that of the middle, and likewise between that of the separation and that of the middle.

15. Describe two fish-figures (matsya): from the middle of these having drawn out two lines projecting through the mouth and tail, wherever their intersection takes place.

16. There, with a line touching the three points, describe an arc: that is called the path of the eclipsing body, upon which the latter will move forward.

The deflection and the latitude of three points in the continuance of the eclipse having been determined and laid down upon the projection, it is deemed unnecessary to take the same trouble with regard to any other points, these three being sufficient to determine the path of the eclipsing body: accordingly, an arc of a circle is drawn through them, and is regarded as representing that path. The method of describing the arc is the same with that which has already been more than once employed (see above, iii. 1, 41-42): it is explained here with somewhat more fulness than before.

Thus, in the figure, T T and T are the three extremities of the moon's latitude, at the moments of contact, opposition, and separation, respectively: we join T T' T' T, and upon these lines describe fish-figures (see note to iii. 1-3): their two extremities ("mouth" and "tail") are indicated by the intersecting dotted lines in the figure: then, at the point, not included in the figure, where these lines drawn through them meet one another, is the centre of a circle passing through T, T', and T.

17. From half the sum of the eclipsed and eclipsing bodies subtract the amount of obscuration, as calculated for any given time: take a little stick equal to the remainder, in digits, and from the central point.

18. Lay it off toward the path upon either side—when the time is before that of greatest obscuration, toward the side of contact; when the obscuration is decreasing, in the direction of separation—and where the stick and the path of the eclipsing body meet one another, from that point describe a circle with a radius equal to half the eclipsing body: whatever of the eclipsed body is included within it, that point out as swallowed up by the darkness (tamas).

19. Take a little stick equal to half the difference of the measures (māna), and lay it off in the direction of contact, calling it the stick of immersion (nimilum): where it touches the path.

20. From that point, with a radius equal to half the eclipsing body, draw a circle, as in the former case: where this meets the circle of the eclipsed body, there immersion takes place.

21. So also for the emergence (unmilana), lay it off in the direction of separation, and describe a circle, as before: it will show the point of emergence in the manner explained.
The method of these processes is so clear as to call for no detailed explanation. The centre of the eclipsing body being supposed to be always in the arc $\frac{1}{4} \beta$, drawn as directed in the last passage, we have only to fix a point in this arc which shall be at a distance from $M$ corresponding to the calculated distance of the centres at the given time, and from that point to describe a circle of the dimensions of the eclipsed body, and the result will be a representation of the then phase of the eclipse. If the point thus fixed be distant from $M$ by the difference of the two semi-diameters, as $M$, $M$ $\ell$, the circles described will touch the disk of the eclipsed body at the points of immersion and emergence, $i$ and $e$.

28. The part obscured, when less than half, will be dusky (sadḥānuma); when more than half, it will be black; when emerging, it is dark copper-color (kṛdinākārām): when the obscuration is total, it is tawny (lalīja).

The commentary adds the important circumstance, omitted in the text, that the moon alone is here spoken of; no specification being added with reference to the sun. Because, in a solar eclipse, the part obscured is always black.

A more suitable place might have been found for this verse in the fourth chapter, as it has nothing to do with the projection of an eclipse.

24. This mystery of the gods is not to be imparted indiscriminately: it is to be made known to the well-tried pupil, who remains a year under instruction.

The commentary understands by this mystery, which is to be kept with so jealous care, the knowledge of the subject of this chapter, the delineation of an eclipse, and not the general subject of eclipses, as treated in the past three chapters. It seems a little curious to find a matter of so subordinate consequence heralded so pompously in the first verse of the chapter, and guarded so cautiously at its close.

CHAPTER VIII.

OF PLANETARY CONJUNCTIONS.

Contents:—1, general classification of planetary conjunctions; 2–6, method of determining at what point on the ecliptic, and at what time, two planets will come to have the same longitude; 7–10, how to find the point on the ecliptic to which a planet, having latitude, will be referred by a circle passing through the north and south points of the horizon; 11, when a planet must be so referred; 12, how to ascertain the interval between two planets when in conjunction upon such a north and south line; 13–14, dimensions of the lesser planets; 15–18, modes of exhibiting the coincidence between the calculated and actual places of the planets; 18–20, definition of different kinds of conjunction; 20–21, when a planet, in con-
Translation and Notes.

junction, is vanquished or victor; 22, farther definition of different kinds of conjunction; 23, usual prevalence of Venus in a conjunction; 24, planetary conjunctions with the moon; 24, conjunctions apparent only; why calculated.

1. Of the star-planets there take place, with one another, encounter (yuddha) and conjunction (samāyama); with the moon, conjunction (samāyama); with the sun, heliacal setting (ustamana).

The "star-planets" (tātrāyaka) are, of course, the five lesser planets, exclusive of the sun and moon. Their conjunctions with one another and with the moon, with the asterisms (nakṣatra), and with the sun, are the subjects of this and the two following chapters.

For the general idea of "conjunction" various terms are indifferently employed in this chapter, as samāyama, "coming together", samyoga, "conjunction," yōga, "junction" (in viii. 14, also, melaka, "meeting"): the word yuni, "union," which is constantly used in the same sense by the commentary, and which enters into the title of the chapter, yuḥya-yuntyādikāra, does not occur anywhere in the text. The word which we translate "encounter," yuddha, means literally "war, conflict." Verses 18-20, and verse 22, below, give distinctive definitions of some of the different kinds of encounter and conjunction.

2. When the longitude of the swift-moving planet is greater than that of the slow one, the conjunction (samāyam) is past; otherwise, it is to come: this is the case when the two are moving eastward; if, however, they are retrograding (vākrin), the contrary is true.

3. When the longitude of the one moving eastward is greater, the conjunction (samāyama) is past; but when that of the one that is retrograding is greater, it is to come. Multiply the distance in longitude of the planets, in minutes, by the minutes of daily motion of each,

4. And divide the products by the difference of daily motions, if both are moving with direct, or both with retrograde, motion: if one is retrograding, divide by the sum of daily motions.

5. The quotient, in minutes, etc., is to be subtracted when the conjunction is past, and added when it is to come: if the two are retrograding, the contrary: if one is retrograding, the quotients are additive and subtractive respectively.

6. Thus the two planets, situated in the zodiac, are made to be of equal longitude, to minutes. Divide in like manner the distance in longitude, and a quotient is obtained which is the time, in days, etc.

The object of this process is to determine where and when the two planets of which it is desired to calculate the conjunction will have the same longitude. The directions given in the text are in the main so clear as hardly to require explication. The longitude and the rate of motion of the two planets in question is supposed to have been found for some time not far removed from that of their conjunction. Then, in
determining whether the conjunction is past or to come, and at what distance, in arc and in time, three separate cases require to be taken into account—when both are advancing, when both are retrograding, and when one is advancing and the other retrograding. In the two former cases, the planets are approaching or receding from one another by the difference of their daily motions; in the latter, by the sum of their daily motions. The point of conjunction will be found by the following proportion: as the daily rate at which the two are approaching or receding from each other is to their distance in longitude, so is the daily motion of each one to the distance which it will have to move before, or which it has moved since, the conjunction in longitude. The time, again, elapsed or to elapse between the given moment and that of the conjunction, will be found by dividing the distance in longitude by the same divisor as was used in the other part of the process, namely the daily rate of approach or separation of the two planets.

The only other matter which seems to call for more special explanation than is to be found in the text is, at what moment the process of calculation, as thus conducted, shall commence. If a time be fixed upon which is too far removed—as, for instance, by an interval of several days—from the moment of actual conjunction, the rate of motion of the two planets will be liable to change in the mean time so much as altogether to vitiate the correctness of the calculation. It is probable that, as in the calculation of an eclipse (see above, note to iv. 7–8), we are supposed, before entering upon the particular process which is the subject of this passage, to have ascertained, by previous tentative calculations, the midnight next preceding or following the conjunction, and to have determined for that time the longitudes and rates of motion of the two planets. If so, the operation will give, without further repetition, results having the desired degree of accuracy. The commentary, it may be remarked, gives us no light upon this point, as it gave us none in the case of the eclipse.

We have not, however, thus ascertained the time and place of the conjunction. This, to the Hindu apprehension, takes place, not when the two planets are upon the same secondary to the ecliptic, but when they are upon the same secondary to the prime vertical, or upon the same circle passing through the north and south points of the horizon. Upon such a circle two stars rise and set simultaneously; upon such a one they together pass the meridian; such a time, then, determines approximately their relative height above the horizon, each upon its own circle of daily revolution. We have also seen above, when considering the deflection (valana—see iv. 24–25), that a secondary to the prime vertical is regarded as determining the north and south directions upon the starry concave. To ascertain what will be the place of each planet upon the ecliptic when referred to it by such a circle is the object of the following processes.

7. Having calculated the measure of the day and night, and likewise the latitude (vikshepa), in minutes; having determined the meridian-distance (nata) and altitude (unnata), in time, according to the corresponding orient ecliptic-point (lagna)—
Translation and Notes.

8. Multiply the latitude by the equinoctial shadow, and divide by twelve; the quotient multiply by the meridian-distance in nadis, and divide by the corresponding half-day:

9. The result, when latitude is north, is subtractive in the eastern hemisphere, and additive in the western; when latitude is south, on the other hand, it is additive in the eastern hemisphere, and likewise subtractive in the western.

10. Multiply the minutes of latitude by the degrees of declination of the position of the planet increased by three signs: the result, in seconds (vikula), is additive or subtractive, according as declination and latitude are of unlike or like direction.

11. In calculating the conjunction (yoga) of a planet and an asterism (nakshatra), in determining the setting and rising of a planet, and in finding the elevation of the moon’s cusps, the operation for apparent longitude (vrikkarmun) is first prescribed.

12. Calculate again the longitudes of the two planets for the determined time, and from these their latitudes: when the latter are of the same direction, take their difference; otherwise, their sum: the result is the interval of the planets.

The whole operation for determining the point on the ecliptic to which a planet, having a given latitude, will be referred by a secondary to the prime vertical, is called its vrikkaran. Both parts of this compound we have had before—the latter, signifying “operation, process of calculation,” in ii. 37, 42, etc.—for the former, see the notes to iii. 28-31, and v. 5-6: here we are to understand it as signifying the “apparent longitude” of a planet, when referred to the ecliptic in the manner stated, as distinguished from its true or actual longitude, reckoned in the usual way: we accordingly translate the whole term, as in verse 11, “operation for apparent longitude.” The operation, like the somewhat analogous one by which the ecliptic-deflection (cukana) is determined (see above, iv. 24-25), consists of two separate processes, which receive in the commentary distinct names, corresponding with those applied to the two parts of the process for calculating the deflection. The whole subject may be illustrated by reference to the next figure (Fig. 29). This represents the projection of a part of the sphere upon a horizontal plane, N and E being the north and east points of the horizon, and Z the zenith. Let C L be the position of the ecliptic at the moment of conjunction in longitude, C being the orient ecliptic-point (layana); and let M be the point at which the conjunction in longitude of the two planets S and V, each upon its parallel of celestial latitude, c L and c L’, and having latitude equal to SM and VM respectively, will take place. Through V and S draw secondaries to the prime vertical, N V and N S, meeting the ecliptic in v and s: these latter are the points of apparent longitude of the two planets, which are still removed from a true conjunction by the distance v s: in order to the ascertainment of the time of that true conjunction, it is desired to know the positions of v and s, or their respective distances from M. From P, the pole of the equator, draw also circles through the two planets, meeting the ecliptic in s’ and v’: then,
in order to find $M'$, we ascertain the values of $s's'$ and $M's'$; and, in like manner, to find $M$, we ascertain the values of $v'v'$ and $M'v'$. Now at the equator, or in a right sphere, the circles $NS$ and $PS$ would coincide, and the distance $s's'$ disappear: hence, the amount of $s's'$ being dependent upon the latitude (äkṣa) of the observer, $NP'$, the process by which it is calculated is called the "operation for latitude" (äkṣadyākkarmān, or ci čäkṣa dyākkarmān). Again, if $P'$ and $P''$ were the same point, or if the ecliptic and equator coincided, $PS$ and $P'S$ would coincide, and $M's'$ would disappear: hence the process of calculation of $M's'$ is called the "operation for ecliptic-deviation" (ayanaḥdyākkarmān, or ayana dyākkarmān). The latter of the two processes, although stated after the other in the text, is the one first explained by the commentary: we will also, as in the case of the deflection (note to iv. 24–25), give it our first attention.

The point $s'$, to which the planet is referred by a circle passing through the pole $P'$, is styled by the commentary ayanaṅgraḥa, "the planet's longitude as corrected for ecliptic-deviation," and the distance $M's'$, which it is desired to ascertain, is called ayanaṅkāḥās, "the correction, in minutes, for ecliptic-deviation." Instead, however, of finding $M's'$, the process taught in the text finds $M$, the corresponding distance on the circle of daily revolution, $DR$, of the point $M$—which is then assumed equal to $M's'$. The proportion upon which the rule, as stated in verse 10, is ultimately founded, is

$$R: \sin MST :: MS : Mt$$

the triangle $MST$, which is always very small, being treated as if it were a plane triangle, right-angled at $t$. But now also, as the latitude $MS$ is always a small quantity, the angle $PSP'$ may be treated as if equal to $PMP'$ (not drawn in the figure); and this angle is, as was shown in connection with iv. 24–25, the deflection of the ecliptic from the equator (ayana vaḷana) at $M$, which is regarded as equal to the declination of the point $90^\circ$ in advance of $M$: this point, for convenience's sake, we will call $M'$. Our proportion becomes, then
all the quantities which it contains being in terms of minutes. To bring
this proportion, now, to the form in which it appears in the text, it is
made to undergo a most fantastic and unscientific series of alterations.
The greatest declination (ii. 28) being 24°, and its sine 1387, which is
nearly fifty-eight times twenty-four—since 58 × 24 = 1382—it is assumed
that fifty-eight times the number of degrees in any given arc of declina-
tion will be equal to the number of minutes in the sine of that arc.
Again, the value of radius, 3438', admits of being roughly divided into
the two factors fifty-eight and sixty—since 58 × 60 = 3480. Substitut-
ing, then, these values in the proportion as stated, we have

58 × 60 : 58 × decl. M' in degr. :: latitude in min. : M t

Cancelling, again, the common factor in the first two terms, and trans-
ferring the factor 60 to the fourth term, we obtain finally

1 : decl. M' in degr. :: latitude in min. : M t × 60

that is to say, if the latitude of the planet, in minutes, be multiplied by
the declination, in degrees, of a point 90° in advance of the planet, the
result will be a quantity which, after being divided by sixty, or reduced
from seconds to minutes, is to be accepted as the required interval on
the ecliptic between the real place of the planet and the point to which
it is referred by a secondary to the equator.

This explanation of the rule is the one given by the commentator,
nor are we able to see that it admits of any other. The reduction of
the original proportion to its final form is a process to which we have
heretofore found no parallel, and which appears equally absurd and
uncalled for. That M t is taken as equivalent to M s' has, as will appear
from a consideration of the next process, a certain propriety.

The value of the arc M s' being thus found, the question arises, in
which direction it shall be measured from M. This depends upon the
position of M with reference to the solstitial colure. At the colure, the
lines PS and PS coincide, so that, whatever be the latitude of a planet,
if, by a secondary to the equator, be referred to the ecliptic at its
tue point of longitude. From the winter solstice onward to the summer
solstice, or when the point M is upon the sun's northward path (auka-
yana), a planet having north latitude will be referred backward on
the ecliptic by a circle from the pole, and a planet having south latitude
will be referred forward. If M, on the other hand, be upon the sun's south-
ward path (dakshinayana), a planet having north latitude at that point
will be referred forward, and one having south latitude backward: this
is the case illustrated by the figure. The statement of the text virtually
agrees with this, it being evident that, when M is on the northward
path, the declination of the point 90° in advance of it will be north; and
the contrary.

We come now to consider the other part of the operation, or the
akasha drkkarman, which forms the subject of verses 7-9. As the first
step, we are directed to ascertain the day and the night respectively of
the point of the ecliptic at which the two planets are in conjunction in
longitude, for the purpose of determining also its distance in time from
the horizon and from the meridian. This is accomplished as follows.
Having the longitude of the point in question (\(M\) in the last figure), we calculate (by ii. 28) its declination, which gives us (by ii. 60) the radius of its diurnal circle, and (by ii. 61) its ascensional difference; whence, again, is derived (by ii. 62–63) the length of its day and night. Again, having the time of conjunction at \(M\), we easily calculate the \(M's\) longitude at the moment, and this and the time together give us (by iii. 40–48) the longitude of \(C\), the orient ecliptic-point; then (by iii. 50) we ascertain directly the difference between the time when \(M\) rose and that when \(C\) rises, which is the altitude in time (\(umnata\)) of \(M\); the difference between this and the half-day is the meridian-distance in time (\(nata\)) of the same point. If the conjunction takes place when \(M\) is below the horizon, or during its night, its distance from the horizon and from the inferior meridian is determined in like manner.

The direct object of this part of the general process being to find the value of \(s s'\), we note first that that distance is evidently greatest at the horizon; farther, that it disappears at the meridian, where the lines \(PS\) and \(NS\) coincide. If, then, it is argued, its value at the horizon can be ascertained, we may assume it to vary as the distance from the meridian. The accompanying figure (Fig. 29) will illustrate the method by which it is attempted to calculate \(s s'\) at the horizon. Suppose the planet \(S\), being removed in latitude to the distance \(MS\) from \(M\), the point of the ecliptic which determines its longitude, to be upon the horizon, and let \(s'\), as before, be the point to which it is referred by a circle from the north pole; it is desired to determine the value of \(s s'\). Let \(DR\) be the circle of diurnal revolution of the point \(M\), meeting \(S s'\) in \(t\), and the horizon in \(w\):

\(S t\, w\) may be regarded as a plane right-angled triangle, having its angles at \(S\) and \(w\) respectively equal to the observer’s latitude and co-latitude. In that triangle, to find the value of \(t\, w\), we should make the proportion

\[
\cos t S\, w : \sin t S\, w :: t S : t w
\]

Now the first of these ratios, that of the cosine to the sine of latitude, is (see above, iii. 17) the same with that of the gnomon to the equinoctial shadow: again, as the difference of \(Mt\) and \(Ms'\) was in the preceding process neglected, so here the difference of \(SM\) and \(St\); and finally, \(tw\), the true result of the process, is accepted as the equivalent of \(s' s\), the distance sought. The proportion then becomes

\[
\text{gnom. : eq. shad. :: latitude : required dist. at horizon}
\]

The value of the required distance at the horizon having been thus ascertained, its value at any given altitude is, as pointed out above, determined by a proportion, as follows: as the planet’s distance in time from the meridian when upon the horizon is to the value of this correction at the horizon, so is any given distance from the meridian (\(nata\)) to the value at that distance; or

\[
\text{half-day : mer.-dist. in time :: result of last proportion : required distance}
\]

The direction in which the distance thus found is to be reckoned, starting in each case from the \(avya graha\), or place of the planet on the
ecliptic as determined by a secondary to the equator, which was ascer-
tained by the preceding process, is evidently as the text states it in verse
9. In the eastern hemisphere, which is the case illustrated by the figure,
s's is additive to the longitude of s', while v's is subtractive from the
longitude of v': in the western hemisphere, the contrary would be the
case. The final result thus arrived at is the longitude of the two points
to which S and V are referred by the circles N S and N V',
drawn through them from the north and south points of the horizon.

The many inaccuracies involved in these calculations are too palpable
to require pointing out in detail. The whole operation is a roughly
approximative one, of which the errors are kept within limits, and the
result rendered sufficiently correct, only by the general minuteness of
the quantity entering into it as its main element—namely, the latitude
of a planet—and by the absence of any severe practical test of its accu-

racy. It may be remarked that the commentary is well aware of, and
points out, most of the errors of the processes, excusing them by its
stereotyped plea of their insignificance, and the merciful disposition
of the divine author of the treatise.

Having thus obtained s and v, the apparent longitudes of the two
planets at the time when their true longitude is M, the question arises,
how we shall determine the time of apparent conjunction. Upon this
point the text gives us no light at all; according to the commentary, we
are to repeat the process prescribed in verses 2-6 above, determining,
from a consideration of the rate and direction of motion of the planets
in connection with their new places, whether the conjunction sought for
is past or to come, and then ascertaining, by dividing the distance v s
by their daily rate of approach or recession, the time of the conjunction.
It is evident, however, that one of the elements of the process of corre-
cction for latitude (akshardakkarman), namely the meridian-distance, is
changing so rapidly, as compared with the slow motion of the planets in
their orbits, that such a process could not yield results at all approaching
to accuracy: it also appears that two slow-moving planets might have
more than one, and even several apparent conjunctions on successive
days, at different times in the day, being found to stand together upon
the same secondary to the prime vertical at different altitudes. We,
do not see how this difficulty is met by anything in the text or in
the commentary. The text, assuming the moment of apparent conjunc-
tion to have been, by whatever method, already determined, goes on to
direct us, in verse 12, to calculate anew, for that moment, the latitudes
of the two planets, in order to obtain their distance from one another.
Here, again, is a slight inaccuracy: the interval between the two, meas-
ured upon a secondary to the prime vertical, is not precisely equal to
the sum or difference of their latitudes, which are measured upon second-
aries to the ecliptic. The ascertaining of this interval is necessary, in
order to determine the name and character of the conjunction, as will
appear farther on (v. 18-20, 22).

The cases mentioned in verse 11, in which, as well as in calculating
the conjunctions of two planets with one another, this operation for
apparent longitude (drakkarman) needs to be performed, are the subjects
of the three following chapters.
13. The diameters upon the moon's orbit of Mars, Saturn, Mercury, and Jupiter, are declared to be thirty, increased successively by half the half; that of Venus is sixty.

14. These, divided by the sum of radius and the fourth hypotenuse, multiplied by two, and again multiplied by radius, are the respective corrected (sphuta) diameters: divided by fifteen, they are the measures (mana) in minutes.

We have seen above, in connection with the calculation of eclipses (iv. 2–5), that the diameters of the sun, moon, and shadow had to be reduced, for measurement in minutes, to the moon's mean distance, at which fifteen yojanas make a minute of arc. Here we find the dimensions of the five lesser planets, when at their mean distances from the earth, stated only in the form of the portion of the moon's mean orbit covered by them, their absolute size being left undetermined. We add them below, in a tabular form, both in yojanas and as reduced to minutes, appending also the corresponding estimates of Tycho Brahe (which we take from Delambre), and the true apparent diameters of the planets, as seen from the earth at their greatest and least distances.

**Apparent Diameters of the Planets, according to the Sûrya-Siddhânta, to Tycho Brahe, and to Modern Science.**

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mars</td>
<td>30</td>
<td>2'</td>
<td>1' 50''</td>
<td>4'' 27''</td>
</tr>
<tr>
<td>Saturn</td>
<td>3-1/4</td>
<td>2' 30''</td>
<td>1' 45''</td>
<td>3'' 40''</td>
</tr>
<tr>
<td>Mercury</td>
<td>45</td>
<td>3'</td>
<td>2' 40''</td>
<td>4'' 27''</td>
</tr>
<tr>
<td>Jupiter</td>
<td>52-1/4</td>
<td>3' 15''</td>
<td>2' 45''</td>
<td>3'' 40''</td>
</tr>
<tr>
<td>Venus</td>
<td>60</td>
<td>4'</td>
<td>3' 12''</td>
<td>9'' 1' 14''</td>
</tr>
</tbody>
</table>

This table shows how greatly exaggerated are wont to be any determinations of the magnitude of the planetary orbs made by the unassisted eye alone. This effect is due to the well-known phenomenon of the irradiation, which increases the apparent size of a brilliant body when seen at some distance. It will be noticed that the Hindu estimates do not greatly exceed those of Tycho, the most noted and accurate of astronomical observers prior to the invention of the telescope. In respect to order of magnitude they entirely agree, and both accord with the relative apparent size of the planets, except that to Mercury and Venus, whose proportional brilliancy, from their nearness to the sun, is greater, is assigned too high a rank. Tycho also established a scale of apparent diameters for the fixed stars, varying from 2', for the first magnitude, down to 20'', for the sixth. We do not find that Ptolemy made any similar estimates, either for planets or for fixed stars.

The Hindus, however, push their empiricism one step farther, gravely laying down a rule by which, from these mean values, the true values of the apparent diameters at any given time may be found. The fundamental proportion is, of course,

true dist. : mean dist. :: mean app. diam. : true app. diam.
The second term of this proportion is represented by radius: for the first we have, according to the translation given, one half the sum of radius and the fourth hypothenuse, by which is meant the "variable hypothenuse" (cau karna) found in the course of the fourth, or last, process for finding the true place of the planet (see above, ii. 43–45). The term, however (tricitukkarna), which is translated "radius and the fourth hypothenuse" is much more naturally rendered "third and fourth hypothenuses"; and the latter interpretation is also mentioned by the commentator as one handed down by tradition (sampradayika): but, he adds, owing to the fact that the length of the hypothenuse is not calculated in the third process, that for finding finally the equation of the centre (mandakurman), and that that hypothenuse cannot therefore be referred to here as known, modern interpreters understand the first member of the compound (tri) as an abbreviation for "radius" (trijya), and translate it accordingly. We must confess that the other interpretation seems to us to be powerfully supported by both the letter of the text and the reason of the matter. The substitution of tri for trijya in such a connection is quite too violent to be borne, nor do we see why half the sum of radius and the fourth hypothenuse should be taken as representing the planet's true distance, rather than the fourth hypothenuse alone, which was employed (see above, ii. 56–58) in calculating the latitude of the planets. On the other hand, there is reason for adopting, as the relative value of a planet's true distance, the average, or half the sum, of the third hypothenuse, or the planet's distance as affected by the eccentricity of its orbit, and the fourth, or its distance as affected by the motion of the earth in its orbit. There seems to us a good reason, therefore, to suspect that verse 11—and with it, probably, also verse 13—is an intrusion into the Sūrya-Siddhānta from some other system, which did not make the grossly erroneous assumption, pointed out under ii. 30, of the equality of the sine of anomaly in the epicycle (bhujeyyaphala) with the sine of the equation, but in which the hypothenuse and the sine of the equation were duly calculated in the processes for finding the equation of the ap-as (mandakurman), as well as in that for finding the equation of the conjunction (asthrakurman).

15. Exhibit, upon the shadow-ground, the planet at the extremity of its shadow reversed: it is viewed at the apex of the gnomon in its mirror.

As a practical test of the accuracy of his calculations, or as a convincing proof to the pupil or other person of his knowledge and skill, the teacher is here directed to set up a gnomon upon ground properly prepared for exhibiting the shadow, and to calculate and lay off from the base of the gnomon, but in the opposite to the true direction, the shadow which a planet would cast at a given time; upon placing then, a horizontal mirror at the extremity of the shadow, the reflected image of the planet's disk will be seen in it at the given time by an eye placed at the apex of the gnomon. The principle of the experiment is clearly correct, and the rules and processes taught in the second and third chapters afford the means of carrying it out, since from them the shadow which any star would cast, had it light enough, may be as readily deter-
mined as that which the sun actually casts. As no case of precisely this character has hitherto been presented, we will briefly indicate the course of the calculation. The day and night of the planet, and its distance from the meridian, or its hour-angle, are found in the same manner as in the process previously explained (p. 168, above), excepting that here the planet's latitude, and its declination as affected by latitude, must be calculated, by ii. 58–59: and then the hour-angle and the ascensional difference, by iii. 34–36, give the length of the shadow at the given time, together with that of its hypotenuse. The question would next be in what direction to lay off the shadow from the base of the gnomon. This is accomplished by means of the base (bhujā) of the shadow, or its value when projected on a north and south line. From the declination is found, by iii. 20–22, the length of the noon-shadow and its hypothenuse, and from the latter, with the declination, comes, by iii. 22–23, the measure of amplitude (aphā) of the given shadow; whence, by iii. 23–25, is derived its base. Having thus both its length and the distance of its extremity from an east and west line running through the base of the gnomon, we lay it off without difficulty.

16. Take two gnomons, five cubits (hasta) in height, stationed according to the variation of direction, separated by the interval of the two planets, and buried at the base one cubit.

17. Then fix the two hypothenuses of the shadow, passing from the extremity of the shadow through the apex of each gnomon; and, to a person situated at the point of union of the extremities of the shadow and hypotenuse, exhibit

18. The two planets in the sky, situated at the apex each of its own gnomon, and arrived at a coincidence of observed place (ārya).

This is a proceeding of much the same character with that which forms the subject of the preceding passage. In order to make apprehensible, by observation, the conjunction of two planets, as calculated by the methods of this chapter, two gnomons, of about the height of a man, are set up. At what distance and direction from one another they are to be fixed is not clearly shown. The commentator interprets the expression “interval of the two planets” (v. 16), to mean their distance in minutes on the secondary to the prime vertical, as ascertained according to verse 12, above, reduced to digits by the method taught in iv. 20; while, by “according to the variation of direction,” he would understand merely, in the direction from the observer of the hemisphere in which the planets at the moment of conjunction are situated. The latter phrase, however, as thus explained, seems utterly nugatory; nor do we see of what use it would be to make the north and south interval of the bases of the gnomons, in digits, correspond with that of the planets in minutes. We do not think it would be difficult to understand the directions given in the text as meaning, in effect, that the two gnomons should be so stationed as to cast their shadows to the same point: it would be easy to do this, since, at the time in question, the extremities of two shadows cast from one gnomon by the two stars would be in the same north and
south line, and it would only be necessary to set the second gnomon as far south of the first as the end of the shadow cast by the southern star was north of that cast by the other. Then, if a hole were sunk in the ground at the point of intersection of the two shadows, and a person enabled to place his eye there, he would, at the proper moment, see both the planets with the same glance, and each at the apex of its own gnomon.

In the eighteenth verse also we have ventured to disregard the authority of the commentator: he translates the words द्युक्तुलयतम इद्दे "come within the sphere of sight," while we understand by द्युक्तुलयतम, as in other cases (ii. 14, iii. 11), the coincidence between observed and computed position.

Such passages as this and the preceding are not without interest and value, as exhibiting the rudeness of the Hindu methods of observation, and also as showing the unimportant and merely illustrative part which observation was meant to play in their developed system of astronomy.

18. . . . When there is contact of the stars, it is styled "de- piction" (विलेक्षण); when there is separation, "division" (धेडङ्गा);

19. An encounter (गृह्वल्लभ) is called "ray-oblitera- tion" (अंचु- विमर्द) when there is mutual mingling of rays: when the interval is less than a degree, the encounter is named "dexter" (अप- सर्यवा)—if, in this case, one be faint (अयोयः).

20. If the interval be more than a degree, it is "conjunction" (समागमा), if both are endowed with power (वल्लु). One that is vanquished (जित) in a dexter encounter (सर्यवा गृह्वल्लभ), one that is covered, faint (अयोयः), destitute of brilliancy,

21. One that is rough, colorless, struck down (विल्हवस्त), situated to the south, is utterly vanquished (अयोयः). One situated to the north, having brilliancy, large, is victor (जयिनः)—and even in the south, if powerful (वल्लु).

22. Even when closely approached, if both are brilliant, it is "conjunction" (समागमा): if the two are very small, and struck down, it is "front" (किदा) and "conflict" (विग्रहः), respectively.

23. Venus is generally victor, whether situated to the north or to the south . . .

In this passage, as later in a whole chapter (chap. xi), we quit the proper domain of astronomy, and trench upon that of astrology. However intimately connected the two sciences may be in practice, they are, in general, kept distinct in treatment—the Siddhântas, or astronomical text-books, furnishing, as in the present instance, only the scientific basis, the data and methods of calculation of the positions of the heavenly bodies, their eclipses, conjunctions, risings and settings, and the like, while the Sanhitâs, Jâtakas, Tâjikas, etc., the astrological treatises, make the superstitious applications of the science to the explanation of the planetary influences, and their determination of human fates. Thus the celebrated astronomer, Varâha-mihira, besides his astronomical works, composed separate astrological works, which are still extant, while the former have become lost. It is by no means impossible that these verses may be an interpolation into the original text of the Sûra-Siddhântas. They form only a disconnected fragment: it is not to be supposed that
they contain a complete statement and definition of all the different kinds of conjunction recognized and distinguished by technical appellations; nor do they fully set forth the circumstances which determine the result of a hostile "encounter" between two planets: while a detailed explanation of some of the distinctions indicated—as, for instance, when a planet is "powerful" or the contrary—could not be given without entering quite deeply into the subject of the Hindu astrology. This we do not regard ourselves as called upon to do here: indeed, it would not be possible to accomplish it satisfactorily without aid from original sources which are not accessible to us. We shall content ourselves with following the example of the commentator, who explains simply the sense and connection of the verses, as given in our translation, citing one or two parallel passages from works of kindred subject. We would only point out farther that it has been shown in the most satisfactory manner (as by Whish, in Trans. Lit. Soc. Madras, 1827; Weber, in his Indische Studien, ii. 230 etc.) that the older Hindu science of astrology, as represented by Varāha-mihira and others, repose entirely upon the Greek, as its later forms depend also, in part, upon the Arab; the latter connection being indicated even in the common title of the more modern treatises, tūjika, which comes from the Persian tūz, "Arab." Weber gives (Ind. Stud. ii. 277 etc.) a translation of a passage from Varāha-mihira's lesser treatise, which states in part the circumstances determining the "power" of a planet in different situations, absolute or relative; partial explanations upon the same subject furnished to the translator in India by his native assistant, agree with these, and both accord closely with the teachings of the Tetarabhūs, the astrological work attributed to Ptolemy.

23. . . . Perform in like manner the calculation of the conjunction (samyuga) of the planets with the moon.

This is all that the treatise says respecting the conjunction of the moon with the lesser planets: of the phenomenon, sometimes so striking, of the occultation of the latter by the former, it takes no especial notice. The commentator cites an additional half-verse as sometimes included in the chapter, to the effect that, in calculating a conjunction, the moon's latitude is to be reckoned as corrected by her parallax in latitude (asyanati), but rejects it, as making the chapter over-full, and as being superfluous, since the nature of the case determines the application here of the general rules for parallax presented in the fifth chapter. Of any parallax of the planets themselves nothing is said: of course, to calculate the moon's parallax by the methods as already given is, in effect, to attribute to them all a horizontal parallax of the same value with that assigned to the sun, or about 4°.

The final verse of the chapter is a caveat against the supposition that, when a "conjunction" of two planets is spoken of, it is meant than that they appear to approach one another when in fact they do not, this apparent approach requires to be treated with caution in its influence upon human fates.

24. Unto the good and evil fortune of men, this system set forth: the planets move on upon their own places, approaching one another at a distance.
CHAPTER VIII.
OF THE ASTERISMS.

Contents:—1–9, positions of the asterisms; 10–12, of certain fixed stars; 12, direction to test by observation the accuracy of these positions; 13, splitting of Rohini’s wain; 14–15, how to determine the conjunction of a planet with an asterism; 16–19, which is the junction-star in each asterism; 20–21, positions of other fixed stars.

1. Now are set forth the positions of the asterisms (bhā), in minutes. If the share of each one, then, be multiplied by ten, and increased by the minutes in the portions (bhāga) of the past asterisms (dhīshya), the result will be the polar longitudes (dhruva).

The proper title of this chapter is nakshatraparavattotpahikāra, “chapter of the conjunction of asterisms and planets,” but the subject of conjunction occupies but a small space in it, being limited to a direction (vv. 14–15) to apply, with the necessary modifications, the methods taught in the preceding chapter. The chapter is mainly occupied with such a definition of the positions of the asterisms—to which are added also those of a few of the more prominent among the fixed stars—as is necessary in order to render their conjunctions capable of being calculated.

Before proceeding to give the passage which states the positions of the asterisms, we will explain the manner in which these are defined. In the accompanying figure (Fig. 30), let E, L, represent the equator, and G, I, the ecliptic, P and P* their respective poles. Let S be the position of any given star, and through it draw the circle of declination P’ S a. Then a is the point on the ecliptic of which the distance from the first of Aries and from the star respectively are here given as its longitude and latitude. So far as the latitude is concerned, this is not unaccordant with the usage of the treatise hitherto. Latitude (vikshēpa, “dissection”) is the amount by which any body is removed from the declination which it ought to have—that is, from the point of the ecliptic which it ought to occupy—declination (krauṣṭi, apakrama) being always, according to the Hindu understanding of the term, in the ecliptic itself. In the case of a planet, whose proper path is in the ecliptic, the point of that circle which it ought to occupy is determined by its calculated longitude: in the case of a fixed star, whose only motion is about the pole of the heavens, its point of declination is that to which it is referred by a
circle through that pole. Thus, in the figure, the declination (krānti) of S would be c a, or the distance of a from the equator at e; its latitude (vikshepa) is a S, or its distance from a. We have, accordingly, the same term used here as before. To designate the position in longitude of a, on the other hand, we have a new term, dhruva, or, as below, (vv. 15), dhruvaka. This comes from the adjective dhruva, "fixed, immovable," by which the poles of the heaven (see below, xii. 43) are designated; and, if we do not mistake its application, it indicates, as here employed, the longitude of a star as referred to the ecliptic by a circle from the pole. We venture, then, to translate it by "polar longitude," as we also render vikshepa, in this connection, by "polar latitude," it being desirable to have for these quantities distinctive names, akin with one another. Colebrooke employs "apparent longitude and latitude," which are objectionable, as being more properly applied to the results of the process taught in the last chapter (vv. 7–10).

The mode of statement of the polar longitudes is highly artificial and arbitrary: a number is mentioned which, when multiplied by ten, will give the position of each asterism, in minutes, in its own "portion" (bhaga), or arc of 13° 26' in the ecliptic (see ii. 64).

This passage presents a name for the asterisms, dhishnya, which has not occurred before: it is found once more below, in vi. 21.

2. Forty-eight, forty, sixty-five, fifty-seven, fifty-eight, four, seventy-eight, seventy-six, fourteen.
3. Fifty-four, sixty-four, fifty, sixty, forty, seventy-four, seventy-eight, sixty-four.
4. Fourteen, six, four: Ûtara-Ashūḍhā, (vārca) is at the middle of the portion (bhaga) of Pūrva-Ashūḍhā (āpya); Abhijit, likewise, is at the end of Pūrva-Ashūḍhā; the position of Čravāna is at the end of Ûtara-Ashūḍhā;
5. Čravishthā, on the other hand, is at the point of connection of the third and fourth quarters (yudhi) of Čravāna: then, in their own portions, eighty, thirty-six, twenty-two.
6. Seventy-nine. Now their respective latitudes, reckoned from the point of declination (aupakrama) of each: ten, twelve, five, north; seven, five, ten, nine;
7. North, six: nothing; south, seven; north, nothing, twelve, thirteen; south, eleven, two: then thirty-seven, north;
8. South, one and a half, three, four, nine, five and a half, five; north, also, sixty, thirty, and also thirty-six;
9. South, half a degree; twenty-four, north, twenty-six degrees; nothing—for Čvīni (darsa), etc., in succession.

The text here assumes that the names of the asterisms, and the order of their succession, are so familiarly known as to render it unnecessary to rehearse them. It has been already noticed (see above, i. 48–51, 55, 56–58, etc.) that a similar assumption was made as regards the names and succession of the months, signs of the zodiac, years of Jupiter's cycle, and the like. Many of the asterisms have more than one appellation: we present in the annexed table those by which they are more
generally and familiarly known; the others will be stated farther on. Nearly all these titles are to be found in our text, occurring here and there; a few of the asterisms, however, (the 5th, 6th, 9th, and 17th), are mentioned only by apppellations derived from the names of the deities to whom they are regarded as belonging, and one (the 25th) changes not to be once distinctively spoken of. We append to the names, in tabular form, the data presented in this passage; namely, the position of each asterism (naksatras) in the arc of the ecliptic to which it gives name, and which is styled its "portion" (bhoga), the resulting polar longitudes, and the polar latitudes. And since it is probable (see note to the latter half of v. 12, below) that the latter were actually derived by calculation from true declinations and right ascensions, ascertained by observation, we have endeavored to restore those more original data by calculating them back again, according to the data and methods of this Siddhanta—the declinations by ii. 28, the right ascensions by iii. 44—48—and we insert our results in the table, rejecting odd minutes less than ten.

**Positions of the Jupiter-Stars of the Asterisms.**

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Position in its Portion</th>
<th>Polar Longitude</th>
<th>Polar Latitude</th>
<th>Right Ascension</th>
<th>True Declination</th>
<th>Interval in Longitude</th>
<th>Interval in R. A.</th>
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<td>10 o N</td>
<td>7 30 o</td>
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</tbody>
</table>
Our calculations, it should be remarked, are founded upon the assumption that, at the time when the observations were made of which our text speaks, the results, the vernal equinox coincided with the initial point of the Hindu sidereal sphere, or with the beginning of the portion of the asterism Aqrvi, a point 10° eastward on the ecliptic from the star Aqrvi; Piscium: this was actually the case (see above, under i. 27) about A. D. 600. The question how far this assumption is supported by evidence contained in the data themselves will be considered later. To fill out the table, we have also added the intervals in right ascension and in polar longitude.

The stars of which the text thus accurately defines the positions do not, in most cases, by themselves alone, constitute the asterisms (nakshatra); they are only the principal members of the several groups of stars—each, in the calculation of conjunctions (yoga) between the planets and the asterisms (see below, vv. 14-15), representing its group, and therefore called (see below, vv. 16-19) the "junction-star" (yogatara) of the asterism.

It will be at once noticed that while, in a former passage (ii. 64), the ecliptic was divided into twenty-seven equal arcs, as portions for the asterisms, we have here presented to us twenty-eight asterisms, very unequally distributed along the ecliptic, and at greatly varying distances from it. And it is a point of so much consequence, in order to the right understanding of the character and history of the whole system, to apprehend clearly the relation of the groups of stars to the arcs allotted to them, that we have prepared the accompanying diagram (Fig. 31) in illustration of that relation. The figure represents, in two parts, the circle of the ecliptic: along the central lines is marked its division into arcs of ten and five degrees: upon the outside of these lines it is further divided into equal twenty-sevenths, or arcs of 13° 20′; and upon the inside into equal twenty-eighths, or arcs of 12° 51′; these being the portions (bhaga) of two systems of asterisms, twenty-seven and twenty-eight in number respectively. The starred lines which run across all the divisions mark the polar longitudes, as stated in the text, of the junction-stars of the asterisms. The names of the latter are set over against them, in the inner columns: the names of the portions in the system of twenty-seven are given in full in the outer columns, and those in the system of twenty-eight are also placed opposite the portions, upon the inside, in an abbreviated form.

The text nowhere expressly states which one of the twenty-eight asterisms which it recognizes is, in its division of the ecliptic into only twenty-seven portions, left without a portion. That Abhijit, the twenty-second of the series, is the one thus omitted, however, is clearly implied in the statements of the fourth and fifth verses. Those statements, which have caused difficulty to more than one expounder of the passage, and have been variously misinterpreted, are made entirely clear by supplying the words "asterism" and "portion" throughout, where they are to be understood, thus: "the asterism Uttara-Ashadha is at the middle of the portion styled Purva-Ashadha; the asterism Abhijit, likewise, is at the end of the portion Purva-Ashadha; the position of the asterism Gravana is at the end of the portion receiving its name from Uttara-Ashadha; while
the asterism Cravishthā is between the third and fourth quarters of the portion named for Čraṇa." After this interruption to the regularity of correspondence of the two systems—the asterism Abhijit being left without a portion, and the portion Cravishthā containing no asterism—they go on again harmoniously together to the close. The figure illustrates clearly this condition of things, and shows that, if Abhijit be left out of account, the two systems agree so far as this—that twenty-six asterisms fall within the limits of portions bearing the same name, while all the discordances are confined to one portion of the ecliptic, that comprising the 20th to the 23rd portions. If, on the other hand, the ecliptic be divided into twenty-eighths, and if these be assigned as portions to the twenty-eight asterisms, it is seen from the figure that the discordances between the two systems will be very great; that only in twelve instances will a portion be occupied by the asterism bearing its own name, and by that alone; that in sixteen cases asterisms will be found to fall within the limits of portions of different name; that four portions will be left without any asterism at all, while four others will contain two each.

These discordances are enough of themselves to set the whole subject of the asterisms in a new light. Whereas it might have seemed, from what we have seen of it hitherto, that the system was founded upon a division of the ecliptic into twenty-seven equal portions, and the selection of a star or a constellation to mark each portion, and to be, as it were, its ruler, it now appears that the series of twenty-eight asterisms may be something independent of, and anterior to, any division of the ecliptic into equal arcs, and that the one may have been only artificially brought into connection with the other, complete harmony between them being altogether impossible. And this view is fully sustained by evidence derivable from outside the Hindu science of astronomy, and beyond the borders of India. The Parsis, the Arabs, and the Chinese, are found also to be in possession of a similar system of division of the heavens into twenty-eight portions, marked or separated by as many single stars or constellations. Of the Persian system little or nothing is known excepting the number and names of the divisions, which are given in the second chapter of the Bundelsh (see Anquetil du Perron's Zendavesta, etc., ii. 349). The Arab divisions are styled māhāl al-kamar, "lunar mansions, stations of the moon," being brought into special connection with the moon's revolution: they are marked, like the Hindu "portions," by groups of stars. The first extended comparison of the Hindu asterisms and the Arab mansions was made by Sir William Jones, in the second volume of the Asiatic Researches, for 1790: it was, however, only a rude and imperfect sketch, and led its author to no valuable or trustworthy conclusions. The same comparison was taken up later, with vastly more learning and acuteness, by Colebrooke, whose valuable article, published also in the Asiatic Researches, for 1807 (ix. 323, etc.: Essays ii. 321, etc.), has ever since remained the chief source of knowledge respecting the Hindu asterisms and their relation to the lunar mansions of the Arabs. To Anquetil (as above) is due the credit of the first suggestion of a coincidence between the Parsi, Hindu, and Chinese systems: but he did nothing more than suggest it: the origin, character, and use of the Chinese divisions were first established, and
their primitive identity with the Hindu asterisms demonstrated, by Biot, in a series of articles published in the Journal des Savants for 1840: and he has more recently, in the volume of the same Journal for 1850, reviewed and restated his former exposition and conclusions. These we shall present more fully hereafter: at present it will be enough to say that the Chinese divisions are equatorial, not zodiacal; that they are named sieu, "mansions"; and that they are the intervals in right ascension between certain single stars, which are also called sieu, and have the same title with the divisions which they introduce. We propose to present here a summary comparison of the Hindu, Arab, and Chinese systems, in connection with an identification of the stars and groups of stars forming the Hindu asterisms, and with the statement of such information respecting the latter, beyond that given in our text, as will best contribute to a full understanding of their character.

The identification of the asterisms is founded upon the positions of their principal or junction-stars, as stated in the astronomical text-books, upon the relative places of these stars in the groups of which they form a part, and upon the number of stars composing each group, and the figure by which their arrangement is represented: in a few cases, too, the names themselves of the asterisms are distinctive, and assist the identification. The number and configuration of the stars forming the groups are not stated in our text; we derive them mainly from Colebrooke, although ourselves also having had access to, and consulted, most of his authorities, namely the Cakrā-Saṅgraha, the Mahābhārata-Śāhāmāni, and the Nata-nālā (as cited by Jones, As. Res., ii. 291). Sir William Jones, it may be remarked, enriched (As. Res., ii. 293, plate) an engraved copy of drawings made by a native artist of the figures assigned to the asterisms. For the number of stars in each group we have an additional authority in al-Biruni, the Arab savant of the eleventh century, who travelled in India, and studied with especial care the Hindu astronomy. The information furnished by him with regard to the asterisms we derive from Biot, in the Journal des Savants for 1845 (pp. 29-31); it professes to be founded upon the Khaṇḍa-Śatākha of Brahmagupta. Al-Biruni also gives an identification of the asterisms, so far as the Hindu astronomers of his day were able to furnish it to him, which was only in part: he is obliged to mark seven or eight of the series as unknown or doubtful. He speaks very slightly of the practical acquaintance with the heavens possessed by the Hindus of his time, and they certainly have not since improved in this respect; the modern investigators of the same subject, as Jones and Colebrooke, also complain of the impossibility of obtaining from the native astronomers of India satisfactory identifications of the asterisms and their junction stars. The translator, in like manner, spent much time and effort in the attempt to derive such information from his native assistant, but was able to arrive at no results which could constitute any valuable addition to those of Colebrooke. It is evident that for centuries past, as at present, the native

* The true form of the name is not altogether certain, it being known only through its Arabic transcription; it seems to designate rather a chapter in a treatise than a complete work of its author.
tradition has been of no decisive authority as regards the position and composition of the groups of stars constituting the asterisms; these must be determined upon the evidence of the more ancient data handed down in the astronomical treatises.

In order to an exact comparison of the positions of the junction-stars as defined by the Hindus with those of stars contained in our catalogues, we have reduced the polar longitudes and latitudes to true longitudes and latitudes, by the following formulas (see Fig. 30):

\[
(1 - \cos \alpha a) \cot E L C = \tan \alpha b \\
\sin \alpha b \sin \alpha a = \sin \beta b \\
\tan \beta b \cot \alpha b = \sin \alpha \beta
\]

\(a\) being the polar longitude as stated in the text \((= \lambda a + 180^\circ)\), \(\alpha a\) the polar latitude, \(E L C\) the inclination of the ecliptic, \(\alpha b\) the true latitude, and \(\alpha b\) a quantity to be added to or subtracted from the polar longitude to give the true longitude. The true positions of the stars compared we take from Flamsteed's Catalogue Britannicus, subtracting in each case \(15^\circ 42'\) from the longitudes there given, in order to reduce them to distances from the vernal equinox of A.D. 560, assumed to coincide with the initial point of the Hindu sphere. There is some discordance among the different Hindu authorities, as regards the stated positions of the junction-stars of the asterisms. The Çakalya-Sanhita, indeed, agrees in every point precisely with the Sûrya-Siddhanta. But the Siddhanta-Ciromani often gives a somewhat different value to the polar longitude or latitude, or both. With it, so far as the longitude is concerned, exactly accord the Brahma-Siddhanta, as reported by Colebrooke, and the Khanda-Kataka, as reported by al-Biruni. The latitudes of the Brahma-Siddhanta also are virtually the same with those of the Siddhanta Cini-mani, their differences never amounting, save in a single instance, to more than \(3'\); but the latitudes of the Khanda-Kataka often vary considerably from both. The Brahma Laghava, the only other authority accessible to us, presents a series of variations of its own, independent of those of either of the other treatises. All these differences are reported by us below, in treating of each separate asterism. The presiding divinities of the asterisms we give upon the authority of the Taittirlya-Sanhita (iv. 4. 10. 1-2), the Taittirya-Brahmana (iii. 1. 1. 2, as cited by Weber, Zeitsch. f. d. K. d. Morg., vii. 266 etc., and Ind. Stud., i. 90 etc.), the Muhûrta-Cintamani, and Colebrooke: those of about half the asterisms are also indirectly given in our text, in the form of appellations for the asterisms derived from them.

The names and situations of the Arab lunar stations are taken from Ideker's Untersuchungen über die Sterne: for the Chinese mansions and their determining stars we rely solely upon the articles of Biot, to which we have already referred.

It has seemed to us advisable, notwithstanding the prior treatment by Colebrooke of the same subject, to enter into a careful re-examination and identification of the Hindu asterisms, because we could not accept in the bulk, and without modification, the conclusions at which he arrived. The identifications by Ideker of the Arab mansions, more thorough and direct than any which had been previously made, and Biot's comparison of the Chinese sicu, have placed new and valuable materials in our
hands: and these—together with a more exact comparison than was attempted by Colebrooke of the positions given by the Hindus to their junction-stars with the data of the modern catalogues, and a new and independent combination of the various materials which he himself furnishes—while they have led us to accept a greater number of his identifications, often establishing them more confidently than he was able to do, have also enabled us in many cases to alter and amend his results. Such a re-examination was necessary, in order to furnish safe ground for a more detailed comparison of the three systems, which, as will be seen hereafter, leads to important conclusions respecting their historical relations to one another.

1. Acvini; this treatise exhibits the form acvini; in the older lists, as also often elsewhere, we have the dual acviniān, acviniyān, “the two horsemen, or Acvini.” The Acvini are personages in the ancient Hindu mythology somewhat nearly corresponding to the Castor and Pollux of the Greeks. They are the divinities of the asterism, which is named from them. The group is figured as a horse’s head, doubtless in allusion to its presiding deities, and not from any imagined resemblance. The dual name leads us to expect to find it composed of two stars, and that is the number allotted to the asterism by the Cikaliya and Khandaka-Katāka. The Sūrya-Siddhānta (follow, v. 16) designates the northern member of the group as its junction star: that this is the star β Arietis (magn. 3.2), and not α Arietis (magn. 2.1), as assumed by Colebrooke, is shown by the following comparison of positions:

\[
\begin{align*}
&\text{Acvini} & \text{long. A.D. 590} & 11^\circ 49' & \text{lat. } 9^\circ 11' N. \\
&\beta \text{ Arietis} & \text{do.} & 15^\circ 56' & \text{do. } 9^\circ 26' N. \\
&\alpha \text{ Arietis} & \text{do.} & 13^\circ 52' & \text{do. } 9^\circ 5' N.
\end{align*}
\]

Colebrooke was misled in this instance by adopting, for the number of stars in the asterism, three, as stated by the later authorities, and then applying to the group as thus composed the designation given by our text of the relative position of the junction-star as the northern, and he accordingly overlooked the very serious error in the determination of the longitude thence resulting. Indeed, throughout his comparison, he gives too great weight to the determination of latitude, and too little to that of longitude: we shall see farther on that the accuracy of the latter is, upon the whole, much more to be depended upon than that of the former.

Considered as a group of two stars, Acvini is composed of β and γ Arietis (magn. 1.3): as a group of three, it comprises also α in the same constellation.

There is no discordance among the different authorities examined by us as regards the position of the junction-star of Acvini, either in latitude or in longitude. The case is the same with the 8th, 10th, 12th, and 13th asterisms, and with them alone.

The first Arab masūil is likewise composed of β and γ Arietis, to which some add α: it is called ash-Shuraṭān, “the two tokens”—that is to say, of the opening year.

The Chinese series of sīeu commences, as did anciently the Hindu system of asterisms, with that which is later the third asterism. The
twenty-seventh sien, named Leu (M. Biot has omitted to give us the
signification of these titles), is $\beta$ Arietis, the Hindu junction-star.

2. **Bharani**; also, as plural, **bharanyas**; from the root **bhar**, "carry":
in the Taïtirîya lists the form **apabharani**, "bearer away," in singular
and plural, is also found. Its divinity is Yama, the ruler of the world
of departed spirits; it is figured as the yoni, or pudendum unisex. All
authorities agree in assigning it three stars, and the southernmost is
pointed out below (v. 18) as its junction-star. The group is unquestion-
able to be identified with the triangle of faint stars lying north of the
back of the Ram, or 35, 39, and 41 Arietis; they are figured by some as
a distinct constellation, under the name of Musca Borealis. The design-
nation of the southern as the junction-star is not altogether unambiguous,
as 35 and 41 were, in A.D. 560, very nearly equidistant from the
equator; the latter would seem more likely to be the one intended,
since it is nearer the ecliptic, and the brightest of the group—being of
the third magnitude, while the other two are of the fourth: the defined
position, however, agrees better with 35, and the error in longitude, as
compared with 41, is greater than that of any other star in the series:

Bharani . . . . . . . 27° 37' . . . . 11° 6' N.
35 Arietis (a Musca) . . . . . 27° 54' . . . . 11° 37' N.
41 Arietis (b Musca) . . . . . 27° 10' . . . . 10° 26' N.

The Graha-Laghava gives Bharani 1° more of polar longitude; this
would reduce by the same amount the error in the determination of its
longitude by the other authorities.

The **second Arab. munzil, al-Buṭain, "the little belly"—i.e., of the
Ram—is by most authorities defined as comprising the three stars in the
haunch of the Ram, or $\tau, \delta$, and $\zeta$ (or else $\zeta$) Arietis. Some, however,
have regarded it as the same with Musca; and we cannot but think that
al-Birûnî, in identifying, as he does, Bharani with al-Buṭain, meant to
indicate by the latter name the group of which the Hindu asterism is
actually composed.

The last Chinese sien, Ori, is the star 35 Arietis, or a Musca.

7. **Krittika**; or, as plural, **krittikas**; the appellative meaning of the
word is doubtful. The regent of the asterism is Agni, the god of fire.
The group, composed of six stars, is that known to us as the Pleiades.
It is figured by some as a flame, doubtless in allusion to its presiding
divinity: the more usual representation of it is a razor, and in the choice
of this symbol is to be recognized the influence of the etymology of the
name, which may be derived from the root **karr**, "cut;" in the configura-
tion of the group, too, may be seen, by a sufficiently prosaic eye, a
broad-bladed knife, with a short handle. If the designation given below
(v. 18) of the southern member of the group as its junction-star, be
strictly true, this is not Alcyone, or $\eta$ Tauri (magn. 3), the brightest
of the six, but either Atlas (27 Tauri: magn. 4) or Merope (23 Tauri:
magn. 5); the two latter were very nearly equally distant from the
equator of A.D. 560, but Atlas is a little nearer to the ecliptic. The
defined position agrees best with Alcyone, nor can we hesitate to regard
this as actually the junction-star of the asterism. We compare the posi-
tions below:
Kritika . . . . . . 39° 8' . . . . . . 4° 44' N.
Aleyone . . . . . . 59° 58' . . . . . . 4° 1' N.
27 Tauri . . . . . . 46° 20' . . . . . . 3° 53' N.
28 Tauri . . . . . . 39° 41' . . . . . . 3° 55' N.

The Siddhánta-Ciromani etc. give Kritika 2° less of polar longitude than the Śūrya-Siddhánta, and the Graha-Lāghava, on the other hand, 30' more; the latter, with the Khandā-Kaṭaka, agree with our text as regards the polar latitude, which the others reckon at 4° 30', instead of 5°.

The Pleiades constitute the third manzil of the Arabs, which is denominated ath-Thuraiya, "the little thick-set group," or an-Najm, "the constellation." Aleyone is likewise the first Chinese sieu, which is styled Mao.

4. Rohini, "muddy"; so named from the hue of its principal star Prajāpati, "the lord of created beings," is the divinity of the asterism. It contains five stars, in the grouping of which Hindu fancy has seen the figure of a wain (compare v. 13, below); some, however, figure it as a temple. The constellation is the well-known one in the face of Taurus to which we give the name of the Hyades, containing ε, δ, γ, 9, α Tauri: the latter, the most easterly (v. 19) and the brightest of the group—being the brilliant star of the first magnitude known as Aklebaran—is the junction-star, as is shown by the annexed comparison of positions:

Rohini . . . . . . 4° 9' . . . . . . 2° 49' S.
Aklebaran . . . . . 3° 45' . . . . . . 2° 28' S.

The Siddhánta-Ciromani etc. here again present the insignificant variation from the polar longitude of our v. 3, of 2° less; the former also makes its polar latitude 1° 30': the Graha-Lāghava reads, for the polar longitude, 10°. All these variations add to the error of defined position.

The fourth Arab manzil is composed of the Hyades: its name is ad-Dabaran, "the follower"—i.e., of the Pleiades. We would suggest the inquiry whether this name may not be taken as an indication that the Arab system of mansions once began, like the Chinese, and like the Hindu system originally, with the Pleiades. There is, certainly, no very obvious propriety in naming any but the second of a series the "following" (sequens or secundus). Modern astronomy has retained the title as that of the principal star in the group, to which alone it was often also applied by the Arabs.

The second Chinese sieu, πι, is the northernmost member of the same group, or ε Tauri, a star of the third to fourth magnitude.

5. Mrgacirsha, or mrgacirus, "antelope's head": with this name the figure assigned to the asterism corresponds; the reason for the designation we have not been able to discover. Its divinity is Soma, or the moon. It contains three stars, of which the northern (v. 16) is the determinative. These three can be no other than the faint cluster in the head of Orion, or ι, φ¹, η² Orionis, although the Hindu measurement of the position of the junction-star, ι (magn. 4), is far from accurate, especially as regards its latitude:

Mrgacirsha . . . . . . 61° 3' . . . . . . 9° 49' S.
ι Orionis . . . . . . 63° 40' . . . . . . 13° 25' S.
In this erroneous determination of the latitude all authorities agree: the Graha-Laghava adds 1° to the error in polar longitude, reading 62° instead of 63°.

Here again there is an entire harmony among the three systems compared. The Arab manzil, al-Hak'ah, is composed of the same stars which make up the Hindu asterism: the third sieu, named Tsæ, is the Hindu junction-star, α Orionis.

6. Ardha, "moist": the appellation very probably has some meteorological ground, which we have not traced out: this is indicated also by the choice of Itudra, the storm-god, as regent of the asterism. It comprises a single star only, and is figured as a gem. It is impossible not to regard the bright star of the first magnitude in Orion's right shoulder, or α Orionis, as the one here meant to be designated, notwithstanding the very grave errors in the definition of its position given by our text: the only visible star of which the situation at all nearly answers to that definition is 135 Tauri, of the sixth magnitude; we add its position below, with that of α Orionis:

\begin{align*}
\text{Ardha} & \ldots \ldots \ 65^3 50' \ldots \ldots \ 8^3 57' \ S. \\
\alpha \text{ Orionis} & \ldots \ldots \ 68^3 43' \ldots \ldots \ 16^3 4' \ S. \\
135 \text{ Tauri} & \ldots \ldots \ 6^0 38' \ldots \ldots \ 9^3 10' \ S.
\end{align*}

The distance from the sun at which the heliacal rising and setting of Ardha is stated below (ix, 14) to take place would indicate a star of about the third magnitude; this adds to the difficulty of its identification with either of the two stars compared. We confess ourselves unable to account for the confusion existing with regard to this asterism, of which al-Biruni also could obtain no intelligible account from his Indian teachers. But it is to be observed that all the authorities, excepting our text and the Çakalya-Suňhta, give Ardha 11° of polar latitude instead of 9°, which would reduce the error of latitude, as compared with α Orionis, to an amount very little greater than will be met with in one or two other cases below, where the star is situated south of the ecliptic; and it is contrary to all the analogies of the system that a faint star should have been selected to form by itself an asterism. The Siddhânta-Ciromâni etc., make the polar longitude of the asterism 20° less than that given by the Sûrya-Siddhânta, and the Graha-Laghava 1° 20' less: these would add so much to the error of longitude.

Here, for the first time, the three systems which we are comparing disagree with one another entirely. The Chinese have adopted for the determinative of their fourth sieu, which is styled Tsâin, the upper star in Orion's belt, or δ Orionis (2)—a strange and arbitrary selection, for which M. Biot is unable to find any explanation. The Arabs have established their sixth station close to the ecliptic, in the feet of Pollux, naming it al-Han'ah, "the pile": it comprises the two stars γ (2.3) and ζ (4.3) Geminorum: some authorities, however, extend the limits of the mansion so far as to include also the stars in the foot of the other twin, or η, ν, μ Geminorum; of which the latter is the next Chinese sieu.

7. Punarrauta; in all the more ancient lists the name appears as a dual, punarrast: it is derived from punar, "again," and varu, "good, brilliant": the reason of the designation is not apparent. The regent
of the asterism is Aditi, the mother of the Adityas. Its dual title indicates that it is composed of two stars, of nearly equal brilliance, and two is the number allotted to it by the Çakalya and Khaṇḍa-Kataka, the eastern being pointed out below (r. 19) as the junction-star. The pair are the two bright stars in the heads of the Twins, or α and β Geminorum, and the latter (1.2) is the junction-star. The comparison of positions is as follows:

Punarvasu . . . . 92° 52’ . . . . 6° 6’ N.
β Geminorum . . 93° 14’ . . . . 6° 39’ N.

The Graha-Laghava adds 1° to the polar longitude of Punarvasu as stated by the other authorities.

Four stars are by some assigned to this asterism, and with that number corresponds the representation of its arrangement by the figure of a house: it is quite uncertain which of the neighboring stars of the same constellation are to be added to those above mentioned to form the group of four, but we think (magn. 4) and 5 (3) those most likely to have been chosen: Colebrooke suggests 7 (3.1) and 1 (3.1).

The determinative of the fifth sinu, Tsiing, is α Geminorum (3), which, as we have seen, is reckoned among the stars composing the sixth mazil: the seventh mazil includes, like the Hindu asterism, α and β Geminorum: it is named adh-Dhirā, “the paw”—i.e., of the Lion; the figure of Leo (see Ideler, p. 152 etc.) being by the Arabs so stretched out as to cover parts of Gemini, Cancer, Canis Minor, and other neighboring constellations.

8. Pushya: from the root push, “nourish, thrive”: another frequent name, which is the one employed by our treatise, is tishya, which is translated “auspicious”: Amara gives also sohyu, “prosperous.” Its divinity is Bhaspati, the priest and teacher of the gods. It comprises three stars—the Khaṇḍa-Kataka alone seems to give it but one—of which the middle one is the junction-star of the asterism. This is shown by the position assigned to it to be δ Cancri (4):

Pushya . . . . 1° 40’ 0” . . . . 6° 5’ N.
δ Cancri . . . . 105° 42’ . . . . 6° 4’ N.

The other two are doubtless γ (4.5) and θ (6) of the same constellation: the asterism is figured as a crescent and as an arrow, and the arrangement of the group admits of being regarded as representing a crescent, or the barbed head of an arrow. Were the arrow the only figure given, it might be possible to regard the group as composed of γ, θ, and δ (4), the latter representing the head of the arrow, and the nebulous cluster, Praesepe, between γ and θ, the feathering of its shaft: θ (105° 43’—6° 48’ S.) would then be the junction-star.

The Arab mazil, an-Nathrah, “the nose-gap”—i.e., of the Lion—comprises γ and δ Cancri, together with Praesepe, or, according to some authorities, Praesepe alone. The sixth sinu, Kui, is δ Cancri, a star which is, at present, only with difficulty distinguished by the naked eye. Ptolemy rates it as of the fourth magnitude, like γ and δ: perhaps it is one of the stars of which the brilliance has sensibly diminished during the past two or three thousand years, or else a variable star of very long period. The possibility of such changes requires to be taken into account, in comparing our heavens with those of so remote a past.
9. ** Açleshā;** or, as plural, açleshās; the word is also written açreshā: its appellative meaning is "entwinder, embracer." With the name accord the divinities to whom the regency of the asterism is assigned, which are sarpas, the serpents. The number of stars in the group is stated as five by all the authorities excepting the Khanda-Katāka, which reads six: their configuration is represented by a wheel. The star α Cancri (4) is pointed out by Colebrooke as the junction-star of Açleshā, apparently from the near correspondence of its latitude with that assigned to the latter, for he says nothing in connection with it of his native helpers: but α Cancri is not the eastern (v. 10) member of any group of five stars; nor, indeed, is it a member of any distinct group at all. Now the name, figure, and divinity of Açleshā are all distinctive, and point to a constellation of a bent or circular form: and if we go a little farther southward from the ecliptic, we find precisely such a constellation, and one containing, moreover, the corresponding Chinese determinative. The group is that in the head of Hydra, or γ, 6, 8, 6 Hydri, α and γ being of the fifth magnitude, and the rest of the fourth: their arrangement is conspicuously circular. There can be no doubt, therefore, that the situation of the asterism is in the head of Hydra, and α Hydri, its brightest star (being rated in the Greenw. Cat. as of magnitude 3.4, while δ is 4.5), is the junction-star:

Åleshā . . . . . 10° 25' 59" . . . . 6° 50' S.
α Hydri . . . . . 11° 22' 26" . . . . . 11° 3' 8" S.
α Cancri . . . . . 11° 32' 5" . . . . . 5° 31' 8" S.

The error of the Hindu determination of the latitude is, indeed, very considerable, yet not greater than we are compelled to accept in one or two other cases. The Khanda-Katāka increases it 1°, giving the asterism 6° instead of 7° of polar latitude. The Siddhānta-Ciromani etc. deduct 1° from the polar longitude of the Sūrya-Siddhānta, and the Graha-Lāghava deducts 2°: both variations would add to the error in longitude.

The Arab manzil is, in this instance, far removed from the Hindu asterism, being composed of α Cancri (5) and γ Leonis (3.4), and called at-Tarf, "the back"—i.e., of the Lion. The seventeenth Chinese sign, likewise, is as already noticed, included in the Hindu group, being δ Hydrae.

10. **Maγhra;** or, as plural, maghās; "might." The pitarus, Fathers, or manes of the departed, are the regents of the asterism, which is figured as a house. It is, according to most authorities, composed of five stars, of which the southern (v. 18) is the junction-star. Four of these must be the bright stars in the neck and side of the Lion, or γ, β, η, and α Leonis, of magnitudes 4.5, 2.3, 4.1, and 1.2 respectively; but which should be the fifth is not easy to determine, for there is no other single star which seems to form naturally a member of the same group with these: v (5), π (5), or η (4) might be forced into a connection with them. This difficulty would be removed by adopting, with the Khanda-Katāka, six as the number of stars included in the asterism: it would then be composed of all the stars forming the conspicuous constellation familiarly known as "the Sickle." The star α Leonis, or Regulus, the most brilliant of the group, is the junction-star, and its position is defined with unusual precision:
Translation and Notes.

Magha . . . . 129° 0’ . . . . 0° 0’
Regulus . . . . 129° 49’ . . . . 0° 27’ N.

The tenth manzil, aj-Jahhah, "the forehead"—i. e., of the Lion—is also composed of γ, γ, γ, α Leonis.

The eighth, ninth, and tenth sien of the Chinese system altogether disagree in position with the groups marking the Hindu and Arab mansions, being situated far to the southward of the ecliptic, in proximity, according to Biot, to the equator of the period when they were established. The eighth, Sing, is α Hydra (2), having longitude (A. D. 560)
127° 16’, latitude 22° 25’ S.

11, 12. Phalguni; or, as plural, phalgunyas; the dual, phalgunyadu, is also found: this treatise presents the derivative form phalguni, which is not infrequently employed elsewhere. The word is likewise used to designate a species of fig-tree: its derivation, and its meaning, as applied to the asterisms, is unknown to us. Here, as in two other instances, later (the 20th and 21st, and the 26th and 27th asterism), we have two groups called by the same name, and distinguished from one another as purva and utara, "former" and "latter"—the is to say, coming earlier and later to their meridian transit. The true original and composition of these three double asterisms has been, if we are not mistaken, not a little altered and obscured in the description of them furnished to us; owing, apparently, to the ignorance or carelessness of the describers, and especially to their not having clearly distinguished the characteristics of the combination constellation from those of its separate parts. In each case, a couch or bedstead (pañcā, manca, pañcakā) is given as the figure of one or both of the parts, and we recognize them all the common characteristic of a constellation of four stars, forming together a regular oblong figure, which admits of being represented—not unsuitably, if rather prosaically—by a bed. This figure, in the case of the Phalgunis, is composed of δ, φ, λ, and γ Leonis, a very distinct and well-marked constellation, containing two stars, δ and λ, of the second to third magnitude, one, φ, of the third, and one, γ, of the fourth. The symbol of a bed, properly belonging to the whole constellation, is given by all the authorities to both the two parts into which it is divided. Each of these latter has two stars assigned to it, and the junction-stars are said (v. 18) to be the northern. The first group is, then, clearly identifiable as λ and α Leonis, the former and brighter being the distinctive star:

Pūrva-Phalguni . . . . 135° 58’ . . . . 11° 19’ N.
δ Leonis . . . . 141° 15’ . . . . 14° 19’ N.
λ Leonis . . . . 143° 24’ . . . . 0° 46’ N.

The Siddhānta-Ciromani etc., and the Graha-Laghava, give Pūrva-Phalguni respectively 3° and 1° more of polar longitude than the Sūrya-Siddhānta. These are more notable variations than are found in any other case, and they appear to us to indicate that these treatises intend to designate φ, the southern member of the group, as its junction-star: we have accordingly added its position also above.

In the latter group, the junction-star is evidently λ Leonis:

Uttara-Phalguni . . . . 150° 10’ . . . . 12° 5’ N.
β Leonis . . . . 151° 37’ . . . . 12° 17’ N.
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This star, however, is not the northern, but the southern, of the two composing the asterism: its description as the southern we cannot but regard as simply an error, founded on a misapprehension of the composition of the double group. To al-Birānī, β Leonis and another star to the northward, in the Arab constellation Coma Berenices, were pointed out as forming the asterism Uttara-Phalguni. The Čākalya gives it five stars, probably adding to β Leonis the four small stars in the head of the Virgin, ε, π, and β, of magnitudes four to five and five.

The regents of Pūrva and Uttara-Phalguni are Bhaga and Aryaman, or Aryaman and Bhaga, two of the Ādityas.

The two corresponding Arab mansions are called az-Zubrah, “the mane”—i.e., of the Lion—and az-Sarraf, “the turn”: they agree as nearly as possible with the Hindu asterisms, the former being composed of δ and β Leonis, the latter of β Leonis alone. The Chinese συν, named respectively Chang and Y, are ε¹ Hydra (5)* and ε Crateris (4).

13. Hasta, “hand.” Savitar, the sun, is regent of the asterism, which, in accordance with its name, is figured as a hand, and contains five stars, corresponding to the five fingers. These are the five principal stars in the constellation Corvus, a well-marked group, which bears, however, no very conspicuous resemblance to a hand. The stars are named—counting from the thumb around to the little finger, according to our apprehension of the figure—δ, α, β, γ, and δ Corvi. The text gives below (v. 17) a very special description of the situation of the junction-star in the group, but one which is unfortunately quite hard to understand and apply: we regard it as most probable, however (see note to v. 17), that γ (3) is the star intended: the defined position, in which all the authorities agree, would point rather to δ (3):

Hasta . . . . 174° 22' . . . . 10° 6' S.
γ Corvi . . . . 170° 43' . . . . 15° 22' S.
δ Corvi . . . . 17° 27' . . . . 12° 10' S.

The Hindu and Chinese systems return, in this asterism, to an accordance with one another: the eleventh συν, Chin, is the star γ Corvi. The Arab system holds its own independent course one point farther: its thirteenth mansion comprises the five bright stars β, γ, γ, δ, α Virginis, which form two sides, measuring about 15° each, of a great triangle: the mansion is named al-Auwaṭ, “the barking dog.”

14. Citrā, “brilliant.” This is the beautiful star of the first magnitude α Virginis, or Spica, constituting an asterism by itself, and figured as a pearl or as a lamp. Its divinity is Tvashtar, “the shaper, artificer.” Its longitude is very erroneously defined by the Sūrya-Siddhānta:

Citrā . . . . 180° 48' . . . . 1° 50' S.
Spica . . . . 182° 49' . . . . 2° 2' S.

All the other authorities, however, saving the Čakalya, remove this error, by giving Citrā 183° of polar longitude, instead of 180°. The only variation from the definition of latitude made by our text is offered by the Siddhānta-Ciromani, which, varying for once from the Brahmas-Siddhānta, reads 1° 45' instead of 2°.

* It is, apparently, by an original error of the press, that M. Biot, in all his tables, calls this star ε¹.
Spica is likewise the fourteenth mansīl of the Arabs, styled by them as-Simāk, and the twelfth sieu of the Chinese, who call it Kio.

15. Svātt, or svāti; the word is said to mean "sword." The Tāttiriyā-Brahmana calls the asterism niskhyā, "outcast," possibly from its remote northern situation. It is, like the last, an asterism comprising but a single brilliant star, which is figured as a coral bead, gem, or pearl. In the definition of its latitude all authorities agree; the Graha-Lāghavā makes its polar longitude 198° only, instead of 199°. The star intended is plainly α Bootis, or Arcturus:

Svātt ........ 183° 2' ....... 33° 50' N.
Arcturus ...... 184° 12' ...... 30° 57' N.

In this instance, the Hindus have gone far beyond the limits of the zodiac, in order to bring into their series of asterisms a brilliant star from the northern heavens: the other two systems agree in remaining near the ecliptic. The fourteenth Chinese sieu, Kang, is α Virginis (4.5); the Arab mansīl, al-Ghafar, "the covering," includes the same star, together with ε, and either λ or φ Virginis.

16. Vićākha, "having spreading branches": in all the earlier lists the name appears as a dual, vićākhe. The asterism is also placed under the regency of a dual divinity, indrāqni, Indra and Agni. We should expect, then, to find it composed, like the other two dual asterisms, the 1st and 7th, of two stars, nearly equal in brilliancy, and two is actually the number assigned to the group by the Çakalya and the Khaṇḍa-Kataka. Now the only two stars in this region of the zodiac forming a conspicuous pair are α and β Librae, both of the second magnitude, and as these two compose the corresponding Arab mansion, while the former of them is the Chinese sieu, we have the strongest reasons for supposing them to constitute the Hindu asterism also. There are, however, difficulties in the way of this assumption. The later authorities give Vićākha four stars, and the defined position of the junction-star identifies it neither with α nor β, but with the faint star ε (4.3) in the same constellation. Colebrooke, overlooking this star, suggests α or β Librae (5): the following comparison of positions will show that neither of them can be the one meant to be pointed out:

Vićākha .......... 21° 3° 50' ...... 0° 25' S.
ε Librae ....... 21° 1° 0' ...... 1° 48' S.
α Librae .......... 20° 5° 5' ...... 0° 23' N.
β Librae .......... 21° 7° 45' ...... 0° 2' N.

The group is figured as a torana: this word Jones and Colebrooke translate "festival," but its more proper meaning is "an outer door or gate, a decorated gateway." And if we change the designation of situation of the junction-star in its group, given belo (v. 10), from "northern" to "southern," we find without difficulty a quadrangle of stars, viz. ε, α, β, γ (4.5) Librae, which admits very well of being figured as a gateway. Nor is it, in our opinion, taking an unwarrantable liberty to make such an alteration. The whole scheme of designations we regard as of inferior authenticity, and as partaking of the confusion and uncertainty of the later knowledge of the Hindus respecting their system of asterisms. That they were long ago doubtful of the position of Vićākha
is shown by the fact that al-Birùnî was obliged to mark it in his list as "unknown." Very probably the Śūrya-Siddhānta, in calling the northern member of the group, intended to include with it only the star 20 Libra (3, 4), situated about 8° to the south of it. Upon the whole, then, while we regard the identification of Viçākhā as in some respects more doubtful than that of any other asterism in the series, we yet believe that it was originally composed of the two stars α and β Libra, and that later the group was extended to include also ε and γ, and, as so extended, was figured as a gateway. The selection, contrary to general usage, of the faintest star in the group as its junction-star, may have been made in order to insure against the reversion of the asterism to its original dual form.

The variations of the other authorities from the position as stated in our text are of small importance: the Siddhānta-Ciromani etc. give Viçākhā 55° less of polar longitude, and the Graha-Lāghava 1° less; of polar latitude, the Siddhānta-Ciromani gives it 10°, the Graha-Lāghava 30° less; the Khānda-Kataka agrees here, as also in the two following asterisms, with the Śūrya-Siddhānta.

The sixteenth Arab manzil, comprising, as already noticed, α and β Libra, is styled az-Zubānān, "the two claws"—i.e., of the Scorpion: the name of the corresponding Chinese mansion, having for its determinative α Libra, is Ti.

17. Anūrâdhā; or, as plural, anūrâdhis: the word means "success." The divinity is Mitra, "friend," one of the Ādityas. According to the Cakalya, the asterism is composed of three stars, and with this our text plainly agrees, by designating (v. 18) the middle as the junction-star: all the other authorities give it four stars. As a group of three, it comprises β, δ, π Scorpius, δ (2, 3) being the junction-star; as the fourth member we are doubtless to add γ Scorpius (3, 4). It is figured as a bell or vati: this Colebrooke translates "a row of oblations": we do not find, however, that the word, although it means both "oblation, offering," and "a row, fold, ridge," is used to designate the two combined: perhaps it may better be taken as simply "a row," the stars of the asterism, whether considered as three or four, being disposed in nearly a straight line. The comparison of positions is as follows:

Anūrâdhā . . . 22° 44' . . . 10° 52' S.
δ Scorpius . . . 22° 24' . . . 10° 5' S.

The Siddhānta-Ciromani and Graha-Lāghava estimate the latitude of Anūrâdhā somewhat more accurately, deducing from the polar latitude, as given by our text, 1° 15' and 1° respectively: the Siddhānta-Ciromani etc. also add the insignificant amount of 5' to the polar longitude of the Śūrya-Siddhānta.

The corresponding Arab manzil, named al-Ikil, "the crown," contains also the three stars β, δ, π Scorpius, some authorities adding φ to the group. The Chinese sien, Fung, is π (3), the southernmost and the faintest of the three.

18. Jyeśthā, "oldest." The Taiktiriya-Saṅhitā, in its list of asterisms, repeats here the name rohini, "muddy," which we have had above as that of the 4th asterism: the appellation has the same ground in this
as in the other case, the junction-star of Jyeshṭa being also one of those which shine with a reddish light. The regent is Indra, the god of the clear sky. The group contains, according to all the authorities, three stars, and the central one (v. 18) is the junction-star. This is the brilliant star of the first magnitude α Scorpionis, or Antares; its two companions are σ (3.4) and τ (3.4) in the same constellation:

<table>
<thead>
<tr>
<th>Star</th>
<th>DEC</th>
<th>RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jyeshṭa</td>
<td>23°</td>
<td>7°</td>
</tr>
<tr>
<td>Antares</td>
<td>22°</td>
<td>44°</td>
</tr>
</tbody>
</table>

The constellation is figured as a ring, or ear-ring; by this may be understood, perhaps, a pendent ear-jewel, as the three stars of Jyeshṭa form nearly a straight line, with the brightest in the middle.

The Siddhānta-Çironam and Graha-Lāghava add to the polar longitude of the junction-star of the asterism, as stated in our text, 9° and 1° respectively, and they deduct from its polar latitude 30° and 1° respectively, making the definition of its position in both respects less accurate.

Antares forms the eighteenth manzil, and is styled al-Kalb, “the heart”—i.e., of the Scorpion: σ and τ are called an-Niyat, “the praecordia.” The Chinese sin, Sin, is the westernmost of the three, or σ.

19. Mūla, “root.” The presiding divinity of the asterism is nirrti, “calamity,” who is also regent of the south-western quarter. It comprises, according to the Çikalya, nine stars; their configuration is represented by a lion’s tail. The stars intended are those in the tail of the Scorpion, or σ, τ, ν, ζ, α, δ, ϵ, c, λ Scorpionis, all of them of the third, or third to fourth, magnitude. Other authorities count eleven stars in the group, probably reckoning α and ζ as four stars; each being, in fact, a group of two closely approximate stars, name 1 in our catalogues μ (3), ν (4), ζ (4.5), ω (4). The Khanda-Kaṭaka alone gives Mūla only two stars, which are identified by al-Kūrin with the Arab manzil al-Shallah, or ο and α Scorpionis. The Tattiriya-Samhitā, too, gives the name of the asterism as nīrtī, “the two relatives”; the Viértāṇa several times spoken of in the Atharva-Veda as two stars of which the rising promotes relief from lingering disease (kshātriya); it is accordingly probable that these are the two stars in the sting of the Scorpion, and that they alone have been regarded by some as composing the asterism: their healing virtue would doubtless be connected with the meteorological conditions of the time at which their helical rising takes place.

Our text (v. 19) designates the eastern member of the group as its junction-star: it is uncertain whether the direction is meant to apply to the group of two, or to that of nine stars; if, as seems probable, λ is the star pointed out by the definition of position, it is strictly true only of the pair λ and ν, since ϵ, τ, and δ are all farther eastward than λ:

<table>
<thead>
<tr>
<th>Star</th>
<th>DEC</th>
<th>RA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mūla</td>
<td>21°</td>
<td>52°</td>
</tr>
<tr>
<td>ν Scorpionis</td>
<td>24°</td>
<td>53°</td>
</tr>
</tbody>
</table>

The Graha-Lāghava gives a more accurate statement of the longitude, adding 1° to the polar longitude as defined by all the other authorities: but it increases the error in latitude, by deducting 1° from that presented by our text: the Siddhānta-Çironam, in like manner, deducts 30°, while the Khanda-Kaṭaka adds the same amount.
The Tattvārya-Sanhitā makes pitarus, the Fathers, the presiding divinities of this asterism, as well as of the tenth.

Bentley states (Hind. Astr., p. 5) that Mūla was originally reckoned as the first of the asterisms, and was therefore so named, as being their root or origin; also that, at another time, or in a different system, the series was made to begin with Jyeṣṭha, which thence received its title of “eldest.” These statements are put forth with characteristic recklessness, and apparently, like a great many others in his pretended history of Hindu astronomy, upon the unsupported authority of his own conjecture. It is, in many cases, by no means easy to discover reasons for the particular appellations by which the asterisms are designated: but we would suggest that Mūla may perhaps have been so named from its being considerably the lowest, or farthest to the southward, of the whole series of asterisms, and hence capable of being looked upon as the root out of which they had grown up the heavens. It would even be possible to trace the same conception farther, and to regard Jyeṣṭha as so styled because it was the first, or “oldest,” outgrowth from this root, while the Vīcākhe, “the two diverging branches,” were the stars in which the series broke into two lines, the one proceeding northward, to Śvātī or Arcturus, the other westward, to Cīrā or Spica. We throw out the conjecture for what it may be worth, not being ourselves at all confident of its accordance with the truth.

The nineteenth Arab manzil is styled ash-Shaulah, “the sting”—i.e., of the Scorpion—and comprises, as already noticed, ν and λ Scorpiones. The determinative of the seventeenth sieu, Uci, is included in the Hindu asterism, being μ2 Scorpiones.

20, 21. Aṣhāyā; or, as plural, aṣṭāḥāv; this treatise presents the alternative form aṣṭāḥā, which is not infrequent elsewhere: the word is “unsupplied.” Here, again, we have a double group, divided into two asterisms, which are distinguished as pūrva and uttara, “former and latter.” Their respective divinities are āpas, “the waters,” and vīra devās, “the collective gods.” Two stars are ordinarily allotted to each asterism, and in each case the northern is designated (v. 10) as the junction-star. By some authorities each group is figured as a bed or couch; by others, the one as a bed and the other as an elephant’s tusk; and here, again, there is a difference of opinion as to which is the bed and which the tusk. The true solution of this confusion is, as we conceive, that the two asterisms taken together are figured as a bed, while either of them alone is represented by an elephant’s tusk. The former group must comprise δ (3.4) and ε (3.2) Sagittarii, the former being the junction-star; this is shown by the following comparison of positions:

| Pūrva-Aṣhāyā | 65° 39′ | 5° 28′ S. |
| Sagittarii   | 25° 34′ | 6° 25′ S. |

The Graha-Laghava gives Pūrva-Aṣhāyā 1° more of polar longitude, and 80′ less of polar latitude, than the Sūrya-Siddhānta: the Siddhānta-Chromani etc. give it 10′ less of the latter.

The latter of the two groups contains, as its southern star, ζ Sagittarii (3.4), and its northern and junction-star can be no other than δ (2.3) in the same constellation, notwithstanding the error in the Hindu determi-
nation of its latitude, which led Colebrooke to regard \( \alpha \) (4.3) as the star intended: we subjoin the positions:

\[
\begin{align*}
\text{Uttara-Ashādha} & \ldots \ldots 260° 23' \ldots \ldots 4° 59' S. \\
\sigma \text{ Sagittarii} & \ldots \ldots 262° 21' \ldots \ldots 3° 24' S. \\
\tau \text{ Sagittarii} & \ldots \ldots 264° 48' \ldots \ldots 5° 1' S.
\end{align*}
\]

The only variation from the position of the junction-star of this asterism as stated in our text is presented by the Graha-Lāghava, which makes its polar longitude 261° instead of 260°.

The Čākalya (according to Colebrooke: our MS. is defective at this point) and the Khandā-Kaṭaka assign four stars to each of the Ashādhsas, and the former represents each as a bed. It would not be difficult to establish two four-sided figures in this region of the constellation Sagittarius, each including the stars above mentioned, with two others: the one would be composed of \( \gamma^2 \) (4.3), \( \delta \), \( \zeta \), \( \eta \) (the star is also called \( \beta \) Telescopii), the other of \( \phi \) (4.3). \( \alpha \), \( \tau \), and \( \zeta \): such is unquestionably the constitution of the two asterisms, considered as groups of four stars; they are thus identified also, it may be remarked, by al-Birūnī. The junction-stars would still be \( \delta \) and \( \phi \), which are the northernmost in their respective constellations; nor is there any question as to which four among the eight are selected to make up the double asterism, since \( \delta \), \( \zeta \), \( \xi \), and \( \phi \) both form the most regular quadrangular figure, and are the brightest stars.

The determinatives of the eighteenth and nineteenth mansions of the Chinese, Ki and Teu, are \( \gamma \) and \( \phi \) Sagittarii, which are included in the two quadruple groups as stated above. The twentieth mansil comprehends all the eight stars which we have mentioned, and is styled an-Naʿāim, “the pasturing cattle”; some also understand each group of four as representing an ostrich, naʿāim. The twenty-first mansil, on the other hand, al-Buldah, “the town,” is described as a vacant space above the head of Sagittarius, bounded by faint stars, among which the most conspicuous is \( \pi \) Sagittarii (4.5).

22. Abhijit, “conquering.” The regent of the asterism is Brahma. The position assigned to its junction-star, which is described as the brightest (v. 19) in a group of three, identifies it with \( \alpha \) Lyrae, or Vega, a star which is exceeded in brilliancy by only one or two others in the heavens:

\[
\begin{align*}
\text{Abhijit} & \ldots \ldots 264° 10' \ldots \ldots 59° 58' N. \\
\text{Vega} & \ldots \ldots 265° 15' \ldots \ldots 61° 46' N.
\end{align*}
\]

The other authorities compared (excepting the Čākalya) define the position in latitude of Abhijit more accurately, adding 2° to the polar latitude given by the Sūrya-Siddhānta; the Graha-Lāghava also improves the position in longitude by adding 1° 20', while the Siddhānta-Ciromanz etc. increase the error by deducting 1° 40'.

The Taittiriya-Saṁhitā (iv. 4.10) omits Abhijit from its list of the asterisms: the probable reason of its omission in some authorities, or in certain connections, and its retention in others, we shall discuss farther on.

Abhijit is figured as a triangle, or as the triangular nut of the \( \text{śrāvasti} \), an aquatic plant; this very distinctly represents the grouping of \( \alpha \) Lyrae.
with the two other fainter stars of the same constellation, α and ζ, both of the fifth magnitude.

In this and the two following asterisms—as once before, in the fifteenth of the series—the Hindus have gone far from the zodiac, in order to bring into their system brilliant stars from the northern heavens, while the Chinese and the Arab systems agree in remaining in the immediate neighborhood of the ecliptic. The twentieth sieu is named Nieu, and is the star β Capricorni (3), situated in the head of the Goat: the twenty-second manzil, Sa’d adh-Dhāhib, "felicity of the sacrificer," contains the same star, the group being α (composed of two stars, each of magnitude 3.4) and β Capricorni.

23. Čravana, "hearing, ear"; from the root āru, "hear"; another name for the asterism, śrond, found occurring in the Tātrirīya lists, is perhaps from the same root, but the word means also "lame." Čravana comprises three stars, of which the middle one (v. 18) is the junction-star: they are to be found in the back and neck of the Eagle, namely as γ, α, and β Aquilae; α, the determinative, is a star of the first to second magnitude, while γ and β are of the third and fourth respectively:

(Čravana . . . . 30° 51' N. 29° 51' N.)

All the authorities agree as to the polar latitude of Čravana: the Siddhānta-Cīrromanī etc. give it 2° less of polar longitude than our treatise, and the Graha-Lāghavā even as much as 5° less.

The regent of the asterism is Viṣṇu, and its figure or symbol corresponds therewith, being three footsteps, representatives of the three steps by which Viṣṇu is said, in the early Hindu mythology, to have strode through heaven. The Čākalya, however, gives a trident as the figure belonging to Čravana. Possibly the name is to be regarded as indicating that it was originally figured as an ear.

The Chinese sieu corresponding in rank with Čravana is called Nū, and is the faint star ε Aquarii (1.3). The Arab manzil Sa’d Bula’, "felicity of a devourer," or al-Bula’, "the devourer," etc., includes the same star, being composed of 3, 4 (1.5), 5 (1.5) Aquarii, or, according to others, of 3 and 5 (6) Aquarii, or of 3 and 5.

24. Čravisithā; the word is a superlative formation from the same root from which came the name of the preceding asterism, and means, probably, "most famous." Another and hardly less frequent appellation is dhaniṣṭhā, an irregular superlative from dhani, "wealthy." The class of deities known as the vasas, "bright, good," are the regents of the asterism. It comprises four stars, or, according to the Čākalya and Khaṇḍa-Kaṭaka, five: the former, which is given by so early a list as that of the Tātrirīya-Brahmana, is doubtless the original number. The group is the conspicuous one in the head of the Dolphin, composed of β, ε, η, δ Delphini, all of them stars of the third, or third to fourth, magnitude, and closely disposed in diamond or lozenge-form: they are figured by the Hindus as a drum or tabor. The junction-star, which is the western (v. 17), is β:

(Čravisithā . . . . 29° 51' . . . . 31° 57' S.)

(β Delphini . . . . 29° 19' . . . . 31° 57' S.)
The only variation from the position assigned in our text to the junction-star of Gravishaṭhā is presented by the Graha-Laghava, which gives it 286°, instead of 200°, of polar longitude. Perhaps its intention is to point out § (5) as the junction-star: this is doubtless the one, adding the other four, on account of its close proximity to them, to make up the group of five; it lies only about half a degree westward from §.

The name of the twenty-fourth mansil, Sa'd as-Sin'ud, "felicity of felicities"—i.e., "most felicitous"—exhibits an accordance with that of the Hindu asterism which possibly is not accidental. The two are, however, as already noticed, far removed in position from one another, the Arab mansion being composed of the two stars § (3) and § (5.4), in the left shoulder of Aquarius, to which some add also 46, or θ, Capricorni (6). The corresponding sīn, Hū, is the first of them, or § Aquarīi.

25. Çatatbhisaj, "having a hundred physicians": the form çatatbhisā, which seems to be merely a corruption of the other, also occurs in later writings. It is, as we should expect from the title, said to be composed of a hundred stars, of which the brightest (v. 19) is the junction-star. This, from its defined position, can only be z Aquarīi (1):

\[\text{çatatbhiṣaj} \quad \text{z Aquarii}\]

The rest of the asterism is to be sought among the yet fainter stars in the knee of Aquarius, and the stream from his arm, of course, the number one hundred is not: we have seen that this is not an error, nor are we to suppose it possible to trace out with any distinctness the figure assigned to the group, which is a čhikā. Tāniyāl-Kotaka, according to al-Bīrūnī, gives Çatatbhisaj only a single star, on this is probably an error of the Arab traveller; he is unable to point out which of the stars in Aquarius is to be regarded as constituting the asterism.

The regent of the 23rd asterism, according to nearly all the authorities, is Varuna, the chief of the Adityas, but later the god of the waters: the Tāttiriya-Saṃhitā alone gives to it and to the 14th asterism, as well as to the 16th, Indra as presiding deity: this is perhaps more blundering.

The Graha-Laghava places the junction-star of Çatatbhisaj precisely on the ecliptic; the Siddhānta-Chiramani etc., give it 20', instead of 30', of polar latitude south.

The corresponding lunar mansion of the Arabs, Sa'd al-Akhbīrīya, "the felicity of tents," comprises the three stars in the right wrist and hand of the Water-bearer, or § (3), § (1), § (4) Aquarīi, together with a fourth, which Idris supposes to be θ (5). Since, however, the twenty-third Chinese determinative, too, is z Aquarīi (3), a star so near as readily to be brought into the same group with the other two, we are inclined to regard it as altogether probable that the mansion was, at least originally, composed of α, β, γ, and δ.

26, 27. Bhadrapada; as plural, bhadrāpadas; also bhadrpadā; from bhāda, "beautiful, happy," and pada, "foot." Another frequent appellation is prosīhapada: prosīha is said to mean "carp" and "ox"; the latter significance might perhaps apply here. We have here, once more, a double asterism, divided into two parts, which are distinguished from
one another as पौर्म and उत्तरा, “former” and “latter.” All authorities agree in assigning two stars to each of the two groups; but there is not the same accordance as regards the figures by which they are represented: by some one, by others the other, is called a couch or bed, the alternate one, in either case, being pronounced a bi-faced figure: the Muhūrta-Cintāmāni calls the first a bed, and the second twins. It admits, we apprehend, of little or no question that the Bhadrapadās are properly the four bright stars ζ, α, γ Pegasi, and α Andromedae—all of them commonly reckoned as of the second magnitude—which form together a nearly perfect square, with sides measuring about 15°: the constellation, a very conspicuous one, is familiarly known as the “Square of Pegasus.” The figure of a couch or bed, then, belongs, as in the case of the other two double asterisms, already explained, to the whole constellation, and not to either of the two separate asterisms into which it is divided, while, on the other hand, either of these latter is properly enough symbolized by a pair of twins, or by a figure with a double face. The appropriateness of the designation “feet,” found as a part of both the names of the whole constellation, is also sufficiently evident, if we regard the group as thus composed. The junction-star of the former half-asterism is, by its defined position, clearly shown to be α Pegasi:

Pūrva-Bhadrāpal... 33° 25’ 22° 30’ N.
α Pegasi... 3° 28’ 17° 55’ N.

The Graha-Lāghava gives the junction-star 1° less of polar longitude, which would bring its position to a yet closer accordance, in respect to longitude, with α Pegasi: the error in latitude, which is common to all the authorities, is not greater than we have met with several times elsewhere. But we are told below (v. 16) that the principal star of each of these asterisms is the northern, and this would exclude ζ Pegasi altogether, bringing in as the other member of the first pair some more southern star, perhaps ζ Pegasi (3.4). The confusion is not less marked, although of another character, in the case of the second asterism: in the definition of position of its junction-star we find a longitude given which is that of one member of the group, and a latitude which is that of the other, as is shown by the following comparison:

Uttara-Bhadrāpad... 34° 10’ 24° 1’ N.
γ Pegasi... 3° 20’ 12° 35’ N.
α Andromedae... 35° 17’ 25° 41’ N.

If we accept either of these two stars as the one of which the position is meant to be defined, we shall be obliged to admit an error in the determination either of its longitude or of its latitude considerably greater than we have met with elsewhere. Nor is the matter mended by any of the other authorities: the only variation from the data of our text is presented by the Graha-Lāghava, which reads, as the polar latitude of Uttara-Bhadrāpad... 27° instead of 20°. There can be no doubt that the two stars recognized as composing the asterism are γ Pegasi and α Andromedae, but there has evidently been a blundering confusion of the two in making out the definition of position of the junction-star. We would suggest the following as a possible explanation of
This confusion: that originally α and γ Pegasi were designated and described as junction-stars of the two half-groups, of which they were respectively the southern members; that afterward, for some reason—perhaps owing to the astrological theory (see above, vi. 21) of the superiority of a northern star—the rank of junction-star was sought to be transferred from the southern to the northern stars of both asterisms: that, in making the transfer, the original constitution of the former group was neglected, while in the latter the attempt was made to define the real position of the northern star, but by simply adding to the polar latitude already stated for γ Pegasi, without altering its polar longitude also. Al-Biruni, it should be remarked, was unable to obtain from his Hindu informants any satisfactory identification of either of these asterisms, and marks both in his catalogue as "unknown."

The view we have taken of the true character of the two Bhadrada's is powerfully supported by their comparison with the corresponding members of the other two systems. The twenty-sixth and twenty-seventh manzils, al-Farq al-Mukhmi and al-Farq al-Mukhi, "the fore and hind spouts of the water-jar," comprise respectively α and β Pegasi, and γ Pegasi and α Andromedae; the determinatives of the twenty-fourth and twenty-fifth sieu, Che and Pi, are α and γ Pegasi.

The regents of these two asterisms are aja ekapati and ahi budhaya, the "one-footed goat" and the "bottom-snake," two mythical figures, of obscure significance, from the Vedic pantheon.

28. Revati, "wealthy, abundant." Its presiding divinity is Pūshana, "the prosperer," one of the Adityas. It is said to contain thirty-two stars, which are figured, like those of Čandrašāna, by a drum or tabor; but it would be in vain to attempt to point out precisely the thirty-two which are intended, or to discover in their arrangement any resemblance to the figure chosen to represent it. The junction-star of the group is said (v. 18) to be its southernmost member; all authorities agree in placing it upon the ecliptic, and all excepting our treatise and the Çakalya make its position exactly mark the initial point of the fixed sidereal sphere. The star intended is, as we have already often had occasion to notice, the faint star σ Piscium, of about the fifth magnitude, situated in the band which connects the two Fishes. It is indeed very near to the ecliptic, having only 13° of south latitude. It coincided in longitude with the vernal equinox in the year 572 of our era.

At the time of al-Biruni's visit to India, the Hindus seem to have been already unable to point out distinctly and with confidence the situation in the heavens of that most important point from which they held that the motions of the planets commenced at the creation, and at which, at successive intervals, their universal conjunction would again take place; for he is obliged to mark the asterism, so not certainly identifiable. He also assigns to it, as to Çatabhiṣa, only a single star.

The twenty-sixth Chinese sieu, Koci, is marked by ζ Andromedae (4), which is situated only 33° east in longitude from ζ Piscium, but which has 17° 38' of north latitude. The last manzil, Baṣṭ al-Ḫut, "the fish's belly," or ar-Rishā, "the band," seems intended to include the stars composing the northern Fish, and with them probably the Chinese determinative also; but it is extended so far northward as to take in the bright
star & Andromeda (2), and to this star alone the name of the mansion is sometimes applied, although its situation, so far from the ecliptic (in lat. 25° 50' N.), renders it by no means suited to become the distinctive star of one of the series of lunar stations.

We present, in the annexed table, a general conspectus of the correspondences of the three systems; and, in order to bring out those correspondences in the fullest manner possible, we have made the comparison in three different ways: noting, in the first place, the cases in which the three agree with one another; then those in which each agrees with one of the others; and finally, those in which each agrees with either the one or the other of the remaining two.

Correspondences of the Hindu, Arab, and Chinese Systems of Asterisms.

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* This supposes the second mansīl to be comprised of the stars in Musca, as defined by some authorities. † The sixth mansīl includes, according to many authorities, the fifth sīru, but as there is, at any rate, a discordance in the order of succession, we have not reckoned this among the correspondences. ‡ We reckon these two as cases of general coincidence, because, although the Chinese sīru is not contained in the Arab mansion, the Hindu asterism includes them both, and the virtual correspondence of the three systems is beyond dispute. § Here we assume the Chinese sīru to be comprised among the stars forming the last mansīl, which is altogether probable, although nowhere distinctly stated.
Owing to the different constitution of the systems, their correspondences are somewhat diverse in character: we account the Hindu asterisms and the Arab mansions to agree, when the groups which mark the two are composed, in whole or in part, of the same stars: we account the Chinese system to agree with the others, when the determinative of a siue is to be found among the stars composing their groups. We have prefixed to the whole the numbers and titles of the Hindu asterisms, for the sake of easy reference back to the preceding detailed identifications and comparisons.

After this exhibition of the concordances existing among the three systems, it can, we apprehend, enter into the mind of no one to doubt that all have a common origin, and are but different forms of one and the same system. The questions next arise—is either of the three the original from which the others have been derived? and if so, which of them is entitled to the honor of being so regarded? and are the other two independent and direct derivatives from it, or does either of them come from the other, or must both acknowledge an intermediate source? In endeavoring to answer these questions, we will first exhibit the views of M. Biot respecting the origin and character of the Chinese siue, as stated in the volumes for 1810 and 1830 of the Journal des Savants.

According to Biot, the siue form an organic and integral part of that system by which the Chinese, from an almost immemorial antiquity, have been accustomed to make their careful and industrious observations of celestial phenomena. Their instruments, and their methods of observation, have been closely analogous with those in use among modern astronomers in the West: they have employed a meridian-circle and a measure of time, the chrysophal, and have observed meridian-transits, obtaining right ascensions and declinations of the bodies observed. To reduce the errors of their imperfect time-keepers, they long ago selected certain stars near the equator, of which they determined with great care the intervals in time, and to these they referred the positions of stars or planets coming to the meridian between them. The stars thus chosen are the siue. Twenty-four of them were fixed upon more than two thousand years before our era (M. Biot says, about B.C. 2357; but it is obviously impossible to fix the date, by internal evidence, within a century or two, nor is the external evidence of a more definite character); the considerations which governed their selection were three: proximity to the equator of that period, distinct visibility—conspicuous brilliancy not being demanded for them—and near agreement in respect to time of transit with the upper and lower meridian-passages of the bright stars near the pole, within the circle of perpetual apparition: M. Biot finds reason to believe that these circumpolar stars had been earlier observed with special care, and made standards of comparison, and that, when it was afterward seen to be desirable to have stations near the equator, such stars were adopted as most nearly agreed with them in right ascension. The other four, being the 8th, 14th, 21st, and 28th, the accession of which completed the system of twenty-eight, were added in the time of Cheu-Kong, about B.C. 1100, because they marked very nearly the positions of the equinoxes and solstices at that epoch: the bright star of the Pleiades, however, which had originally been made the first of the
series, from its near approach to the vernal equinox of that remoter era, still maintained, as it has ever since maintained, its rank as the first. Since the time of Ch'eu-Kong the system has undergone no farther modification, but has been preserved unaltered and unimproved, with the obstinate persistency so characteristic of the Chinese, although many of the determinative stars have, under the influence of the precession, become far removed from the equator, one of them even having retrograded into the preceding mansion.

If the history of the Chinese signs, as thus drawn out, is well-founded and true, the question of origin is already solved: the system of twenty-eight celestial mansions is proved to be of native Chinese institution—just as the system of representation of the planetary movements by epicycles is proved to be Greek by the fact that we can trace in the history of Greek science the successive steps of its gradual elaboration. That history rests, at present, upon the authority of M. Biot alone: we are not aware, at least, that any other investigator has gone independently over the same ground; and he has not himself laid before us, in their original form, the passages from Chinese texts which furnish the basis of his conclusions. But we regard them as entitled to be received, upon his authority, with no slight measure of confidence: his own distinguished eminence as a physicist and astronomer, his familiarity with researches into the history and archeology of science, his access to the abundant material for the history of Chinese astronomy collected and worked up by the French missionaries at Peking, and the zealous assistance of his M. Edouard Lévy, the eminent Sinologist, whose premature death, in 1850, has been so deeply deplored as a severe loss to Chinese studies—all these advantages, rarely united in such fullness in the person of any one student of such a subject, give very great weight to views arrived at by means as the results of laborious and long-continued investigation. Nor do we see that any general considerations of importance can be brought forward in opposition to those views. It is, in the first place, by no means inconsistent with what we know in other respects of the age and character of the culture of the Chinese, that they should have devised such a system at so early a date. They have, from the beginning, been as much distinguished by a tendency to observe and record as the Hindus by the lack of such a tendency; they have always attached extreme importance to astronomical labors, and to the construction and rectification of the calendar; and the industry and accuracy of their observations is attested by the use made of them by modern astronomers—thus, to take a single instance, of the cometary orbits which have been calculated, the first twenty-five rest upon Chinese observations alone: and once more, it is altogether in accordance with the clever empiricism and practical shrewdness of the Chinese character that they should have originated at the very start a system of observation exceedingly well adapted to its purpose, stopping with that, working industriously on thenceforth in the same beaten track, and never developing out of so promising a commencement anything deserving the name of a science, never devising a theory of the planetary motions, never even recognizing and defining the true character of the cardinal phenomenon of the precession.
Again, although it might seem beforehand highly improbable that a system of Chinese invention should have found its way into the West, and have been extensively accepted there, many centuries before the Christian era, there are no so insuperable difficulties in the way as should destroy the force of strong presumptive evidence of the truth of such a communication. It is well known that in very ancient times the products of the soil and industry of China were sought as objects of luxury in the West, and mercantile intercourse opened and maintained across the deserts of Central Asia; it even appears that, as early as about B. C. 600 (Isaiah lix. 12), some knowledge of the Sinim, as a far-off eastern nation, had penetrated to Babylonia and Judea. On the other hand, we do not know how much, if at all, earlier than this it may be necessary to acknowledge the system of asterisms to have made its appearance in India. The literary memorials of the earliest period, the Vedas period proper, present no evidence of the existence of the system: indeed, it is remarkable how little notice is taken of the stars by the Vedics poets; even the recognition of some of them as planets does not appear to have taken place until considerably later. In the more recent portions of the Vedas- text—that in the nineteenth book of the Atharva-Veda, a modern appendage to that modern collection, and in parts of the Yajur-Veda, of which there is reason to believe that the canon was not closed until a comparatively late period—full lists of the asterisms are found. The most unequivocal evidence of the early date of the system in India is furnished by the character of the divinities under whose regency the several asterisms are placed: these are all from the Vedic pantheon; the popular divinities of later times are not to be found among them; but, on the other hand, more than one whose consequence is lost, and whose names almost are forgotten, even in the epic period of Hindu history, appear in the list. Neither this, however, nor any other evidence known to us, is sufficient to prove, or even to render strongly probable, the existence of the asterisms in India at so remote a period that the system might not be believed to have been introduced, in its fully developed form, from China.

If, now, we make the attempt to determine, upon internal evidence, which of the three systems is the primitive one, a detailed examination of their correspondences and differences will lead us first to the important negative conclusion that no one among them can be regarded as the immediate source from which either of the other two has been derived. It is evident that the Hindu asterisms and the Arab manazil constitute, in many respects, one and the same system; both present to us constellations or groups of stars, in place of the single determinatives of the Chinese sien; and not only are those groups composed in general of the same stars, but in several cases—as the 7th, 10th, 11th, and 12th members of the series—where they differ widely in situation from the Chinese determinatives, they exhibit an accordance with one another which is too close to be plausibly looked upon as accidental. But if it is thus made to appear that neither can have come independently of the other from a Chinese original, it is no less certain that neither can have come through the other from such an original; for each has its own points of agreement with the sien, which the other does not share—the Hindu in
the 9th, 13th, and 21st asterisms, the Arab in the 15th, 22nd, 23rd, 24th, and 25th mansions. The same considerations show, inversely, that the Chinese system cannot be traced to either of the others as its source, since it agrees in several points with each one of them where that one differs from the third. It becomes necessary, then, to introduce an additional term into the comparison; to assume the existence of a fourth system, differing in some particulars from each of the others, in which all shall find their common point of union. Such an assumption is not to be looked upon as either gratuitous or arbitrary. Not only do the mutual relations of the three systems point distinctly toward it, but it is also supported by general considerations, and will, we think, be found to remove many of the difficulties which have embarrassed the history of the general system. It has been urged as a powerful objection to the Chinese origin of the twenty-eightfold division of the heavens, that we find traces of its existence in so many of the countries of the West, geographically remote from China, and in which Chinese influence can hardly be supposed to have been directly felt. And it is undoubtedly true that neither India nor Arabia has stood in ancient times in such relations to China as should fit it to become the immediate recipient of Chinese learning, and the means of its communication to surrounding peoples. The great route of intercourse between China and the West led over the trade-land of Central Asia, and into the northeastern territory of Iran, the seat of the Zoroastrian religion and culture; thence the roads diverged. One led westward, the other south-eastward into India; reaching the very gate of the Indian peninsula. Within or upon the limits of this central land of Iran we conceive the system of mansions to have received that form of which the Hindoo mukhbatras and the Arab muwazzil are the somewhat altered representatives; precisely where, and whether in the hands of Semitic or of Aryan races, we would not at present attempt to say. There are, as has been noticed above, traces of an Iranian system to be found in the Budh-us; but this is a work which, although probably not later than the time of Peria's excavations and under her Sassanian rulers, can pretend to no rich antiquity and like traces have as yet been pointed out in the earliest Iranian memorial, the Zendavesta. Weber (Ind. Literatugeschichte, p. 221). In the other hand, see the mazzoth and mazzoreph of the Scriptures (Job xxxviii. 32; 11 Kings xxiii. 5)—words radically akin with the Arab's 'muwazzil'—indications of the early existence of the system in question among the western Semites, and sanctions for it a Chaldaic origin: but the allusions appear to us too obscure and equivocal to be urged as proof of this, nor is it easy to believe that such a method of division of the heavens should have prevailed so far to the west, and from so ancient a time, without our hearing of it from the Greeks; and especially, if it formed part of the Chaldaic astronomy. This point, however, may fairly be passed over, as one to be determined, perhaps, by future investigations, and not of essential importance to the present inquiry. The question of originality is at least definitely settled adversely to the claims of both the Hindu and the Arab systems, and can only lie between the Chinese and that Persian system from which the other two have together descended. And
as concerns these, we are willing to accept the solution which is furnish
ished us by the researches of M. Biot, supported as we conceive it to be
by the general probabilities of the case. Any one who will trace out,
by the help of a celestial globe or map,* the positions of the Chinese
determinatives, cannot fail to perceive their general approach to a great
circle of the sphere which is independent of the ecliptic, and which
accords more nearly with the equator of B.C. 2350 than with any other
later one. The full explanations and tables of positions given by Biot
(Journ. d. Sav., 1840, pp. 243-254) also furnish evidence, of a kind
appreciable by all, that the system may have had the origin which he
attributes to it, and that, allowing for the limitations imposed upon it by
its history, it is consistent with itself, and well enough adapted to the
purposes for which it was designed. With the positions of its determinative
stars seem to have agreed those of the constellations adopted by
the common parent of the Hindu and Arab systems, excepting in five or
six points: those points being where the Chinese make their one unac-
countable leap from the head to the belt of Orion, and again, where the
sieu are drawn off far to the southward, in the constellations Hydra and
Crater: and this, in our view, looks much more as if the series of the
sieu were the original, whose guidance had been closely followed excepting
in a few cases, than as if the asterisms composing the other systems
had been independently selected from the groups of stars situated along
the zodiac, with the intention of forming a zodiacal series. It is easy to
see, farther, how the single determinatives of the sieu should have become
the nuclei for constellations such as are presented by the other systems;
but if, on the contrary, the sieu had been selected by the Chinese, in
each case, from groups previously constituted, there appears no reason
why their brightest stars should not have been chosen, as they were cho-
sen later by the Hindus, in the establishment of junction-stars for the
asterisms.

We would suggest, then, as the theory best supported by all the evi-
dence thus far elicited, that a knowledge of the Chinese astronomy, and
with it the Chinese system of division of the heavens into twenty-eight
mansions, was carried into Western Asia at a period not much later
than B.C. 1100, and was there adopted by some western people, either
Semitic or Iranian. That in their hands it received a new form, such as
adapted it to a ruder and less scientific method of observation, the limiting
stars of the mansions being converted into zodiacal groups or con-
stellations, and in some instances altered in position, so as to be brought
nearer to the general planetary path of the ecliptic. That in this
changed form, having become a means of roughly determining and de-
scribing the places and movements of the planets, it passed into the
keeping of the Hindus—very probably along with the first knowledge
of the planets themselves—and entered upon an independent career of
history in India. That it still maintained itself in its old seat, leaving its
traces later in the Bundelkesh: and that it made its way so far westward
as finally to become known to, and adopted by, the Arabs. The farther

* We propose to furnish at the close of this publication, in connection with the
additional notes, such a map of the zodiacal zone of the heavens as will sufficiently
illustrate the character and mutual relations of the three systems compared.

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modifications introduced into it by the latter people all have in view a single purpose, that of establishing its stations in the immediate neighborhood of the ecliptic: to this purpose the whole Arab system is not less constantly faithful than is the Chinese to its own guiding principle. The Hindu sustains in this respect but an unfavorable comparison with the others: the arbitrary introduction, in the 15th, 29th, 23rd, and 24th asterisms, of remote northern stars, greatly impairs its unity, and also furnishes an additional argument of no slight force against its originality; for, on the one hand, the derivation of the others from it becomes thereby vastly more difficult, and, on the other, we can hardly believe that a system of organic Indian growth could have become disfigured in India by such inconsistencies; they wear the aspect, rather, of arbitrary alterations made, at the time of its adoption, in an institution imported from abroad.

It might, at first sight, appear that the adoption by the Arabs of the mansil corresponding to Acvini as the first of their series indicated that they had derived it from India posterior to the transfer by the Hindus of the first rank from Kyttikà, the first of the seis, to Acvini: but the circumstance seems readily to admit of another interpretation. The names of many of the Arab mansions show the influence of the Greek astronomy, being derived from the Greek constellations: the same influence would fully explain an arrangement which made the series begin with the group coinciding most nearly with the beginning of the Greek zodiac. The transfer on the part of the Hindus, likewise, was unquestionably made at the time of the general reconstruction of their astronomical system under the influence of western science. The two series are thus to be regarded as having been brought into accordance in this respect by the separate and independent working of the same cause.

M. Diot insists strongly, as a proof of the non-originality of the system of asterisms among the Hindus, upon its gross and palpable lack of adaptedness to the purpose for which they used it; he compares it to a gimlet out of which they have tried to make a saw. In this view we can by no means agree with him: we would rather liken it to a hatchet, which, with its edge dulled and broken, has been turned and made to do duty as a hammer, and which is not ill suited to its new and coarser office. Indeed, taking the Hindu system in its more perfect and consistent form, as applied by the Arabs, and comparing it with the Chinese seis at any time within the past two thousand years, we are by no means sure that the advantage in respect to adaptation would not be generally pronounced to be upon the side of the former. The distance of many of the seis during that period from the equator, the faintness of some among them, the great irregularity of their intervals, render them anything but a model system for measuring distances in right ascension. On the other hand, to adopt a series of conspicuous constellations along the zodiac, by their proximity to which the movements of the planets shall be marked, is no unmotivated proceeding: just such a division of the ecliptic among twelve constellations preceded and led the way to the Greek method of measuring by signs, having exact limits, and independent of the groups of stars which originally gave name to them. M. Diot's error lies in his misapprehension, in two important
respects, of the character of the Hindu asterisms: in the first place, he constantly treats them as if they were, like the sira, single stars, the intervals between whose circles of declination constituted the accepted divisions of the zodiac; and in the second place, he assumes them to have been established for the purpose of marking the moon’s daily progress from point to point along the ecliptic. Now, as regards the first of these points, we have already shown above that the conversion of the Chinese determinatives into constellations took place, in all probability, before their introduction to the knowledge of the Hindus: there is, indeed, an entire unanimity of evidence to the effect that the Hindu system is from its inception one of groups of stars: this is conclusively shown by the original dual and plural names of the asterisms, or by their otherwise significant titles—compare especially those of the 13th and 25th of the series. The selection of a "junction-star" to represent the asterism appears to be something comparatively modern: we regard it as posterior to the reconstruction of the Hindu astronomy upon a truly scientific basis, and the determination, by calculation, of the precise places of the planets: this would naturally awaken a desire for, and lead to, a similarly exact determination of the position of some star representing each asterism, which might be employed in the calculation of conjunctions, for astrological purposes; the astronomical uses of the system being no longer of much account after the division of the ecliptic into signs. And the choice of the junction-star has fallen, in the majority of cases, not upon the Chinese determinative itself, but upon some other and more conspicuous member of the group originally formed about the latter. Again, there is an entire absence of evidence that the "portions" of the asterisms, or the arcs of the ecliptic named from them, were ever measured from junction-star to junction-star: whatever may be the discordance among the different authorities respecting their extent and limits, they are always freely, and often arbitrarily, taken from parts of the ecliptic adjacent to, or not far removed from, the successive constellations.

As regards the other point noticed, it is, indeed, not at all to be wondered at that M. Riot should treat the Hindu nakshatras as a system bearing special relations to the moon, since, by those who have treated of them, they have always been styled "houses of the moon," "moon-stations," "lunar asterisms," and the like. Nevertheless, these designations seem to be founded only in carelessness, or in misapprehension. In the Sūrya-Siddhānta, certainly, there is no hint to be discovered of any particular connection between them and the moon, and for this reason we have been careful never to translate the term nakshatra by any other word than simply "asterism." Nor does the case appear to have been otherwise from the beginning. No one of the general names for the asterisms (nakshatra, bha, dhishya) means literally anything more than "star" or "constellation": their most ancient and usual appellation, nakshatra, is a word of doubtless etymology (it may be radically akin with nakti, nax, nakt, "night"), but it is not infrequently met with in the Vedic writings, with the general signification of "star," or "group of stars": the moon is several times designated as "sovereign of the nakshatras," but evidently in no other sense than that in which
we style her “queen of night”; for the same title is in oth3er passages
given to the sun, and even also to the Milky Way. When the name
came to be especially applied to the system of zodiacal asterisms, we
have seen above that a single one of the series, the 6th, was placed un-
der the regency of the moon, as another, the 13th, under that of the
sun: this, too, by no means looks as if the whole design of the system
was to mark the moon’s daily motions. Naturally enough, since the
moon is the most conspicuous of the nightly luminaries, and her revolu-
tions more rapid and far more important than those of the others, the
asterisms would practically be brought into much more frequent use in
connection with her movements: their number, likewise, being nearly
accordant with the number of days of her sidereal revolution, could not
but tempt those who thus employed them to set up an artificial relation
between the two. Hence the Arabs distinctly call their divisions of the
zodiac, and the constellations which mark them, “houses of the moon,”
and, until the researches of M. Biot, no one, so far as we are aware, had
ever questioned that the number of the asterisms or mansions, wherever
found, was derived from and dependent on that of the days in the
moon’s revolution. It was most natural, then, that Western scholars,
having first made acquaintance with the Arab system, should, on finding
the same in India, call it by the same name: nor is it very strange, even,
that Ideler should have gone a step farther, and applied the familiar title
of “lunar stations” to the Chinese sien also; an error for which he is
sharply criticised by M. Biot (Journ. d. Sav., 1859, p. 480). The latter
cites from al-Biruni (Journ. d. Sav. 1855, p. 49; 1859, pp. 487-8) two
passages derived by him from Varaha-mihira and Brahmagupta respect-
ively, in which are recorded attempts to establish a systematic relation
between the asterisms and the moon’s true and mean daily motions.
One of these passages is exceedingly obscure, and both are irreconcil-
able with one another, and with what we know of the system of asteri-
isms from other sources: two conclusions, however, bearing upon the
present matter, are clearly derivable from them: first, that, as the “por-
tions” assigned to the asterisms had no natural and fixed limits, it was
possible for any Hindu system-maker so to define them as to bring them
into a connection with the moon’s daily motions; and secondly, that
such a connection was never deemed an essential feature of the system,
and hence no one form of it was generally recognized and accepted.
The considerations adduced by us above are, we think, fully sufficient to
account for any such isolated attempts at the establishment of a con-
nection as al-Biruni, who naturally sought to find in the Hindu naksha-
tras the corollaries of his own manzil al-kamar, was able to discover
among the works of Hindu astronomers: there is no good reason why
we should deprive the former of their true character, which is that of
zodiacal constellations, rudely marking out divisions of the ecliptic, and
employable for all the purposes for which such a division is demanded.

The reason of the variation in the number of the asterisms, which are
reckoned now as twenty-eight and now as twenty-seven, is a point of no
small difficulty in the history of the system. M. Biot makes the acute
question that the omission of Abhijit from the series took place be-
tween the mansion belonging to that asterism was on the point of becom-
ing extinguished, the circle of declination of its junction-star being brought by the precession to a coincidence with that of the junction-star of the preceding asterism about A.D. 972. But it has been shown above that M. Biot’s view of the nature of a nakshatra—that it is, namely, the arc of the ecliptic intercepted between the circles of declination of two successive junction-stars—is altogether erroneous: however nearly those circles might approach one another, there would still be no difficulty in assigning to each asterism its “portion” from the neighboring region of the ecliptic. Again, this explanation would not account for the early date of the omission of Abhijit, which, as already noticed, is found wanting in one of the most ancient lists, that of the Taittiriya-Sanhitā. It is to be observed, moreover, that M. Biot, in calculating the period of Abhijit’s disappearance, has adopted v Sagittarii as the junction-star of Uttara-Ashādha, while we have shown above that σ, and not v, is to be so regarded: and this substitution would defer until several centuries later the date of coincidence of the two circles of declination. According to the Hindu measurements, indeed (see the table of positions of the junction-stars, near the beginning of this note), Abhijit is farther removed from the preceding asterism, both in polar longitude and in right ascension, than are five of the other asterisms from their respective predecessors; nor does the Hindu astronomical system acknowledge or make allowance for the alteration of position of the circles of declination under the influence of the precession; their places, as data for the calculation of conjunctions, are ostensibly laid down for all future time. For these various reasons, M. Biot’s explanation is to be rejected as insufficient. A more satisfactory one, in our opinion, may be found in the fact, illustrated above (see Fig. 31, beginning of this note), that the asterisms are in general so distributed as to accord quite well with a division of the ecliptic into twenty-seven equal portions, but not with a division into twenty-eight equal portions; that the region where they are too much crowded together is that from the 20th to the 23rd asterism, and that, among those situated in this crowded quarter, Abhijit is farthest removed from the ecliptic, and so is more easily left out than any of the others, in dividing the ecliptic into portions. We cannot consider it at all doubtful that Abhijit is as originally and truly a part of the system of asterisms as any other constellation in the series, which is properly composed of twenty-eight members, and not of twenty-seven; the analogy of the other systems, and the fact that treatises like this Siddhānta, which reckon only twenty-seven divisions of the ecliptic, are yet obliged, in treating of the asterisms as constellations, to regard them as twenty-eight, are conclusive upon this point. The whole difficulty and source of discordance seems to lie in this—how shall there, in any systematic method of division of the ecliptic, be found a place and a portion for a twenty-eighth asterism? The Khaṇḍa-Kaṭaka, as cited by al-Birūnī—in making out, by a method which is altogether irrespective of the actual positions of the asterisms with reference to the zodiac, the accordance already referred to between their portions and the moon’s daily motions—allots to Abhijit so much of the ecliptic as is equivalent to the mean motion of the moon during the part of a day by which her revolution exceeds twenty-seven days.
Others follow it a share in the proper portions of the two neighboring asterisms; thus the Muhūrta-Māla, a late work, of date unknown to us, says: "the last quarter of Uttara-Aśādha and the first fifteenth of Čhātra together constitute Abhijit: it is so to be accounted when twenty-eight asterisms are reckoned; not otherwise." Ordinarily, however, the division of the ecliptic into twenty-seven equal "portions" is made, and Abhijit is simply passed by in their distribution. After the introduction of the modern method of dividing the circle into degrees and minutes, this last way of settling the difficulty would obviously receive a powerful support, and an increased currency, from the fact that a division by twenty-seven gave each portion an even number of minutes, 800, while a division by twenty-eight yielded the awkward and unmanageable quotient 7713.

Much yet remains to be done, before the history and use of the asterisms, as a part of the ancient Hindu astronomy and astrology, shall be fully understood. There is in existence an abundant literature, ancient and modern, upon the subject, which will doubtless at some time provoke laborious investigation, and repay it with interesting results. To us hardly any of that literature is accessible, and only the final results of wide-extended and long-continued studies upon it could be placed here. We have already allotted to the nakshatras more than to some may seem advisable; our excuse must be the increasing interest of the history of the system, as part of the ancient history of the rise and spread of astronomical science; the importance attaching to the researches of M. Biot, the inadequate attention hitherto paid them, and the recent renewal of their discussion in the Journal des Sar-voins; and finally and especially, the fact that in and with the asterisms is bound up the whole history of Hindu astronomy, prior to its transformation under the overpowering influence of western science. In the modern astronomy of India, the nakshatras are of subordinate consequence only, and appear as hardly more than reminiscences of a former order of things: from the Sūrya-Siddhānta might be struck out every text referring to them, without serious alteration of the character of the treatise.

Before bringing this note to a close, we present, in the annexed table, a comparison of the true longitudes and latitudes of the junction-stars of the twenty-eight asterisms, as derived by calculation from the positions stated in our text, with the actual longitudes and latitudes of the stars with which they are probably to be identified. In a single case, (the 27th asterism), we compare the longitude of one star and the latitude of another; the reason of this is explained above, in connection with the identification of the asterism. We add columns giving the errors of the Hindu determinations of position: in that for the latitude north direction is regarded as positive, and south direction as negative.

Upon examining the column of errors of latitude presented in this table, it will be seen that they are too considerable, and too irregular, both in amount and in direction, to be plausibly accounted for other than as direct errors of observation and calculation. The gross errors, as has already been pointed out, are committed in the measure of southern latitudes, when of considerable amount, and they are
### Longitude, A. D. 560.

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<td>Kṛttika</td>
<td>39 8</td>
<td>38 58</td>
<td>- 0 50</td>
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<td>4 103</td>
<td>+ 0 43</td>
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<td>4</td>
<td>Rohini</td>
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<td>Mrgagiraha</td>
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<td>63 40</td>
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<td>Punarvasu</td>
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<td>14 19</td>
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<td>12 10 8</td>
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<td>183 48</td>
<td>- 3 11</td>
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<td>2 2</td>
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<td>184 12</td>
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<td>0 24</td>
<td>13 S.</td>
<td>+ 0 5</td>
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all in the same direction, giving the star a place too far to the north. The column of errors in longitude, on the other hand, shows a very marked preponderance of minus errors, their sum being $33\degree\ 54\arcmin$, while the sum of plus errors is only $7\degree\ 52\arcmin$. Upon taking the difference of these sums, and dividing it by twenty-eight, we find the average error of longitude to be $-56\arcmin$, the greatest deviation from it in either direction being $-2\degree\ 4\arcmin$ and $+3\degree\ 27\arcmin$.\* So far as this goes, it would indicate that

*In a comparison in which a high degree of exactness was desired, and was not, in the nature of the case, attainable, it would of course be necessary to take into account the proper motions of the stars compared. This we have not thought it worth while, in the present instance, to do. We may remark, however, that the juncti-star of the 18th asterism, Areturus, has a much greater proper motion than any other in the series; and that, if this were allowed for, according to its value determined by Halm (Mem. Roy. Astr. Soc., vol. vii., 4to, 1861), the Hindu signs of longitude would be diminished about $22\arcmin$, but that of latitude increased about $2\arcmin$.\*
by the Hindus for this purpose, such a determination of date cannot, indeed, be relied upon as exact or conclusive, yet it is the best and surest that we can attain. The general conclusion, at any rate, stands fast, that the positions of the junction-stars of the asterisms were fixed not far from the time when the vernal equinox coincided with the initial point of the Hindu sidereal sphere, or during the sixth century of our era.

Since, according to the Hindu theory, the initial point of the sidereal sphere is also, for all time, the mean place of the vernal equinox, which always reverts to it after a libration of 27° in either direction (see above, iii. 9–12), we are not surprised to find the positions of the asterisms primarily defined upon the supposition of their coincidence. But it is not a little strange that the effect of the precession in altering the direction of the circles of declination drawn through the junction-stars, and so the pole longitudes and latitudes of the latter, should be made no account of (see, however, the latter half of v. 12, below, and the note upon it), that directions for calculating the conjunctions of the planets with the asterisms according to their positions as thus stated should be given (vv. 14–15), unaccompanied by any hint that a modification of the data of the process would ever be found necessary. This carelessness is perhaps to be regarded as additional evidence of the small importance attached, after the reconstruction of the Hindu astronomy, to calculation in which the asterisms were concerned; although it also tends strongly to prove what we have suggested above (note to iii. 9–12), that in the construction of the Hindu astronomical system the precession was ignored altogether. It is to be noticed that the two systems of yugas (see above, ii. 65, and additional note upon that passage), originally founded upon actual conjunctions with the asterisms, have been divorced from any real connection with them. A like consideration might restrain us from accepting the determinations of position here presented as the best results which Hindu observers and instruments were capable of attaining; yet in the absence of other tests of their powers, we cannot well help arriving the conclusion that the accuracy of a Hindu observation is not to be relied on within a degree or two.

10. Agastya is at the end of Gemini, and eighty degrees south; and Mravyadha is situated in the twentieth degree of Gemini;

11. His latitude (vikshepa), reckoned from his point of declination (gakrama), is forty degrees south: Agni (hutabhy) and Brahmarshay are in Taurus, the twenty-second degree;

12. And they are removed in latitude (vikshipti), northward, eight and thirty degrees respectively. . . .

In connection with the more proper subject of this chapter we also have laid before us, here and in a subsequent passage (vv. 20–21), the defined positions of a few fixed stars which are not included in the system of zodiacal asterisms. The definition is made in the same manner as before, by polar longitudes and latitudes. It is not at all difficult to identify the stars referred to in these verses; they were correctly pointed out by Colebrooke, in his article already cited (An. Rev., vol. ix), Agastya Navis, or Canopus, a star of the first magnitude, and one of the
most brilliant in the southern heavens. Its remote southern position, only 37° from the pole, renders it invisible to an observer stationed much to the northward of the Tropic of Cancer. Its Hindu name is that of one of the old Vedic rasis, or inspired sages. The comparison of its true position with that assigned it by our text—which, in this instance, does not require to be reduced to true longitude and latitude—is as follows:

Agastya  . . . . . 90° 0' . . . . . . 80° 0' S.
Canopus  . . . . . 85° 4' . . . . . . 75° 50' S.

The error of position is here very considerable, and the variations of the other authorities from the data of our text are correspondingly great. The Siddhânta-Cîromâni and (according to Colebrooke) the Brahma-Siddhânta give Agastya 87° of polar longitude, and 77° of latitude, which is a fair approximation to the truth: the Graha-Lâghava also places it correctly in lat. 76° S., but makes its longitude only 80°, which is as gross an error as that of the Sûrya-Siddhânta, but in the opposite direction. The Cakapala-Sanhitâ agrees precisely with our text as respects the positions of these four stars, as it does generally in the numerical data of its astronomical system.

Mrâgavādhaka, “deer-hunter”—it is also called Lubdhaka, “hunter” is α Canis Majoris, or Sirius, the brightest of the fixed stars:

Mrâgavādhaka  . . . . . 76° 39' . . . . . . 39° 52' S.
Sirius  . . . . . . . . . . . . . . . . . 81° 7' . . . . . . 39° 32' S.

Here, while all authorities agree with the correct determination of the latitude of Sirius presented by our text, the Siddhânta-Cîromâni greatly reduce its error of longitude, by giving the star 88°, instead of 80°, of polar longitude: the Graha-Lâghava reads 81°.

The star named after the god of fire, Agni, and called in the text by one of his frequent epithets, Anubhûj, “devourer of the sacrifice,” is the one which is situated at the extremity of the northern horn of the Bull, or β Tauri: it alone of the four is of the second magnitude only:

Agni  . . . . . . 54° 5' . . . . . . 7° 44' N.
β Tauri  . . . . . . . . 62° 31' . . . . . . 5° 22' N.

The very gross error in the determination of the longitude of this star is but slightly reduced by the Graha-Lâghava, which gives it 53°, instead of 52°, of polar longitude. The Siddhânta-Cîromâni and Brahma-Siddhânta omit all notice of any of the fixed stars excepting Canopus and Sirius.

Brahmahârdaya, “Brahma’s heart,” is α Aurigae, or Capella:

Brahmahârdaya  . . . . . 60° 29' . . . . . . 26° 53' N.
Capella  . . . . . . . . . . . . . . . . . 61° 50' . . . . . . 2° 52' N.

The Graha-Lâghava, leaving this erroneous determination of latitude unamended, adds a greater error of longitude, in the opposite direction to that of our text, by giving the star 4° more of polar longitude.

We shall present these comparisons in a tabular form at the end of the chapter, in connection with the other passage of similar import.
What is the true meaning and scope of this passage, is a question with regard to which there may be some difference of opinion. The commentator explains it as intended to satisfy the inquiry whether the polar longitudes and latitudes, as stated in the text, are constant, or whether they are subject to variation. Now although, he says, owing to the precession, the values of these quantities are not unalterably fixed, yet they are given by the text as they were at its period, and as if they were constant, while the astronomer is directed to determine them for his own time by actual observation. For this purpose he is to take such a sphere as is described below (chap. xiii)—of which the principal parts, and the only ones which would be brought into use in this process, are hoops or circles representing the colures, the equator, and the ecliptic—and is to suspend upon its poles an additional movable circle, graduated to degrees: this would be, of course, a revolving circle of declination. The sphere is next to be adjusted in such manner that its axis shall point to the pole, and that its horizon shall be water-level. Then, in the night, the junction-star of Revati (Pisces) is to be looked at through a hole in the centre of the instrument, and the corresponding point of the ecliptic, which is 10° east of the end of the constellation Pisces, is to be sought over it; after that, it will be necessary only to bring the revolving circle of declination, as observed through the hole in the centre of instrument, over any other star of which it is desired to determine determination, and its polar longitude and latitude may be read off directly upon the ecliptic and the movable circle respectively.

Colebrooke (As. Res., ix. 326; Essays, ii. 324) found this passage similarly explained in other commentaries upon the Sūrya-Siddhānta to which he had access, and also met with like directions in the commentaries on the Siddhānta-Cīrākumāra.

There are, however, very serious objections to such an interpretation of the brief direction contained in the text. It is altogether inconsistent with the whole plan and method of a Hindu astronomical treatise to leave, and even to order, matters of this character to be determined by observation. Observation has no such important place assigned to it in the astronomical system: with the exception of terrestrial longitude and latitude, which, in the nature of things, are beyond the reach of a treatise, it is intended that the astronomer should find in his text-book everything which he needs for the determination of celestial phenomena, and should resort to instruments and observation only by way of illustration. The sphere of which the construction is prescribed in the thirteenth chapter is not an instrument for observation: it is expressly stated to be "for the instruction of the pupil," and it is encumbered with such a number and variety of different circles, including parallels of declination for all the asterisms and for the observed fixed stars, that it could not be used for any other purpose: it will be noticed, too, that the commentary is itself obliged to order here the addition of the only appliances—the revolving circle of declination and the hole through the centre—which make of it an instrument for observation. The simple and original meaning of the passage seems to be that, having constructed a sphere in the manner to be hereafter described, one may examine the asterisms as marked upon it, and note their coincidence.
with the actual positions of the stars in the heavens. And we would regard the other interpretation as forced upon the passage by the commentators, in order to avoid the difficulty pointed out by us above (near the end of the note on the last passage but one) and to free the Siddhánta from the imputation of having neglected the precessional variation of the circles of declination. M. Biot pronounces the method of observation explained by the commentators "almost impracticable," and it can, accordingly, hardly be that by which the positions of the asterisms were at first laid down, or by which they could be made to undergo the necessary corrections. Another method, more in accordance with the rules and processes of the third chapter, and which appears to us to be more authentic and of higher value, is described by Colebrooke (as above) from the Siddhánta-Sarvabhauma, being there cited from the Siddhánta-Sundara; it is as follows:

"A tube, adapted to the summit of the gnomon, is directed toward the star on the meridian; and the line of the tube, pointed to the star, is prolonged by a thread to the ground. The line from the summit of the gnomon to the base is the hypotenuse; the height of the gnomon is the perpendicular; and its distance from the extremity of the thread is the base of the triangle. Therefore, as the hypotenuse is to its base, so is the radius to a base, from which the sine of the angle, and consequently the angle itself, are known. If it exceed the latitude [or place of observation], the declination is south; or, if the contrary, north. The right ascension of the star is calculated from the time of night, and from the right ascension of the sun for that time. The declination of the corresponding point of the ecliptic being found, the sum or difference of the declinations, according as they are of the same or of different denominations, is the distance of the star from the ecliptic. The longitude of the same point is computed; and from these elements, with the actual precession of the equinox, may be calculated the true longitude of the star; as also its latitude on a circle passing through the poles of the ecliptic."

The Siddhánta-Sarvabhauma also gives the true longitudes and latitudes of the asterisms, professedly as thus obtained by observation and calculation, and they are reported by Colebrooke in his general table of data respecting the asterisms.

If we are not mistaken, the amount and character of the errors in the stated latitudes of the asterisms tend to prove that this, or some kindred process, was that by which their positions were actually determined.

13. In Taurus, the seventeenth degree, a planet of which the latitude is a little more than two degrees south, will split the wain of Rohini.

The asterism Rohini, as has been seen above, is composed of the five principal stars in the head of Taurus, in the constellation of which is seen the figure of a wain. The divinity is Prajapati. The distances of its stars in longitude from the initial point of the sphere vary from 45° 40' (7) to 49° 45' (8): hence the seventeenth degree of the second sign—the reckoning commencing at the initial point of the sphere, taken as coinciding also with the vernal equinox—is very nearly the middle of...
Mādhava. The latitude of its stars again varies from 2° 30' (e) to 5° 47'. (f) S.; hence, to come into collision with, or to enter, the wain, a planet must have more than two degrees of south latitude. The Siddhānta does not inform us what would be the consequences of such an occurrence; that belongs rather to the domain of astrology than of astronomy. We cite from the Pañcatantra (vv. 238-241) the following description of these consequences, derived from the astrological writings of Varāha-mihira:*

"When Saturn splits the wain of Rohini here in the world, then Mādhava rains not upon the earth for twelve years.

"When the wain of Prājapati's asterism is split, the earth, having as it were committed a sin, performs, in a manner, her surface being strewn with ashes and bones, the kāpālikā penance.

"If Saturn, Mars, or the descending node splits the wain of Rohini, why need I say that, in a sea of misfortune, destruction befalls the world?

"When the moon is stationed in the midst of Rohini's wain, then men wander recklessly about, deprived of shelter, eating the cooked flesh of children, drinking water from vessels burnt by the sun."

Upon what conception this curious feature of the ancient Hindu astrology is founded, we are entirely ignorant.

14. Calculate, as in the case of the planets, the day and night of the asterisms, and perform the operation for apparent longitude (āyakarman), as before: the rest is by the rules for the conjunction (melaka) of planets, using the daily motion of the planet as a divisor: the same is the case as regards the time.

15. When the longitude of the planet is less than the polar longitude (dharvaka) of the asterism, the conjunction (yoga) is to come; when greater, it is past: when the planet is retrograding (vakragati), the contrary is to be recognized as true of the conjunction (samāgyama).

The rules given in the preceding chapter for calculating the conjunction of two planets with one another apply, of course, with certain modifications, to the calculation of the conjunctions of the planets with the asterisms. The text, however, omits to specify the most important of these modifications—that, namely, in determining the apparent longitude of an asterism, one part of the process prescribed in the case of a planet, the ayanādṛkkarman, or correction for ecliptic deviation, is to be omitted altogether; since the polar longitude of the asterism, which is given, corresponds in character with the ayanā graha, or longitude of the planet as affected by ecliptic deviation, which must be ascertained by the ayanādṛkkarman. The commentary notices the omission, but offers neither explanation nor excuse for it. The other essential modification—that, the asterism being fixed, the motion of the planet alone is

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* Our translation represents the verses as amended in their readings by Benfey (Pañcatantra etc., 3rd Theil, pp. 234-237). In the third of the verses, however, the reading of the published text, par, "moon," would seem decidedly preferable to the "descending node": since the node, being always necessarily in the ecliptic, never come into collision with Rohini's wain.
to be used as divisor in determining the place and time of the conjunction—is duly noticed.

The inaccuacacies in the Hindu process for determining apparent longitudes, which, as above noticed, are kept within bounds, where the planets alone are concerned, by the small amount of their latitudes, would be liable in the case of many of the asterisms to lead to grave errors of result.

16. Of the two Phalguni, the two Bhūrāpadās, and likewise the two Aṣṭādīhās, of Viṣṇukā, Aśvinī, and Maṅgaśeṣhā (śaṁya), the junction-star (yogatāra) is stated to be the northern (uṣā). It is the western:

17. That which is the western northern star, being the situated westward, that is the junction-star of Hasta; viśātha it is the western:

18. Of Jyesṭhā, Čravaṇa, Anurādhā (maitra), and Pushya (bhraspatya), it is the middle star: of Bharaṇī, Kṛttikā (āṅgeya), and Magha (pitrīya), and likewise of Revati, it is the southern:

19. Of Bṛhaṇī, Punarvasu (āḍita), and Mula, it is the eastern and so also of Aḍgheshā (sārya): in the case of each of the others, the junction-star (yogatāraka) is the great (sthūla) one.

We have had occasion above, in treating of the identification of the asterisms, to question the accuracy of some of these designations of the relative position of the junction-stars in the groups containing them. We do not regard the passage as having the same authenticity and authority with that in which the determinations of the polar longitudes and latitudes are given; and indeed, we are inclined to suspect that all which follows the fifteenth verse in the chapter may be a later addition to its original content. It is difficult to see otherwise why the statements given in verses 20 and 21 of the positions of certain stars should be separated from those presented above, in verses 10-12. A designation of the relative position of the junction-star in each group ought also properly to be connected with a definition of the number of stars composing each, and a description of its configuration—such as are presented along with it by other treatises, as the Čākalya-Saṁhitā. The first is even in some points ambiguous unless accompanied by the others, since there are cases in which the same star has a different position in its asterism according as the latter is to be regarded as including a less or a greater number of stars. In this respect also, then, the passage looks like a disconnected fragment. Nor is the method of designation so clear and systematic as to inspire us with confidence in its accuracy. Upon a consideration of the whole series of asterisms, it is obvious that the brightest member of each group is generally selected as its junction-star. Hence we should expect to find a general rule to that effect laid down, and then the exceptions to it specially noted, together with the cases in which such a designation would be equivocal. Instead of this, we have the junction-stars of only two asterisms containing more than one star, namely Abhijit and Čātabhisaj, described by their superior brilliancy, while that of the former is not less capable of being pointed out by its position than are any of the others in the series. Again, there are cases
in which it is questionable which star is meant to be pointed out in a group of which the constitution is not doubtful, owing to the very near correspondence of more than one star with the position as defined. And once more, where, in a single instance, a special effort has apparently been made to fix the position of the junction-star beyond all doubt or cavil, the result is a failure; for it still remains a matter of dispute how the description is to be understood, and which member of the group is intended. The case referred to is that of Hasta, which occupies nearly all of verse 17. That Colebrooke was not satisfied as to the meaning of the description is clear from the fact that he specifies, as the star referred to, "γ or δ Corvi." His translation of the verse, "2nd W. of 1st N.W.," conveys to us no intelligible meaning whatever, as applied to the actual group. He evidently understood pacemottarātṝḍyā as a single word, standing by euphony for -tṝḍyas, ablative of -tṝḍ. Our own rendering supposes it divided into the two independent words pacemottarātṝḍ yā, or the three pacemottarātṝḍ yā. This interpretation is, in the first place, supported by the corresponding passage in the Čākalya-Sanhitā, which reads, "of Hasta, the north-western (vāyasi): it is also the second western." Again, it applies without difficulty to one of the stars in the group, namely to γ, which we think most likely to be the one pointed out—and mainly, because either of the others would admit of being more simply and briefly designated, δ as the northern; β as the western, α as the southern, and τ as the western star. We should, then, regard the description as unambiguous, were it not for what is farther added, "being the second situated westward," for γ is the first or most westerly of the five in longitude, and the third in right ascension, while the second in longitude and in right ascension respectively are the two faint stars τ and α. We confess that we do not see how the difficulty is to be solved without some emendation of the text.

We conceive ourselves to be justified, then, in regarding this passage as of doubtful authenticity and inferior authority: as already partaking, in short, of that ignorance and carelessness which has rendered the Hindu astronomers unable, at any time during the past thousand years, to point out in the heavens the complete series of the groups of stars composing their system of asterisms. None of the other authorities accessible to us gives a description of the relative places of the junction-stars, excepting the Čākalya-Sanhitā, and our manuscript of its text is so defective and corrupt at this point that we are able to derive from it with confidence the positions of only about a third of the stars. So far, it accords with the Śrūya-Siddhānta, save that it points out as the junction-star of Pūrva-Aśādāḥā the brightest, instead of the northernmost, member of the group; and here there is a difference in the mode of designation only, and not a disagreement as regards the star designated.

20. Situated five degrees eastward from Brahmārdraya is Prājāpati: it is at the end of Taurus, and thirty-eight degrees north.

21. Apānātasa is five degrees north from Cīrā: somewhat greater than it, as also six degrees to the north of it, in Apas.

The three stars whose positions are defined in this passage are not mentioned in the Čākalya-Sanhitā, nor in the Siddhānta-Ciromāṇi and
(according to Colebrooke) the Brahma-Siddhânta; only the latter of them, Āpas, is omitted by the Graha-Lâghava, being noticed in the Sûrya-Siddhânta alone. It may fairly be questioned, for the reason remarked above, whether the original text of our treatise itself contained the last two verses of this chapter: moreover, at the end of the next chapter (ix. 18), where those stars are spoken of which never set heli- 
scally, on account of their high northern situation, Prajâpati is not 
mentioned among them, as it ought to be, if its position had been 
previously stated in the treatise. Still farther on (xiii. 9), in the descrip-
tion of the armillary sphere, it is referred to by the name of Brahma, 
which, according to the commentary on this passage, and to Colebrooke, 
it also customarily bears. Perhaps another evidence of the unauthen-
ticity of the passage is to be seen in the fact that the two definitions 
of the polar longitude of Prajâpati do not, if taken in connection with verse 
11, appear to agree with one another: a star which is 5° east from the 
position of Brahmarâjadaya, as there stated, is not “at the end of Taurus,” 
but at its twenty-seventh degree: this may, however, be merely an inac-
curate expression, intended to mean that the star is in the latter part, or 
near the end, of Taurus. The Graha-Lâghava, which defines the posi-
tions of all these stars directly, by degrees of polar longitude and lati-
tude, and not by reference either to the signs or to other stars, gives Prajâ-
atyi 61° of polar longitude, or 5° more than it assigned to Brahmâ-
âdnya: it also adds 1° to the polar latitude as stated in our text. The 
star referred to can hardly be any other than that in the head of the 
Wagoner, or 5 Aurigae (i):

<table>
<thead>
<tr>
<th>Star</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prajâpati</td>
<td>6° 11'</td>
<td>30° 49' N.</td>
</tr>
<tr>
<td>5 Aurigae</td>
<td>6° 31'</td>
<td>31° 49' N.</td>
</tr>
</tbody>
</table>

The error of latitude is about the same with that which was committed 
with reference to Brahmarâjadaya, or Capella. Why so faint and incon-
spicuous a star should be found among the few of which the Hindu 
astronomers have taken particular notice is not easy to discover.

The position of the star named Apâmvatsa, “Waters’ Child,” is de-
scribed in our text by reference to Citrâ, or Spica Virginis: it is said to 
be in the same longitude, 180°, and 5° farther north; and this, since 
Citrâ itself is in lat. 2° S., would make the latitude of Apâmvatsa 3° N. 
The Graha-Lâghava gives it this latitude directly, and also makes its lon-
gitude agree with that of Spica, which, as already noticed, it places at 
the distance of 183° from the origin of the sphere. Āpas, “Waters” 
(the commentary, however, treats the word as a singular masculine, Āpa), 
is put 6° north of Apâmvatsa, or in lat. 9° N. It is identified by Cole-
brooke with 6 Virginis (3), and doubtless correctly:

<table>
<thead>
<tr>
<th>Star</th>
<th>Longitude</th>
<th>Latitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apas</td>
<td>176° 23'</td>
<td>8° 15' N.</td>
</tr>
<tr>
<td>6 Virginis</td>
<td>171° 28'</td>
<td>8° 38' N.</td>
</tr>
</tbody>
</table>

Colebrooke pronounces Apâmvatsa to comprise “the nebulous stars marked b 1, 2, 3” in Virgo. We can find, however, no such stars upon any map, or in any catalogue, accessible to us, and hence presume that Colebrooke must have been misled here by some error of the authority on which he relied. There is, on the other hand, a star, 6 Virginis (4),
slept between Spica and β, and at such a distance from it as shows almost beyond question that it is the star intended:

<table>
<thead>
<tr>
<th>Name</th>
<th>Hindu position</th>
<th>True position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lat.</td>
<td>long.</td>
</tr>
<tr>
<td>Agastya</td>
<td>90</td>
<td>0</td>
</tr>
<tr>
<td>Jyotisadha</td>
<td>80</td>
<td>0</td>
</tr>
<tr>
<td>Agni</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td>Brahmahrodha</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td>Prajapati</td>
<td>57</td>
<td>0</td>
</tr>
<tr>
<td>Aparvatsa</td>
<td>180</td>
<td>0</td>
</tr>
<tr>
<td>Apan</td>
<td>180</td>
<td>0</td>
</tr>
</tbody>
</table>

It is not less difficult in this than in the former case to account for the selection of these stars, among the hundreds equalling or excelling them in brilliancy, as objects of special attention to the astronomical observers of ancient India. Perhaps we have here only the scattered and disconnected fragments of a more complete and shapely system of stellar astronomy, which flourished in India before the scientific reconstruction of the Hindu astronomy transferred the field of labor of the astronomers from the skies to his text-books and his tables of calculation.

The annexed table gives a comparative view of the positions of the seven stars spoken of in this and a preceding passage (vr. 10-12) as defined by our text and as determined by modern observers:

The gross errors in the determinations of position of these stars give us a yet lower idea of the character of Hindu observations than we derived from our examination of the junction-stars of the asterisms.

The essay of Colbeck's in the ninth volume of the Asiatic Researches, to which we have already so often referred, gives further information of much interest respecting such matters connected with the Hindu astronomy of the fixed stars as are passed without notice in our treatise. He states the rules laid down by different authorities for calculating the time of heliacal rising of Agastya, or Canopus, upon which depends the performance of certain religious ceremonies. He also presents a view of the Hindu doctrine of the Seven Sages, or ṛbhās, by which name are known the bright stars in Ursa Major forming the well-known constellation of the Wain, or Dipper. To these stars the ancient astronomers in India, and many of the modern upon their authority, have attributed an independent motion about the pole of the heavens, at the rate of 8° yearly, or of a complete revolution in 2700 years. The Śūrya-Siddhānta alludes in a later passage (xiii. 9) to the Seven Sages, but it evidently is to be understood as rejecting the theory of their proper motion, which is also ignored by the Siddhānta-Ciromāṇi. That so absurd a dogma should have originated and gained a general currency in India, and that it should still maintain itself in many of the astronomical text-books, is, however, too striking and significant a circumstance to be left out of sight in estimating the character of the ancient and native Hindu astronomy.
CHAPTER IX.

OF HELIACAL RISINGS AND SETTINGs.

CONTENT:—1, subject of the chapter; 2–3, under what circumstances, and at which horizon, the planets rise and set heliacally; 4–5, method of calculating their distances in oblique ascension from the sun; 6–9, distances from the sun at which they disappear and re-appear; 10–11, how to find the time of heliacal setting or rising past or to come; 12–15, distances from the sun at which the asterisms and fixed stars disappear and re-appear; 16–17, mode of determining their times of rising and setting; 18, what asterisms and stars never set heliacally.

1. Now is set forth the knowledge of the risings (udaya) and settings (astamaya) of the heavenly bodies of inferior brilliancy, whose orbs are overwhelmed by the rays of the sun.

The terms used for the heliacal settings and risings of the heavenly bodies, or their disappearance in the sun’s neighborhood and their return to visibility, are precisely the same with those employed to denote their rising (udaya) and setting (asta, astamaya, astaman) above and below the horizon. The title of the chapter, udayastathikara, is literally translated in our heading.

2. Jupiter, Mars, and Saturn, when their longitude is greater than that of the sun, go to their setting in the west; when it is less, to their rising in the east; so likewise Venus and Mercury, when retrograding.

3. The moon, Mercury, and Venus, having a swifter motion, go to their setting in the east when of less longitude than the sun; when of greater, to their rising in the west.

These specifications are of obvious meaning and evident correctness. The planets which have a slower motion than the sun, and so are overtaken by him, make their last appearance in the west, after sunset, and emerge again into visibility in the east, before sunrise: of those which move more rapidly than the sun, the contrary is true: Venus and Mercury belong to either class, according as their apparent motion is retrograde or direct.

4. Calculate the longitudes of the sun and of the planet—in the west, for the time of sunset; in the east, for that of sunrise—and then make also the calculation of apparent longitude (dr̥kakar-man) of the planet.

5. Then the ascensional equivalent, in respirations, of the interval between the two (agnanuvatraprânás) will give, when divided by sixty, the degrees of time (kalânâcás); or, in the west, the ascensional equivalent, in respirations, of the interval between the two when increased each by six signs.

Whether a planet will or will not be visible in the west after sunset, or in the east before sunrise, is in this treatise made to depend solely
upon the interval of time by which its setting follows, or its rising precedes, that of the sun, or upon its distance from the sun in oblique ascension; to the neglect of those other circumstances—as the declination of the two bodies, and the distance and direction of the planet from the ecliptic—which variously modify the limit of visibility as thus defined. The ascertainment of the distance in oblique ascension, then, is the object of the rules given in these verses. In explaining the method of the process, we will consider first the case of a calculation made for the eastern horizon. The time of sunrise having been determined, the true longitudes and rates of motion of the sun and the planet in question are found for that moment, as also the latitude of the planet. Owing to the latter's removal in latitude from the ecliptic, it will not pass the horizon at the same moment with the point of the ecliptic which determines its longitude, and the point with which it does actually rise must be found by a separate process. This is accomplished by calculating the apparent longitude of the planet, according to the method taught in the seventh chapter. There is nothing in the language of the text which indicates that the calculation is not to be made in full, as there prescribed, and for the given moment of sunrise; but conducted, however, it would evidently yield an erroneous result, for, the planet being above the horizon, the point of the ecliptic to which it is then referred by a circle through the north and south points of the horizon is not the one to which it was referred by the horizon itself at the moment of its own rising. The commentary removes this difficulty, by specifying that the akshadṛkkarman, or that part of the process which gives the correction for latitude, is to be performed “only as taught in the first half-verse”—that is, according to the former part of vii. 8, which contains the rule for determining the amount of the correction at the horizon—omitting the after process, by which its value is made to correspond to the altitude of the planet at the given time. Having thus ascertained the points of the ecliptic which rise with the sun and with the planet respectively, the corresponding equatorial intervals, or the distance of the planets in oblique ascension, is found by a rule already given (iii. 50). The result is expressed in respirations of sidereal time, which are equivalent to minutes of the equator (see above, 1-12); they are reduced to degrees by dividing by sixty: and the degrees thus found receive the technical name of “time-degrees” (kalāṅgas, kuṭahāṅgas); they are also called below “degrees of setting” (astāṅgas), and “degrees of visibility” (dayāṅgas).

If the planet for which the calculation is made has greater longitude than the sun, the process, being adapted to the time of sunset, and to the western horizon, requires a slight modification, owing to the fact that the equivalents of the signs in oblique ascension (iii. 42-45) are given only as measured at the eastern horizon. Since 180 degrees of the ecliptic are always above the horizon, any given point of the ecliptic will set at the same moment that another 180° distant from it rises; by adding, then, six signs to the calculated positions of the sun and the planet, and ascertaining, by iii. 50, the ascensional difference of the two points as found, the interval between the setting of the sun and that of the planet will be determined.
Before going on to explain how, from the result thus obtained, the

time of the planet's disappearance or re-appearence may be derived, the
text defines the distances from the sun, in oblique ascension or "degrees
of time," at which each planet is visible.

6. The degrees of setting (astānāda) are, for Jupiter, eleven;
for Saturn, fifteen; for Mars, moreover, they are seventeen:
for Venus, the setting in the west and the rising in the east

take place, by reason of her greatness, at eight degrees; the
setting in the east and the rising in the west occur, owing to her
inferior size, at ten degrees:

8. So also Mercury makes his setting and rising at a distance
from the sun of twelve or fourteen degrees, according as he is
retrograding or rapidly advancing.

9. At distances, in degrees of time (kālahādatās), greater than
these, the planets become visible to men; at less distances they
become invisible, their forms being swallowed up (grastā) by the
brightness of the sun.

The moon, it will be noticed, is omitted here; her heliacal rising and
setting are treated of at the beginning of the next following chapter.

In the case of Mercury and Venus, the limit of visibility is at a greater
or less distance from the sun according as the planet is approaching its
inferior or superior conjunction, the diminution of the illuminated pos-
tion of the disk being more than compensated by the enlargement of
the disk itself when seen so much nearer to the earth.

Ptolemy treats, in the last three chapters (ch. 7-9) of his work, of
the disappearance and re-appearence of the planets in the neighborhood
of the sun, and defines the limits of visibility of each planet when in
the sign Cancer, or where the equator and ecliptic are nearly parallel.
His limits are considerably different from those defined in our text, being,
for Saturn, 14°; for Jupiter, 12° 45'; for Mars, 14° 30'; for Venus and
Mercury, in the west, 5° 40' and 11° 30' respectively.

10. The difference, in minutes, between the numbers thus sta-
ted and the planet's degrees of time (kalānāda), when divided by
the difference of daily motions—or, if the planet be retrograding
by the sum of daily motions—gives a result which is the time, in
days etc.

11. The daily motions, multiplied by the corresponding ascen-
sional equivalents (kalagnāsaras), and divided by eighteen hun-
dred, give the daily motions in time (kālagītī); by means of these
is found the distance, in days etc., of the time past or to come.

Of these two verses, the second prescribes so essential a modification
of the process taught in the first, that their arrangement might have
been more properly reversed. If we have ascertained, by the previous
rules, the distance of a planet in oblique ascension from the sun, and if
we know the distance in oblique ascension at which it will disappear or
re-appear, the interval between the given moment and that at which dis-
appearance or re-appearence will take place may be readily found by
dividing by the rate of approach or separation of the two bodies the difference between their actual distance and that of apparition and disappearance: but the divisor must, of course, be the rate of approach in oblique ascension, and not in longitude. The former is derived from the latter by the following proportion: as a sign of the ecliptic, or 1800', is to its equivalent in oblique ascension, as found by iii. 42-45, so is the arc of the ecliptic traversed by each planet in a day to the equatorial equivalent of that arc. The daily rates of motion in oblique ascension thus ascertained are styled the "time-motions" (kālayūṭi), as being commensurate with the "time-degrees" (kālāṇḍās).

12. Svātī, Agastya, Mrgavyādha, Cītrā, Jyeshṭhā, Punarvasu, Abhijit, and Brahmaṁḍaya rise and set at thirteen degrees.

13. Hasta, Čravāna, the Phalgunī, Čravishṭhā, Rohini, and Maghā become visible at fourteen degrees; also Viṣṇukha and Āśvinī.

14. Kṛttikā, Anurādhā (māitra), and Mūla, and likewise Āgleshā and Ārdrā (māndrakṛṣṇa), are seen at fifteen degrees; so, too, the pair of Ashādhaṃs.

15. Bharani, Pushya, and Mrgavīrsha, owing to their faintness, are seen at twenty-one degrees; the rest of the asterisms become visible and invisible at seventeen degrees.

These are specifications of the distances from the sun in oblique ascension (kālāṇḍās) at which the asterisms, and those other of the fixed stars whose positions were defined in the preceding chapter, make their heliacal risings and settings. The asterisms we are doubtless to regard as represented by their junction-stars (yugatārā). The classification here made of the stars in question, according to their comparative magnitude and brilliancy, is in many points a very strange and unaccountable one, and by no means calculated to give us a high idea of the intelligence and care of those by whom it was drawn up. The first class, comprising such as are visible at a distance of 130' from the sun, is, indeed, almost wholly composed of stars of the first magnitude; one only, Punarvasu (β Gemīnorum), being of the first to second, and having for its fellow one of the first (α Gemīnorum). But the second class, that of the stars visible at 14°, also contains four which are of the first magnitude, or the first to second; namely, Altēbarān (Rohini), Regulus (Magha), Denēb or β Leonis (Uttarā Phalgunī), and Atair or α Aquilae (Cravāna); and, along with these, one of the second to third magnitude, δ Leonis (Pūrva Phalgunī), three of the third, and one, α Librae (Viṣṇukha), of the fourth. In this last case, however, it might be possible to regard α Librae, of the second magnitude; as the star which is made to determine the visibility of the asterism. Among the stars of the third class, again, which are visible at 15°, is one, α Orionis (Ārdrā), which, though a variable star, does not fall below the first to second magnitude; while with it are found ranked six stars of the third magnitude, or of the third to fourth. The class of those which are visible at 17°, and which are left unspecified, contains two stars of the fourth magnitude, but also two of the second, one of which,
Translation and Notes.

Andromeda or Pegasi (Uttara-Bhadrapada), is mentioned below (v. 16) among those which are never obscured by the too near approach of the sun. The stars forming the class which are not to be seen within 21° of the sun are all of the fourth magnitude, but they are no less distinctly visible than two of those in the preceding class; and indeed, Bharani is palpably more so, since it contains a star of the third magnitude, which is perhaps (see above) to be regarded as its junction-star. Since Agui, Brahuna, Apamvatya, and Apas are not specially mentioned, it is to be assumed that they all belong in the class of those visible at 17°, and they are so treated by the commentator: the first of them (β Tauri) is a star of the second magnitude; for the rest, see the last note to the preceding chapter.

Some of the apparent anomalies of this classification are mitigated or removed by making due allowance for the various circumstances by which, apart from its absolute brilliancy, the visibility of a star in the sun’s neighborhood is favored or the contrary—such as its distance and direction from the equator and ecliptic, and the part of the ecliptic in which the sun is situated during its disappearance. Many of them, however, do not admit of such explanation, and we cannot avoid regarding the whole scheme of classification as one not founded on careful and long-continued observation, but hastily and roughly drawn up in the beginning, and perhaps corrupted later by unintelligent imitators and copyists.

16. The degrees of visibility (āryāṇās), if multiplied by eighteen hundred and divided by the corresponding ascensional equivalent (udayāṣacakas), give, as a result, the corresponding degrees on the ecliptic (kṣentrāṅgās); by means of them, likewise, the time of visibility and of invisibility may be ascertained.

This verse belongs, in the natural order of sequence, not after the passage next preceding, with which it has no special connection, but after verse 11. Instead of reducing, as taught in that verse, the motions upon the ecliptic to motions in oblique ascension, the “degrees of time” (kālāṅgās) may themselves be reduced to their equivalent upon the corresponding part of the ecliptic, and then the time of disappearance of re-appearance calculated as before, using as a divisor the sum of difference of daily motions along the ecliptic. The proportion by which the reduction is made is the converse of that before given; namely, as the ascensional equivalent of the sign in which are the sun and the planet is to that sign itself, or 1800°, so are the “degrees of visibility” (āryāṅgās, or kālāṅgās) of the planet to the equivalent distance upon that part of the ecliptic in which it is then situated. The technical name given to the result of the proportion is kṣentrāṅgās: kṣeta means literally “field, territory,” and the meaning of the compound may be thus paraphrased: “the limit of visibility, in degrees, measured upon that part of the ecliptic which is, at the time, the territory occupied by the planets in question, or their proper sphere.”

17. Their rising takes place in the east, and their setting in the west; the calculation of their apparent longitude (ārāṅgānās)
It is to be made according to previous rules; the ascertainment of the time, in days etc., is always by the daily motion of the sun alone.

This verse should follow immediately after verse 15, so which it attaches itself in the closest manner. The dislocation of arrangement in the latter part of this chapter is quite striking, and is calculated to suggest a suspicion of interpolations.

The directions given in the verse require no explanation: they are just such an adaptation of the processes already prescribed to the case of the fixed stars as that made in verse 14 of the last chapter. The commentary points out again that the calculation of the correction for latitude (ōkshodṛkkarman) is to be made only for the horizon, or as stated in the first half-verse of the rule.

18. Abhijit, Brahmacara, Svātī, Čravaṇa (vaishnava), Čraviszāppā (vāsava), and Uttara-Bhādrapāda (ahirbudhnya), owing to their northern situation, are not extinguished by the sun's rays.

It may seem that it would have been a more orderly proceeding to omit the stars here mentioned from the specifications of verses 12-15 above; but there is, at least, no inconsistency or inaccuracy in the double statement of the text, since some of the stars may never attain that distance in oblique ascension from the sun which is there pointed out as their limit of visibility. We have not thought it worth the trouble to go through with the calculations, and ascertain whether, according to the data and methods of this treatise, these six stars, and these alone, of those which the treatise notices, would never become invisible at Ujjayinī. It is evident, however, as has already been noticed above (viii. 20-21), that the star called Brahma or Prajāpati (8 Auriqa) is not here taken into account, since it is 8° north of Brahmacara, and consequently can not become invisible where the latter does not.

CHAPTER X.

OF THE MOON'S RISING AND SETTING, AND OF THE ELEVATION OF HER CUSPS.

Contents:—1, of the heliacal rising and setting of the moon; 2-5, how to find the interval from sunset to the setting or rising of the moon; 6-8, method of determining the moon's relative altitude and distance from the sun at sunset; 9, to ascertain the measure of the illuminated part of her disk; 10-14, method of delineating the moon's appearance at sunset; 15, how to make the same calculation and delineation for sunrise.

1. The calculation of the heliacal rising (udaya) and setting (āsā) of the moon, too, is to be made by the rules already given. At twelve degrees' distance from the sun she becomes visible in the west, or invisible in the east.
In determining the time of the moon's disappearance in the neighborhood of the sun, or of her emergence into visibility again beyond the sphere of his rays, no new rules are required; the same methods being employed as were made use of in ascertaining the time of heliacal setting and rising of the other planets: they were stated in the preceding chapter. The definition of the moon's limit of visibility would have been equally in order in the other chapter, but is deferred to this in order that the several processes in which the moon is concerned may be brought together. The title of the chapter, ēṛgonaṃnatayadhiśtri, "chapter of the elevation of the moon's cusps" (ēṛga, literally "horn"), properly applies only to that part of it which follows the fifth verse.

The degrees spoken of in this verse are, of course, "degrees of time" (kālānapās), or in oblique ascension.

2. Add six signs to the longitudes of the sun and moon respectively, and find, as in former processes, the ascensional equivalent, in respirations, of their interval (lagnāntarāśava): if the sun and moon be in the same sign, ascertain their interval in minutes.

3. Multiply the daily motions of the sun and moon by the result, in nādis, and divide by sixty; add to the longitude of each the correction for its motion, thus found, and find anew their interval, in respirations;

4. And so on, until the interval, in respirations, of the sun and moon is fixed: by so many respirations does the moon, in the light half-month (cakṣa), go to her setting after the sun.

5. Add half a revolution to the sun's longitude, and calculate the corresponding interval, in respirations: by so many respirations does the moon, in the dark half-month (kṛṣṇapakṣa), come to her rising after sunset.

The question here sought to be solved is how long after sunset upon any given day will take place the setting of the moon in the crescent half-month, or from new to full moon, and the rising of the moon in the waning half-month, or from full to new moon. The general process is the same with that taught in the last chapter, for obtaining a like result as regards the other planets or fixed stars: we ascertain, by the rules of the seventh chapter—applying the correction for the latitude according to its value at the horizon, as determined by the first part of vii. 8—the point of the ecliptic which sets with the moon; and then the distance in oblique ascension between this and the point at which the sun set will measure the required interval of time. An additional correction, however, needs to be applied to the result of this process in the case of the moon, owing to her rapid motion, and her consequent perceptible change of place between the time of sunset and that of her own setting or rising: this is done by calculating the amount of her motion during the interval as first determined, and adding its equivalent in oblique ascension to that interval; then calculating her motion anew for the increased interval and adding its ascensional equivalent—and so on, until the desired degree of accuracy is attained.
The process thus explained, however, is not precisely that which is prescribed in the text. We are there directed to calculate the amount of motion both of the sun and moon during the interval between the setting of the sun and that of the moon, and, having applied them to the longitudes of the two bodies, to take the ascensional equivalent of the distance between them in longitude, as thus doubly corrected, for the precise time of the setting of the moon after sunset. In one point of view this is false and absurd; for when the sun has once passed the horizon, the interval to the setting of the moon will be affected only by her motion, and not at all by his. In another light, the process does not lack reason: the allowance for the sun's motion is equivalent to a reduction of the interval from sidereal (nâkṣatra) time to civil, or true solar (sawan) time, or from respirations which are thirty-six-hundredths of the earth's revolution on its axis to such as are like parts of the time from actual sunrise to actual sunrise. But such a mode of measuring time is unknown elsewhere in this treatise, which defines (i. 11-12) and employs sidereal time alone, adding (ii. 59) to the sixty nâdîs which constitute a sidereal day so much sidereal time as is needed to make out the length of a day that is reckoned by any other method. It seems necessary, then, either to suppose a notable blunder in this passage, or to recognize in it such a departure from the usual methods of the treatise as would show it to be an interpolation. Probably the latter is the alternative to be chosen: it is, at any rate, that which the commentator prefers; he pronounces the two verses beginning with the second half of verse 2, and ending at the middle of verse 4, to be spurious, and the true text of the Siddhânta to comprise only the first half of verse 2 and the second of verse 4; these would form together a verse closely analogous in its method and expression with verse 5, which teaches the like process for moon-rise, in the waning half-month. Fortified by the authority of the commentator, we are justified in assuming that the Sûrya-Siddhânta originally neglected, in its process for calculating the time of the moon's setting, her motion during the interval between that time and sunset, and that the omission was later supplied by another hand, from some other treatise, which reckoned by solar time instead of sidereal. This does not, however, explain and account for the second half of the second verse; which, if it has any meaning at all, different from that conveyed in the former part of the same verse, seems to signify that when the sun and moon are so near one another as to be in the same sign, the discordance between distances on the ecliptic and their equivalents upon the equator may be neglected, and the difference of longitude in minutes taken for the interval of time in respirations.

If the time is between new and full moon, the object of the process is to obtain the interval from sunset to the setting of the moon; as both take place at the western horizon, the two planets are transferred to the eastern horizon, in order to the measurement of their distance in ascension: if, on the other hand, the moon has passed her full, the time of sunrise is sought; here the sun alone is transferred, by the addition of 160° to his longitude, to the eastern horizon, as taught in verse 5. The addition to be applied to the longitudes of both planets is found by the familiar proportion—as sixty nâdîs are to the given interval in nâdîs,
is the true daily motion of the planet to its actual motion during that interval.

6. Of the declinations of the sun and moon, if their direction be the same, take the difference; in the contrary case, take the sum: the corresponding sine is to be regarded as south or north, according to the direction of the moon from the sun.

7. Multiply this by the hypothenuse of the moon’s mid-day shadow, and, when it is north, subtract it from the sine of latitude (aksha) multiplied by twelve; when it is south, add it to the same.

8. The result, divided by the sine of co-latitude (lamdo), gives the base (blujja), in its own direction; the gnomon is the perpendicular (koṭi); the square root of the sum of their squares is the hypothenuse.

In explaining the method of this process, we shall follow the guidance of the commentator, pointing out afterwards wherein he varies from the strict letter of the text: for illustration we refer to the accompanying figure (Fig. 32).

The figure represents the south-western quarter of the visible sphere, seen as projected upon the plane of the meridian; Z being the zenith, Y the south point, WY the intersection of the horizontal and meridian planes, and W the projection of the west point. Let ZQ equal the latitude of the place of observation, and let QT and QO be the declinations of the sun and moon respectively, at the given time: then WQ, ST, and NO will be the projections of the equator and of the diurnal circles of the sun and moon. Suppose, now, the sun to be upon the horizon, at S, and the moon to have a certain altitude, being at M: draw from M the perpendicular to the plane of the horizon ML, and join MS: it is required to know the relation to one another of the three sides of the triangle SLM, in order to the delineation of the moon’s appearance when at M, or at the moment of sunset.

Now M-L is evidently the sine of the moon’s altitude at the given time, which may be found by methods already more than once described and illustrated. And SL is composed of the two parts SN and NL, of which the former depends upon the distance of the moon in declination from the sun, and the latter upon the moon’s altitude. But SN is one of the sides of a right-angled triangle, in which the angle NSN is equal to the observer’s co-latitude, and NL to the sum of the sine of declination of the sun, εδ or Wα, and that of the moon, νε. Hence
\[
\sin \delta \sin \phi : \sin \phi = \frac{R \times \text{sum of sines of decl.}}{R \times \text{sum of sines of decl.} + \text{sun co-lat.}}
\]
and
\[
\sin \phi = (R \times \text{sum of sines of decl.}) + \text{sun co-lat.}
\]

In like manner, since, in the triangle MNL, the angles at M and N are respectively equal to the observer's latitude and co-latitude,
\[
\sin \angle MNL = \frac{\sin \angle LMN \times \sin \angle MLN}{\sin \angle MLN} = \frac{\sin \angle MLN \times \sin \angle MNL}{\sin \angle MNL}.
\]
and
\[
N \times \text{sun co-lat.} = (\text{sun alt.} \times \text{sun lat.}) - \text{sun co-lat.}
\]

We have thus found the values of ML and the two parts of SL in terms of the general sphere, or of a circle whose radius is tabular radius: it is desired farther to reduce them to terms of a circle in which ML shall equal the gnomon, or twelve digits. And since the gnomon is equal to the sine of altitude in a circle of which the hypotenuse of the corresponding shadow is radius (compare above, iii. 25-27 etc.), this reduction may be effected by multiplying the quantities in question by the hypotenuse of the shadow and dividing by radius. That is to say, representing the reduced values of SN and NL by \(n\) and \(n'\) respectively,
\[
\frac{R \times \text{hyp. shad.}}{\text{sun co-lat.}} = \frac{ML \times \text{gnom.}}{\text{sun co-lat.}}, \quad \text{and} \quad \frac{R \times \text{hyp. shad.}}{\text{sun co-lat.}} = \frac{NL \times \text{gnom.}}{\text{sun co-lat.}}.
\]

Substituting, now, in the second and third of these proportions, the values of SN and NL found for them above, and substituting \(n\) in the third the value of the hypotenuse of the shadow derived from the first, we have
\[
\frac{R \times \text{sum of sines of decl.}}{\text{sun co-lat.}} = \frac{n', \text{ and} \quad \frac{R \times \text{gnom.}}{\text{sun co-lat.}} = \frac{n' \times \text{sun co-lat.}}{\text{sun co-lat.}}}
\]
which reduce to
\[
n = \frac{\text{hyp. shad} \times \text{sum of sines of decl.}}{\text{sun co-lat.}}, \quad \text{and} \quad n' = \frac{\text{sun lat} \times \text{gnom.}}{\text{sun co-lat.}}.
\]

Hence, if the perpendicular ML be assumed of the constant value of the gnomon, or twelve digits, we have
\[
SL = \frac{\text{hyp. shad} \times \text{sum of sines of decl.} + (\text{sun lat} \times \text{gnom.})}{\text{sun co-lat.}}
\]

In the case thus far considered the sun and moon have been supposed upon opposite sides of the equator. If they are upon the same side, the sun setting at S', or if their sines of declination, S'd and N c, are of the same direction, the value of S'N, the corresponding part of the base S'L, will be found by treating in the same manner as before the difference of the sines, S'e, instead of their sum. In this case, too, the value of S'e being north, S'N will have to be subtracted from NL to give the base S'L. Other positions of the two luminaries with respect to one another are supposeable, but those which we have taken are sufficient to illustrate all the conditions of the problem, and the method of its solution.

It is evident that, in two points, the process as thus explained by the commentator is discordant with that which the text prescribes. The

\(\text{shad.}\) in the first place, tells us to take, not the sum or difference of the
sines of declination; but the sine of the sum or difference of declinations, as the side b N of the triangle S N b. This seems to be a mere inaccuracy on the part of the text, the difference between the two quantities, which could never be of any great amount, being neglected: it is, however, very hard to see why the less accurate of the two valuations of the quantity in question should have been selected by the text; for it is, if anything, rather less easy of determination than the other. The other discordance is one of much more magnitude and importance: the text speaks of the "hypotenuse of the moon's mid-day shadow" (madhyad 
manduprabhakarna), for which the commentary substitutes that of the shadow cast by the moon at the given moment of sunset. The commentator attempts to reconcile the discrepancy by saying that the text means here the moon's shadow as calculated after the method of a noon-shadow; or again, that the time of sunset is, in effect, the middle of the day, since the civil day is reckoned from sunrise to sunrise: but neither of these explanations can be regarded as satisfactory. The commentator further urges in support of his understanding of the term, that we are expressly taught above (vi. 11) that the calculation of apparent longitude (arkkaran) is to be made in the process for finding the elevation of the moon's cusps: while, if the hypotenuse of the moon's meridian-shadow be the one found, there arises no occasion for making that calculation. It seems clear that, unless the commentator's understanding of the true scope and method of the whole process be erroneous, the substitution which he makes must necessarily be admitted. This is a point to which we shall recur later.

9. The number of minutes in the longitude of the moon diminished by that of the sun gives, when divided by nine hundred, her illuminated part (ruktla): this, multiplied by the number of digits (angula) of the moon's disk, and divided by twelve, gives the same corrected (aphuta).

The rule laid down in this verse, for determining the measure of the illuminated part of the moon, applies only to the time between new moon and full moon, when the moon is less than 180° from the sun: when her excess of longitude is more than 180°, the rule is to be applied as stated below, in verse 15. As the whole diameter of the moon is illuminated when she is half a revolution from the sun, one half her diameter at a quarter of a revolution's distance, and no part of it at the time of conjunction, it is assumed that the illuminated portion of her diameter will vary as the part of 180° by which she is distant from the sun; and hence that, assuming the measure of the diameter of her disk to be twelve digits, the number of digits illuminated may be found by the following proportion: as half a revolution, or 10,800', is to twelve digits, so is the moon's distance from the sun in minutes to the corresponding part of the diameter illuminated: the substitution, in the first ratio, of 900 : 1 for 10,800 : 12, gives the rule as stated in the text. Here, it will be noticed, we have for the first and only time the Greek method of measuring the moon's diameter, by equal twelfths, or digits: from this scale a further reduction is made to the proper Hindu scale, as determined by the methods of the fourth chapter (see above, iv. 3–5, 75).
by another proportion: as twelve is to the true diameter in digits, so is the result already found to the true measure of the part of the diameter illuminated.

It is not to be wondered at that the Hindus did not recognize the ellipticity of the line forming the inner boundary of the moon's illuminated part: it is more strange that they ignored the obvious fact that, while the illuminated portion of the moon's spherical surface visible from the earth varies very nearly as her distance from the sun, the apparent breadth of the bright part of her disk, in which that surface is seen projected, must vary rather as the versed sine of her distance.

10. Fix a point, calling it the sun: from that lay off the base, in its own proper direction; then the perpendicular, toward the west; and also the hypotenuse, passing through the extremity of the perpendicular and the central point.

11. From the point of intersection of the perpendicular and the hypotenuse describe the moon's disk, according to its dimensions at the given time. Then, by means of the hypotenuse, first make a determination of directions;

12. And lay off upon the hypotenuse, from the point of its intersection with the disk, in an inward direction, the measure of the illuminated part: between the limit of the illuminated part and the north and south points draw two fish-figures (malsya);

13. From the point of intersection of the lines passing through their midst describe an arc touching the three points; as the disk already drawn appears, such is the moon upon that day.

14. After making a determination of directions by means of the perpendicular, point out the elevated (unnata) cusp at the extremity of the cross-line: having made the perpendicular (koti) to be erect (unnata), that is the appearance of the moon.

15. In the dark half-month subtract the longitude of the sun increased by six signs from that of the moon, and calculate, in the same manner as before, her dark part. In this case lay off the base in a reverse direction, and the circle of the moon on the west.

Having made the calculations prescribed in the preceding passages, we are now to project their results, and to exhibit a representation of the moon as she will appear at the given time. The annexed figure (Fig. 33) will illustrate the method of the projection.

We first fix upon a point, as $S$, which shall represent the position of the sun's centre upon the western horizon at the moment of sunset, and we determine, in the manner taught at the beginning of the third chapter, the lines of cardinal direction of which it is the centre. From this point we then lay off the base ($bhuya$) $S L$, according to its value in digits as ascertained by the previous process, and northward or southward, according to its true direction as determined by the same process. From its extremity, is laid off the perpendicular ($koti$), which has the fixed number of twelve digits. This, being a line perpendicular to the plane of the horizon, may be regarded as having no proper direction of its own
upon the surface of projection: but the text directs us to lay it off westward from L apparently in order that the observer, standing upon the eastern side of his base SL, and looking westward toward the setting sun, may have his figure duly before him. The western extremity of the perpendicular, M, represents the moon’s place, and from that as a centre, and with a radius equal to the semi-diameter of the moon in digits, as ascertained by calculation for the given moment, a circle is described, representing the moon’s disk. Next we are to prolong the hypotenuse, SM, to s, and to draw, by the usual means, the line sa at right angles to it: the directions upon the disk thus determined by the hypotenuse, as the text phrases it, are called by the commentary “moon-directions” (candradighas). The sun being at S, the illuminated half of the moon’s circumference will be swa, the cusps will be at s and w, and w will be the extremity of the diameter of greatest illumination. From w, then, lay off upon the hypotenuse an amount, wx, equal to the measure in digits of the illuminated part of the diameter, and through s, x, and w describe an arc of a circle, in the manner already more than once explained (see above, vi. 14–16); the crescent swx will represent the amount and direction of the moon’s illuminated part at the given time. Now we once more make a determination of directions upon the disk according to the perpendicular LM; that is to say, we prolong LM to s’, and draw s’n’ at right angles to it: the directions thus established are styled in the commentary “sun-directions” (siryadihas), although without obvious propriety: they might rather be called “apparent directions,” or “directions on the sphere,” since s’n’ should represent a line parallel with the horizon, and w’s’ one perpendicular to it. The line s’n’ is called in the text the “cross-line” (tiryaksutra), and whichever of the moon’s cusps is found upon that line is, we are told, to be regarded as the elevated (unajata) cusp, the other being the depressed one (nata). Whenever there is any base (bhuja), as SL, or whenever the moon and sun are not upon the same vertical line ML, there will take place, of course, a tilting of the moon’s disk, by which one of her cusps will be raised higher above the horizon than the other; the relative value of the base to the perpendicular will determine the amount of the tilting, and of the deflection of the points of direction swsw from n’s’e’s’w’; and the elevated cusp will always be that upon the same side of the perpendicular on which the base lies. What is meant by the latter half of verse 14 is not altogether clear. The commentator explains it in quite a different manner from that in which we have translated it; he understands kati as meaning in this instance “cusp,” which significance it is by derivation well adapted to bear, and does actually receive, although not in any other passage of this treatise: and he explains the verb krivd, “having made,” by dhrivd, “having seen”: the phrase would then read “beholding the elevated cusp.” We cannot accept
this explanation as a plausible one: to us the meaning seems rather to be that whereas, in the projection, the perpendicular (koti) LM is drawn on a horizontal surface, we are, in judging of the projection as an actual representation of the moon’s position, to conceive of that line as erected, set up perpendicularly.

We have thus far only supposed a case in which the calculations are made for the moment of sunset, the situation of the moon being in the western hemisphere of the heavens. In the text, however, there is nothing whatever to limit or determine the time of calculation, and it is evident that the process of finding the base and perpendicular will be precisely the same, if S (Fig. 32) be taken upon the eastern horizon, and the triangle SLM in the eastern hemisphere. The last verse supposes those to be the conditions of the problem, and lays down rules for determining in such a case the amount of illumination, and for drawing the projection. As regards the measure of the illuminated part, we are to follow the same general method as before, only substituting for the moon’s distance in longitude from the sun her distance from the point of opposition, and regarding the result obtained as the measure of that part of the diameter which is obscured (asita, “black”): since, during the waning half-month, darkness grows gradually over the moon’s face in the same manner as illumination had done during the crescent half-month. But why the base (bhujā) is now to be laid off in the opposite to its calculated direction, we find it very hard to see. The commentator says it is because all the conditions of the problem are reversed by our having to calculate and lay off the obscured, instead of the illuminated, part of the moon’s disk: but the force of this reason is not apparent.

The establishment in the projection of a point representing the position of the sun, in effect, the one condition which sufficiently determines all the rest: if we are to make a projection corresponding to that drawn in illustration of the other case, we ought, it should seem, to draw the base in its true direction, and, stationing the observer upon the western side of it, looking eastward, to lay off the perpendicular away from him, toward the east; and then to proceed as before, only measuring the obscured part of the diameter from its remoter extremity, instead of from that next the sun. This latter direction is regarded by the commentator as actually conveyed in the final clause of verse 15: he interprets “the circle (mandala) of the moon” to mean the dark part of the moon’s disk, or that which is to be pointed out as increasing during the waning half-month, and “on the west” to mean on the western side of the complete disk, which is the side now turned away from the sun. It seems to us exceedingly questionable whether the passage fairly admits of this interpretation, but we have no other explanation of it to offer—unless, indeed, it is to be looked upon as a virtual repetition of the former direction to lay off the perpendicular, which determines the position of the moon’s disk, towards the west.

We must confess that we feel less satisfied with our comprehension of the scope and methods of this chapter than of any that precedes it. We are disappointed at finding the result arrived at one of so indefinite a character, and of so little significance. The whole laborious calculation seems to be made simply for the sake of delineating the appearance of
the moon at a given moment, and pointing out which of her two horns has the greater altitude. No determination is made of the amount of angular deflection, upon which any consequences, meteorological, astrological, or of any other character, could be founded; nor is any hint of the way in which the results of the process are to be turned to account. Moreover, while the object aimed at seems thus to be merely a projection, a time is selected at which the moon is not ordinarily visible, so that she can not be seen to exhibit an accordance with her delineated appearance! Once more, the whole process is an extremely faulty one: it is, in fact, only when the moon is herself at the horizon that her visible disk can be regarded as in the same plane with lines parallel with and perpendicular to the horizon, or that \( w' \) and \( n's' \) (Fig. 33) represent actual directions upon her face: anywhere else, the relations of the moon's disk at \( M \) in the first figure (Fig. 32) and at \( M \) in the other figure (Fig. 33) are so different that the latter cannot fairly represent the former. It would seem, indeed, as if the moment of the moon's own setting or rising were the one for which such a calculation and projection as this would have most significance: at that time, the disappearance or appearance of one of her horns before the other would be such a phenomenon as might seem to a Hindu astronomer worth the trouble of delineating, as a decisive proof of the accuracy of his scientific knowledge. We have not found it possible, however, to make the rules of the text apply to such a case, and the commentary is explicit in its definition of the time of the calculation, as sunset or sunrise alone, to the exclusion of any other moment. But the discordance existing at more than one point in the chapter between the text and the commentary suggests the conjecture that the original design of the one and the traditional interpretation of it represented by the other may be at variance, and we are not without suspicions that the text may have been altered, so as not now fairly and accurately to represent any one consistent process. A better understanding of the general object of the calculation and the use made of its results, and an acquaintance with the solutions of the problem presented by other astronomical treatises, might throw additional light upon these points; but we are not able at present fully to avail ourselves of such assistance, nor is the importance of the subject such as to render incumbent upon us its fuller elucidation.

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CHAPTER XI.

OF CERTAIN MALIGNANT ASPECTS OF THE SUN AND MOON.

Contents:—1–5, definition and description of the malignant aspects of the sun and moon, when of equal declination; 6–11, to find the longitude of the sun and moon when their declinations are equal; 12–13, to ascertain the corresponding time; 14–15, to determine the duration of the aspect, and the moment of its beginning and end; 16–18, its continuance and its influences; 19, when such an aspect may occur more than once, or not at all; 20, occurrence of the yoga of like name and character; 21, of unlucky points in the circle of asterisms; 22, caution as to these unlucky aspects and points; 23, introductory to the following chapters.
1. When the sun and moon are upon the same side of either solstice, and when, the sum of their longitudes being a circle, they are of equal declination, it is styled *vādhrīta*.

2. When the moon and sun are upon opposite sides of either solstice, and their minutes of declination are the same, it is *vyatipāta*, the sum of their longitudes being a half-circle.

3. Owing to the mingling of the nets of their equal rays, the fire arising from the wrathfulness of their gaze, being driven on by the provector (*pravaha*), is originated unto the calamity of mortals.

4. Since a fault (*pātu*) at this time often causes the destruction of mortals, it is known as *vyatipāta*, or, by a difference of title, *vādhrīti*.

5. Being black, of frightful shape, bloody-eyed, big-bellied, the source of misfortune to all, it is produced again and again.

Of all the chapters in the treatise, this is the one which has least interest and value. It is styled *pātuḥṣikāra*, "chapter of the *pāta*," and concerns itself with giving a description of the malignant character of the times when the sun and moon have equal declination, upon the same or opposite sides of the equator, and with laying down rules by which the time of occurrence of these malignant aspects may be calculated. The latter part alone properly falls within the province of an astronomical treatise like the present: the other would better have been left to works of a professedly astrological character. The term *pāta*, applied to the aspects in question, means literally "fall," and hence also either "fault, transgression," or "calamity." We have often met with it above, in the sense of "node of a planet's orbit"; as so used, it was probably first applied to the moon's nodes, because they were the points of danger in her revolution, near which the sun or hercess was liable to fall into the jaws of Ḍāhu (see above, iv. 6); and it was then transferred also, though without the same reason, to the nodes of the other planets. As it is employed in this chapter, we translate it simply "aspect." Why the time when the sun and moon are equally distant from the equator should be looked upon as so especially unfortunate is not easy to discover, notwithstanding the lucid explanation furnished in the third verse. For the "provector" (*pravaha*), the wind which carries the planets forward in their orbits, see above, ii. 3. When the equal declinations are of opposite direction, the aspect is denominated *vādhrīta*, or *vādhrīti*. This word is a secondary derivative from *vidṛti*, "holding apart, withholding," or from *vidhrīta*: it has been noted above (under ii. 65) as the name of the last *yoga*; and its use here is not discordant with that, since the twenty-seventh *yoga* also occurs when the sum of the longitudes of the sun and moon is 360°. The title of the other aspect (*pātu*), which occurs when the sun and moon are equally removed from the equator upon the same side of it, is *vyatipāta*, which may be rendered "very excessive sin or calamity." This, too, is the name of one of the *yogas*, but not of that one which occurs when the sum of longitudes of the sun and moon is 180°: the discordance gives occasion for the ex-
Translation and Notes.

Explanations contained in verse 20, below. The specification of the text, that the aspects take place when the sum of longitudes equals a circle or a half-circle respectively, or when the two luminaries are equally distant from either solstice, or either equinox, is not to be understood as exact: this would be the case if the moon had no motion in latitude; but owing to that motion, the equality of declinations, which is the main thing, occurs at a time somewhat removed from that of equality of distance from the equinoxes: the latter is called in the commentary madhyapata, "the mean occurrence of the aspect." The terms translated by us "upon the same and upon the opposite sides of either solstice" are ekaśyapata and viparitāyānahata, literally "situated in the same and in contrary ayanas"; ayanas being, as already pointed out (end of note to iii. 9–12), the name of the halves into which the ecliptic is divided by the solstices.

6. When the longitudes of the sun and moon, being increased by the degrees etc. found for the coincidence of the solstice with its observed place, are together nearly a circle or nearly a half-circle, calculate the corresponding declinations.

7. Then, if the declination of the moon, she being in an odd quadrant, is, when corrected by her latitude (vikṣhepa), greater than the declination of the sun, the aspect (pāta) is already past;

8. If less, it is still to come: in an even quadrant, the contrary is the case. If the moon's declination is to be subtracted from her latitude, the rules as to the quadrant are to be reversed.

As in other processes of a similar character (see above, iv. 7–8; vii. 2–6), we are supposed to have found by trial, for the starting-point of the present calculation, the midnight next preceding or following the occurrence of the aspect in question, and to have determined for that moment the longitudes and rates of motion of both bodies, and the moon's latitude. In finding the longitudes, we are to apply the correction for precession; this is the meaning of the expression in verse 6, drkṣṭāya sacrifice, which may be literally translated "degrees etc. calculated for accordance with observed place"; the reference is to the similar expression for the precession contained in iii. 11. Next the declinations are to be found, and that of the moon as corrected for her latitude. And since, in the odd quadrants—that is to say, the first and third, counting from the actual vernal equinox—declination is increasing, while in the others it is decreasing, if the declination in an odd quadrant of the moon, the swifter moving body, is already greater than that of the sun, the time of equality of declination is evidently already past and the converse. But if, on the other hand, the moon's declination (using that term in its Hindu sense) is so small, and her latitude so great, being of opposite directions, that her actual distance from the equator is measured by the excess of the former over the latter, and so is of direction contrary to that of her declination, then, as declination increases, distance from the equator diminishes, or the contrary, and the conditions as formerly stated are reversed throughout.
9. Multiply the sines of the two declinations by radius, and divide by the sine of greatest declination: the difference of the results, or half that difference, is to be added to the moon's longitude when the aspect (pdda) is to come; and is to be subtracted from the moon's longitude when the aspect is past. If the same quantity be multiplied by the sun's motion and divided by the moon's motion, the result is an equation, in minutes, which is to be applied to the sun's place, in the same direction as the other to the moon's.

11. So also is to be applied, in the contrary direction, a like equation to the place of the moon's node. This operation is to be repeated, until the declinations of the two bodies come to be the same.

By this process are ascertained the longitudes of the sun and moon at the time when their declinations are equal. Its method may be briefly explained as follows. At the midnight assumed as the starting-point of the whole calculation, there is found to be a certain difference in the two declinations: we desire to determine how far the paths of the two luminaries must be traced forward or backward, in order that that difference may be removed; and this must be effected by means of a series of approximations. We commence our calculation with the moon, as being the body of more rapid motion. By a proportion the inverse of that upon which the rule for deriving the declination from the longitude (ii. 28) is founded, we ascertain at what longitude the moon would have the sun's actual declination, and at what longitude she would have her own actual declination, as corrected by her latitude: the difference between the two results is a measure of the amount of motion in longitude, forward or backward, by which she would gain or lose the difference of declination, if the sun remained stationary and her own latitude unchanged. Since, however, that is not the case, we are compelled to calculate the corresponding motion of the sun, and also the moon's latitude in her new position; and in order to the latter, we must correct the place of the node also for its retrograde motion during the interval. The motions of the sun and node are found by the following proportion: as the moon's daily motion is to that of the sun, or to that of the node, so is the correction applied to the moon's place to that which must be applied to the place of the sun, or to that of the node. A new set of positions in longitude having thus been found, the declinations are again to be calculated, and the same approximative process repeated—and so on, until the desired degree of accuracy is attained.

The text permits us to apply, as the correction for the place of the moon, either the whole or the half of the difference of longitude found as the result of the first proportion: it is unessential, of course, in a process of this tentative character, what amount we assume as that of the first correction, provided those which we apply to the places of the sun and node be made to correspond with it; and there may be cases in which we should be conducted more directly to the final result of the process by taking only half of the difference.
12. The aspect (pāka) is at the time of equality of declinations; if, then, the moon's longitude, as thus increased or diminished, be less than her longitude at midnight, the aspect is past; if greater, it is to come.

13. The minutes of interval between the moon's longitude as finally established and that at midnight give, when multiplied by sixty and divided by the moon's daily motion, the time of the aspect, in nādīs.

We had thus far found only the longitudes of the sun and moon at the time of equality of declination, and not that time itself: the latter is now derived from the former by this proportion: as the moon's daily motion is to a day, or sixty nādīs, so is the difference between the moon's longitude at midnight and at the time of the aspect to the interval between the latter time and midnight.

14. Multiply the half-sum of the dimensions (māna) of the sun and moon by sixty, and divide by the difference of their daily motions: the result is half the duration (sthitā), in nādīs etc.

15. The corrected (sphuta) time of the aspect (pāka) is the middle: if that be diminished by the half-duration, the result is the time of the commencement; if increased by the same, it is the time of the end.

16. The time intervening between the moments of the beginning and end is to be looked upon as exceedingly terrible, having the likeness of a consuming fire, forbidden for all works.

The continuance of the centres of the sun and moon at the point of equality of declination is, of course, only momentary; but the aspect and its malignant influences are to be regarded as lasting as long as there is virtual contact of the two disks at that point, or as long as a central eclipse of the sun would last if it took place there. Its half-duration, then, or the interval from its middle to its beginning or end respectively, is found by a proportion, as follows: if in a day, or sixty nādīs, the two centres of the sun and moon become separated by a distance which is equal to the difference of their daily motions, in how many nādīs will they become separated by a distance which is equal to the sum of their semi-diameters? or

\[
\text{diff. d. motions} : 60 :: \text{sum semi-diam.} : \text{half-duration}
\]

And if this amount be subtracted from and added to the time of equality of declination, the results will be the moments at which the aspect will begin and end respectively.

Such is the plain and obvious meaning of the text in this passage. The commentator, however, in accordance with his interpretation of the next following verse (see below), declares that the aspect actually lasts as long as any portion of the moon's disk has the same declination with any portion of that of the sun; and that, accordingly, it commences—the moon's declination being supposed to be increasing—whenever her remoter limb comes to have the same declination with the nearer limb of the sun, and ends when her nearer limb comes to have the same de-
elation with the remoter limb of the sun—the contrary being the case when her declination is decreasing. He acknowledges that the text does not seem to teach this, but puts in the plea which is usual with him when excusing a palpable inaccuracy in the statements or processes of the treatise; namely, that the blessed author of the work, moved by pity for mankind, permitted here the substitution of difference of longitude for difference of declination, in view of the greater ease of its calculation, and the insignificance of the error involved. That error, however, is quite the reverse of insignificant; it is, indeed, so very gross and palpable that we cannot possibly suppose it to have been committed intentionally by the text; we regard it as the easier assumption that the conditions of the continuance of the aspect are differently estimated in the text and in the commentary, being by the former taken to be as we have stated them above, in our explanation of the process. The view of the matter taken by the commentator, it is true, is decidedly the more natural and plausible one: there seems no good reason why an aspect which depends upon equality of declination should be determined as to continuance by motion in longitude, or why the aspect should only occur at all when the two centres are equally distant from the equator; why, in short, there should not be partial aspects, like partial eclipses of the sun. If the doctrine of the commentary is a later development, or an independent form, of that which the text appears to represent, it is a naturally suggested one, and such as might have been expected to arise.

17. While any parts of the disks of the sun and moon have the same declination, so long is there a continuance of this aspect, causing the destruction of all works.

18. So, from a knowledge of the time of its occurrence, very great advantage is obtained, by means of bathing, giving, prayer, ancestral offerings, vows, oblations, and other like acts.

We have translated verse 17 in strict accordance with the interpretation of it presented in the commentary, although we must acknowledge that we do not see how that interpretation is to be reconciled with the actual form of the text. The term ekāyunagatu, which the commentator renders “having equal declination,” is the same with that which in the first verse signified “situated in the same ayana”; mandala, although it is sometimes used with the meaning “disk,” here attributed to it by him, is the word employed in that same verse for a “circle,” or “360°”; and anūra, which he explains by ekadeṣa, “any part,” never, so far as we know, is properly used in that sense, while it is of frequent occurrence elsewhere in this treatise with the meaning “interval.” The natural rendering of the line would seem to be “when there is between the sun and moon the interval of a circle, situated in the same ayana.” This, however, yields no useful meaning, since such a description could only apply to an actual conjunction of the sun and moon. We do not see how the difficulty is to be solved, unless it be allowed us, in view of the discordance already pointed out as existing between the plain meaning of the previous passage and that attributed to it by the commentator, to assume that the text has been tampered with in this verse, and made to furnish a different sense from that it originally had, partly by a