this habitable earth. His confutation of that absurdity is copied by BHAS-CARA, who has added to it from PRITHÚDACA's gloss on a different passage of BRAHMEGUPTA, a refutation of another notion ascribed by him to the same sect, respecting the translation of the earth in space.

This idea has no other origin than the notion, that the earth, being heavy and without support, must perpetually descend: and has, therefore, no relation whatever to the modern opinion of a proper motion of the sun and stars.

# आवर्तनमर्वाकेन पतनि समुच्छायाः कस्नात् ॥

#### Bráhme sp'hula siddhánta.

• The commentator wrote at least seven centuries ago; for he is quoted by Buáscana in the text and notes of the Sirómani.

† For an outline of Anyanuatta's system of astronomy, see a note at the close of this Essay. (p. 414.)

2 A 2



Fart of the passage of BHASCARA has been quoted in a former essay.\* What regards the further subject now noticed, is here subjoined.

'The earth stands firm, by its own power, without other support in space.

'If there be a material support to the earth, and another upholder of that, and again another of this, and so on, there is no limit. If finally self-support must be assumed, why not assume it in the first instance ? why not recognise it in this multiform earth ?

'As heat is in the sun and fire, coldness in the moon, fluidity in water, hardness in iron; so mobility is in air; and immobility in the earth, by nature. How wonderful are the implanted faculties !

'The earth possessing an attractive force,<sup>+</sup> draws towards itself any heavy substance situated in the surrounding atmosphere, and that substance appears as if it fell. But whither ean the earth fall in ethereal space which is equal and alike on every side ?

'Observing the revolution of the stars, the Bauddhast acknowledge, that the earth has no support; but as nothing heavy is seen to remain in the atmosphere, they thence conclude that it falls in ethereal space.

Whence dost thou deduce, O Bauddha, this idle notion, that, because any heavy substance thrown into the air, falls to the earth, therefore the earth itself descends ?'S

He adds this further explanation in his notes: "For if the earth were falling, an arrow shot into the air would not return to it when the projectile force was expended, since

† Like the attraction of the loadstone for iron. Marichi on Buka-CARA.

# Meaning the Jainas; as appears from the author's own annotation on this passage.

§ Sirómanii, Goládhyáya, c. i. v. 2, 4, 7 and 9.

<sup>·</sup> As. Res., vol. ix. p. 322. [p. 224, of the present volume.]



both would descend. Nor can it be said that it moves slower, and is overtaken by the arrow; for heaviest bodies fall quickest, and the earth is heaviest.'

It has been observed in a former part of this essay, that BEAHMEGUPTA'S treatise of astronomy is founded on an anterior one entitled Brahme siddhanta; and the authenticity of the book extant under BEAHMEGUPTA'S name has been relied upon, and passages have been freely cited from it, as the genuine performance of that ancient astronomer. These matters appear to be of sufficient importance to deserve a more particular explanation of their grounds.

The source from which BRAHMEGUPTA drew, is indicated by the author himself, in his introductory couplet, cited by LACSHMÍDÁSA in the commentary on BHÁS-CARA;\*

### बच्चोत्तयद्वगणितं सहता कालेन यस्विलीस्रतं ।

### अभिधीयते स्फुटं तत् जिष्णुमुतब्रह्मगुन्नेन ॥

which, in a literal version, will stand thus :-- 'The computation of planets, as declared by BRAHMA, and become imperfect by great length of time, is perspicuously (*sp'huta*) explained by BRAHMEGUPTA, son of JISHNU.'

The ambiguity imputable to this passage is obviated by the more explicit terms of the initial stanza of his eleventh chapter, where BRAHMEGUPTA announces a refutation of opinions opposed to the Brahme siddhanta:

# ये ऽज्ञानपटलारुद्व हुशी ऽन्यद्वाह्वाददन्ति सिद्धा-नात् । तेषां युगादिसेदाचे दोषास्तान्यवच्यासि ॥

\* The Ganita tatwa chintámani, dated in 1423 Sáca, or 1501 A. D.

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'I will refute the errors (respecting the *yugas* and other matters) of those who, misled by ignorance, maintain things contrary to the *Bráhme siddhánta*.'

What the work is, to which BRAHMEGUPTA refers under the title specified by him, and corresponding to a subsequent mention by him of the Paitámaha siddhánta (both titles being of the same import), is explained by the scholists of BHASCARA and of the Súrya siddhánta. NRI-SINHA, a commentator on both texts,\* affirms that BRAH-MEGUPTA's rules are formed from the Vishinu dharmóttara purana, in which the Brohme siddhanta is contained;t BHÁSCARA'S commentator, MUNÍŚWARAI, remarks, that BRAHMEGUPTA, having verified by observation the revolutions stated in the Brahme siddhanta of the Vishnu dharmóttara, and having found them suitable to his own time, adopted these numbers, rejecting the revolutions taught by SÚRYA and the rest. In other places the commentator cites parallel passages from BRAHMEGUPTA and the Brahme (also termed by him Paitamaha) siddhanta of the Vishnu dharmóttara. S and these with numerous

\* He is the author of a commentary on the Súrya siddhánta, and of the Vásaná vártica on Buáscana's text and notes. It is dated in 1543 Sáca, or 1621 A. D.

† As. Res., vol. ii. p. 242. -

‡ Anthor of the Máricki on BHASCABA'S Śirómańi, and of a distinct treatise of astronomy, the Siddhánta sárvabhauma. The earliest copy of the Márichi is dated 1560 Šáca (A. D. 1638), which is not much later than the date of the work itself; for the Emperor Núryddin JEHANOFR is mentioned at the close of the book, as he also is in the preface of a commentary on the Súrya siddhánta by the author's father RANGANAT'HA.

§ Take the following as examples :

1st. The number of sidereal days in a calpa, (viz. 1582,236,450,000)



quotations from BRAHMEGUPTA in the *Chintámańi* and in other commentaries on BHÁSCARA, as well as in the author's notes on his own text, are exactly conformable with the *Bráhme sp'huta siddhánta* now in my possession, and which is accompanied by the gloss of BRAHMEGUPTA's celebrated commentator CHATURVÉDA PRIT'HÚDACA swámf.

It appears then, from a collation of the passages so cited, that BRAHMEGUPTA'S work is, at least in part, a paraphrase of the Bráhme or Paitámaha; containing, how-

which the Paitámaha siddhánta of the Vishnu dhermóttara (cited in Márichi, ch. i.) expresses by these words :

चलारि ग्रूग्यानि पद्यवेदरमाग्नियमपचाष्टग्र -रेन्द्रवः कच्येन प्रति नचचोदयाः ॥

and BRAHMEGUPTA renders by the equivalent terms,

### पर्विता खचतुष्टयग्रराखिरसगुणयमदिवसु -

#### तिययः॥

2d. The commencement of the calpa, on Sunday, 1st. Chaitra, at the moment of sunrise on the meridian of Lancá, which the Brákme siddhánta of the Vishńu dharmóltara purána (Márichi, ch. ii.) thus expresses :

खद्भायामर्कीदये चैत्रग्रक्तप्रतिपदारस्ने ऽर्कदिना-दावश्विन्यादी किंस्तुव्रादी रीद्रादी काले प्रष्ट -त्ति: ॥

and BRAHMEGUPTA by the following couplet,

चैत्रसितादेरुदयाद्वानोर्दिनमासवर्षथुगकच्याः । सृष्ट्यादी लद्धायां समं प्रष्टत्तादिने ऽर्कस्य ॥



ever, additional matter: and it is accordingly termed by one of the scholiasts of the Súrya siddhánta,\* a commentary on the Paitámaha; and CHATURVÉDA'S gloss is denominated, by the same scholiast, an interpretation of the Paitámaha bháshya.

In support of what has been here said, I shall adduce a few instances of quotation on subjects possessing some degree of interest.

The first is one in which BHÁSCARA vindicates a passage of BRAHMEGUPTA from the objections of his commentator, quoting the passage itself in his notes, and there naming the scholiast, CHATURVÉDA: from which be it remarked, the commentary is ascertained to be anterior to BHÁSCARA'S work: I have a further reason, however, for citing the passage, as it furnishes occasion for some observations on the Indian theory of astronomy.

The Hindus, as is well known, place the earth in the centre of the world, and make the Sun and Moon and minor planets revolve round it, apparently in concentric orbits, with unequal or irregular motion. For a physical explanation of the phænomena, they imagine the planets driven by currents of air along their respective orbits (besides one great vortex carrying stars and planets with prodigious velocity, round the earth, in the compass of a day). The winds or currents, impelling the several planets, communicate to them velocities, by which their motion should be equable and in the plane of the ecliptic; but the planets are drawn from this course by certain controlling powers, situated at the apogees, conjunctions, and nodes.

These powers are clothed by Hindu imaginations with celestial bodies invisible to human sight, and furnished with hands and reins, by which they draw the planets from their

• Даравнаї.



direct path and uniform progress. The being at the apogee, for instance, constantly attracts the planet towards itself, alternately, however, with the right and left hands. The deity of the node diverts the planet, first to one side then to the other, from the ecliptic. And lastly, the deity at the conjunction causes the planet to be one while stationary, another while retrograde, and to move at different times with velocity accelerated or retarded. These fancied beings are considered as invisible planets; the nodes and apogees having a motion of their own in the ecliptic.

This whimsical system, more worthy of the mythologist than of the astronomer, is gravely set forth in the Súrya siddhánta: and even BHÁSCARA gives into it, though not without indications of reluctant acquiescence; for he has not noticed it in his text, and only briefly in his notes.

To explain on mathematical principles the irregularity of the planetary motions, the Hindu astronomers remove the earth from the centre of the planet's orbit, and assume the motion in that excentric to be really equable, though it appear irregular as viewed from the earth. Another hypothesis is also taught by them; according to which the planet revolves with an equal but contrary motion in an epicycle, of which the centre is carried with like but direct motion on a concentric orbit.

BHÁSCABA remarks, that both theories are equivalent, giving the same results in computation: but he maintains, that the planet's motion in an excentric orbit (pratimandala) is consonant to the truth; and the other hypothesis of an epicycle (nichóchcha writta) is merely a device for the facility of computation.

Both theories, with certain modifications, which will be subsequently noticed, suffice for the anomaly of the Sun and Moon. To account for the still greater apparent irre-

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gularities of the five minor planets, the Hindu astronomers make them revolve with direct motion on an epicycle borne on an excentric deferent. (In the case of the two inferior planets, the revolution in the excentric is performed in the same time with the Sun: consequently the planet's motion in its epicycle is in fact its proper revolution in its orbit. In the instance of the superior planets, on the contrary, the epicycle corresponds in time to a revolution of the Sun, and the excentric deferent answers to the true revolution of the planet in its orbit.)

So far the Indian system, as already remarked by Mr. DAVIS in his treatise on the astronomical computations of the Hindus,\* agrees with the Ptolemaic. At the first glance it will remind the reader of the hypothesis of an excentric orbit devised by HIPPARCHUS; and of that of an epicycle on a deferent, said to have been invented by APOLLONIUS, but applied by HIPPARCHUS. At the same time the omission of an equant (having double the excentricity of the deferent) imagined by PTOLEMY for the five minor planets, as well as the epicycle with a deferent of the centre of the excentric, contrived by him to account for the evection of the Moon; and the circle of anomaly of excentricity, adapted to the inequality of Mercury's motions, cannot fail to attract notice.

The Hindus, who have not any of PTOLEMY'S additions to the theory of HIPPARCHUS, have introduced a different modification of the hypothesis, for they give an oval form to the excentric or equivalent epicycle, as well as to the planet's proper epicycle. That is, they assume the axis of the epicycle greater at the end of the (sama) even quadrants of anomaly (or, in the line of the apsides and conjunctions), and least at the end of the (vishama) odd

\* As. Res., vol. ii. p. 250.

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quadrants (1st and 3d), and intermediately in proportion.\* This contrivance of an oval epicycle is applied by certain astronomers to all the planets; and by others, is restricted to few; and by some, is altogether rejected. ÁRYABHATTA, for example, and the Súrya siddhánta, make both epicycles of all the planets oval, placing however the short axis of the proper epicycles of Jupiter and Saturn in the line of mean conjunction, termed by Hindu astronomers their quick apogee (sighróchcha). BRAHMEGUPTA and BHÁSCARA, on the contrary, acknowledge only the epicycles of Mars and Venus to be oval, and insist that the rest are circular. The author of the Siddhánta sárvabhauma goes a step further, maintaining that all are circular, and taking the mean between the numbers given in the Súrya siddhánta.

• Rad: Sine of anomaly :: Diff. between circles described on greatest and least axis : Diff. between circles described on greatest axis and on the diameter of the epicycle for the proposed anomaly. Whence the circle described on that diameter is determined; and is used for the epicycle in computations for that anomaly. Since circles are to each other as their radii, the proportion above stated answers to the following; semitransverse axis : diff. between transverse and conjugate semiaxis :: ordinate of the circle : a fourth proportional; which is precisely the difference between that ordinate and an ordinate of the ellipse for the same absciss. Hindu astronomers take it for the difference between the radius of the circumscribed circle and the semidiameter of the ellipse at an angle with the axis equal to the proposed anomaly; and, in an ellipsis very little excentric, the error is small.



DIMENSIONS OF THE EPICYCLES IN DEGREES OF THE DEFERENT.

Epicycle of anomaly	⊙ 13° 40′	<b>C</b> 31° 36'	<sup>5</sup> 0 70° ± 6° 40 <sup>™</sup>	¥ 38° 0'	24 33° 0'	\$ 11°&9°†	ъ 80° 0'	
BRASCARA	-	-	×	-	-	-	50 0	
circle described on the great axis of the aval epicycle	14 0	32 0	75 0 —	30 0	33 0	12	49 0	
Circle described on the less axis	18 40	31 40	72 0 —	28 0	32 0	11	48 0	
Proper epicycle ВКАНМЕВUPTA,		-	$243 40 \pm 6 40$	* 132 0	68 0	258&263†	40 0	
Circle on the great axis of the oval epicycle (Súrya siddhánta)	-	-	235 0 —	133 0	72 0	262	40 0	
Circle on the less axis,		-	232 0 -	132 0	70 0	260	39 0	

\* The spicycles of Mars, according to BRAHMEGUPTA and BHASCARA, are increased in six signs and diminished in six other signs of anomaly, by a quantity found by this proportion; sine of 45°: sine or cosine of anomaly (whichever be the least) :: 6° 40': correction additive in six first signs, and subtractive in six last.

+ The epicycles of Venus are oval, and the circles described on the transverse and conjugate axis (circles circumscribed and inscribed) are here stated.

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A further difference of theory, though not of practice, occurs among the Hindu astronomers, in regard to curvature of the excentric deferents, and the consequent method of computing on the equivalent hypothesis of epicycles.

A reference to Mr. DAVIS'S Essay,<sup>\*</sup> and to the diagrams which accompany it, will render intelligible what has been already said, and what now remains to be explained. It is there observed, that it is only in computing the retrogradations, and other particulars respecting the minor planets, that the Hindus find the length, of the carńa  $\in \bigoplus^+$  (or line drawn from the centre of the earth to the planet's place in the epicycle). In other cases, as for the anomalistic equation of the Sun and Moon, they are satisfied to take hc as equal to the sine  $lm^+_{,}$  (that is, the sine of mean anomaly, reduced to its dimensions in the epicycle in parts of the radius of the concentric, equal to the sine of the anomalistic equation). The reason is subjoined: 'The difference, as the commentator on the Súrya siddhdata observes, being inconsiderable.'

Most of the commentators on the Súrya siddhánta do assign that reason; but some of them adopt BRAHME-GUPTA'S explanation. This astronomer maintains, that the operation of finding the carna is rightly omitted in respect of the excentrics or equivalent epicycles of all the planets, and retained in regard to the proper epicycles of the minor planets carried by the excentric deforents. His hypothesis, as briefly intimated by himself, and as explained by BHÁSCARA, supposes the epicycle, which represents the excentric, to be augmented in the proportion

\* As. Res., vol. ii. p. 249.

† As. Res., vol. ii. p. 250. Diagram, fig. 2.

\$ Ibid.

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which carna (or the distance of the planet's place from the earth's centre) bears to the radius of the concentric; and it is on this account, and not as a mere approximation, that the finding of the carna, with the subsequent operation to which it is applicable, is dispensed with.\*

The scholiast of BRAHMEGUPTA objects to his author's doctrine on this point, that, upon the same principle, the process of finding the carha, with the subsequent employment of it to find the sine of the anomalistic equation, should in like manner be omitted in the proper epicycle of the five minor planets; and he concludes therefore, that the omission of that process has no other ground, but the very inconsiderable difference of the result in the instance of a small epicycle. For, as remarked by another author,† treating on the same subjet, the equation itself and its sine are very small near the line of the apsides; and at a distance from that line, the carha and radius approach to equality.

BHASCARA, in the *Śirómańi*, quotes succinctly BRAH-MEGUPTA's doctrine, and the scholiast's objection to it; and replies to the latter: and in his notes in the Vásaná bháshya cites the text of BRAHMEGUPTA and CHATURvéDA's reasoning, which he tries to confute. His quotation agrees perfectly with the present text of the Brahme

• For Rad : periphery of the epicycle :: carsa : sugmented epicycle. And circle : sine of anomaly :: augmented epicycle : sine of anomaly in augmented epicycle.

Lastly, carna: sine of anomaly in augmented epicycle :: radius : sine of anomalistic equation.

Whence periphery  $\times \frac{Carna}{Radius} \times \frac{Radius}{Carns} \times \frac{Sine of Anomaly}{Circle} \equiv sine of anomalistic equation.$ 

And, abridging, periphery  $\times \frac{\text{Sine of Anomaly}}{\text{Circle}} \equiv \text{sine of anomalistic equation.}$ 

† In the Marichi.

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sp'huta siddhánta and commentary of CHATORVEDA PRI-T'HÚDACA SWÁMÍ, which is annexed to it.

The passage which has required so much preparatory explanation, is itself short :

# चिज्याभकः कर्णः परिधिगुणोवाडकोटिंगुणकारः । असलन्मन्दे तत्पालमाद्यसमं नाच कर्णो ऽस्मात् ॥

'The carna, or longest side of the triangle, multiplied by the periphery of the epicycle and divided by radius, becomes the multiplier of the sine and cosine of anomaly. The same result, as before, is obtained by a single operation in the instance of the anomalistic epicycle: and therefore carna is not here employed.'

BLASCARA's words in the *Śirómańi* are these: 'Some say that in this system, in the operation of finding the equation of anomaly, the carńa or long side of the triangle, is not employed, because the difference in the two modes of computation is very inconsiderable. But others maintain that, if the carńa be used, the periphery of the epicycle must in this operation be corrected, by multiplying it by carńa and dividing by radius. Wherefore the result is the same as by the former method; and on that account, they say, the carńa is not employed. It is not to be objected, why is not the same method used in the *sighra* epicycle ? For the principles of the two differ.'

In his notes on this part of his text, he cites, as before observed, the precise passage of BRAHMEGUPTA which has been inserted above, and a portion of CHATURVÉDA'S comment on it, and names the author.

In another instance BHASCARA quoted in his Śirómańi BRAHMEGUPTA by name, and the commentator by implication, (and fuller quotations of both occur in the notes and commentaries), for a disagreement in regard to the latitude

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of stars and planets measured from the ecliptic both on a circle drawn through its poles, and on one passing through the poles of the equator; the latter termed sphuta or apparent, and the other asp'huta or unapparent.\* BHASCARA remarks that BRAHMEGUPTA has directed the latitudes of planets to be computed by one mode, and has given those of the stars in the other, but has stated no rule for reducing the latitude of one denomination to the other, or for rectifying the true latitude from the measure given on the circle of declination. The reason he considers to be the little difference between them (which is true in respect of the planets, though not so in the case of most of the stars), and the frequent occasion in astronomical computations, for the declination of stars, while their proper latitude is not an element in any calculation ; whereas, in the case of the planets, both are employed on different occasions: he adverts to a strained interpretation proposed by the commentator to construe BRAHMEGUPTA's rule as adapted to the same denomination of latitude which is employed by him for the stars. BHASCARA refutes that interpretation, and justifies BRAHMEGUPTA's text taken in its obvious and natural sense.

This passage of the Sirómani+ confirms what was said

\* Asp'hula sara is the true latitude of a star or planet : <math>sp'hula sara is its declination  $\pm$  declination of the point of intersection in the ecliptic.

† त्रह्मगुप्तादिभिः खच्यात्तरत्वात्मछतः स्फुटः । स्थित्यर्इपरिचेखादी गणितागत एव हि ॥ नचचाणां स्फुटा एव स्थिरत्वात्पटिताः ग्रराः । दृद्धर्भणायनेनेषां संस्कृताञ्च तथा धुवाः ॥ &c. अठावंत्रेभ्रं dhyáya, c. viii. v. 11, &c.



by me, from other authority, in a former essay,\* concerning the Hindu method of determining a star's place with reference to the ecliptic, by the intersection of a circle of declination, and by taking the latitude and longitude of the star to that point of intersection, instead of employing a perpendicular to the ecliptic.

The only other passage to which I shall draw the reader's attention, is one of considerable length, in which BRAHME-GUPTA, although he has rightly given the theory of solar and lunar eclipses, with the astronomical principles on which they are to be computed, affirms in compliance with the prejudices of Hindu bigots, the existence of Ráhu as an eighth planet and as the immediate cause of eclipses, and reprehends VARAHAMIHIRA, ÁRVABHATTA, ŚRÍSHÉŃA and VISHŃUCHANDRA for rejecting this orthodox explanation of the phenomenon. The passage is quoted by BHÁSCARA'S commentator in the *Chintamanii* on the occasion of a more concise text of the *Śirómanii* affirming the agency of *Ráhu* in eclipses.<sup>+</sup>

This quotation from the Bråhme siddhånta comprising seven couplets in the Chintamani, has been verified in the text of the Bråhme spihuta siddhånta of BRAHMEGUPTA.<sup>‡</sup>

All these, with numerous other instances in the annotations and commentaries of the *Śirómańi*, which I refrain from adducing, lest the reader's patience should be tired, have established to my entire conviction the genuineness of the *Sp'huta siddhánta* founded on a prior trestise entitled *Bráhme siddhánta*.

I am not unapprised, that, under a feeling of great distrust or unwillingness to admit the conclusions which follow from this position, a variety of hypotheses might be formed

† Part 2, ch. vii. v. 10. ‡ Goladhydya

<sup>\*</sup> As. Res., vol. ix. [p. 324, &c. of the present volume.]

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to a different effect. BRAHMEGUPTA, supposing him to be entirely an original writer, may have referred to an imaginary work to give that kind of authority to his performance which the Hindus most fancy; or he may have fathered on a purdha a synopsis of his own doctrine for the same purpose; or some other writer, from whatever motive, may have fabricated a pretended extract of a purdna containing the heads of BRAHMEGUPTA's system, and have given currency to it on the strength of the reference in that astronomer's treatise to an anterior work. These and other suppositions grounded on surmise of fraud and forgery may be formed. I shall not discuss them : for I have no concern but with the facts themselves. BHASCABA, writing 650 years ago, declares, and so do all his commentators, that he has followed BRAHMEGUPTA as his guide. They quote numerous passages from his work; and BHASCARA affirms that BRAHMEGOPTA took the number of revolutions assigned to the planets in the great period termed calpa from an earlier authority. The commentators, who wrote from two to four centuries ago, assert, that those numbers were taken from a treatise in form of dialogue between BHAGAVAT (or BRAHMA) and BHRIGU, inserted in the Vishnu dharmóttara purana and distinguished by the title of Bráhma or Paitámaha siddhánta. They cite parallel passages, which do in fact exactly accord in sense and import. They occasionally quote observations on BRAHMEGUPTA by his scholiast CHATURVEDA PRIT'HÚ-DACA SWAMI. A book is extant (a copy, partly deficient, however, having come into my possession with other astronomical collections) and which consists of a text under the title of Brahme sp'hutá siddhanta accompanied by a continual commentary by CHATURVEDA PRIT'HUDACA SWAMI. The text contains the same astronomical doctrine which BHASCARA teaches, and which he professes to have derived

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from BRAHMEGUPTA; and passages quoted by him in his text, or at more length in his notes, or by his commentators, or by other astronomical writers, as the words of BRAHME-GUPTA, are found verbatim in it. I consider it therefore as the genuine text of the treatise used by BHASCARA, as BRAHMEGUPTA'S; and seeing no reason for suspicion and distrust, I quote it as the authentic work of that celebrated astronomer.

As the evidence which has been here collected with reference to particular points, bears also upon other questions, I shall now state further conclusions, regarding the history of Indian astronomy, which appear to me to be justly deducible from the premises. Those conclusions will be supported, when necessary, by additional references to authorities.

BRAHMEGUPTA and VARAHAMIHIRA, though named at the head of astronomers by BHASCARA and SATÁNANDA and by the herd of later writers, are not to be considered as the authors of the Indian system of astronomy. They abound in quotations from more ancient astronomers, upon whose works their own are confessedly grounded. In addition to the names before-mentioned,\* those of PRA-DYUMNA, LALA SINHA, and LADHACHARYA, may be here specified. But the Brdhme siddháata and the works of ÁRYABHAŤTA are what principally engages BRAHME-GUPTA's attention: and the five Siddhántas have been the particular subject of VARAHAMIHIRA'S labours. He appears to have been anterior to BRAHMEGUPTA, being actually eited by him among other writers, whose errors are exposed and corrected.

VARAHAMIHIRA, constantly quoted as the author of the Váráhí sanhitá and Pancha siddhánticá, must be

> \* Page 386. 2 B 2

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judged from those works, which are undoubtedly his by the ananimous consent of the learned, and by the testimony of the ancient scholiast BHATTÓTPALA. The minor works, ascribed to the same author, may have been composed in later times, and the name of a celebrated author have been affixed to them, according to a practice, which is but too common in India as in many other countries. The Jdtaedrhava, for example, which has been attributed to him, may not improbably be the work of a different author. At least, I am not apprized of any collateral evidence (such as quotations from it in books of some antiquity) to support its genuineness, as a work of VARAHAMIHIRA'S.

In the Varahi sanhita, this author has not followed the system which is taught in the Sarya Siddhanta. For instance, his rule for finding the year of the cycle of sixty years, founded on the mean motions of Jupiter, shews that he employed a different number from that which the Sarya siddhanta furnishes, viz. 364,224 revolutions in a yuga, instead of 364,200; and it appears from a quotation of the scholiast that ARYABHATTA is the authority for that number of revolutions of Jupiter.

Before the age of VARAHAMIHIRA and BRAHME-GUPTA, and subsequently to that of GARGA, a number of illustrious astronomers flourished, by whom the science was cultivated and promoted, but whose works unhappily are lost, or at least have not been yet recovered, and are at present known to us only by quotation. No less than ten intermediate writers are cited by BRAHMEGUPTA; of whom five at the least are noticed by VARAHAMIHIRA.\*

The proficiency of the Yavanas in astronomy was known to VARAHAMIHIRA. He has mentioned it with applause,

\* See before, p. 386, 388, and 409.

के की च्छा हि यवनारतेषु सम्यक्षास्त्रभिदं स्थितं ।



and has more than once referred to the authority of their writers. The name of YAVAN ACHARYA, which occurs frequently in the compilations of Hindu astronomers,<sup>\*</sup> has apparently reference to an author of that nation; which is characterized by VARAHAMIHIRA as a people of *Mléck'kas*, or barbarians. The title of *Rómaca' siddhánta*, given by Śrisuńwa, to his astronomical treatise, which is quoted under this title by VARAHAMIHIRA and BRAHMEGUPTA, may be presumed also to carry some allusion to the system of the astronomers of the West.

If these circumstances, joined to a resemblance hardly to be supposed casual, which the Hindu astronomy, with its apparatus of excentrics and epicycles, bears in many respects to that of the Greeks, be thought to authorize a belief, that the Hindus received from the Greeks that knowledge which enabled them to correct and improve their own imperfect astronomy, I shall not be inclined to dissent from the opinion. There does, indeed, appear ground for more than a conjecture, that the Hindus had obtained a knowledge of Greeian astronomy before the Arabs began to cultivate the science; and that the whole cluster of astronomers mentioned by BRAKMEGUPTA must be placed in the interval between the age of HIPPARCHUS, and possibly that of PTOLEMY, and the date of BRAHMEGUPTA's revision of the Brahme siddhánta.

In reforming the Indian astronomy, BEAHMEGUPTA, and the astronomers who preceded him, did not take implicitly the mean motions of the planets given by the Gre-

# चिषिवनेऽपि पूज्यने किं पुनर्देवविद्विजः ॥

"For the *Favanas* are barbarians; but this science is well established among them; and they are revered like holy sages: much more shall a priest who is learned in it be venerated."

\* As. Res., vol. ix. p. 376 [see p. 365, 367, and 368 of the present volume.]