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A BRIEF TRANSLATION OF MAHAVĪRA'S "SURYA-PRAJNAPTI", OR "THE KNOWLEDGE OF THE SUN."

BY DR. R. SHAMA SASTRY, B.A., PH.D.

THE Sūryaprajñapti consists of twenty lessons on astronomy taught by the Vardhamāna to Gautama, his disciple. It is written in Prākṛit. The Commentator, Malayagiri, says in the fifth introductory verse that owing to the bad influence of Kali, the commentary written by Bhadrabāhu has now become extinct. It is probable that this Bhadrabāhu is one of the Gaṇadharas. In p. 16 the Commentator calls Bhadrabāhu Bhadrabāhuswāmi, though in the fifth verse he is styled as Bhadrabāhusūri, perhaps, for the sake of the metre's not permitting the use of swāmi.

Mahāvīra is said to have been residing in Mithila while teaching this astronomy to Gautama. (p. 2.)

Various Kinds of Years.—In a Nakshatra month there are 819 $\frac{27}{67}$ muhurtas. This is proved thus: A Yuga consists of three lunar years and two intercalary lunar years, *i.e.*, of 1830 days. This divided by 67 gives 27 days 9 muhurtas $\frac{27}{67}$. This when reduced to muhurtas is equal to $819\frac{27}{67}$. (A day = 30 muhurtas.) (pp. 1 to 10.)

Likewise for solar and other months: A Yuga of five years = 1830 days: $1830 \div 60 = 30\frac{1}{2}$ days for a solar month = 915 muhurtas. Likewise in a Yuga there are 62 lunar months. Hence in one month $\frac{1830}{62} = 29\frac{32}{62}$ days or $29\frac{32}{62} \times 30 = 885\,\frac{60}{62}$ muhurtas. Likewise Karma māsa $= \frac{1830}{61} = 30 = 900$ muhurtas.

Length of Day and Night.—In the solar year of 366 days there is only one day of 18 muhurtas and only one night of 18 muhurtas and likewise only one day of 12 m. and one night of 12 m. In the first six months the first day is of 18 m. and the night of 12 m. while the last night in the six months is of 18 m. and the day of 12 m. This is proved thus :—

In a year the two suns move in 366 diurnal circles, each moving through half a circle. These circles are one within the other. Each circle may be imagined to be divided into 1830 parts. Since each day = 30 muhurtas, the two suns together take 60 muhurtas to complete the circle of 1830 divisions. Hence in one muhurta $\frac{1830}{60} = 30\frac{1}{2}$ divisions $= \frac{61}{2}$. Hence one division is passed through $\frac{2}{61}$ muhurtas.

Again in the course of 183 days 6 muhurtas increase or decrease: what is the rate of increase or decrease per day? If there is an increase of 6 muhurtas in 183 days, the rate of increase per day is $= \frac{6}{183} = \frac{2}{61}$ muhurtas. This is only when the suns are moving in the second external or internal diurnal circle. So when they are moving in the third external or internal circle the increase or decrease will be $\frac{4}{61}$. That is when they are in the third internal circle, the day will fall from 18 to $(18 - \frac{4}{61})$ muhurtas and the night will rise from 12 to $(12 + \frac{4}{61})$ muhurtas; and so on when they move through the outermost circle (183rd circle), then the day will fall by $183 \times \frac{2}{61} = 6$ muhurtas and the night will gain by $\frac{183 \times 2}{61} = 6$ muhurtas. Thus the longest night is the last 183rd night of the first six months and the longest day of 18 muhurtas is the last 183rd day of the second six months. (pp. 10 to 16.)

Likewise the shortest day of 12 m. is the last 183rd day of the first six months and the shortest night of 12 m. is the last 183rd night of the second six months.

This implies that the 92nd day in the first and the second six months is of 15 muhurtas. (pp. 18-24.)

Yuga circle is divided into 124 divisions corresponding to 124 Parvas, *i.e.*, 62 full moons and 62 new moons.

The theory of two suns is thus explained (p. 22):—

"There are two suns: Bhārata and Airāvata. They both move through half a diurnal circle in the course of 30 muhurtas; *i.e.*, in the course of 60 muhurtas or 2 days, they complete each a complete diurnal circle. That sun who moves in the outermost circle in the southern hemisphere is called Bhārata, because he illumines the Bharatakhaṇḍa. The other who moves through the same outer circle in the northern hemisphere is called Airāvata, because he illuminates the Airāvata area. The Bhārata is visible to us. The circle through which this sun moves has to be imagined as being divided into 124 divisions. The same circle should also be cut into four parts by drawing the vertical and horizontal diameters (davarika). Of these four parts the south-eastern must be made to contain 92 diurnal circles, the north-western 91, the north-eastern 92 and south-western 91 circles. (p. 23.) Of these circles the Bhārata in the second half of the year moves through 92 circles and the Airāvata 91 circles. Likewise in the north-western division, the Airāvata moves through 92 circles and the Bhārata through 91 circles." The suns rise simultaneously and move through half a circle, one in the north and the other in the south of Mēru and passing to the west go to the ocean or the nether world, as variously stated by a number of Tīrthas or astronomers. Again the next morning the Airāvata rises in the second circle in the south

and the Bhārata in the second circle in the north and they complete the diurnal circle. In this way they are said to complete 183 circles in each half year, increasing the day in the Dakshiṇāyana, the first half of the year and decreasing the night at the same time by 6 muhurtas. Likewise in the Uttarāyaṇa, they complete 183 diurnal circles together alternately changing places and making night longer and the day shorter by 6 muhurtas gradually.

There are six different views as to the intervening distance between the two suns. Some say that the distance is 1133 yojanas. Others say that it is 1134 yojanas. A third school is of opinion that it is 1135 yojanas. A fourth view is that an island and an ocean separate the two suns from each other. A fifth doctrine is that there are two islands and two oceans between them, while a sixth school maintains that there are three islands and three oceans between them. All these are false. The real distance between the first two diurnal circles is $5\frac{35}{61}$ yojanas and the distance between any two circles increases at this rate per two circles from the innermost to the outermost. (p. 25.)

When the Bhārata and the Airāvata suns move through the innermost diurnal circle, then they are separated from each other by a distance of 99,640 yojanas. (p. 26.) The reason for this is as follows:—

Now the diameter of the Jambudvīpa is 1,00,000 yojanas, in length. Out of this, each sun moves through the circumference of a circle, the diameter of which is 180 yojanas, when both of the suns move through the innermost diurnal circle. Thus they make the total length of the diameter 360 yojanas. Deducting this from 1,00,000, we have 99,640 yojanas as the intervening distance between the two suns.

When the two suns move through the innermost circle, then the day is of 18 muhurtas and the night of 12 muhurtas; when beginning a new year they move through the second innermost circle, then they will be separated from each other by a distance of $99{,}645\frac{35}{61}$ yojanas.

Now the second innermost circle is greater than the first by $2\frac{48}{61}$ yojanas. Considering the circles of the two suns, the increase is $2\frac{48}{61} \times 2 = 5\frac{35}{61}$ yojanas. Then the day will be $18 - \frac{2}{61}$ muhurtas and the night $12 + \frac{2}{61}$ muhurtas.

When they move through the third inner circle the distance between them will be $99{,}651\frac{9}{61}$ yojanas and the day will be $18 - \frac{4}{61}$ muhurtas and the night $12 + \frac{4}{61}$ muhurtas.

When they move through the outermost circle, on the 183rd day, *i.e.*, the last day of the first Ayana, the distance between them will be 1,00,660 yojanas. The reason for this is as follows:—

Each day the distance will increase at the rate of $5\frac{35}{61}$. Hence

$5\frac{35}{61} \times 183 - 1{,}020$ yojanas. This when added to the distance of 99,640 yojanas in the innermost circle makes it 1,00,660 yojanas. The night will be then of 18 muhurtas and the day of 12 muhurtas. This will be reversed gradually when they move towards the innermost circle. (p. 28.) When they are in the innermost circle, the distance will be reduced to 99,640 yojanas and the day will be of 18 muhurtas and the night of 12 muhurtas.

Thus when they move through the innermost circle, *i.e.*, traverse a circle of 180 yojanas in diameter the day will be of 18 and the night of 12 muhurtas. (p. 31.) Regarding the rate of increase in yojanas per circle from the innermost to the outermost, there are seven different opinions:—(p. 33.)

(1) Some say that it is $2\frac{42\frac{1}{2}}{183}$ yojanas.
(2) Others say that it is $2\frac{1}{2}$ yojanas.
(3) „ „ $2\frac{1}{3}$ „
(4) „ „ $3\frac{46\frac{1}{2}}{183}$ „
(5) „ „ $3\frac{1}{2}$ „
(6) „ „ $3\frac{3}{4}$ „
(7) „ „ $4\frac{51\frac{1}{2}}{183}$ „

All these are false.

According to our own view it is $2\frac{48}{61}$ yojanas or $5\frac{35}{61}$ yojanas with the two suns. The reason for this has already been noticed and will also be explained later on.

Regarding the shape of Vimānas or the cars of the sun and the moon there are as many as eight different views:—(p. 36.)

(1) They are spherical.
(2) „ like a square.
(3) „ rectangular.
(4) „ rhombic.
(5) „ cylindrical.
(6) „ like a cone.
(7) „ twisted cylinders.
(8) „ like an umbrella.

Of these the first view is correct and acceptable to Mahāvīra.

Now regarding the views of those who, taking the vertical and horizontal diameters of the diurnal circles of the sun and the moon to be 1,133 yojanas, multiply it by 3 to arrive at the measure of the circumference, we say that they are all wrong not only with regard to the length they assign to the diameters, but also in making the circumference thrice the diameter. For really the circumference of a circle is equal to $\sqrt{D^2 \times 10}$ where D is diameter. Accordingly 3×1133 is less than $\sqrt{1133^2 \times 10}$. Likewise with those who take the

diameter to be 1,134 or 11,35 yojanas and multiply it by 3 to get the circumference.

Our own view is that each half circle differs from the other by $2\frac{48}{61}$ yojanas.

Now the diametrical length of the Jambudvīpa is 1,00,000 yojanas. Of this, 180 yojanas go to make up the diametrical length of half of the innermost diurnal circle (south of the Meru) and 180 yojanas the diametrical length of the other half of the innermost diurnal circle in the north. Put together, they amount to 360 yojanas. Deducting this from the diametrical length of the Jambudvīpa, we have $1{,}00{,}000 - 360 = 99{,}640$ yojanas, *i.e.*, the distance between the two suns in the innermost diurnal circle. Hence the measure of the circumference of Jambu circle of 99,640 yojanas in diameter is $\sqrt{99640^2 \times 10} = \sqrt{99281296000} = 315089$, the remainder 218079 being neglected. Likewise while the suns are in the second innermost circle the distance between them is of $99{,}645\frac{35}{61}$ yojanas in diametrical length. For while in the second innermost circle, the two suns together move $5\frac{35}{61}$ yojanas more. Hence converting this into a circle of $5\frac{35}{61}$ yojanas in diameter, we have $\sqrt{(5\frac{35}{61})^2 \times 10} = \sqrt{(\frac{1075}{61})^2} = 17\frac{38}{61}$ or 18 yojanas for circumference. Hence adding this to 3,15,089, we have 3,15,107 yojanas.

Likewise when they are in the third innermost circle, the distance between them increases by $5\frac{35}{61}$ yojanas or $17\frac{38}{61}$ yojanas or 18 yojanas in round numbers. Adding this to 3,15,107, we have 3,15,125 yojanas.

Similarly when they are in the outermost circle, the distance between them will be 3,18,315 yojanas. (p. 44.)

Regarding the movements of the sun there are various theories: some say that the sun, a mass of burning rays, rises in the east, and going across high up in the sky, vanishes in space in the west in the evening. Others who regard the earth as a sphere say that the sun rises in the east and going above the earth transversely descends down in space below in the evening and comes up again next morning. A few say that in the morning he ascends the summit of the eastern mountain, and going across the earth descends on the summit of the western mountain. Some others say that he rises from the ocean and sinks in the western ocean again in the evening, while others think that he visits the earth from a different world and goes back to another different world in the evening. Some think that he rises in the east and illuminating the southern hemisphere goes to the north through the west; and that when he is in the south, the north will be in the dark and *vice versa*. (p. 46.)

The real aspect of the question is this:—

Let us imagine a circle high above the Jambudvīpa. Let the circumference of the circle be divided into 124 equal divisions, the horizontal and vertical diameters being also drawn dividing the circle into four quadrants. Thus there will be 184 diurnal circles, in the south-eastern quadrant divided into 31 divisions. This quadrant is visible to this gem-like earth. About 800 yojanas high above the earth, the two suns rise here, the Bhārata sun in the south-eastern quadrant, the Airāvata in the north-eastern. Then they move through their diurnal circles, one in the south and the other in the north, illuminating the southern and the northern sides of the Meru, keeping at the same time the eastern and the western of the Jambu island in the darkness of the night. That is the Airāvata traverses across in the north and then in the east of Meru, while the Bhārata moving across the south, traverses in the west of Meru. Thus when they move in the east and the west, they keep the north and the south in the dark. Then the Airāvata rises in the south-eastern quadrant and the Bhārata in the north-eastern quadrant the next day.

There are four different views regarding the velocity of the sun per muhurta:—(pp. 48-64.)

Some say that he moves 6,000 yojanas per muhurta: Others say that he moves 5,000 per muhurta: a few say that he goes through 4,000 yojanas per muhurta. Some others say that he moves in three different velocities, *i.e.*, six, five, and four thousand yojanas, per muhurta.

Now regarding the first school:—

When the sun is in the innermost diurnal circle, then he moves through 6,000 yojanas per muhurta and then the day is of 18 muhurtas and the night of 12 muhurtas. It is evident that the area illuminated and heated by the sun is as much as he traverses in half a day. Now in 9 muhurtas he moves $9 \times 6{,}000 = 54{,}000$ yojanas. Hence to that extent he heats and illuminates the world both in front and behind. Hence the whole area heated and illuminated by the sun will be 54,000 yojanas in front and 54,000 yojanas behind. Hence 1,08,000 yojanas he will illuminate and will be visible. When he is on the outermost circle, the day will be of 12 muhurtas and the night of 18 muhurtas. Hence the area illuminated will be $12 \times 6{,}000 = 72{,}000$ yojanas.

Likewise according to the second school the illuminated area will be 90,000 yojanas when he is in the innermost circle and 60,000 yojanas when he is in the outermost circle.

Similarly it is easy to calculate the extent of illuminated area according to the third school, *i.e.*, 72,000 yojanas and 48,000 yojanas respectively.

According to the 4th school, the sun is quickest for a muhurta in the

morning and the evening, and slowest for a muhurta in the midday and moderate during the rest of the time. Hence he moves at the rate of 6,000 yojanas 2 muhurtas in the morning and evening put together; hence 12,000 yojanas; at 4,000 yojanas for a muhurta in the midday; at 5,000 yojanas for 15 muhurtas; hence $5 \times 15{,}000 = 75{,}000$. Adding together, he illuminates 91,000 yojanas when he is in the innermost circle.

But while he moves through the outermost diurnal circle when the day is of 12 muhurtas and the night of 18 muhurtas, the area illuminated will be $12{,}000 + 45{,}000 + 4{,}000 = 61{,}000$ yojanas.

Mahāvīra's own view of this question is that while in the innermost circle, the sun moves through $5{,}251\frac{29}{60}$ yojanas per muhurta. The reason for this is as follows:—

The two suns complete one diurnal circle in one day, *i.e.*, one sun completes one circle in two days. The circumference of the innermost circle is 3,15,089 yojanas. Hence in one muhurta the sun goes through $3{,}15{,}089 \div 60 = 5{,}251\frac{29}{60}$. Now the illuminated area will be as much as the sun traverses in half a day. Hence, the day being of 18 muhurtas, in 9 muhurtas he goes through $9 \times 5{,}251\frac{29}{60} = 47{,}263\frac{21}{60}$ yojanas.

Similarly, the second circle being of 3,15,107 yojanas in circumference, he moves through $\frac{315107}{60} = 5{,}251\frac{47}{60}$ yojanas per muhurta. Now half a day in the second diurnal circle is $\frac{18-2/61}{2}$ muhurtas $= \frac{548}{61}$ muhurtas. Hence $5{,}251\frac{47}{60} \times \frac{548}{61} = 47{,}179\ \frac{57}{60}$ yojanas.

Likewise the velocity, too, becomes more by $\frac{18}{60}$ yojanas per yojana per outer circle than in the previous circle, *i.e.*, 18 yojanas more than the previous circle. Likewise each outer circle gets larger by 18 yojanas.

When the sun moves through the third diurnal circle on the second day of the new year of a cycle, then his velocity per muhurta is $5{,}252\frac{52}{60}$ yojanas; for the circumference of this circle is 3,15,125 yojanas; $\frac{315125}{60}\frac{\text{yojanas}}{\text{muhurtas}} = 5{,}252\frac{52}{60}$ yojanas per muhurta or we may add to the sun's velocity per muhurta in the second diurnal circle $\frac{18}{61}$th more per yojana and get the same result. The illuminated and visible area while the sun is in this circle is $47{,}096\frac{33}{60}+\frac{2}{61}$ yojanas.

The reason for this is as follows:—

Now the day measure on this day is $= \frac{18-4/61}{2} = 9 - \frac{2}{61} = \frac{547}{61}$ muhurtas. Hence the illuminated area $= \frac{315125}{60} \times \frac{547}{61} = 47{,}096\ \frac{88}{60} + \frac{2}{61}$ yojanas.

The constants used in ascertaining the rate of velocity and the illuminated and visible area in each diurnal circle are (1) $\frac{18 \times 2}{60}$ and (2) 84 or $83\frac{28}{60}$.

The first constant denotes the excess of velocity gained by the sun in each circle as he advances from the innermost diurnal circle to the outer

circle in succession. The second constant is the decrease in the heated and visible area as he advances from the inner to the outer circles one after another.

The reason for the first has already been pointed out. The reason for the second is this:—

Now in the innermost circle the measure of the visible area is $47{,}263\frac{21}{60}$. This is attained in 9 muhurtas. Hence if we consider the area attained in $\frac{1}{61}$ of a muhurta, we divide $47{,}263\ \frac{21}{60}$ by $9 \times 61 = 549$. The quotient will be $47{,}263\frac{21}{60} \div 549 = 86\frac{5}{60} + \frac{24}{61}$ yojanas.

Now the excess of velocity gained by the sun per outer circle is $\frac{18}{60}$th of a yojana per yojana; and also the circumference gets larger by 18 yojanas in each outer circle than the previous circle.

Now on the third day the measure of half the day is $9 - \frac{1}{61}$ muhurtas $= \frac{548}{61}$ muhurtas.

Multiplying the excess of area $\frac{18}{60}$ by $\frac{548}{61}$ we have 2 yojanas $+ \frac{41}{60} + \frac{43}{61}$ yojanas.

Deducting this from $86\frac{5}{60} + \frac{24}{61}$ we have $83\frac{28}{60} + \frac{42}{61}$ yojanas which is taken for 84 in the text. If we deduct this from the visible area of the first inner circle we get the visible area of the next second outer circle. Hence this is the constant used in ascertaining the visible area in each outer diurnal circle.

We add to this constant $\frac{36}{61}$ and deduct the sum from the visible area of the second outer circle. The remainder is the visible area of the third outer circle. Likewise in the case of the fourth outer circle, we add to the constant $\frac{36 \times 2}{61}$ and deduct the sum from the visible area of the third circle—so if we want to know the heated and visible area while the sun is on the 183rd circle, compared to the third outer circle, then we multiply $\frac{36}{61}$ by 183 and add the sum to the constant thus:—$\frac{36}{61} \times 183 + 83\frac{28}{60} + \frac{42}{61} = 85\frac{11}{60} + \frac{6}{61}$ and deduct this sum from the visible area of the third. The remainder is the visible area when the sun is on the 183rd circle.

The reason for multiplying the number of circles by $\frac{36}{60}$ in the case of the third, $\frac{36 \times 2}{60}$ in the case of the fourth, $\frac{36 \times 3}{60}$ in the case of the fifth circle and so on, is this:—

From the second diurnal circle onwards, the day measure falls short of 18 muhurtas by $\frac{2}{61}$ muhurtas. Hence in 18 muhurtas the total decrease will be $\frac{2}{61} \times \frac{18}{60} = \frac{36}{61 \times 60}$, *i.e.*, 36 sixty-one times sixtieth parts.

This is in round numbers; but really speaking the decrease is somewhat less and the excess amounts to $\frac{68}{61}$ Kalas in the 182nd circle. This will be deducted there and the real visible area taken to be $85\frac{9}{60} + \frac{60}{61}$.

Now the visible and heated area while the sun is on the 182nd circle is 31,916 $\frac{39}{60}+\frac{60}{61}$ yojanas. Deducting from this $85\frac{9}{60}+\frac{60}{61}$ we have $31,831\frac{30}{60}$ yojanas for the visible area when the sun is on the 183rd outer diurnal circle.

Thus as the sun advances from one diurnal circle to another, he lessens the visible area by a little less than 84 yojanas.

Now when he is on the outermost circle, he moves $5,305\frac{15}{60}$ yojanas per muhurta; for the circumference of this circle is 3,18,315 yojanas. This divided by 60 muhurtas gives $5,305\frac{15}{60}$ yojanas per muhurta. The visible or heated area, *i.e.*, the distance at which the sun becomes visible to men, is $31,831\frac{30}{60}$; for the day when he is on the outermost circle is of 12 muhurtas. Hence multiplying by half of day time the rate of yojana per muhurta, we have $6 \times 5,305\frac{15}{60} = 31,831\frac{30}{60}$ yojanas at which he becomes visible.

When the sun moves on the last outermost circle but one, then his velocity will be $5,304\frac{57}{60}$ per muhurta for $\frac{318297}{60}\ \frac{\text{circumference}}{\text{muhurtas}} = 5,304\frac{57}{60}$.

Likewise the visible area = half the day × circumference of the circle or velocity per muhurta.

Hence, the day being of $12+\frac{2}{61}$ muhurtas, we have $(6+\frac{1}{61}) \times \frac{318297}{60}$ $= 31,916\frac{39}{60}+\frac{60}{61}$ yojanas.

In the same way the visible area and the sun's velocity may be ascertained in other diurnal circles. When he goes from outer circle to inner circle, his velocity will be less by $\frac{18 \times 2}{60}$ yojanas per muhurta per circle and the heated area gets less by 84 or 85 yojanas than in the previous outer circle.

The decrease by 85 yojanas of the visible area in the inner circles is correct only in the case of a few inner circles nearer the outermost diurnal circle. For example in the outermost circle, the decrease is, as already shown, $85+\frac{9}{60}+\frac{60}{61}$ yojanas.

In the second outer circle it is almost the same again.

In the third outer circle, we multiply $\frac{36}{61}$ by 1 and deduct it from the constant $85+\frac{9}{60}+\frac{60}{61}$.

Hence $85+\frac{9}{60}+\frac{24}{61}$ is the remainder. Adding this to the visible area in the previous outer circle, we get $31,916\frac{39}{60}+\frac{60}{61}$ yojanas.

Regarding the area illuminated by the sun or the moon, there are twelve different views:—

(1)	Some say that it is one island and one ocean.				
(2)	"	"	three islands and three oceans.		
(3)	"	"	$3\frac{1}{2}$	"	$3\frac{1}{2}$ "

(4)	Some say that it is seven islands and seven oceans.				
(5)	"	"	10	"	10 "
(6)	"	"	12	"	12 "
(7)	"	"	42	"	42 "
(8)	"	"	72	"	72 "
(9)	"	"	142	"	142 "
(10)	"	"	172	"	172 "
(11)	"	"	1042	"	1042 "
(12)	"	"	1072	"	1072 "

All these are untrustworthy.

According to Mahāvīra's own view, the suns and the moons illuminate $\frac{3}{10}$th of the area of the Jambudvīpa. Suppose the Jambu circle is divided into 3,660 parts. Of these parts, one sun illuminates $\frac{3}{10}$ of 3,660 = 1,098 parts and the other a similar number of parts. Put together, they illuminate 2,196 parts. Hence $\frac{2}{10}$ parts of the Jambu circle will be in the dark with reference to one sun; with reference to both the suns $\frac{4}{10}$ parts or 1,464 divisions will be in the dark.

Now when the sun is on the innermost diurnal circle, the day is of 18 and the night of 12 muhurtas. So when he is on the second innermost circle on the second day of the year, one sun illuminates $\frac{1}{5}+\frac{1}{10}$ *minus* $\frac{2}{3660}$ parts of the Jambudvipa and the other as much. Similarly on the third day one sun illuminates $(\frac{1}{5}+\frac{1}{10}-\frac{4}{3660})$ parts of the Jambu and the other as much.

Thus the illuminated part falls short by $\frac{2}{3660}$ each day with reference to each sun. Thus on the 183rd day the decrease amounts to $\frac{2}{3660} \times 183$ $= \frac{366}{3660} = \frac{1}{10}$ parts of the Jambu for one sun.

Hence for both the suns the decrease will be $\frac{2}{10} = \frac{1}{5}$ of the Jambu, *i.e.*, so much will be in the dark. Hence the constant quantity illuminated on all day is $\frac{1}{5}$ of the Jambu for each sun.

(To be Continued.)

VIII. THE GENERAL MUSEUM OF FINE ARTS, *Boston, Mass., U.S.A.*
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मिथिक् समाज एव टबार्ड् गुरुः । टबार्ड् गुरुरेव मिथिक् समाजः ॥

(H. H. The Yuvaraja of Mysore.)

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various settlements. And the idea of the Neolithic folk may have been permeated by the survival of a similar Palæolithic idea.

This theory seems really to rival the Indian theory put forward by me. I have indeed no quarrel with those who advocate a 'homogeneity of race, homogeneity of belief' theory. Those who deal with myths are all in the same plight, *i.e.*, to the historians they are no better than the knights of the poet who following the *Holy Grail* were stuck in the quagmire. For they say, from the 'arid wastes' of mythology—(myths and legends and all the kindred brood)—can only crop up 'Mirages of History'!

I have presented a theory which seems to me to be very probable.

A BRIEF TRANSLATION OF MAHAVIRA'S "SURYAPRAGNAPTI" OR "THE KNOWLEDGE OF THE SUN".

By Dr. R. Shama Sastry.

The Increase and Decrease in the Area of Day and Night.

We divide the diurnal circle into 1830 equal parts. The reason why we divide it into so many parts is this:—Now each complete diurnal circle is illuminated by two suns in a day or by one sun in two days or sixty muhurtas. Hence we divided the circle into sixty divisions first. Now the two suns together advance on each outer circle from the first innermost circle by lessening the day time together by $\frac{2}{61}$ of a muhurta or $\frac{1}{61}$ of a muhurta each; *i.e.*, the area of diurnal circle will be lessened by $30\frac{1}{2}$ parts of $\frac{1}{60}$th division. In other words, they lessen each division of $\frac{61 \times 60}{2} = 1830$ divisions, and increase one division of 1830 divisions in the area of the night. Hence on the 183rd circle on the 183rd day they lessen 183 of 1830 divisions or $\frac{1}{10}$th of the whole circle.

Śrâvaṇa Bahuḷa pratipat is the Yugâdi (New Year's Day). Then one sun is in the south-eastern quarter, and the other in the north. Likewise one moon is in the south-western quarter and another in the north-eastern quarter.

The length of days and nights in both the sides of the Meru is similar; likewise the seasons. When it rains in the south, it also rains in the north.

When the sun rises, the shadows caused by him are longer and as he rises up high, they become less long and begin to get longer and longer as day declines.

Some say that there is a day when shadow is cast measuring four Purushas in the morning and likewise in the evening. Here the word Purusha means anything that casts the shadow. Hence four Purushas mean four times the height of the thing casting shadow. They say that there is also a day when in the morning and in the evening shadow equal to a Purusha is cast.

Others say that there is a day when shadow is cast, equal to a Purusha both in the morning and in the evening; and likewise a day when both in the morning and in the evening no shadow is cast.

As regards the first it must be said that on the day when it is eighteen muhurtas and the night twelve muhurtas, the shadow cast by a thing either

in the morning or in the evening is four Purushas when the sun is on the outermost diurnal circle, and when the night is eighteen muhurtas and the day is twelve muhurtas, then the shadow is two Purushas. There are, however, as many as ninety-six different views regarding the length of shadow in different localities. Some say that there is a day when shadow cast in the morning or in the evening is one Purusha or two Purushas; and so on. They can better be guessed than described. Mahāvīra's own view is this:—Both in the morning and in the evening the sun causes shadows equal to a little more than fifty-nine Purushas. When three parts of the day have elapsed or remain to be passed then the shadow is half Purusha; when four parts are passed or remain to be passed, then the shadow is one Purusha. When the fifth part is passed or is to pass then the shadow is $1\frac{1}{2}$ Purusha.

Constellations.

The Nakshatras begin with Kṛittika and end with Bharaṇi according to some and others follow a different order. Our order is beginning with Abhijit.

(1) There is a constellation which unites with the moon for $9\frac{27}{67}$ muhurtas.

(2) There are constellations which unite with the moon for fifteen muhurtas.

(3) There are constellations which unite with the moon for thirty muhurtas.

(4) There are constellations which unite with the moon for forty-five muhurtas.

1. Abhijit remains with the moon for $9\frac{27}{67}$ muhurtas.

The reason for this is as follows:—The sīma-vishkambha or the diameter of the Abhijit circle is 630 in terms of muhurta. This when divided by sixty-seven nakshatra month periods of a Yuga is equal to $\frac{630}{67} = 9\frac{27}{67}$. Accordingly it is stated that the Abhijit remains with the moon $\frac{21}{67}$ parts of a day. This in terms of muhurtas is equal to $\frac{21 \times 30}{67} = 9\frac{27}{67}$.

2. Śatabhishak, Bharaṇi, Ārdra, Āślēsha, Svāti, Jyēshṭha remain with the moon for fifteen muhurtas. For each of these six remains with the moon $\frac{33\frac{1}{2}}{67}$ parts of a day $= \frac{67}{2} \times \frac{30}{67} =$ fifteen muhurtas.

3. Śravaṇa and other fifteen stars unite with the moon for thirty muhurtas; for their area is 2010 muhurtas. This when divided by $67 = 30$.

4. Uttarābhādra and other six stars combine with the moon 3015 muhurtas.

This divided by $67 = \frac{3015}{67} =$ forty-five muhurta periods.

The Nakshatras and the Sun.

(1) There is a constellation which lasts in union with the sun for four days and six muhurtas.

(2) There are constellations which remain in union with the sun for six days and twenty-one muhurtas.

(3) There are others which unite with the sun for thirteen days and twelve muhurtas.

(4) And there are also some which remain with the sun for twenty days and three muhurtas.

1. It is the Abhijit which unites with the sun for four days and six muhurtas.

The ancient rule regulating the combination of the constellations with the sun is as follows:—

" Jam rikham Javayiye Vajjayi Chandenabhaga Sattatthi tam paṇabage rāyindivassa sūrena tavayiye."

"That constellation which unites with the moon for how many sixty-seventh divisions of a whole day, the same constellation unites with the sun for one-fifth of so many days and nights." For example, the Abhijit combines with the moon for twenty-one times of one-sixty-seventh divisions of a whole day. Now one-fifth of twenty-one is equal to four days and six muhurtas.

Hence it is said that Abhijit remains with the sun for four days and six muhurtas.

2. Those constellations which combine with the sun for six days and twenty-one muhurtas are six. For each of them remains with the moon for $\frac{33\frac{1}{2}}{67}$ parts of a day and night. Hence one-fifth of $33\frac{1}{2} = \frac{67}{2} \div 5 =$ six days and twenty-one muhurtas. These are Śatabhishak, Bharaṇi, Ārdra, Āślēsha, Svāti and Jyēshṭha.

3. Again those which combine with the moon for complete sixty-seven parts combine with the sun for one-fifth of sixty-seven parts, *i.e.*, thirteen days and twelve muhurtas.

4. Uttarābhādrapada and other remaining stars unite with the moon for $\frac{100}{67} + \frac{1}{67 \times 2}$ parts of a whole day. Hence these combine with the sun for $\frac{100}{5} + \frac{1}{2 \times 5}$ days = twenty days $+ \frac{30}{10} =$ three muhurtas.

The constellations may be classed into four groups in respect of the duration of their union with the moon.

(1) Those which unite with the moon for thirty muhurtas are constellations of whole or even union area (Samakshetra) and of earlier commencement.

(2) Those which unite with the moon for thirty muhurtas but begin their union during the later part of the day and have yet whole or even union area.

(3) Those which unite with the moon for fifteen muhurtas, having half of union area.

(4) Those which unite with the moon for a whole day and a half, *i.e.*, forty-five muhurtas having one and a half union area.

1. Those of the first class are six, Pūrvābhādra, etc.
2. Those of the second class are ten, Abhijit, etc.
3. Those of the third class are six, Śatabhishak, etc.
4. Those of the fourth class are six, Uttarābhādra, etc.

The two constellations, Abhijit and Śravaṇa, are of later union and of whole union area. Of these two Abhijit is of neither whole union area, nor of half union area, nor even of one and half union area. Still, as it is connected with Śravaṇa, it is said to be of whole union area. The area occupied by them together is a little more than thirty-nine muhurtas; nine muhurtas for Abhijit and thirty muhurtas for Śravaṇa. It is in the twilight that they come in contact with the moon. At the beginning of the Yuga, cycle of five years, the Abhijit comes into contact with the moon in the morning. Still, connected as it is with Śravaṇa, it is said to form union with the moon in the evening. All that is meant is that in the evening on the first day of the Yuga they unite with the moon and remain so for a little more than the whole of the next half a day (fifteen muhurtas). Then they leave the moon for union with the Dhanishṭha. The last also unites with the moon in the evening and remains so for thirty muhurtas.

Then Śatabhishak comes in contact for fifteen muhurtas beginning in the evening.

Then two Bhādrapadas. The first of these comes into contact with the moon in the morning and remains so for thirty muhurtas. The Uttarābhādra comes also in contact with the moon in the morning and remains for the whole day and night and sends the moon at twilight to unite with the Revati. The two Bhādrapadas are, however, said to have one and a half of union area each.

Revati is of samakshetra and lasts for thirty muhurtas with the moon.

Aśvini is of later union for thirty muhurtas, one night and day.

Bharaṇi is also of later union and of half union area lasting for fifteen muhurtas.

Kṛittika unites in the morning, *i.e.*, of earlier union and remains whole night and whole day and more and hence it is of one and a half of union area.

Rōhiṇi is also of one and a half of union area.

Mṛigaśira is of union for thirty muhurtas, beginning in the evening.

Ārdra is like Śatabhishak of fifteen muhurtas.

Punarvasu is of one and a half of union area like Uttarābhādra.

Pushya like Dhanishṭha unites in the evening and remains so for thirty muhurtas.

Āślēsha like Śatabhishak remains in union for thirty muhurtas.

Magha is of earlier union and remains for thirty muhurtas.

Pūrva-phalguni like Pūrvābhādra remains in union for thirty muhurtas.

Uttara-phalguni is of one and a half of union area like Uttarābhādrapada.

Hasta comes in union in the evening and remains so for thirty muhurtas.

Chitra comes in union a little later in the evening and lasts for thirty muhurtas.

Svāti is of half union area and lasts for fifteen muhurtas.

Viśākha is of one and a half of union area.

Anūrādha is like Dhanishṭha of even area for thirty muhurtas.

Jyeshṭha is like Śatabhishak of half area for fifteen muhurtas.

Mūla like Pūrvābhādrapada has even area for thirty muhurtas.

Pūrvāshāḍha comes in contact in the morning and remains so for thirty muhurtas.

Uttarāshāḍha like Uttarābhādrapada is of one and a half of union area.

Thus some are of earlier union, some of later union, some of union only at night and some of union for a day and night.

The Nakshatras are again divided into kulas (houses), upakulas (apparent houses), and kulōpakulas (petty apparent houses). There are twelve kula constellations, twelve upakulas and four kulōpakulas. Those like Śravishṭha, Bhādrapada, Aśvini, etc., which complete a lunar month are kulas; those which nearly complete the month are upakulas; and those, like Abhijit, Pūrvābhādra, Śatabhishak and Anūrādha, which are far removed from the moon at the close of corresponding months are kulōpakulas.

The names of months terminating with full moons (and also new moons) in particular constellations are derived from corresponding constellations. There are twelve full moons and twelve new moons, as. Śravishṭhi, Praushṭhapadi, etc. Śravishṭhi is that which takes place in Śrāvaṇa month and Praushṭhapadi is that which takes place in Bhādrapada month. Likewise Āśvayuji is that which occurs in the month called Āśvayuk. It is to be noted that as many as three constellations may alternately unite with the moon to make a full or new moon; for example, Abhijit, Śravaṇa, Dhanishṭha may come in contact with the moon to make the full moon of Śravishṭhi month. Abhijit, however, does not at all combine with the moon; still, because it is so near the Śravaṇa star, it is also considered as making that particular full or new moon.

Constellations and Full Moons or New Moons.

To determine the constellation in which a particular new moon takes place, it is necessary to ascertain the Parva constant (Parva dhruvarāśi).

This is done as follows :—

In the course of 124 Parvas the sun performs five sidereal circuits. How many circuits does he perform in two Parvas ?

In 124 Parvas he makes five circuits.

∴ in two........................$\frac{5\times2}{124}$ circuits $= \frac{5\times2}{124}\times 1830$ day circuits,

$= \frac{9150}{62} = \frac{9150}{62}\times 30 = \frac{274500}{62}$ muhurta circuits,

$= \frac{2745000}{62\times67}$ sidereal muhurta circuits $= 66\,\frac{386}{62\times67} = 66$ muhurtas, 5 sixty-secondths of a muhurta and $\frac{1}{67}$ of sixty-secondth of a muhurta.

This is Parva constant, as stated in the text.

This constant is to be multiplied by the number of the Parva under question. Then a nakshatra correction is also to be made before finding the particular Parva in a particular constellation. The corrections vary with each nakshatra. They are as follows :—

For Punarvasu it is 22 muhurtas and $\frac{46}{62}$ of a muhurta.

For constellations from Punarvasu to Uttara-phalguni it is 172 muhurtas $+\frac{46}{62}$ of a muhurta.

For constellations from Uttara-phalguni to Viśākha it is 292 muhurtas $+\frac{46}{62}$ of a muhurta.

For constellations from Viśākha to Uttarāshāḍha it is 442 muhurtas $+\frac{46}{62}$ of a muhurta.

The correction is thus obtained :—

If in 124 Parvas sun's five sidereal circuits are completed, how many will they be in one Parva after one Parva ?

i.e., 124 Parvas contain 5 sidereal circuits.

1 Parva contains $\frac{5}{124} = \frac{5}{124}\times$ 1830 day circuits,

$= \frac{9150}{124} = \frac{4575}{62}$ day circuits,

$= \frac{4575}{62\times67} = \frac{4575}{4154}$ day sidereal circuits.

Now $\frac{23}{67}$ of a muhurta parts of Pushya unite with the sun in the final Parva of the previous Yuga. This is to be multiplied and divided by 62 and deducted from the above (i) $\frac{23}{67}\times 62 = \frac{1426}{67\times62}$.

Hence $\frac{4575}{62\times67} - \frac{1426}{62\times67} = \frac{3149}{62\times67}$ day sidereal circuits $= \frac{3149}{62\times67}\times 30 = \frac{94470}{62\times67}$ muhurta sidereal circuits = 22 muhurtas and $\frac{46}{62}$ of a muhurta.

This is the correction for Punarvasu constellation.

These corrections are from Punarvasu to the end of Uttarāshāḍha. The second correction is as follows :—

Then for Abhijit it is 9 muhurtas and $\frac{24}{62}$ of a muhurta and $\frac{66}{67}$ of 62nd of a muhurta.

For Prōshṭhapada 159 muhurtas.

For Uttarābhādra 159 muhurtas.

Then for stars up to the end of Rōhiṇi 309 muhurtas.

Then for stars up to the end of Punarvasu 399 muhurtas.

Then for stars up to the end of Uttara-phalguni 519 muhurtas.

Then for stars up to the end of Viśākha 669 muhurtas.

Then for stars up to the end of Mūla 744 muhurtas.

Then for stars up to the end of Uttarāshāḍha 819 muhurtas.

In all these $\frac{24}{62}$ of a muhurta and $\frac{66}{67}$ of 62nd part of a muhurta is also to be included.

Thus the constant multiplied by the number of the new moon in question *minus* the two corrections will give the particular constellation from Abhijit, in which the new moon happens.

Likewise to ascertain the constellation making a full moon, the same constant is to be multiplied by the number of the full moon and the correction from Abhijit to the end of Uttarāshāḍha should be applied but not the correction from Punarvasu and onward (*i.e.*, the first correction).

Examples :—

In what Nakshatra does the first full moon Śravishṭhi get completion ?

Now the constant is $66+\frac{5}{62}+\frac{1}{67}$

$(66+\frac{5}{62}+\frac{1}{67})\times 1 - (9+\frac{24}{62}+\frac{66}{67}) = 56+\frac{42}{62}+\frac{2}{67}$ for Abhijit.

Then this *minus* 30 for Śravaṇa $= 26+\frac{42}{62}+\frac{2}{67}$.

This when deducted from 30 muhurtas of Dhanishṭha

$\left\{30-(26+\frac{42}{62}+\frac{2}{67})\right\}$ will give 3 muhurtas $+\frac{19}{62}+\frac{65}{67}$, *i.e.*,

when 3 muhurtas, $\frac{19}{62}$ of a muhurta and $\frac{65}{67}$ of 62nd part of a muhurta remain in Śravaṇa, then the full moon happens.

Now if the question is where does the second Śravishṭhi full moon get completion ?

The answer is as follows:—

$(66+\frac{5}{62}+\frac{1}{67})\times 13$. (We multiply the constant by 13 since the second full moon is the thirteenth from the first) $= 858+\frac{65}{62}+\frac{13}{67}$.

Now deduct from this $819+\frac{24}{62}+\frac{66}{67}$ which is equal to one sidereal circuit.

Hence the remainder is $39+\frac{40}{62}+\frac{14}{67}$.

Deduct the correction for Abhijit from this.

$39+\frac{40}{62}+\frac{14}{67}-(9+\frac{24}{62}+\frac{66}{67}) = 30+\frac{15}{62}+\frac{15}{67}$.

From this deduct 30 muhurtas of Śravaṇa.

Then when 29 muhurtas and $\frac{41}{62}+\frac{52}{67}$ of a muhurta remain in Dhanishṭha, the second full moon is completed.

Likewise for the third Śravishṭhi full moon.

It is the twenty-fifth full moon. Hence multiply the constant by 25.

$$(66+\frac{75}{62}+\frac{1}{67})\times 25 = 1650+\frac{125}{62}+\frac{25}{67}.$$

Deduct from this $1638+\frac{48}{62}+\frac{132}{67}$ being two sidereal rounds. Then the remainder is $12+\frac{75}{62}+\frac{27}{67}$.

Then apply Abhijit correction ; we have

$$(12+\frac{75}{62}+\frac{27}{67})-(9+\frac{24}{62}+\frac{66}{67})=3+\frac{50}{62}+\frac{28}{67},$$

i.e., when 26 muhurtas and $\frac{11}{62}+\frac{39}{67}$ of a muhurta remain in Śravaṇa the third full moon is completed.

Likewise the 4th full moon happens when $16+\frac{83}{62}+\frac{25}{67}$ remain in Dhanishṭha.

Thus Śravishṭhi full moon happens either in Śravaṇa or in Dhanishṭha.

Likewise Bhādrapadi full moon happens in Śatabhishak, Prōshṭhapada, or in Uttarāprōshṭhapada.

The first full moon happens when $27+\frac{14}{62}+\frac{64}{67}$ remain in Uttarā-bhādrapada.

The second when $8+\frac{41}{62}+\frac{51}{67}$ remain in Pūrvābhādrapada.

The third when $5+\frac{6}{62}+\frac{28}{67}$ remain in Śatabhishak.

The fourth full moon when $40+\frac{41}{62}+\frac{24}{67}$ remain in Uttarābhādrapada.

The fifth when $21+\frac{55}{62}+\frac{11}{67}$ remain in Pūrvābhādrapada.

Likewise the Āśvayuji full moon happens either in Revati or in Aśvini. Sometimes Uttarābhādrapada nakshatra too makes this full moon. Still it is usual for people to consider Uttarābhādrapada with Praushṭhapadi full moon.

The first Āśvayuji full moon happens when $21+\frac{63}{67}$ remain in Aśvini.

The second when $17+\frac{36}{62}+\frac{50}{67}$ remain in Revati.

The third when $14+\frac{1}{62}+\frac{37}{67}$ remain in Uttarābhādrapada.

The fourth when $4+\frac{38}{62}+\frac{23}{67}$ remain in Revati.

The fifth when $\frac{50}{62}+\frac{10}{67}$ remain in Uttarābhādrapada.

The Kārtiki full moon may happen in Bharaṇi, Kṛittika, and sometimes in Aśvini.

Prominence is however given to Kṛittika.

The first happens when $\frac{4}{62}+\frac{62}{67}$ of a muhurta remain in Kṛittika.

The second when 26 muhurtas and $\frac{81}{62}+\frac{49}{67}$ of a muhurta remain in Kṛittika.

The third when 7 muhurtas and $\frac{58}{62}+\frac{86}{67}$ of a muhurta remain in Aśvini,

The fourth when $16+\frac{58}{62}+\frac{22}{67}$ remain in Kṛittika.

The fifth when $9+\frac{54}{62}+\frac{9}{67}$ remain in Bharaṇi.

Then Mārgaśira full moon may happen in Rohiṇi, or Mṛigasíras.

The first when $8+\frac{61}{67}$ remain in Mṛiga.

The second when $5+\frac{26}{62}+\frac{48}{67}$ „ in Rohiṇi.

The third when $21+\frac{53}{62}+\frac{45}{67}$ „ in Rohiṇi.

The fourth when $22+\frac{13}{62}+\frac{21}{67}$ „ in Mṛigaśiras.

The fifth when $18+\frac{40}{62}+\frac{8}{67}$ „ in Rohiṇi.

Then Paushi full moon may happen in Ārdra or Punarvasu or Pushya.

The first when $2+\frac{56}{62}+\frac{60}{67}$ in Punarvasu.

The second when $29+\frac{21}{62}+\frac{47}{67}$ in Punarvasu.

The third when (before Adhikamāsa, intercalary month), $10+\frac{48}{62}+\frac{84}{67}$ remain in Ārdra.

The $\frac{\text{fourth}}{\text{third}}$ Intercalary when $19+\frac{43}{62}+\frac{88}{67}$ in Pushya.

The fourth when $16+\frac{8}{62}+\frac{20}{67}$ in Punarvasu.

The fifth when $42+\frac{85}{62}+\frac{7}{67}$ in Punarvasu.

Then Maghi full moon may occur in Āślēsha, Magha, or sometimes Pūrva-phalguni.

The first when $11+\frac{51}{62}+\frac{59}{67}$ remain in Magha.

The second when $8+\frac{16}{62}+\frac{46}{67}$ „ in Āślēsha.

The third when $28+\frac{88}{62}+\frac{82}{67}$ „ in Pūrva-phalguni.

The fourth when $25+\frac{8}{62}+\frac{19}{67}$ „ in Magha.

The fifth when $6+\frac{80}{62}+\frac{6}{67}$ „ in Pushya.

Then Phalguni full moon occurs in Pūrva-phalguni, or Uttara-phalguni.

The first when $20+\frac{46}{62}+\frac{53}{67}$ remain in Uttara.

The second when $2+\frac{11}{62}+\frac{54}{67}$ „ in Pūrva-phalguni.

The third when $7+\frac{88}{62}+\frac{81}{67}$ „ in Uttara-phalguni.

The fourth when $33+\frac{60}{62}+\frac{18}{67}$ „ in Uttara-phalguni.

The fifth when $15+\frac{25}{62}+\frac{5}{67}$ „ in Pūrva-phalguni.

Then Chaitri full moon may occur in Hasta or in Chitra.

The first when $14+\frac{41}{62}+\frac{57}{67}$ remain in Chitra.

The second when $11+\frac{6}{62}+\frac{40}{67}$ „ in Hasta.

The third when $1+\frac{28}{62}+\frac{40}{67}$ „ in Chitra.

The fourth when $27+\frac{55}{62}+\frac{17}{67}$ „ in Chitra.

The fifth when $24+\frac{20}{62}+\frac{4}{67}$ „ in Hasta.

Then Vaiśhākhi full moon in Svāti or Viśākha, or Anūrādha.

The first when $8+\frac{86}{62}+\frac{56}{67}$ remain in Viśākha.

The second when $25 + \frac{1}{62} + \frac{48}{67}$ remain in Viśākha.

The third when $25 + \frac{23}{62} + \frac{29}{67}$ „ in Anūrādha.

The fourth when $21 + \frac{50}{62} + \frac{16}{67}$ „ in Viśākha.

The fifth when $3 + \frac{15}{62} + \frac{8}{67}$ „ in Svāti.

Then Jyēshṭha happens in Anūrādha, Jyēshṭha, or Mūla.

The first when $17 + \frac{81}{62} + \frac{55}{67}$ remain in Mūla.

The second when $13 + \frac{58}{62} + \frac{42}{67}$ „ in Jyeshṭha.

The third when $4 + \frac{18}{62} + \frac{28}{67}$ „ in Mūla.

The fourth when $0 + \frac{45}{62} + \frac{15}{67}$ „ in Jyēshṭha.

The fifth when $12 + \frac{10}{62} + \frac{2}{67}$ „ in Anūrādha.

Then Āshāḍhi full moon in Pūrva or Uttarāshāḍha.

The first when $26 + \frac{26}{62} + \frac{54}{67}$ remain in Uttarāshāḍha.

The second when $7 + \frac{58}{62} + \frac{41}{67}$ „ in Pūrvāshāḍha.

The third when $13 + \frac{18}{62} + \frac{27}{67}$ „ in Uttarāshāḍha.

The fourth when $39 + \frac{40}{62} + \frac{14}{67}$ „ in „

The fifth when Uttarāshāḍha completes itself.

Kula, Upakula and Kulopakula.

The Śravishṭhi full moon happens in Kula when it is in Dhanishṭha; Upakula in Śravaṇa, and Kulōpakula in Abhijit. The last in the third year's full moon unites with the moon when there remains a little more than 12 muhurtas. Then with Śravaṇa the moon comes in contact. Likewise the Kula, Upakula and Kulopakula union with the moon in other constellations may be understood.

The New Moons.

The Śravishṭhi new moon may happen in Āślēsha or Magha. Here the new moon takes place in the fifteenth constellation from that in which the corresponding full moon takes place, and *vice versa*; the fifteenth from the new moon constellation is the constellation of the full moon. It is usual to designate that whole tithi as Amāvāsya, in which it may happen for a short time at the commencement. In reality Punarvasu, Pushya, or Āślēsha makes Śravishṭhi new moon.

If it is questioned where the first Śravishṭhi new moon happens, then we proceed as follows :—

The constant is $66 + \frac{5}{62} + \frac{1}{67}$. Multiplied by one it is the same. Then deduct from it Punarvasu correction $22 + \frac{48}{62}$.

The remainder is $43 + \frac{21}{62}$.

Then deduct the 30 muhurtas of Pushya.

Then $13 + \frac{21}{62}$ remains.

Āślēsha being of half union area its space comes to 15 muhurtas. Hence when $1 + \frac{40}{62} + \frac{66}{67}$ remain in Āślēsha, the first Amāvāsya is completed.

For the second new moon, the constant is multiplied by 13 and the corrections are made as follows :—

$$\left(66 + \frac{5}{62} + \frac{1}{67}\right) 13 = 858 + \frac{65}{62} + \frac{18}{67}.$$

Then deduct $442 + \frac{46}{62}$ being the correction upto Uttarāshāḍha. Then what remains is $416 + \frac{19}{62} + \frac{18}{67}$.

Deduct again $399 + \frac{24}{62} + \frac{66}{67}$ from the above.

Then remains $16 + \frac{56}{62} + \frac{14}{67}$.

Hence in Pushya the new moon occurs when there remains 16 muhurtas and $\frac{56}{62} + \frac{14}{67}$ of a muhurta in that constellation.

For the third new moon in Śravishṭha, multiply the constant $66 + \frac{5}{62} + \frac{1}{67}$ by 25. The result is $1650 + \frac{125}{62} + \frac{25}{67}$.

Deduct $442 + \frac{46}{62}$ up to Uttarāshāḍha.

The remainder is $1208 + \frac{79}{62} + \frac{25}{67}$.

Deduct again $819 + \frac{24}{62} + \frac{66}{67}$ being one sidereal circuit.

The remainder is $389 + \frac{54}{62} + \frac{26}{67}$ circuit.

Then deduct $309 + \frac{24}{62} + \frac{66}{67}$ being the circuit correction or from Abhijit upto Rōhiṇi.

Then the remainder is $80 + \frac{29}{62} + \frac{27}{67}$.

Then remove 30 for Mṛigaśiras and 15 for Ārdra. Then when $35 + \frac{29}{62} + \frac{27}{67}$ muhurtas are elapsed in Punarvasu, the 3rd Śravishṭhi new moon happens.

Likewise the fourth new moon occurs when $\frac{7}{62} + \frac{41}{67}$ muhurtas have elapsed in Āślēsha.

The fifth when $3 + \frac{42}{62} + \frac{54}{67}$ muhurtas have passed in Pushya.

Praushṭhapadi new moon happens in Magha, Pūrva-phalguni or Uttara-phalguni.

The first occurs when $4 + \frac{26}{62} + \frac{2}{67}$ have elapsed in Uttara-phalguni.

The second when $7 + \frac{61}{62} + \frac{15}{67}$ have elapsed in Pūrva-phalguni.

The third when $11 + \frac{34}{62} + \frac{28}{67}$ „ Magha.

The fourth when $21 + \frac{12}{62} + \frac{42}{67}$ „ Pūrva-phalguni.

The fifth when $24 + \frac{47}{62} + \frac{55}{67}$ „ Magha.

Then Aśvayuji new moon occurs in Uttara-phalguni, Hasta, or Chitra.

The first occurs when $25 + \frac{31}{62} + \frac{8}{67}$ have elapsed in Hasta.

The second when $44 + \frac{4}{62} + \frac{15}{67}$ have passed in Uttara-phalguni.

The third when $17 + \frac{89}{62} + \frac{29}{67}$ „ „

The fourth when $12 + \frac{17}{62} + \frac{43}{67}$ „ Hasta.

The fifth when $30 + \frac{52}{62} + \frac{54}{67}$ have passed in Uttara-phalguni.

Then Kārtiki new moon happens in Svāti, Viśākha, or Chitra.

The first when $16 + \frac{36}{62} + \frac{4}{67}$ have passed in Viśākha.
The second when $5 + \frac{22}{62} + \frac{17}{67}$,, Svāti.
The third when $8 + \frac{44}{62} + \frac{80}{67}$,, Chitra.
The fourth when $13 + \frac{22}{62} + \frac{44}{67}$,, Viśākha.
The fifth when $21 + \frac{57}{62} + \frac{57}{67}$,, Chitra.

Then Mārgaśīrshi new moon may occur in Anūrādha, Jyēshṭha or Mūla according to popular view, but really Viśākha, Anūrādha, or Jyēshṭha.

The first when $7 + \frac{41}{62} + \frac{5}{67}$ have passed in Jyēshṭha.

The Jyēshṭhamūliya new moon may occur in Rōhiṇi or Mṛigaśiras in popular view, but really in Rōhiṇi or Kṛittika.

The first when $19 + \frac{46}{62} + \frac{12}{67}$ have elapsed in Rōhiṇi.
The second when $23 + \frac{19}{62} + \frac{25}{67}$,, Kṛittika.
The third when $32 + \frac{59}{62} + \frac{89}{67}$,, Rōhiṇi.
The fourth when $6 + \frac{82}{62} + \frac{52}{67}$,, ,,
The fifth when $10 + \frac{5}{62} + \frac{65}{67}$,, Kṛittika.

The Āshāḍhi new moon may happen in Ārdra, Punarvasu, or Pushya, according to popular view, but really Mṛigaśiras, Ārdra or Punarvasu.

The first when $12 + \frac{51}{62} + \frac{18}{67}$ have passed in Ārdra.
The second when $14 + \frac{24}{62} + \frac{26}{67}$,, Mṛigaśiras.
The third when $9 + \frac{2}{62} + \frac{40}{67}$,, Punarvasu.
The fourth when $27 + \frac{37}{62} + \frac{58}{67}$,, Mṛigaśiras.
The fifth when $22 + \frac{16}{62} + 0$,, Punarvasu.

(*To be Continued.*)

KALAHASTI AND ITS INSCRIPTIONS.

By V. Venkatasubba Ayyar, Esq., B.A.

(Continued from Vol. XVI, No. 1.)

An inscription of Rājarāja III (1216-1248) dated in the eighth year records that Mallikārjunamuḍaiya-Nāyaṉār was set up in the temple of Maṇikaṇṭēśvara by Śaśikula sāḷukki-taṉiniṉṟuveṉṟa Vīra-Nārasiṅgadēvaṉ *alias* Yādavarāyaṉ. Besides setting up this image, he made provision also for its *puja*, offerings and lamps by assigning evidently a forest as a *dēvadāna* which had to be cleared of trees and then made cultivable. Another record dated in 1528 A.D. in the reign of the Vijayanagara king Kṛishṇarāya tells us that a certain lady set up a *Ganesa* on the way round the hill and that she made provision for offerings to this image. Madhurāntakamārāyaṉ, son of Daṇḍa-Nāyakaṉ Sōmaṉ, says in an inscription that he built a temple and a big *mandapa* in that temple calling it after his name. This temple and the *mandapa* are not to be easily identified now. A Telugu inscription of Kṛishṇarāya dated in 1516-17 A.D. mentions the king's visit to Kalahasti and his building the 100-pillared *mandapa* and the big *gopura*. It is curious to note that this *gopura* in the recent renovation has been disconnected from the temple proper and it now stands aloof to the north of the temple.

Kṛishṇarāya was so much attached to the deity that he presented a valuable necklace set with precious stones to God Kāḷahastēśvara for his special worship. His successor Achyutarāya showed his veneration to the temple by celebrating his coronation in the presence of God Kāḷahastēśvara in the cyclic year Virodhi, Saka 1452=1530 A.D. On this occasion, Achyutarāya granted $7\frac{3}{4}$ villages as well as the proceeds of the duties on exports and imports collected at certain sea-ports to the god. We thus see that the temple of Kāḷahastēśvara was in existence in the eleventh century A.D., and it might have existed in some form or other even before as the *Tēvāram* authors have sung about this place; and that the temple of Maṇikaṇṭēśvara was nearly contemporaneous with the big temple though its present building might date from the last quarter of the twelfth century. The Vijayanagara kings took great interest in the temple and the most illustrious of them even came here to adorn it with a huge *gopura* and a *mandapa*.

There has been no dearth of devotees to this temple from very early times. In fact, this temple was surrounded by many *matams* for pilgrims to halt. Some of the important *matams* are Tiruppāśuram-uḍaiyār-*maṭam*,

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SŪRYAPRAGNAPTI.

BY DR. R. SHAMA SASTRY, B.A., PH.D., M.R.A.S.

(Continued from Vol. XVI, No. 3.)

The Kula Nakshatras of New Moons.

THE Śravishṭhi new moon happens in Kula Nakshatra named Magha according to popular view, but really in the Kula Nakshatra of Pushya. In popular parlance though new moon has passed and the Pratipad has come in, it is usual to call the next day still new moon day. Likewise,

The 2nd when $11 + \frac{14}{62} + \frac{18}{67}$ muhurtas remain in Anūrādha.

The 3rd when $29 + \frac{49}{62} + \frac{31}{67}$,, in Viśākha.

The 4th when $24 + \frac{27}{62} + \frac{45}{67}$,, in Anūrādha.

The 5th when $43 + 0 + \frac{58}{67}$,, in Viśākha.

Then Paushi new moon may happen in Pūrvāshāḍha or Uttarāshāḍha according to popular view, but in reality in Mūla, Pūrvāshāḍha or Uttarāshāḍha.

The 1st when $28 + \frac{26}{62} + \frac{6}{67}$ muhurtas have passed in Pūrvāshāḍha.

The 2nd when $2 + \frac{19}{62} + \frac{19}{67}$,, ,, ,,

The 3rd intercalary when $11 + \frac{59}{62} + \frac{33}{67}$ have passed in Uttarāshāḍha.

The 4th when $15 + \frac{56}{62} + \frac{46}{67}$ muhurtas have passed in Pūrvāshāḍha.

The 5th when $19 + \frac{5}{62} + \frac{59}{67}$,, ,, in Mūla.

Then Maghi new moon may happen in Abhijit, Śravaṇa or Dhanishṭha, according to popular view, but really Uttarāshāḍha, Abhijit or Śravaṇa.

The 1st when $10 + \frac{26}{62} + \frac{8}{67}$ muhurtas have passed in Śravaṇa.

The 2nd when $3 + \frac{26}{62} + \frac{20}{67}$,, in Abhijit.

The 3rd when $23 + \frac{39}{62} + \frac{85}{67}$,, in Śravaṇa.

The 4th when $6 + \frac{37}{62} + \frac{47}{67}$,, in Abhijit.

The 5th when $25 + \frac{10}{62} + \frac{60}{67}$,, in Uttarāshāḍha.

The Phalguni new moon may happen in Śatabhishak or Pūrvābhādrapada according to popular view, but really Dhanishṭha, Śatabhishak or Pūrvābhādra.

The 1st when $6 + \frac{81}{62} + \frac{8}{67}$ muhurtas have passed in Pūrvābhādrapada.

The 2nd when $20 + \frac{4}{62} + \frac{22}{67}$,, ,, in Dhanishṭha.

The 3rd when $14 + \frac{44}{62} + \frac{86}{67}$,, ,, in Pūrvāshāḍha.

The 4th when $3 + \frac{17}{62} + \frac{49}{67}$,, ,, in Śatabhishak.

The 5th when $6 + \frac{52}{62} + \frac{62}{67}$,, ,, in Dhanishṭha.

Then Chaitra new moon may happen in Uttarābhādrapada, Revati, or Aśvini, according to popular view, but really Pūrvābhādrapada, Uttarābhādrapada or Revati.

The 1st when $37 + \frac{36}{62} + \frac{10}{67}$ muhurtas have expired in Uttarābhādra.

The 2nd when $11 + \frac{9}{62} + \frac{28}{67}$,, ,, ,,

The 3rd when $5 + \frac{49}{62} + \frac{87}{67}$,, ,, in Revati.

The 4th when $23 + \frac{22}{62} + \frac{50}{67}$,, ,, in Uttarābhādra.

The 5th when $27 + \frac{57}{62} + \frac{63}{67}$,, ,, in Pūrvābhādrapada.

The Vaishākhi new moon may occur in Bharaṇi or Kṛittika in popular view, but really Revati, Aśvini or Bharaṇi.

The 1st when $28 + \frac{41}{62} + \frac{11}{67}$ muhurtas have expired in Aśvini.

The 2nd when $2 + \frac{39}{62} + \frac{28}{67}$,, ,, ,,

The 3rd when $11 + \frac{54}{62} + \frac{88}{67}$,, ,, in Bharaṇi.

The 4th when $15 + \frac{27}{62} + \frac{51}{67}$,, ,, in Aśvini.

The 5th when $19 + 0 + \frac{64}{67}$,, ,, in Revati.

Belief and truth differ from each other in other cases. Accordingly the Śravishṭhi new moon may occur in Kula or Upakula constellations but not in Kulopakula constellations. Similarly Mārgaśirshi, Maghi, Phalguni and Ashāḍhi new moons happen either in Kula or Upakula. The rest happen only in Kulopakula.

What is to be specially remembered in this connection is this:—According to popular belief the new moon occurs in the 15th or 14th constellation from that in which full moon happens. Thus when Śravishṭhi full moon occurs in Dhanishṭha or Śravishṭha as it is also called, the new moon that precedes it must have been in Magha. Likewise the full moon in Magha is followed by new moon in Śravishṭha which is 15th from Magha; full moon in Uttarābhādrapada is followed by new moon in Uttaraphalguni, the 15th from the former. There is, however, the Abhijit between them. But as it comes in only for a short time with the moon, it may be dropped out of account. Accordingly the *Samavayanga Sūtra* says that in Jambudvīpa it is usual to deal with only 27 stars leaving off the Abhijit. Hence it is not included in calculation.

Hence Uttaraphalguni may be regarded as the 15th from Uttarābhādra. This is said regarding Bhādrapada month. But when the full moon takes place in Uttaraphalguni, then it will be followed by the new moon in Pūrvābhādrapada which is 14th from Uttaraphalguni. This is said regarding the month of Phālguna.

The full moon in Aśvini will be followed by the new moon in Chitra (Chaitri), which is 15th from Aśvini. This is according to popular view.

But in reality no new moon in the month of Āśvayuja occurs in Chitra. Similarly the full moon in Chitra will be followed by new moon in Aśvini according to popular view. But really no new moon in the month of Chaitra occurs in Aśvini. Hence the Sūtra must be taken to refer to Chaitramāsa in Aśvini.

The full moon in Kṛittika will be preceded by new moon in Viśākha which is 15th from Kṛittika in the reverse order. When full moon happens in Viśākha, it will be followed by new moon in Kṛittika, which is 14th from Viśākha, if counted back. This is said regarding Kārtika and Vaiśākha months.

The appearances of the constellations are thus described :—

Abhijit	Cow head.
Śravaṇa	Fish.
Dhanishṭha	Bird.
Śatabhishak	Flower.
Pūrvābhādra, Uttarābhādra	Lake.
Revati	Boat.
Aśvini	Horse's head.
Bharaṇi	Bhaga.
Kṛittika	Knife.
Rohiṇi	Cart (Wheel).
Mṛigaśīrsha	Deer's head.
Ārdra	Drops of blood.
Punarvasu	Balance.
Pushya	Pendal.
Āślēsha	Flag.
Magha	Fort wall.
Pūrvaphalguni, Uttara ,, ...	Palanquin.
Hasta	Hand.
Chitra	Face of a man.
Svāti	Cheva ? = Pearl.
Viśākha	Screw or a nail.
Anūrādha	Damani ? Umbrella.
Jyēshṭha	Necklace.
Mūla	Elephant = Tusk.
Pūrvāshāḍha, Uttarāshāḍha	Square ?

Constellations and Days and Shadow.

Uttarāshāḍha	Rainy 1st month	14 days.
Abhijit		7 ,,
Śravaṇa		8 ,,
Dhanishṭha		1 ,,
		30 days of Śravaṇa month, shadow 2 padas and 4 angulas.
Dhanishṭha	Rainy 2nd month	14 days.
Śatabhishak		7 ,,
Pūrvābhādrapada		8 ,,
Uttarābhādrapada		1 ,,
		30 days of Bhādrapada, shadow 2 padas and 8 angulas.
Uttarābhādrapada	Rainy 3rd month	14 days.
Revati		15 ,,
Aśvini		1 ,,
		30 days of Āśvayuja, shadow 2 padas and 12 angulas or 3 padas.
Aśvini	Rainy 4th month	14 days.
Bharaṇi		15 ,,
Kṛittika		1 ,,
		30 days of Kārtika, shadow 3 padas and 4 angulas.
Kṛittika	Hēmanta 1st month	14 days.
Rohiṇi		15 ,,
Mṛigaśīrsha or Santhana		1 ,,
		30 days of Mārgaśīrsha, shadow 3 padas and 8 angulas.
Mṛigasīrsha	Hēmanta 2nd month	14 days.
Ārdra		7 ,,
Punarvasu		8 ,,
Pushya		1 ,,
		30 days of Pushya, shadow 4 padas.

On the last day of Pushya the shadow measures 4 padas.

Pushya Āślesha Magha	Hēmanta 3rd month	14 days. 15 „ 1 „
		30 days of Māgha, shadow 3 padas and 8 angulas on the last day.

Magha Pūrvaphalguni Uttaraphalguni	Hēmanta 4th month	14 days. 15 „ 1 „
		30 days of Phālguṇa, shadow 3 padas and 4 angulas on the last day.

Uttaraphalguni Hasta Chitra	Grīshma 1st month	14 days. 15 „ 1 „
		30 days of Chaitra, shadow 3 padas on the last day.

Chitra Svāti Viśākha	Grīshma 2nd month	14 days. 15 „ 1 „
		30 days of Vaiśākha, shadow 2 padas and 8 angulas.

Viśākha Anūrādha Jyēshṭha & Mūla	Grīshma 3rd month	14 days. 15 „ 1 „
		30 days of Jyeshṭha, shadow 2 padas and 4 angulas.

Mūla Pūrvāshāḍha Uttarāshāḍha	Grīshma 4th month	14 days. 15 „ 1 „
		30 days of Āshāḍha, shadow 2 padas.

How to Find Out Ayanas.

When the length of the shadow on any lunar day (tithi) of any parva is sought to be known, then all the parvas of the previous cycle (Yuga) are counted, and multiplied by 15. To the product is added the sum of all the lunar days elapsed up to the lunar day in question. Then the sum is divided

by 186 (186 being the number of lunar days in an Ayana of 183 solar days) (solar diurnal circles). If the quotient happens to be an odd number like 1, 3, 5, 7 or 9, then the near Dakshiṇāyana is to be regarded as current. If even like 2, 4, 6, 8, or 10, then it is to be considered as Uttarāyaṇa.

If the sum is not divisible by 186 or a remainder remains, then the remainder is multiplied by 4 and divided by one-fourth of the total number of parvas, *i.e.*, 31. The quotient is the number of the angulas of the shadow cast, either more than the constant fixed for the Dakshiṇāyana or less than the constant fixed for the Uttarāyaṇa.

The reason for this is as follows:—

If in 186 lunar days 24 angulas of shadow are obtained, how many will they be in one day?

186 days	...	...	24 angulas.
1 „	...	...	$\frac{24}{186} = \frac{4}{31}$ angulas.

This is the constant. This increases at the rate of $\frac{4}{31}$ angulas per lunar day upto 4 padas in the Dakshiṇāyana. On the first day, *i.e.*, Śrāvaṇa Bahula Pratipad, the shadow will be 2 padas; this is the minimum. Similarly in the Uttarāyaṇa commencing on the seventh lunar day of Māgha Bahula the shadow decreases from four padas at the rate of $\frac{4}{31}$ angulas per day to 2 padas at the end of Uttarāyaṇa. This is in the first year of the Yuga. In the second year the increase and decrease begin to take place on Śrāvaṇa Bahula 13 and Māgha Śukla 4. In the third year the dates are Śrāvaṇa Śukla 10 and Māgha Bahula 1. In the fourth year the increase begins on Śrāvaṇa Bahula 7 and the decrease on Māgha Bahula 13. In the fifth the dates are Śrāvaṇa Śukla 4 and Māgha Śukla 10. This is according to the ancient teachers (not mentioned in the Gāthas here).

If one asks what is the measure of shadow on the 85th parva day from the beginning of the yuga or cycle, we take 84th parva and find the measure on the 5th day after it. Now $84 \times 15 = 1260$ and add 5 to it. Hence it becomes 1265.

This divided by 186, is $= \frac{1265}{186} = 6 + \frac{149}{186}$ *i.e.*, 6 ayanas and 149 days; $149 \times \frac{4}{31} = \frac{596}{31} = 19\frac{7}{31} =$ One pada (12 angulas) $+ 7\frac{7}{31}$ angulas.

Now the 6th ayana is Uttara and the 7th is Dakshiṇa. Hence there is increase on the constant of two padas of shadow; *i.e.*, the shadow measure is 3 padas $+ 7\frac{77}{31}$ angulas $= 3$ padas $+ 7$ angulas $+ 1$ yava $+ \frac{25}{31}$ (One angula $= 8$ yavas) on the 85th parva.

If it be asked what is the measure of the shadow on 97th parva panchami, we proceed as follows:—

Taking 96th parva, we multiply it by 15.

$96 \times 15 = 1440$. With 5 it becomes 1445. Divided by 186, this gives ayanas. $\frac{1445}{186} = 7 + \frac{148}{186}$. 143 of the remainder is the number of days.

$\therefore 143 \times \frac{4}{31} = \frac{572}{31} = 18 + \frac{14}{31}$ angulas.

$=$ One pada $+ 6\frac{14}{31}$ angulas.

$\therefore$ The eighth being Uttarāyaṇa, the shadow has decreased from 4 padas, one pada and $6\frac{14}{31}$ angulas. Hence on the day the shadow $(4 \times 12 = 48)$—$18\frac{14}{31}$ angulas $= 2$ padas and $5\frac{17}{31}$ angulas.

Similarly applying the same process we can find out the number of elapsed days in any ayana, provided the shadow measure above the constant of 2 padas is given. For example:

In the Dakshiṇāyana the shadow is 4 angulas above 2 padas. How many days have then elapsed?

The increase is $\frac{4}{31}$ angulas per day. Hence 4 angulas will be gained in $\frac{31}{4} \times 4 = 31$ days.

Likewise if 4 padas decrease by 8 angulas in the Uttarāyaṇa, then the number of days past will be $\frac{31}{4} \times 8 = 62$.

In the month of Āshāḍha, the shadow cast, when $\frac{1}{4}$ of the day is past or remains, is equal to the length of the thing casting the shadow.

Then the text goes on to describe the situations of the constellations north or south, etc., to the moon and the Yōjanas of the diurnal circles of the moon.

The deities of the constellations are Abhijit, Brahma; Śravaṇa, Vishṇu; then Vasu, Varuṇa, Aja, Pūsha, Gandharva, Yama, Agni, Prajāpati, Soma, Rudra, Aditi, Bṛihaspati, Nāga, Pitṛi, Bhaga, Aryama, Savitṛi, Tvashṭa, Vāyu, Indrāgni, Mitra, Indra, Nirriti, Apah, and Viśvedevas (all Vedic).

Then the text enumerates the names of the muhurtas:—

1	Rudra	11	Īśāna	21	Gandharva
2	Śrēyan	12	Tvashṭa	22	Agnivisya
3	Mitra	13	Bhavitātma	23	Śatavṛishabha
4	Vāyu	14	Vaiśravaṇa	24	Atapavan
5	Supita	15	Varuṇa	25	Amama
6	Abhichandra	16	Ānanda	26	Rinavan
7	Mahendra	17	Vijaya	27	Bhauma
8	Balavan	18	Viśvasena	28	Vṛishabha
9	Brahma	19	Prajāpatya	29	Sarvārtha
10	Bahusutya	20	Upasama	30	Rākshasa

Then the text enumerates the names of 15 days and nights, which are different from those given in the *Taittirīya Āraṇyaka.*

Then the text goes to say something of Rāhu, the demon believed to be causing the eclipses of the sun and the moon. There are two Rāhus; one Parva Rāhu and another Dhruva Rāhu. The Dhruva Rāhu is of black disc (Vimāna) and moves 4 angulas below the moon. The moon's disc is divided into 62 parts. Of these, 2 parts are always uncovered by Rāhu. The rest 60 parts are covered by Rāhu at the rate of 4 parts a day during the 15 days of the dark half of the month and uncovered in the other half at the same rate. The time taken by the 4 parts to increase or decrease is what is called Tithi, lunar day.

As regards Parva Rāhu, something will be said later on. Then the text enumerates the names of the 30 tithis of a month; and mentions the names of the Gotras of the 28 stars, such as Garga, Mandalya, Sankhayana, etc.

The stars and their situation with reference to the moon's ecliptic circle:—

Of the 28 constellations there are some which are situated to the south, and some to the north, and a few both to the north and the south of the moon's ecliptic.

Mṛigaśirah, Ārdra, Pushya, Āślēsha, Hasta and Mūla, these six are to the south, and outside the 15th circle of the moon.

Abhijit, Śravaṇa, Dhanishṭha, Śatabhishak, Pūrvābhādrapada, Uttarābhādrapada, Revati, Aśvini, Bharaṇi, Pūrvaphalguni, Uttaraphalguni and Svāti, these twelve are to the north; when the moon is in conjunction with any of these, he may be in any one of his circles.

Kṛittika, Rohiṇi, Punarvasu, Magha, Chitra, Viśākha, Anūrādha, and according to some Jyēshṭha also are situated both north and south and partake of both the sides (Pramarda Yoga or Ubhaya-yōgi).

Uttarāshāḍha and Pūrvāshāḍha are to the south but unite with the moon in Pramarda Yoga, *i.e.*, outside the circle. Jyeshṭha alone has Pramarda Yoga with the moon.

The Lunar Diurnal Circles.

There are fifteen lunar diurnal circles. There are some circles which always pass through some constellations. There are others through which the sun, the moon and the stars also pass. There are a few circles through which the sun never moves.

The following eight circles always pass through some constellations:—

The first circle passes through (1) Abhijit, (2) Śravaṇa, (3) Dhanishṭha, (4) Śatabhishak, (5) two Bhādrapadas, (7) Revati, (8) Aśvini, (9) Bharaṇi, (10) & (11) two Phalgunis, and (12) Svāti.

The 3rd circle through Punarvasu and Magha.
The 6th „ Kṛittika
The 7th „ Rohiṇi and Chitra.

The 8th circle	though	Viśākha
The 10th	,,	Anūrādha
The 11th	,,	Jyeshṭha
The 15th	,,	Mṛigaśirah, Ārdra, Pushya, Āślesha, Hasta, Mūla and the two Āshāḍhas.

Of these, the first six are, however, outside the fifteenth circle; still as they are very near to it, they are counted as such. Hence nothing of inconsistency in the statement.

Similarly the following seven out of the fifteen circles do not pass through any constellation:—The second, fourth, fifth, ninth, twelfth, thirteenth and the fourteenth circle.

The following four are common to both the sun, the moon and the constellations:—The first, the second, the eleventh and the fifteenth circle.

The following five are beyond the sun's path:—The sixth, seventh, eighth, ninth and the tenth circle.

Accordingly it is clear that the first, second, third, fourth, fifth, eleventh, twelfth, thirteenth, fourteenth, and the fifteenth, are common to the sun also.

The rest, sixth, seventh, eighth, ninth, and tenth are peculiar to the moon *i.e.*, the sun never passes through them.

Now in those cases in which the sun's ecliptic circle passes beyond the moon's, the distance between them is thus determined by ancient teachers:—

To understand this we have to know the rate of increase or decrease in the circumference of the sun's and the moon's diurnal circles. The circumference of the sun's diurnal circles increases at the rate of $2\frac{48}{61}$ yōjanas per circle from the innermost circle. Hence in 183 days, the total increase or decrease from the outermost diurnal circle is $\frac{170}{61}\times 183=510$ yōjanas.

Now for the moon it is $509\frac{25}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas, for the increase or decrease in one day for the moon is $36\frac{25}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjana.

Hence in 14 days it is $(36+\frac{25}{61}+\frac{4}{7}$ of $\frac{1}{61})\times 14=\frac{15551}{427}\times 14=\frac{31102}{61}=509+\frac{58}{61}$ yōjanas.

Now as stated in the Jambu-prajñapti, the distance between any two diurnal circles of the sun is 2 yōjanas only, and the distance between any two diurnal circles of the moon is $35+\frac{30}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjana. The same *plus* the measure of the respective diameters of circles of the sun and the moon becomes the measure of the rate in the sun's or the moon's increase or decrease per respective diurnal circle; for example, the measure of the diameter of the sun's circle is $\frac{48}{61}$ yōjanas. Hence $2+\frac{48}{61}$ yōjanas is the rate of increase or decrease per diurnal circle of the sun. Likewise the distance

between any two diurnal circles of the moon *plus* the diameter of his circle is the rate of increase or decrease per diurnal circle of the moon.

Thus the total of increase or decrease at the final diurnal circle of the sun or the moon is the distance between any two diurnal circles of the sun or the moon.

Now if it is desired to deduce the rate of increase in the diameter of the diurnal circles of the sun or the moon from the total increase or decrease, the following is the method, as stated by ancient teachers:—

Now the sun's total of increase in 183 days is, as already shown, 510 yōjanas. Hence in one day it is $\frac{510}{183}=2\frac{48}{61}$ yōjanas per circle.

Likewise for the moon:—

The total increase in 14 lunar days is $509\frac{58}{61}$.

Hence in one day, $509\frac{58}{61}\div 14=36+\frac{25}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjana.

Now the first diurnal circle of the sun is completely enclosed in the moon's diurnal circle; but $\frac{8}{61}$ parts of the moon's still remain outside, for the sun's is less than the moon's by $\frac{8}{61}$ parts.

Then in the interval before the second diurnal circle of the moon there can be 12 sun's paths. Now the distance between two moon's paths is $35+\frac{30}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas or $\frac{2165}{61}$ times one-sixtieth parts of a yōjana.

The sun's increased circle is $2\frac{48}{61}$ yōjanas or $\frac{170}{61}$ times one-sixtieth parts of a yōjana.

Dividing the former by the latter, we have $\frac{2165}{170}\times\frac{61}{61}=12\frac{125}{170}$; that is, twelve circles of the sun can be enclosed in the interval before the 2nd moon's circle. There remain still $\frac{125}{61}+\frac{8}{61}=2$ yōjanas $+\frac{11}{61}$ of a yōjana $+\frac{4}{7}$ of $\frac{1}{61}$ of a yōjana.

Taking this away from $2\frac{48}{61}$ of another diurnal circle measure of the sun as equal to $2\frac{48}{61}-(2\frac{11}{61}+\frac{4}{7})$, we have $\frac{36}{61}+\frac{3}{7}$ of $\frac{1}{61}$ yōjanas of the sun mingled with the second diurnal circle of the moon.

(i) Now the rate of increase per moon's circle is $36+\frac{25}{61}+\frac{4}{7}$ of $\frac{1}{61}$.

(ii) and the distance between two circles of the moon is $35+\frac{30}{61}+\frac{4}{7}$.

Hence i—ii is the diameter of the moon's circle, *i.e.*, $(36+\frac{25}{61}+\frac{4}{7})$ of $\frac{1}{61}$ $-(35+\frac{30}{61}\div\frac{4}{7})=\frac{55}{61}$ yōjanas.

Hence deducting the remainder, $\frac{36}{61}+\frac{3}{7}$ of $\frac{1}{61}$ of the sun's 13th circle from the 2nd circle of the moon, $\frac{55}{6}-(\frac{36}{61}+\frac{3}{7})=$ we have $\frac{19}{61}+\frac{4}{7}$ of the moon's circle outside the sun's circle.

Now for the space between the second and the third circles of the moon, we have $35+\frac{30}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas. In this space there will be enclosed, as already pointed out, 12 circles of the sun, leaving $2+\frac{8}{61}+\frac{4}{7}$ of $\frac{1}{61}$

yōjanas in space, which with the remainder $\frac{19}{61}+\frac{4}{7}$ of the second circle will amount to $2+\frac{28}{61}+\frac{1}{7}$ of $\frac{1}{61}$ yōjanas; *i.e.*, after the second circle of the moon and before his third circle there will be 12 solar paths and next to it $2+\frac{28}{61}+\frac{1}{7}$ yōjanas of the sun's circle will be enclosed in the space itself, leaving $2\frac{48}{61}-(2\frac{23}{61}+\frac{1}{7})=\frac{24}{61}+\frac{6}{7}$ yōjanas to mingle with the moon's third diurnal circle. Deducting this from the third circle of the moon as $\frac{55}{61}-(\frac{24}{61}+\frac{6}{7})$, we have $\frac{31}{61}+\frac{1}{7}$ of $\frac{1}{61}$ of the moon's third circle outside.

Again, in the next space there will be 12 paths of the sun $+\,2+\frac{8}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas which with the remainder of the previous circle $\frac{31}{61}+\frac{1}{7}$ will amount to $2+\frac{34}{61}+\frac{5}{7}$; *i.e.*, after the third circle there will be 12 solar paths and thereafter the thirteenth will after passing 2 yōjanas come in the space between the third and the fourth circles to the extent of $\frac{34}{61}+\frac{5}{7}$ of $\frac{1}{61}$ yōjanas, requiring $\frac{18}{61}+\frac{1}{7}$ of $\frac{1}{61}$ yōjanas for its completion.

Hence deducting $\frac{18}{61}+\frac{1}{7}$ from $\frac{55}{61}$ of the moon's fourth circle, we have $\frac{55}{61}-(\frac{18}{7}+\frac{1}{7})=\frac{42}{61}+\frac{5}{7}$ yōjanas of the moon's fourth circle stretching out.

Again, in the space between the fourth and the fifth circles there will be 12 solar paths $+\,2+\frac{3}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas, which with the previous remainder $\frac{42}{61}+\frac{5}{7}$ will amount to $\frac{46}{61}+\frac{2}{7}$ yōjanas; *i.e.*, there will be 12 paths and after that, there will be a solar path which passing 2 yōjanas will project in the space between the fourth and the fifth circles to the extent of $\frac{46}{61}+\frac{2}{7}$ of $\frac{1}{61}$ yōjanas. Deducting this from the solar circle, we have $\frac{48}{61}-(\frac{46}{61}+\frac{2}{7})=\frac{1}{61}+\frac{5}{7}$ of the solar circle mingled with the moon's fifth diurnal circle. Hence $\frac{55}{61}-(\frac{1}{61}+\frac{5}{7})=\frac{54}{61}+\frac{2}{7}$ of $\frac{1}{61}$ of the moon's will be outside.

Thus five lunar internal diurnal circles will be mingled with the solar circles and there will be 12 solar paths in each of the four interval spaces.

Now we shall proceed to deal with the next five lunar circles (from sixth to the tenth) which do not come in contact with the solar paths. The space between the fifth and the sixth lunar paths is $35+\frac{80}{61}+\frac{4}{7}$ of $\frac{1}{61}$ which with the previous remainder $\frac{54}{61}+\frac{2}{7}$ of $\frac{1}{61}$ will amount to 2219 of $\frac{1}{61}$ parts.

Likewise the solar space is $2\frac{48}{61}$ yōjanas or $\frac{170}{61}$ yōjanas. Hence $\frac{2219\times 61}{170\times 61}=13\frac{9}{170}+\frac{6}{7}$ of $\frac{1}{61}$ (left before unnoticed). That is, there will be in this space 13 solar paths and above those paths there will be $\frac{9}{61}$ yōjanas and $\frac{6}{7}$ of $\frac{1}{61}$ yōjanas; beyond this there will be the sixth lunar path measuring $\frac{56}{61}$ yōjanas. Beyond this and before the next solar path measuring $\frac{48}{61}$ yōjanas, there will be $\frac{56}{61}+\frac{1}{7}$ of $\frac{1}{61}$ yōjanas. Beyond this there will be a solar path. Beyond that there will be space measuring $35+\frac{30}{61}+\frac{4}{7}-(\frac{104}{61}+\frac{1}{7}$ of $\frac{1}{61})$ yōjanas before the next lunar circle. Then there will be

12 solar paths; and adding together the fractions, we have in this space also 13 solar paths; beyond the thirteenth solar path and before the next lunar path there will be space to the extent of $\frac{21}{61}+\frac{8}{7}$ of $\frac{1}{61}$ yojanas. Then the seventh lunar path. Beyond that there will be within a distance of $\frac{44}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas another solar path. Thereafter there will be space again to the extent of $35+\frac{80}{61}+\frac{4}{7}-(\frac{92}{61}+\frac{4}{7}$ of $\frac{1}{61})$ yōjanas. Here also in this space there will be 12 solar paths; and adding together fractions, we have here also 13 solar paths and beyond the thirteenth solar path and before the eighth lunar path there will be space to the extent of $\frac{38}{61}$ yōjanas. Then the eighth lunar path. Beyond this there will be within a distance of $\frac{83}{61}$ yōjanas a solar path. Then again there will be space to the extent of $35+\frac{80}{61}+\frac{4}{7}$ of $\frac{1}{61}-(\frac{81}{61})=34+\frac{10}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas. Again 12 solar paths in this space; and adding the fractions 13 solar paths as before. Then beyond the thirteenth solar path and before the ninth lunar path there will be $\frac{44}{61}+\frac{4}{7}$ of $\frac{1}{61}$ yōjanas as space. Then the ninth lunar path. Beyond that there will be within the space of $\frac{21}{61}+\frac{8}{7}$ of $\frac{1}{61}$ yōjanas a solar path. Then again there comes the usual lunar space to the extent of $35+\frac{80}{61}+\frac{4}{7}-(\frac{69}{61}+\frac{8}{7}$ of $\frac{1}{61})$ yōjanas. Here again adding the fractions, we get 13 solar paths. Beyond the thirteenth solar path and before the tenth lunar path there will be space to the extent of $\frac{56}{61}+\frac{1}{7}$ of $\frac{1}{61}$ yōjanas. Then there comes the lunar path (Chandramaṇḍala, moon's disc) and beyond that there will be within a space of $\frac{9}{61}+\frac{6}{7}$ of $\frac{1}{61}$ yōjanas the solar path (Sūryamaṇḍala, sun's disc or solar path). Then again there comes the usual space to the extent of $35+\frac{80}{61}+\frac{4}{7}-(\frac{57}{61}+\frac{6}{7})$ yōjanas.

Then again 12 or rather 13 solar paths, adding fractions together. Then beyond the thirteenth solar path and before the eleventh lunar path there will be space to the extent of $\frac{67}{61}+\frac{5}{7}$ of $\frac{1}{61}$ yōjanas.

Thus there are five lunar paths not connected with the solar paths, and there are thirteen lunar paths in each of the six intervening spaces.

Now $\frac{54}{61}+\frac{2}{7}$ of $\frac{1}{61}$ of the eleventh lunar path are found out of the solar path; $\frac{1}{61}+\frac{5}{7}$ of $\frac{1}{61}$ of that path are found connected with the solar $\frac{46}{61}+\frac{2}{7}$ of $\frac{1}{61}$ of the eleventh solar path are out of the eleventh lunar path. Hence the next lunar space is equal to $35+\frac{80}{61}+\frac{4}{7}-(\frac{46}{61}+\frac{2}{7})=34+\frac{45}{61}+\frac{2}{7}$ of $\frac{1}{61}$. Hence there will be only 12 solar paths with a space of $\frac{79}{61}+\frac{2}{7}$ of $\frac{1}{61}$ yōjanas separating the twelfth solar path from the twelfth lunar path which is thus found in space separated from the next solar path by $\frac{42}{61}+\frac{5}{7}$ of $\frac{1}{61}$ yōjanas. Hence only $\frac{18}{61}+\frac{2}{7}$ of $\frac{1}{61}$ of it come in contact with

the solar path. Hence the solar path stretches out of the twelfth lunar path to the extent of $\frac{84}{61} + \frac{5}{7}$ of $\frac{1}{61}$ yōjanas. Then there comes again the lunar space to the extent of $35 + \frac{80}{61} + \frac{4}{7} - (\frac{34}{61} + \frac{5}{7}) = 34 + \frac{56}{61} + \frac{6}{7}$ of $\frac{1}{61}$ yōjanas. Here also the space includes twelve solar paths leaving $\frac{90}{61} + \frac{6}{7}$ of $\frac{1}{61}$ yōjanas beyond the twelfth solar path and separating the thirteenth lunar path which is found in space beyond the solar path to the extent of $\frac{81}{61} + \frac{1}{7}$ of $\frac{1}{61}$ and in connection with it to the extent of $\frac{24}{61} + \frac{6}{7}$ of $\frac{1}{61}$ yōjanas. Hence the solar path stretches out of the thirteenth lunar path to the extent of $\frac{23}{61} + \frac{1}{7}$ of $\frac{1}{61}$ yōjanas. Hence the next lunar space $35 + \frac{80}{61} + \frac{4}{7}$ of $\frac{1}{61}$ is lessened by this amount, *i.e.*, $\frac{28}{61} + \frac{1}{7}$ of $\frac{1}{61}$. Here also there are 12 solar paths and beyond the twelfth there is within a distance of $\frac{102}{61} + \frac{8}{7}$ of $\frac{1}{61}$ yōjanas the fourteenth lunar path. This path is in space out of the solar path to the extent of $\frac{19}{61} + \frac{4}{7}$ of $\frac{1}{61}$ yōjanas. The remaining $\frac{36}{61} + \frac{8}{7}$ of $\frac{1}{61}$ yōjanas are in contact with the solar path. Hence $\frac{11}{61} + \frac{4}{7}$ of $\frac{1}{61}$ of the solar path are beyond the fourteenth lunar path. Hence the next lunar space is equal to $35 + \frac{80}{61} + \frac{4}{7} - (\frac{11}{61} + \frac{4}{7}) = 35 + \frac{19}{61}$ yōjanas. Here also there will be 12 solar paths. And beyond the twelfth solar path there will be the fifteenth lunar path at a distance of $\frac{514}{61}$ yōjanas. This lunar path falls in space separated from the last solar path by $\frac{8}{61}$ yōjanas. The remaining $\frac{48}{16}$ parts are in contact with the solar path.

Thus the five lunar paths from the eleventh to the fifteenth are connected with the solar paths; and in each of the four intervening lunar spaces there are 12 solar paths.

Tithi or Lunar Day.

A Tithi or lunar day is equal to $\frac{61}{62}$ parts of a day. Hence a day being divided into 30 muhurtas, a tithi will be equal to $\frac{61}{62} \times 30$ muhurtas $= 29\frac{32}{62}$ muhurtas.

The Tithis are of two kinds : (1) day tithis and night tithis ; both kinds are divided into a week of five lunar days, called (1) Nanda, (2) Bhadra, (3) Jaya, (4) Tuchchha, (5) Pūrṇa in the case of day tithis ; and (1) Ugravati, (2) Bhogavati, (3) Yaśōmati, (4) Sarvasiddha, (5) Śubhanāma, in the case of night tithis. Thus three weeks of day tithis and three weeks of night tithis will make fifteen complete lunar days.

Success in work undertaken on lunar days with special diet :—Curd diet on the Kṛittika day will enable a man to succeed in his works. Rōhiṇi, flesh ; Mṛigaśirah, flesh of wild beasts ; Ārdra, butter ; Punarvasu, clarified butter ; Pushya, milk ; Āślēsha, the flesh of Dīpaka ; Magha, Kasoti ; Pūrvaphalguni, the flesh of Medhaka, an animal ; Uttara, the flesh of Naksi ;

Hasta, Vardana (?) ; Chitra, Mudgasupa ; Svāti, fruits ; Viśākha, Asitti (?); Anūrādha, vegetables ; Jyēshṭha, Lathiya (?) ; Pūrvāshāḍha, Amalaka (Jujube) ; Uttarāshāḍha, Bilva ; Abhijit, flowers ; Śravaṇa, milk ; Śatabhishak, dalls ; Pūrvābhādra, Karila (?) ; Uttarābhādra, pig's flesh ; Revati, fish ; Aśvini, the flesh of Tittiri bird ; Bharaṇi, rice.

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before a Marwari or Gujarati gentleman's house where are provided ample supplies of grass to these sacred beasts. Pure milk is only to be got at these *Pinjrapoles* * conducted on a very modest scale and dispersed all over the city. This personal observation of the writer seems to justify the above contentions of Dr. D. R. Bhandarkar. But the *Pinjrapole* does not seem to have been fully developed throughout the country on really efficacious lines. While they seem to be not very popular as their number is quite modest, the development of this institution is fraught with very good results and it is a desirable institution to be fully developed.

I will now close this chapter with a working exposition of the animal hospital of the Jains at Allahabad which shows the amity existing between man and beast in India. Mr. L. Moresby writes in the *Herald of the Golden Age* : † " In Ahmadabad I visited the Jain Hospital for Animals—a most wonderful and touching place. It is a compound in the midst of the city with trees in it and large sheds where the sick and wounded animals are tended. The Pariah dogs in India are a very painful sight—so lean and starved that their ribs stand out like the ribs of a stranded hulk; so ravenous that they run beside the train as it leaves a station, watching with famished eyes for morsels that some kind hand but seldom throws. Here I saw some lying contentedly with their puppies nestling besides them, and food before them fresh from the great cauldrons in which it is boiled for all the guests tended and cared for as part of our common brotherhood. Beside them was standing a bullock, with shining coat like grey velvet and a cruel scar healing along his flank. Above in the trees the grey monkeys chattered and held out tiny black paws for alms. The goats stood by with their kids, and men and boys went about feeding and tending them, and I have seldom seen a happier place (though indeed there were sights of suffering), because it seemed to re-knit the bond between man and beast and to speak of a debt owed for faithful service, and therefore ungrudgingly paid."

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* *Pin,rapole* is used here, as is passed off generally, as a place where cows are gathered either for milking or feeding.

† Vol. XVI. Quoted in *The Jaina Gazette*, Vol. XXI, No. 7, July 1925, pp. 208-209.

SURYAPRAGNAPTI.

BY DR. R. SHAMA SASTRY, B.A., PH.D., M.R.A.S.

(Continued from Vol. XVIII, No. 1.)

The Motions of the Moon and the Sun.

THE moon moves and unites 67 times with Abhijit in a Yuga of 5 years.

The sun comes in contact five times with the same star in a Yuga.

The names of the months are :—

1. Śrâvaṇa	...	...	Abhinanda
2. Bhādrapada	...	...	Supratishṭha
3. Âśvayuja	...	...	Vijaya
4. Kārtika	...	...	Prītivardhana
5. Mārgaśirsha	...	...	Śrēyān
6. Pushya	...	...	Śiva
7. Māgha	...	...	Śiśira
8. Phālguna	...	...	Haimavān
9. Chaitra	...	...	Vasanta
10. Vaiśākha	...	...	Kusumasambhava
11. Jyēshṭha	...	...	Nidāgha
12. Āshāḍha	...	...	Vanavirodhi.

Years :—

(1) Nakshatra samvatsara = Nakshatra māsas = $12 \times 27 \frac{21}{67}$ days = $327 + \frac{51}{67}$ days.

(2) Yugasamvatsara = 5 years. (cyclic year)

(3) Pramāṇasamvatsara (to be explained later on).

(4) Saturn-year (").

The first is of 12 kinds, as Śrâvaṇa, Bhādrapada, etc.; when Jupiter completes the whole circle of constellations once, it is called, a Nakshatra-samvatsara of 12 years.

Lunar year = $29 \frac{32}{62} \times 12 = 354$ days $+ \frac{12}{62}$ days.

Intercalary lunar year = $383 + \frac{44}{62}$ days.

Solar year = $12 \times 30\frac{1}{2} = 366$ days.

Hence once in 30 solar months there will be one intercalary lunar month. Hence in a yuga of 60 solar months there will be two intercalary lunar months.

Each lunar month contains two parvas.

Hence a lunar year " 24 "

Intercalary year " 26 "

Then the text proceeds with the solution of some problems regarding the particular Ayana and particular diurnal circle in which a desired Parva occurs. If, for example, the question be asked "At what Ayana and what circle at the beginning of a cycle does the first parva attain completion ?" the general method of solution is as follows :—

There is here a constant which is the fixed difference between the parva area and the Ayana area. It is 1 circle + $\frac{4}{67}$ of a circle + $\frac{9}{31}$ of one-sixty-seventh part of a circle. The reason for this difference will be discussed later on. This constant is multiplied by the number of the desired parva. Then 1 is added to the number denoting Ayanas. If then the moon's Ayana area be greater or complete, then the parva area is deducted from it. The addition is for the purpose of facilitating the subtraction. It indicates an equal number of parvas. If the multiplier be odd number it shows that the parva is in the interior circle; if it be even, then the parva will be in the outer circle.

Now the constant is 1 Ayana + 1 Circle + $\frac{4}{67}$ of a Circle + $\frac{9}{81}$ of $\frac{1}{67}$ of a circle.

Multiply this by one and add 1 to Ayana.

Then the result is $2 + 1 + \frac{4}{67} + \frac{9}{81}$ of $\frac{1}{67}$.

Since the circle with its parts is less than two, Ayana cannot be subtracted from circle. Hence add 2 to circle. It becomes 3. Hence the answer is that the first parva happens in the second Ayana, third internal diurnal circle when $\frac{4}{67} + \frac{9}{81}$ of $\frac{1}{67}$ parts of a circle have elapsed. This Ayana is lunar. In the case of lunar Ayanas, the first Ayana in the beginning of a cycle is northern and the second is southern.

Similarly if the parva asked be 2nd, then the constant multiplied by 2 $= 2\text{ A} + 2\text{ C} + \frac{8}{67} + \frac{18}{81 \times 67}$. Then add 1 to Ayana and two to circle. The sum $= \frac{A}{3} + \frac{C}{4} + \frac{8}{67} + \frac{18}{81 \times 67}$. Hence the answer is that the 2nd Parva happens in the 3rd Ayana when $\frac{8}{67} + \frac{18}{67 \times 81}$ parts of a circle have passed in the 4th circle.

Likewise if the 14th parva be asked, then the constant $\times$ 14 $= 14\text{ A} + 14\text{ C} + \frac{56}{67} + \frac{126}{31 \times 67} = 14 + 14 + \frac{60}{67} + \frac{2}{31 \times 67}$.

Here since 13 circles + $\frac{18}{67}$ of a circle are = 1 Ayana. Hence adding this one Ayana and also one more as usual and 2 to the circle number the number of Ayanas we get becomes 16, *i.e.*, $16 + 3 + \frac{47}{67} + \frac{2}{81 \times 67}$.

That is the 14th parva happens in the 16th Ayana when $\frac{47}{67} + \frac{2}{81 \times 67}$ parts of the third circle have passed away.

Likewise for 62nd parva. $(1 + 1 + \frac{4}{67} + \frac{9}{81 \times 67}) \times 62 = 62 + 62 + \frac{248}{67} + \frac{558}{81 \times 67} = 62 + 65 + \frac{65}{67} + 0 = 62 + 5$ Ayanas = 67 Ayanas.

Since there is no fraction here, nothing will be added to the Ayana number. The circles also being even whole number, no addition is also made to their number. Hence the circle is external. Accordingly the answer is that the 62nd parva takes place when 67 Ayanas and the next outer circle are completely passed away.

The answers for all parvas are as follows :—

1st	Parva happens when	2	Ayanas	$+ \frac{4}{67} + \frac{9}{31 \times 67}$	of the	3rd	circle are passed.
2nd	,,	3	,,	$+ \frac{8}{67} + \frac{18}{31 \times 67}$	,,	4th	,,
3rd	,,	4	,,	$+ \frac{12}{67} + \frac{27}{81 \times 67}$	,,	5th	,,
4th	,,	5	,,	$+ \frac{17}{67} + \frac{5}{81 \times 67}$	,,	6th	,,
5th	,,	6	,,	$+ \frac{21}{67} + \frac{14}{81 \times 67}$	,,	7th	,,
6th	,,	7	,,	$+ \frac{25}{67} + \frac{23}{81 \times 67}$	,,	8th	,,
7th	,,	8	,,	$+ \frac{30}{67} + \frac{1}{81 \times 67}$	,,	9th	,,
8th	,,	9	,,	$+ \frac{34}{67} + \frac{10}{81 \times 67}$	,,	10th	,,
9th	,,	10	,,	$+ \frac{38}{67} + \frac{19}{81 \times 67}$	,,	11th	,,
10th	,,	11	,,	$+ \frac{42}{67} + \frac{28}{81 \times 67}$	,,	12th	,,
11th	,,	12	,,	$+ \frac{47}{67} + \frac{6}{81 \times 67}$	,,	13th	,,
12th	,,	14	,,	$+ \frac{38}{67} + \frac{15}{31 \times 67}$	,,	1st	,,
13th	,,	15	,,	$+ \frac{42}{67} + \frac{24}{81 \times 67}$	,,	2nd	,,
14th	,,	16	,,	$+ \frac{47}{67} + \frac{2}{31 \times 67}$	,,	3rd	,,
15th	,,	17	,,	$+ \frac{51}{67} + \frac{11}{31 \times 67}$	,,	4th	,,

Similarly for the rest.

Now regarding the question which parva is completed in which star, the ancient method is as follows :—

Multiply by the required number of parvas the constant, *viz.*, $\frac{67}{124}$. Then if there be a remainder multiply it by 1830 and subtract from the product 1302, this being the correction for Abhijit (for $\frac{21}{67}$ is Abhijit area. This multiplied by 62 = 1302 of $\frac{1}{67}$th part).

Then the remainder is divided by 67×62 and the quotient shows the number of stars passed. The remainder is the part passed in the next star.

The reason for the process is as follows :—

If in 124 parvas 67 sidereal revolutions are performed,
then in 1 there will be $\frac{67}{124}$,,

$\frac{67}{124}$ revolutions $= \frac{67}{124} \times 1830$ stars $= \frac{915}{62} \times 67 = \frac{61305}{62}$. Deduct from this 1302 parts of Abhijit. Then what remains is $\frac{60008}{62}$. Then

divide this by 67. The quotient is 14; *i.e.*, the 14 stars from Śravaṇa to Pushya are passed. Then there is the remainder $\frac{1847}{67 \times 62}$ day stars. This multiplied by 30 gives muhūrtas, as $\frac{55410}{67 \times 62} = 13 + \frac{1408}{67 \times 62} = 13 + \frac{21}{62} + \frac{1}{67}$ muhūrtas; *i.e.*, the 1st parva is completed when $13 + \frac{21}{62} + \frac{1}{67}$ muhūrtas in Āślesha have elapsed.

Likewise for two parvas : $\frac{67}{124} \times 2 = \frac{67}{62} = 1 + \frac{5}{62}$, *i.e.*, one revolution + $\frac{5}{62}$ of a revolution. This divided by $\frac{1830}{67} = \frac{9150}{67 \times 62}$. Deduct from this $\frac{1802}{67}$ of Abhijit.

Then the remainder is $\frac{7848}{67 \times 62} = \frac{7848}{4154} = 1 + \frac{3694}{4154}$, *i.e.*, one star, namely Śravaṇa and the remainder. Multiply it by 30 to reduce it to muhūrtas. $\frac{3694}{4154} \times 30 = 26 + \frac{42}{62} + \frac{2}{67}$ of $\frac{1}{62}$, *i.e.*, when so many muhūrtas in Dhanishṭha have passed the 2nd parva is completed.

The results for all the parvas are thus enumerated :—

1st	Parva	...	Serpent, *i.e.*,	...	Āślēsha
2nd	,,	...	...	...	Dhanishṭha
3rd	,,	...	Aryama	...	Uttaraphalguni
4th	,,	...	Abhivṛiddhi	...	Uttarābhādrapada
5th	,,	...	...	...	Chitra
6th	,,	...	Aśva	...	Aśvini
7th	,,	...	Indrāgni	...	Viśākha
8th	,,	...	...	...	Rōhiṇi
9th	,,	...	...	...	Jyēshṭha
10th	,,	...	...	...	Mṛigaśira
11th	,,	...	Viśvēdēvas	...	Uttarāshāḍha
12th	,,	...	Aditi	...	Punarvasu
13th	,,	...	...	...	Śravaṇa
14th	,,	...	Pitṛi	...	Magha
15th	,,	...	Aja	...	Pūrvābhādra
16th	,,	...	Abhivṛiddhi	...	Uttarābhādra
17th	,,	...	Aryama	...	Uttaraphalguni
18th	,,	...	...	...	Chitra
19th	,,	...	...	...	Aśvini
20th	,,	...	...	...	Viśākha
21st	,,	...	...	...	Rōhiṇi
22nd	,,	...	...	...	Mūla
23rd	,,	...	...	...	Ārdra
24th	,,	...	...	...	Uttarāshāḍha
25th	,,	...	...	...	Pushya
26th	,,	...	...	...	Dhanishṭha

27th	Parva	...	Bhaga	...	Pūrvaphalguni
28th	,,	...	Aja	...	Pūrvābhādrapada
29th	,,	...	Aryama	...	Uttaraphalguni
30th	,,	...	...	...	Revati
31st	,,	...	...	...	Svāti
32nd	,,	...	...	...	Kṛittika
33rd	,,	...	Mitra	...	Anūrādha
34th	,,	...	...	...	Rōhiṇi
35th	,,	...	...	...	Pūrvāshāḍha
36th	,,	...	...	...	Punarvasu
37th	,,	...	...	...	Uttarāshāḍha
38th	,,	...	Atri	...	Āślesha
39th	,,	...	Vasu	...	Dhanishtha
40th	,,	...	...	...	Pūrvaphalguni
41st	,,	...	...	...	Uttarābhādrapada
42nd	,,	...	...	...	Hasta
43rd	,,	...	...	...	Aśvini
44th	,,	...	...	...	Viśākha
45th	,,	...	...	...	Kṛittika
46th	,,	...	...	...	Jyēshṭha
47th	,,	...	...	...	Mṛigaśirah
48th	,,	...	...	...	Pūrvāshāḍha
49th	,,	...	...	...	Punarvasu
50th	,,	...	...	...	Śravaṇa
51st	,,	...	...	...	Magha
52nd	,,	...	Varuṇa	...	Śatabhishak
53rd	,,	...	Bhaga	...	Pūrvaphalguni
54th	,,	...	...	...	Uttarābhādra
55th	,,	...	...	...	Chitra
56th	,,	...	...	...	Aśvini
57th	,,	...	...	...	Viśākha
58th	,,	...	Agni	...	Kṛittika
59th	,,	...	...	...	Mūla
60th	,,	...	...	...	Ārdra
61st	,,	...	...	...	Uttarāshāḍha
62nd	,,	...	...	...	Pushya

Thus in the 1st half of the cycle the Parva stars are enumerated in order.

Similarly for the 2nd half they can be ascertained by employing the method specified above.

The Sun and the Parvas.

Equally necessary is the knowledge of the method of ascertaining in which Ayana and in which diurnal circle a particular parva (full moon or new moon) occurs.

The method is as follows :—

The number of the parva in question will be multiplied by 15 and one will be added to it. Then if there are any Avamarātras (lower nights, *i.e.*, the six nights between 354 days of the lunar and 360 days of the Savana year), they will be deducted. Then the remainder will be divided by 183. The quotient represents Ayanas. The remainder, being the number of days, will show the number of diurnal circles and the last of them will be the outer or interior circle in which the parva occurs. In the Uttarāyaṇa, it is the outer circle and in the Dakshiṇāyana, it is the inner.

Now for example,—the problem in which circle does the sun complete the 1st parva in the cycle is thus solved.

$1 \times 15 + 1 = 16$ days.

There are no lower nights here, it being less than a year. Hence the answer is that in the beginning of a cycle, the sun completes the 1st parva in the Dakshiṇāyana in the sixteenth circle from the innermost circle.

Likewise for the 4th Parva.

$4 \times 15 + 1 = 61$ days.

There being one Avama night for sixty days it will be deducted from it. Hence the number of days = 60.

Hence the 4th parva will be completed in the 60th circle from the innermost in the Dakshiṇāyana.

Likewise for the 25th Parva.

$25 \times 15 + 1 = 376$ days. Deduct six Avamas.

$\therefore 376 - 6 = 370$ days.

Dividing this by 183 we have $\frac{370}{183} = 2\frac{4}{183}$; *i.e.*, two Ayanas completed and in the 3rd Ayana (Dakshiṇa of course) 4th innermost circle, the 25th parva will be completed.

Similarly 124th Parva.

$124 \times 15 + 1 = 1861$. There being 30 Avamas, they will be deducted.

$\therefore 1861 - 30 = 1831$. $\frac{1831}{183} = 10\frac{1}{183}$; *i.e.*, the tenth Ayana (uttara) and the 1st innermost circle.

The Parvas and the Sun in Union with the Nakshatras.

In order to ascertain the particular star in which the sun completes a particular parva, we proceed as follows : Let x be the Parva number.

In 124 Parvas the sun completes 5 revolutions.

" 1 " " $\frac{5}{124}$ "

" x " " $\frac{5}{124} \times x$ "

$= \frac{5x}{124} \times \frac{1880 \text{(days in a cycle)}}{67 \text{(stars in a cycle)}} = \frac{5x \times 915}{62 \times 67}$ stars.

$= \frac{4575x}{62 \times 67}$ Take $x = 1$.

Deduct from this the parts of Pushya star, it being $44 \times 62 = 2728$ in 62 Parvas.

$\therefore$ The remainder is $\frac{1847x}{68 \times 67} = \frac{1847}{4154}x$ stars after Pushya. This reduced to Muhūrtas and sixty-secondths of a muhūrta will be equal to $\frac{1847}{4154} \times 30 = 13$ m. $+ \frac{21}{62} + \frac{1}{67}$, *i.e.*, the 1st parva will be completed in Āślēsha when 13 muhūrtas and $\frac{21}{62}$ of a muhūrta and one-sixty-sevenths of one-sixty-secondths of a muhūrta have elapsed.

Similarly the 2nd Parva is as follows :—$\frac{5}{124} \times 2 \times \frac{1830}{67} = \frac{9150}{62 \times 67}$.

Deduct from this 2728 parts of Pushya.

The remainder is $\frac{6422}{62 \times 67}$ stars $= \frac{6422}{4154} = 1\frac{2268}{4154}$ stars. One star = 30 muhūrtas. But the star Āślēsha being of half an area takes only 15 muhūrtas. Hence deducting this we have 15 muhūrtas $+ \frac{2268}{4154}$ stars or $15 + \frac{68040}{4154}$ muhūrtas $= 15 + 16\frac{1576}{4154} = 31 + \frac{23}{62} + \frac{35}{67}$ muhūrtas. By 30 Magha is completed. Hence the 2nd Parva occurs when $1 + \frac{23}{62} + \frac{35}{67}$ muhūrtas have elapsed in Pūrvaphalguni.

Similarly the third Parva—$\frac{5}{124} \times 3 \times \frac{1830}{67} = \frac{15 \times 915}{62 \times 67} = \frac{13725}{4154}$ stars.

Deduct 2728 parts of Pushya from this. The remainder is $\frac{10997}{4154} = 2\frac{2689}{4154}$ stars.

The two stars Āślēsha and Magha. For Āślēsha only 15 muhūrtas and Magha 30 muhūrtas are gone. Hence there remains 15 m. $+ \frac{2689}{4154} \times 30$ muhūrtas $= 34 + \frac{26}{62} + \frac{2}{67}$ muhūrtas. Of these, by 30 muhūrtas Pūrvaphalguni is passed. Hence the 3rd Parva (new moon) is completed when $4 + \frac{26}{62} + \frac{2}{67}$ muhūrtas in Uttaraphalguni are passed.

Similarly for the rest. Or there is also another ancient process of ascertaining the parva stars of the sun. Here 33 muhūrtas $+ \frac{2}{62}$ of a muhūrta $+ \frac{34}{67}$ of 62ndths of a muhūrta is a constant. This multiplied by the required number of parvas *minus* the corrections for Pushya and other stars will give the required star.

The constant is obtained thus :—

In 124 parvas there are 5 sun's revolutions.

" 1 " " $\frac{5}{124}$ "

$= \frac{5}{124} \times \frac{1830}{67} = \frac{4575}{4154}$ stars $= \frac{137250}{4154}$.

Muhūrtas $= 33 + \frac{2}{62} + \frac{34}{67}$ Muhūrtas.

The corrections for Pushya and other stars are as follows :—

i. $19 + \frac{43}{62} + \frac{33}{67}$ for Pushya.

This also is obtained as follows :—

When a cycle is completed, $\frac{23}{67}$ parts of Pushya are passed, leaving behind $\frac{44}{67}$ parts, which in Muhūrtas is equal to $\frac{44 \times 30}{67} = \frac{1320}{67} = 19 + \frac{43}{62} + \frac{33}{67}$ Muhūrtas.

ii. Then from Āślēsha up to Uttaraphalguni star 139 muhūrtas are to be deducted.

iii. Then up to Viśākha 259.

iv. Then up to Uttarāshāḍha 409.

In all these deductions the deduction for Pushya should be made separately.

v. Then for Abhijit $4 + \frac{6}{67} + \frac{32}{67}$ muhūrtas are to be deducted.

vi. Then up to Uttarābhādrapada 569.

vii. Then up to Rohiṇi 719.

viii. Then up to Punarvasu 809.

Now according to this method, the first three parva stars can be ascertained thus :—

$$\left(33 + \frac{2}{62} + \frac{34}{67}\right) \times 1 = 33 + \frac{2}{62} + \frac{34}{67}.$$

Deduct from this the correction for Pushya $19 + \frac{43}{62} + \frac{33}{67}$.

The remainder is $13 + \frac{21}{62} + \frac{1}{67}$, *i.e.*, the sun completes the parva when so much in Āślēsha has elapsed.

Likewise for 2nd Parva ;

$$\left(33 + \frac{2}{62} + \frac{34}{67}\right) \times 2 = 66 + \frac{4}{62} + \frac{68}{67}.$$

Making deduction for Pushya there remains

$$\left(66 + \frac{4}{62} + \frac{68}{67}\right) - \left(19 + \frac{43}{62} + \frac{33}{67}\right) = 46 + \frac{23}{62} + \frac{35}{67}.$$

Giving 15 for Āślēsha and 30 for Magha, we have $1 + \frac{23}{62} + \frac{35}{67}$, *i.e.*, the parva is completed when so much has elapsed in Pūrvaphalguni.

Similarly for 3rd Parva :—$(33 + 2 + 34) \times 3 = 99 + 7 + 35$ (denominator being omitted). Deduction for Pushya as above. Remainder is $69 + 26 + 2$. Then 15 for Āślēsha, 30 for Magha, 30 Pūrvaphalguni ; there remains $4 + 26 + 2$, *i.e.*, when so much has elapsed in Uttaraphalguni, the 3rd parva is completed.

The several stars in which the sun completes the parvas in the 1st half of a cycle are thus enumerated in order by ancient sages.

1st Parva	...	...	Āślēsha
2nd „	...	...	Pūrvaphalguni
3rd „	...	...	Uttaraphalguni
4th „	...	...	„

5th Parva	...	...	Hasta
6th „	...	...	Chitra
7th „	...	...	Viśākha
8th „	...	...	Anūrādha
9th „	...	...	Jyēshṭha
10th „	...	...	Mūla
11th „	...	...	Pūrvāshāḍha
12th „	...	...	Uttarāshāḍha
13th „	...	...	Śravaṇa
14th „	...	...	Dhanishṭha
15th „	...	...	Pūrvābhādrapada
16th „	...	...	Uttarābhādrapada
17th „	...	...	„
18th „	...	...	Revati
19th „	...	...	Aśvini
20th „	...	...	Kṛittika
21st „	...	...	Rohiṇi
22nd „	...	...	Mṛigaśirah
23rd „	...	...	Ārdra
24th „	...	...	Punarvasu
25th „	...	...	Pushya
26th „	...	...	Magha
27th „	...	...	Pūrvaphalguni
28th „	...	...	Uttaraphalguni
29th „	...	...	„
30th „	...	...	Chitra
31st „	...	...	Svāti
32nd „	...	...	Viśākha
33rd „	...	...	Anūrādha
34th „	...	...	Jyeshṭha
35th „	...	...	Pūrvāshāḍha
36th „	...	...	Uttarāshāḍha
37th „	...	...	„
38th „	...	...	Śravaṇa
39th „	...	...	Dhanishṭha
40th „	...	...	Pūrvābhādrapada
41st „	...	...	Uttarābhādrapada
42nd „	...	...	„
43rd „	...	...	Aśvini
44th „	...	...	Bharaṇi
45th „	...	...	Kṛittika

46th	Parva	... ...	Rohiṇi
47th	"	... ...	Mṛigaśirah
48th	"	... ...	Punarvasu
49th	"	... ...	"
50th	"	... ...	Pushya
51st	"	... ...	Magha
52nd	"	... ...	Pūrvaphalguni
53rd	"	... ...	Uttaraphalguni
54th	"	... ...	Hasta
55th	"	... ...	Chitra
56th	"	... ...	Svāti
57th	"	... ...	Viśākha
58th	"	... ...	Anūrādha
59th	"	... ...	Mūla
60th	"	... ...	Pūrvāshaḍha
61st	"	... ...	Uttarāshāḍha
62nd	"	... ...	Abhijit.

Likewise following the Karaṇa process shown above the parva stars in the 2nd half of the cycle can be ascertained.

We are now going to explain the Karaṇa verses of ancient teachers as to which parva attains completion on the last day of the cycle and after the expiration of how many muhūrtas :—

The verses in prakrit run as follows :—

When one remains after the number of parvas is divided by 4, it is termed Kalyoja ; when two is the remainder, it is termed Dvāparayugma. When three, Treta ; when four Kṛitayugma. In Kalyoja 93 is the addition ; in Dvāpara, 62 ; in Tretaiya it is 31 ; but in Kṛita there is no addition. When the number of parvas with the above additions is divided by 124, the remainder is reduced to half and multiplied by 30. The product is then divided by 62. The quotient is the number of muhūrtas elapsed with the parva.

This is the meaning of the verses :—

Now as to how many muhūrtas will have elapsed in the last day of the year before or with the completion of the first parva in a cycle, we proceed as follows :—

The parva is one. And one is a Kalyoja number. Hence we add 93 (parvas) to it. The sum becomes 94. We divide it by 124, (it being the number of parvas in a cycle). The numerator being less than the denominator, there will be no quotient. Anyhow we reduce the numerator to half, *i.e.*, 47, and multiply it by 30. The product is $47 \times 30 = 1410$; and divide it by 62.

$\therefore \frac{1410}{62} = 22\frac{28}{31}$ muhūrtas.

That is, the first parva is completed when $22\frac{28}{31}$ muhūrtas of the last day have elapsed.

ii. Likewise for 2nd parva ;

2 is Dvāpara. Hence $2 + 62 = 64$.

$\frac{64}{124}$ does not give a quotient (integer).

Hence halving (the numerator), we get 32.

$32 \times \frac{30}{62} = \frac{480}{31} = 15\frac{15}{31}$ *i.e.*, the 2nd parva is completed when $15\frac{15}{31}$ muhūrtas have elapsed on the last day.

Similarly for the 3rd parva :—

We take 3. It is Treta. Hence 31 is added.

The sum = 34. This is not divisible by 124. Hence halving it and multiplying it by 30 and dividing the product we get $17 \times \frac{30}{62} = 17 \times \frac{15}{31} = \frac{255}{31} = 8\frac{7}{31}$, *i.e.*, the 3rd parva is completed when $8\frac{7}{31}$ muhūrtas have expired on the last day.

For the 4th parva, we proceed similarly :—

Take 4. Add nothing. It is not divisible by 124. Halving it we have 2. Multiply by 30. We get 60. Dividing it by 62 we get $\frac{30}{31}$ of a day when the parva is completed.

For 124th parva.

$\frac{124}{4}$ gives no remainder. Hence it is Kṛitayugma. Hence no addition. 124 divided by 124 gives no remainder. Hence we conclude that the last parva attains completion with the whole day.

Pramana Samvatsara.

This is of 5 kinds : Nakshatra (sidereal), Ṛitu (seasonal), Chāndra (lunar), Āditya (solar) and intercalary lunar.

The sidereal and lunar years have already been treated of. The Ṛitu and Āditya will be explained :—

2 Ghaṭikas	=	1 Muhūrta
30 Muhūrtas	=	1 Day and night
15 Days	=	1 Paksha
2 Pakshas	=	1 Month
12 Months	=	1 Year.

The year of 360 days and nights is a Ṛitu-samvatsara. This has two more names, Karma-samvatsara and Sāvana-samvatsara ; karma = work (laukika vyavahāra). Hence that year which is prominently observed by workmen is so called. This is said of it.

Karma month has no fraction and facilitates work, worldly transaction ; the rest have fractions and so in usage it is difficult to understand.

Sāvana means engagement in work. Hence that year which is chiefly agreeable to work is sāvana year.

The year of 360 days is called Karma year and also Sāvana year.

Similarly the time taken by the rainy and other seasons for completion of this one revolution is called solar year. It is, however, usual to assign 60 days to each of the rainy and other seasons. Still really each of them has 61 days. Hence the solar year contains 366 days.

The Karma or Sāvana year	...	...	360 days
The lunar	...	...	$354\frac{12}{62}$ „
The Nakshatra year	...	...	$327\frac{51}{67}$ „
The intercalary lunar year	...	...	$383\frac{40}{62}$ „

In a Yuga there are three ordinary lunar years of $354\frac{12}{62}$ days and two intercalary years. Hence in a Yuga there are 62 lunar months, 67 nakshatra months.

The Measure of Solar and other Months.

A solar year is = 366 days.

i. Hence one solar month $= \frac{366}{12} = 30\frac{1}{2}$ days.

ii. A Karma-samvatsara is = 360 days.

Hence 1 Karma month $= \frac{360}{12} = 30$ days.

iii. A lunar year is $= 354\frac{12}{62}$ days.

Hence one lunar month is $= \dfrac{354\frac{12}{62}}{12} = 29\frac{32}{62}$ days.

iv. A Nakshatra year is $= 327\frac{51}{67}$ days.

Hence one Nakshatra month is $= \dfrac{327\frac{51}{61}}{12} = 27\frac{21}{67}$ days.

v. An Intercalary lunar year is $= 383\frac{44}{61}$ days.

Hence one intercalary month $= \dfrac{383\frac{44}{62}}{12} = 31\frac{121}{124}$ days.

(1) In a yuga or cycle of 5 years or 1830 days there are 60 Solar months.
(2) „ „ 61 Sāvana months.
(3) „ „ 62 Lunar months.
(4) „ „ 67 Nakshatra months.
(5) „ „ 57 Intercalary months, 7 days, $11\frac{23}{62}$ muhūrtas.

For an intercalary month $= 31\frac{121}{124}$ days.

Hence $\dfrac{1830 \text{ days}}{31\frac{121}{124}} = \dfrac{226920}{3965}$ days =

57 months, 7 days, $11\frac{23}{62}$ muhūrtas.

A HINDU SHRINE IN CHINA.

BY K. RAMA VARMA RAJA, ESQ., B.A., M.R.A.S.

WE are told in the *Devi-Bhāgavata Purāna*, that there exists (or existed then) in China a celebrated holy shrine of the goddess *Nīla-Sarasvati* which is worth visiting ("तथा नीलसरस्वत्याः स्थानं चीनेषु विश्रुतम् "—VII—38—13). This passage occurs in a context wherein the Primæval Supreme Goddess is supposed to mention all the important centres of her worship in different forms to her faithful devotee, the mountain deity of the Himalayas, standing in obeisance before her. The goddess *Nīla-Sarasvati* may be identified with *Tāra*, who is addressed as mother, '*Nīla-Sarasvati*', in the opening verse of '*Tārāshtaka*' in '*Nīla-tantra*' (*Bṛihat-Stōtra Ratnākara*, pp. 181 and 182, Nirnayasagara Press, Bombay). Tāra is again an important and well-known form or manifestation of the supreme goddess, and her figure is found also among the Buddhist sculptures of the Northern (Mahāyāna) school in China, Japan and Tibet along with several other familiar forms—Kubera, Maitreya, Manjusri, Kwan-yin, Vajrapani, etc. The author's preface to *The Gods of Northern Buddhism* concludes with a formal dedication to the goddess Sarasvati and with a sincere prayer to her for inspiration of her consort Manjusri (the God of Wisdom or of Speech) "to draw his sword of wisdom and 'cleave the clouds of ignorance' so that in time the West may come to a clearer understanding of the East." Kubera and Maitreya, as they appear in the Buddhist and Hindu mythologies, have been referred to in my paper published in *The Mythic Society's Quarterly Journal* for July 1926, Memorial Number, (Vol. XVII, No. 1, p. 28); and I have tried elsewhere to identify Kwan-yin, 'the Goddess of Mercy' with the goddess 'Kanyā-Cumarī'* of the Cape

* The above title is the appellation of the benign virgin goddess worshipped in the well-known Hindu temple at Cape Comorin, both of which—the temple as well as the place—are therefore called after this divinity. This compound word is made up of two nouns *Kanya* and *Cumari*, each of which means 'a maiden' or 'a virgin' and therefore repeats the same idea. This duplication or bilingualism is met with in the sacred formulas also. For example, Nagesa Bhatta, in the concluding portion of his commentary on the "*Sapta Sati*" *Stotra* quotes two Vedic *mantras*, one from *Samavidhi Brahmana* and the other (*a gayatri*) from *Yajurveda*, in both of which this combination occurs; in the first as *Kanyam..... Cumarinim* and in the second as *Kanyam Kumarini* but offers no explanation for this repetition of the idea by means of synonyms. It is perhaps a *Tantraic* and mystic combination. The goddess is also referred to simply as 'Kanya' (and possibly as Cumari also) in the sacred literature, and is further known in tradition as a patron deity of sea-voyage, being offered, and receiving, homage and presents from the sea-faring people rounding the rocky cape for securing safe passage.

The temple is situated at the south end of the Malabar Coast and Ghats. Somewhere about this must have been the ancient mount Potalaka or Potala of the Buddhist period and fame 'where

SURYAPRAGNAPTI.

BY DR. R. SHAMA SASTRY, B.A., PH.D., M.R.A.S.

(Continued from Vol. XVIII, No. 2.)

The Nakshatras and Their Zodiacal Circle.

THE reason why we divide the zodiacal circle into 109800 divisions is this :—

There are three kinds of stars; those that are of complete day and night area, those that are of one-half area and those that are of $1\frac{1}{2}$ area. Those that are of complete area are fifteen as :—

1. Śravaṇa	6. Kṛittika	11. Hasta
2. Dhanishṭha	7. Mṛigaśirah	12. Chitra
3. Pūrvābhādrapada	8. Pushya	13. Anūrādha
4. Revati	9. Magha	14. Mūla
5. Aśvini	10. Pūrvaphalguni	15. Pūrvāshāḍha

Those that are of one-half area are six :—

1. Śatabhishag	4. Āślesha
2. Bharaṇi	5. Svāti
3. Ārdra	6. Jyēshṭha

Those that are of $1\frac{1}{2}$ area are also six :—

1. Uttarābhādrapada	4. Rohiṇi
2. Uttaraphalguni	5. Punarvasu
3. Uttarāshāḍha	6. Viśākha

Now in conformity with the diameter of the area of each of the stars, we divide the whole day into 67 parts and assign 67 parts in full to each of the stars having complete area. There being 15 such stars, the number of parts of them all comes to $67 \times 15 = 1005$ parts.

Those that are of $\frac{1}{2}$ area give	$\frac{67}{2} \times 6 = 201$ parts.
Those of $1\frac{1}{2}$ area give	$100\frac{1}{2} \times 6 = 603$ parts.
Abhijit gives	21 parts.
	Total 1830 parts.

This is for half a circle. So we multiply this by 2 to have the divisions of a complete circle. Hence the product comes to $1830 \times 2 = 3660$, *i.e.*, 3660 parts of a whole divided into 67 parts. Reducing them to Muhurtas we have $3660 \times 30 = 109800$ parts of a muhurta divided into 67 parts.

The Nakshatras and New Moons.

Now there are two sets of stars, one set to the south of Meru and the other set to the north of Meru. Hence two sets of each of the 28 stars. The

two Abhijits come in contact with the moon only in the morning on the 44th new moon day in each cycle. This is explained by the following ancient Karaṇa verse :—

If we are to find out the number of tithis or lunar days in the middle of a cycle, we multiply the number of past lunar months by 30 and divide the product by 62. Then we multiply the remainder by 61 and divide the product by 62. The remainder will denote the measure. Of the tithis on the day for example :—

Now 44th new moon means 43 lunar months and a Parva or half a lunar month.

∴ The number of tithis are $43 \times 30 + \frac{1}{2} \times 30 = 1305$. Dividing this by 62 we have $\frac{1305}{62} = 21\frac{3}{62}$. We reject 21 and take the remainder 3 and multiplying it by 61 divide it by 62. Hence we have $3 \times \frac{61}{62} = 2\frac{59}{62}$. We reject 2. Hence we say $\frac{59}{62}$ parts are occupied by the new moon tithi on that day.

We have already explained the Karaṇa method to find out the star on new moon or full moon days. Here for example we employ the same constant $66 + \frac{5}{62} + \frac{1}{67}$. Multiplying this by 44, we have $2904 + \frac{220}{62} + \frac{44}{67}$. From this we deduct $442\frac{46}{62}$ being the correction for stars from Punarvasu to Uttarāshāḍha. Then what remains is $2462 + \frac{174}{62} + \frac{44}{67}$. From this we take as many complete revolutions as possible, one revolution being equal to $819 + \frac{24}{62} + \frac{66}{67}$.

Thus removing three revolutions we have $6 + \frac{37}{62} + \frac{47}{67}$ as remainder.

Hence we may say that the 44th new moon takes place when in the Abhijit star there have elapsed 6 muhūrtas, 37 sixty-secondths of a muhūrta and 47 sixty-sevenths of one sixty-secondth part of a muhūrta.

Now with regard to Lakshaṇa samvatsaras or ideal years :—These are of five kinds: Nakshatra, lunar, Karma or Ṛitusamvatsara, solar, and the intercalary lunar year. The ideal Nakshatra year is that in which the full moons terminate the moon's stay at the close of the month in the area of that star which lends its name to the month, as for example Āshāḍhi, *i.e.*, the month in which the moon completes his stay in the Āshāḍha star at the close of the month. Likewise the characteristic of Nakshatra year must also be such that its months correspond not only with the stars, but also with the seasons which correspond to the months such as Āshāḍha with hot season. That year in which the stars and the months indicated by the stars of month-names are at divergence and in which heat, cold, and disease cause much suffering is called the lunar year by ancient teachers. The characteristic or Lakshaṇa karma-samvatsara is that in which trees produce untimely fruits and flowers. The characteristic solar year is that in which agricultural produce and water are on a par and conducive to the well-being of the

people. That year in which all tanks, lakes and pits become filled with water is styled characteristic intercalary lunar year by ancient teachers.

Now with reference to the Saturn year :—

This is of twenty-eight kinds, such as Abhijit Saturn year, Śravaṇa Saturn year, up to Uttarāshāḍha Saturn year. That year in which the Saturn unites with Abhijit is called Abhijit Saturn year; and so on with other stars. The great planet Saturn completes the circle of stars in the course of 30 years. This year, *i.e.*, the cycle of 30 years, is called Saturn year.

The Gates of the Stars.

Those stars which do good to a man going towards the east are termed stars of eastern gates. They are the seven stars from Kṛittika. Anūrādha and other seven stars are said to be of southern gates. There are others who differ in this view and term other stars to be of eastern or southern gates.

Just as there are said to be two suns and two moons in the Jambudvīpa, so it is said that there are 56 stars.

The Area of Stars.

Stars may be of whole area, half area, or one and half area. Those stars which move through the same area as the moon moves in a day are said to be of whole area. They are Śravaṇa, Dhanishṭha, Pūrvabhādrapada, Revati, Aśvini, Kṛittika, Mṛigaśirah, Pushya, Magha, Pūrvaphalguni, Hasta, Chitra, Anūrādha, Mūla, and Pūrvāshāḍha.

Those which move half the area the moon moves are of half area and they are Śatabhishak, Bharaṇi, Ārdra, Āślesha, Svāti and Jyēshṭha. Those which have $1\frac{1}{2}$ area are Uttarabhādrapada, Uttaraphalguni, Uttarāshāḍha, Rohiṇi, Punarvasu, and Viśākha.

The day is divided into 67 parts in order to determine the area of the stars. Those stars which have whole area are given $\frac{1}{67}$ part of the circle each. The stars of half area, $1/33\frac{1}{2}$ part each. The stars of $1\frac{1}{2}$ area are assigned $1/100\frac{1}{2}$ part each. For Abhijit, $\frac{21}{67}$ parts.

The stars of whole area are 15. Hence $67 \times 15 = 1005$ parts. Those of half area are 6. Hence $6 \times 33\frac{1}{2} = 201$. Those of $1\frac{1}{2}$ area are 6. Hence $6 \times 100\frac{1}{2} = 603$. Abhijit has 21. Hence the sum of all these = 1830 parts contained in half the circle. Similar parts in the other half. Total parts = 3660, *i.e.*, day parts moved through by the stars in the northern and southern circles of Meru by 56 stars.

Thus Jaina astronomers believe in two sets of 28 stars corresponding to their two suns and two moons.

Now regarding the question which of the stars combine with the moon in the morning, which in the evening, and which at both times, Mahāvīra says that there is no such hard and fast rule. He says that of the 56 stars

the two Abhijits combine in every cycle with the moons only in the morning on the 44th new moon day. The proof of this is as follows :—For this we have to know the process of ascertaining the Tithis, as stated by ancient teachers :— We multiply the number of all the elapsed lunar months by 30 and divide it by 62. Then we multiply the remainder by 61 and divide it by 62. The remainder is the measure of the tithi.

For example :—

The tithi measure on 44th New Moon is to be ascertained. Here 43 lunar months are past and also one Parva. Hence 43 is to be multiplied by 30 and 15 of the additional parva to be added to it.

$43 \times 30 + 15 = 1305$. Now $\frac{1305}{62} = 21\frac{3}{62}$. Here take the remainder 3 and multiplying by 61 divide the product by 62. Hence $3 \times \frac{61}{62} = \frac{183}{62} = 2\frac{59}{62}$; that is $\frac{59}{62}$ parts of day is the measure of the New Moon on the day.

The method of finding out the star on the new moon or full moon day has already been noticed. The constant employed here is $66 + \frac{5}{62} + \frac{1}{67}$. Multiply this by 44 for determining the star on the 44th new moon. $44 \times (66 + \frac{5}{62} + \frac{1}{67}) = 2904 + \frac{220}{62} + \frac{44}{67}$. Then deduct $442\frac{46}{62}$ from the above for correction for stars from Punarvasu to Uttarāshāḍha. Then remains $2462 + \frac{174}{62} + \frac{44}{67}$. Then deduct again $819 + \frac{24}{62} + \frac{66}{67}$ from it for correction for the stars from Abhijit onwards. Here we multiply the quantity to be deducted by 3 to include in it the three-fold correction. Hence $(2462 + \frac{174}{62} + \frac{44}{67}) - 3\,(819 + \frac{24}{62} + \frac{66}{67}) = 6 + \frac{87}{62} + \frac{47}{67}$.

That is, the new moon is completed when so much has elapsed in the Abhijit star.

Now Gautama asks Mahāvīra where the first full moon of the 62 full moons and 62 new moons in a cycle gets completion. Mahāvīra says that a circle through all the stars inclusive of the point where the final full moon of the past cycle is completed should be drawn and divided into 124 equal parts. At the 32nd division from the point of the last full moon, the first full moon will be completed. Likewise the 2nd full moon will be completed at the 32nd division of the 124 divisions, into which the circle from the point of first full moon through all the stars is divided. Similarly the 3rd and the 12th also. The 12th from the first is the 9th from the 3rd. Now $9 \times 32 = 288$. That is the 288th division repeatedly counted in the circle divided into 124 parts.

The proof of this is as follows :—Describe a circle so that the point of the final 62nd full moon of the past cycle is on the circumference. Divide it into 124 parts, the point of the final full moon being the first division. Then the 32nd from it is the place of the first full moon. Now 62 are the

full moons in a cycle. Hence $62 \times 32 = 1984$. Divide this by 124. The quotient is 16. That is, the moon goes 16 rounds in the circle to make 62 full moons.

Now regarding the question where the last full moon of the cycle is completed, Mahāvīra graphically describes it as follows :—

Imagine a circle in the sky above the Jambudvīpa. Divide this circle into 4 parts by drawing diameters. Then make thirty-one divisions in each of the four quadrants by drawing diameters N.-E. to S.-W. and S.-E. to N.-W. Here in S.-E. quadrant there are 31 divisions. Of these the moon completes 27 divisions and $\frac{18}{20}$ parts or kalas of the 28th division, leaving $\frac{3}{31}$ divisions and $\frac{2}{20}$ of the 28th division also without completing when the final 62nd full moon is made.

The Sun and the Full Moons.

Now regarding the question, at what place does the sun complete the first full moon, we say that he does so at the 94th division from that point where he completed the final full moon of the previous cycle, the circle being divided into 124 divisions. The reason for this is as follows :—

The lunar month is $= 29\frac{32}{62}$ days. Hence before the sun completes the 30th day, *i.e.*, when there are $\frac{30}{62}$ parts of a day more to be completed, the full moon takes place.

Regarding the 2nd full moon we proceed similarly :—He completes it at the 94th division from the point of the first full moon, the circle being divided into 124 divisions.

Similarly for the 3rd and the 12th full moon.

The 12th full moon from the 1st is the 9th full moon from the 3rd. Hence $94 \times 9 = 846$, *i.e.*, 846th division, in other words 102nd division from the point of the 3rd full moon, $(6 \times 124) = 744$, 6 times 124 divisions being completed.

Similarly the final full moon at 62×94th division. Now $62 \times \frac{94}{124} = 47$, that is, the same place where he completed the final full moon of the previous cycle. Here also there will remain $\frac{3}{31} + \frac{2}{31 \times 20}$ parts of the 124 divisions untraversed by the sun.

The Moon and the Sun and the New Moons.

Now in reply to the question, where does the moon complete first new moon, we say that at the 32nd division from the point of the final new moon of the previous cycle, the moon completes the first new moon in the current cycle, the circle being divided into 124 divisions as in the case of full moons.

Similarly the 2nd, the 3rd and the 12th and the like.

Similarly the sun also completes the new moon at the 94th division from the point of the previous new moon, the circle being divided into 124 divisions as in the case of full moons.

The Nakshatras and the Full Moons.

Now regarding the question, in what Nakshatra does the moon complete the 1st full moon, we say in the Dhanishṭha, as already stated, when $3 + \frac{19}{62} + \frac{65}{67}$ muhūrtas still remain in the star. This is ascertained as follows:—

The constant for Nakshatras and full moons is $66 + \frac{5}{62} + \frac{1}{67}$. Multiply this by the number of the full moon, 1. The product is the same. Then deduct from this $9 + \frac{24}{62} + \frac{66}{67}$, being the correction for Abhijit. Then deduct 30 muhūrtas for Śravaṇa. There remain 26 muhūrtas. This being deducted from 30 muhūrtas of Dhanishṭha, we have still $3 + \frac{19}{62} + \frac{65}{67}$ muhūrtas in Dhanishṭhas.

Now regarding the sun, the Nakshatra, and the first new moon the reply is that he completes it in the Pūrvaphalguni, when there remain $28 + \frac{88}{62} + \frac{32}{67}$ muhūrtas in that star.

This is ascertained as follows :—

$(66 + \frac{5}{62} + \frac{1}{67}) \times 1 - (19 + \frac{48}{62} + \frac{38}{67})$ correction for Pushya $= 46 + \frac{23}{62} + \frac{85}{67}$.

Then deduct 15 muhūrtas for Āślesha and 30 for Magha. Then there remains $1 + \frac{23}{62} + \frac{85}{67}$, *i.e.*, when there remain $28 + \frac{88}{62} + \frac{82}{67}$ in Pūrvaphalguni, the sun completes the new moon. The Pushya correction is made for the reason that at the close of the cycle only $\frac{28}{67}$ parts of Pushya are traversed by the sun, leaving $\frac{44}{67}$ parts still to be traversed. $\frac{44}{67}$ parts are $= \frac{44}{67} \times 30 = \frac{1820}{67}$ $= 19 + \frac{48}{62} + \frac{63}{67}$.

These are solar muhūrtas.

13 days of 30 such muhūrtas $+ \frac{12}{30}$ of a day is the duration of the sun's stay in a star.

Similarly for 2nd full moon :—

$(66 + \frac{5}{62} + \frac{1}{67}) \times 2 - (9 + \frac{24}{62} + \frac{66}{67}$ for Abhijit $+ 30$ for Śravaṇa $+ 30$ for Dhanishṭha $+ 15$ for Śatabhishak $+ 30$ for Pūrvābhādra$) = 17 + \frac{47}{62} + \frac{3}{67}$, *i.e.*, when so much yet remains in Uttarābhādra the 2nd full moon is completed. Likewise for the 2nd full moon and the sun :—

$(66 + \frac{5}{62} + \frac{1}{67}) \times 2 - (19 + \frac{48}{62} + \frac{88}{67}$ for Pushya $+ 15$ for Āślesha $+ 30$ for Magha $+ 30$ Pūrvaphalguni$) = 27 + \frac{28}{62} + \frac{86}{67}$, *i.e.*, when so much has elapsed in Uttaraphalguni, the sun completes the same full moon.

Similarly for the 3rd full moon and the star with the moon or the sun may be ascertained. Also for 62nd full moon and the star with the moon or the sun.

In the last case there remain in Pushya $19 + \frac{48}{62} + \frac{33}{67}$ muhūrtas when the sun completes that final full moon.

Likewise in the case of new moons :—

$(66 + \frac{5}{62} + \frac{1}{67}) \times 1 - (22 + \frac{46}{62}$ for Punarvasu $+ 30$ for Pushya) $= 13 + \frac{21}{62} + \frac{1}{67}$, *i.e.*, when so much out of the 15 muhūrtas of Āśles̀ha has elapsed, the first new moon is completed by the sun.

Likewise in the case of the 2nd, 3rd, 12th or the 62nd new moons of a cycle, the last new moon occurring in the Punarvasu star.

Motion of the Stars and the Planets.

The stars are quicker than the planets; among the latter the sun is slower than the moon.

The commentator traverses the same ground here he has already done before indicating durations of the moon's or the sun's stay with each of the 28 stars, then refers again to two suns, two moons and two sets of 28 stars.

The teacher now proceeds to speak of the beginnings of the various years of a cycle.

The closing point of the previous years is the initial point of the succeeding years. For example, 2nd year will be completed in the close of the 24th full moon. Now the parva constant multiplied by 24 *minus* the period of the sidereal revolutions of the moon or the sun as the case may be in a year together with the corrections for the stars concerned gives the beginning, as :—

$(66 + \frac{5}{62} + \frac{1}{67}) \times 24 - (819 + \frac{24}{62} + \frac{66}{67}$ being one Nakshatraparyāya) $= 765 + \frac{95}{62} + \frac{25}{67}$. From this deduct $744 + \frac{24}{62} + \frac{66}{67}$ being the correction for stars from Abhijit to Mūla.

The remainder $= 22 + \frac{8}{62} + \frac{26}{67}$, *i.e.*, at the beginning of the second lunar year there remain $7 + \frac{35}{62} + \frac{41}{67}$ muhūrtas in Pūrvāshāḍha.

Similarly for the solar year :—

$(66 + \frac{5}{62} + \frac{1}{67}) \times 24 - (819 + \frac{24}{62} + \frac{66}{67}$ being one sidereal revolution of the sun) $= 765 + \frac{95}{62} + \frac{25}{67}$. Deduct from this $19 + \frac{48}{62} + \frac{33}{67}$ correction for Pushya and $744 + \frac{24}{62} + \frac{66}{67}$ for stars from Āśles̀ha to Ārdra. Then there remain $2 + \frac{26}{62} + \frac{60}{67}$, *i.e.*, the second solar year commences when there remain in the Punarvasu star $42 + \frac{35}{62} + \frac{7}{67}$ muhūrtas.

Likewise for other years.

Then the teacher again speaks of the various years, sidereal, lunar, Sāvana and solar, and determines their respective lengths.

Other Cycles.

The lunar year and also the solar year commence at the same point or day and close at the same point or day once in every cycle of 30 years which is equal to 6 cycles of 5 years each. For the lunar gains 6×2 months and thus completes one complete intercalary year.

Similarly the solar, the Sāvana or seasonal, the lunar, and the Nakshatra years begin on the same day and close on the same day or simultaneously begin and close once at the close of 12 cycles of 5 years each, *i.e.*, 60 years.

It must be noted here that the lunar is really equal to $354 + 5\text{m.} + \frac{50}{62}\text{m.}$

For in a cycle of 5 years there are

60 Solar months.
61 Ṛitu months.
62 Lunar months.
67 Nakshatra months.

Hence $60 \times \frac{12}{12} = \frac{61}{12} \times 12 = \frac{62}{12} \times 12 = 67 \times \frac{12}{12}$, when the numerator denotes number of cycles of 5 years each and the denominator stands for 12 months of a year. In less than 12 cycles of 5 years each all of them will not be complete years.

Similarly the intercalary lunar year, the solar, the Ṛitu or Sāvana, the lunar and the Nakshatra years will simultaneously begin and close once in a great cycle of 156 cycles of 5 years each; for 156×5 years are equal to 744 intercalary lunar years, 780 solar, 793 Ṛitu years, 806 lunar, and 871 Nakshatra years.

Imperfect Cycle.

If it be asked whether a cycle made of the five years, *viz.*, 1 Nakshatra year, 1 lunar, 1 Ṛitu year, 1 solar, and 1 intercalary, would be perfect, the answer should be 'no'; for

The Nakshatra year	=	$327\frac{51}{67}$ days.
The lunar year	=	$354\frac{12}{62}$,,
The Ṛitu year	=	360 ,,
The solar ,,	=	366 ,,
The intercalary lunar	=	383 days $21\frac{18}{62}$ muhūrtas.

Total $= 1790$ days $+ 51 \times \frac{30}{67}$ muhūrtas $+ 12 \times \frac{30}{62}$ muhūrtas $+ 21\frac{18}{62}$ muhūrtas.

$= 1790$ days $+ 27\frac{6}{62}$ muhūrtas $+ \frac{1530}{67}$ muhūrtas.

$= 1791$ days $+ 19$ muhūrtas $+ (\frac{6}{62} + \frac{56}{67})$ muhūrtas.

$= 1791$ days $+ 19$ muhūrtas $+ \frac{57}{62} + \frac{55}{67}$ muhūrtas.

Now a perfect cycle is = 1830 days.

Hence 1830 days = (1791 + 19 muhūrtas + $\frac{57}{62}$ + $\frac{55}{67}$ muhūrtas) = 38 days + 10 muhūrtas + $\frac{4}{62}$ + $\frac{12}{67}$ muhūrtas is what is required to make that cycle a complete or perfect cycle.

The Seasons.

The rains, the autumn, the dewy, the spring, and the summer.

These are the seasons. They are of two kinds, the solar and the lunar. The solar season is equal to two solar months = 61 days. We speak of the lunar seasons later on. The seasons commence with the Āshāḍha month though the cycle of 5 years commences with the 1st day of the dark half of the month of Śrāvaṇa. Hence we count the number of parvas elapsed since the beginning of the cycle and multiply it by 15 in order to reduce them to lunar days. Then we add the remaining days above the parva up to the day in question. Then we deduct the Avama days at the rate of $\frac{1}{62}$ per day. Then we double the remainder and add again 61. Then we divide the sum by 122 and the quotient by six; the latter quotient is the number of expired Ṛitus and the remainder divided by two gives the days of the current season.

For example we are going to determine the season on the 1st Dīpōtsava day.

The number of parvas from the beginning of the cycle on 1st day of the dark half of Śrāvaṇa to the day in question are 7. So 7 × 15 = 105 lunar days. Now 105 × $\frac{1}{62}$ = nearly 2, *i.e.*, two Avama rātris. Deducting this from 105, we have 103.

103 × 2 = 206. 206 + 61 = 267.

$\frac{267}{122} = 2 + \frac{23}{122}$.

As two is not divisible by two, we leave it.

$\frac{23}{2} = 11\frac{1}{2}$.

Now counting the seasons from Āshāḍha, we may say two seasons are past and that 11 days have elapsed in the third season.

Now with regard to the question which season closes with what lunar day, this is the saying of ancient teachers :—

Take the number of the seasons in question and double it and deduct one from it. Then double it again. Then keep this product in two rows. One indicates the number of parvas; and the other being reduced to half shows the number of lunar days (tithis).

Now regarding the question, on what lunar day the first season in a cycle happens, we apply the formula as follows :—

Number of seasons = 1.

∴ 1 × 2 − 1 = 1. Again 1 × 2 = 2.

Keeping on two rows, as

2 2, we halve one of them.

The result is 2 and 1.

That is, 2 parvas have elapsed and that on the Pratipat day the first Ṛitu closed.

Similarly for the 2nd season—

2 × 2 − 1 = 3.

3 × 2 = 6.

6 6. Halving one

we have 6...........3.

That is, 6 parvas have elapsed and that on the 3rd day the second season has closed.

To this end there is also another saying as follows :—

With regard to the solar seasons months should be considered with Āshāḍha and that tithis from Bhādrapada.

The 1st season closes with the end of the Bhādrapada. Then leaving one month in the middle, the second season closes with the end of Kārtika and third leaving one month closes with the next month and so on.

The 1st season closes on the Pratipat day.		
The 2nd	,,	3rd day.
The 3rd	,,	5th ,,
The 4th	,,	7th ,,
The 5th	,,	9th ,,
The 6th	,,	11th ,,
The 7th	,,	13th ,,
The 8th	,,	15th ,,

All these close in the dark half of the months.

Then the 9th season closes on the		2nd day	white half.	
the 10th	,,	4th	,,	,,
the 11th	,,	6th	,,	,,
the 12th	,,	8th	,,	,,
the 13th	,,	10th	,,	,,
the 14th	,,	12th	,,	,,
the 15th	,,	14th	,,	,,

These seven close on the white half of the month. All these 15 seasons occur in half a cycle. Likewise 15 more occur in the other half.

In order to determine the stars with the moon or the sun at the close of a season, there are some Kāraṇa verses of ancient teachers. I am going to explain them now :—

$\frac{305}{134}$ parts of a day is the constant used in determining the star with the moon or the sun at the close of a season. This is multiplied by the number of the required season. The number of the season for the first is 1 and that of the seasons from 2 to 30 has to be doubled and added to the first. With this sum the constant is to be multiplied in the case of the second and other seasons up to 30. Then from the product thus obtained we have to deduct corrections for stars. 67 is to be deducted for stars of half area; $67 \times 2 = 134$ is to be deducted for stars of whole area; and $67 \times 3 = 201$ for stars of one and half area. In the case of the sun the corrections must begin with Pushya onwards and in the case of the moon with the Abhijit onwards. Here correction for Pushya is 88 (in addition) and 42 for Abhijit. Then the remainder shows the star with which the moon or the sun is in contact at the close of the season.

Example :—

Now in the case of the first season, we multiply 305 by one. Then the product is the same. Deduct 42 for Abhijit from this. The remainder is 263. Then deduct 134 for Śravaṇa from this. Then there remains 129. From this the correction for Dhanishṭha cannot be deducted. Hence we conclude that having traversed $\frac{129}{134}$ parts of Dhanishṭha the moon completes the first season.

Likewise for the second season :—

Constant $305 \times 3 = 915$. $915 - 42$ for Abhijit $= 873$.

Deduct from this 134 for Śravaṇa + 134 for Dhanishṭha + 67 for Śatabhishak + 134 for Pūrvābhādra + 201 for Uttarābhādra + 134 for Revati.

Then there remains 69. Hence we say that having traversed $\frac{69}{134}$ parts of Aśvini, the moon completes the second season.

So for the 30th season :—

The constant is 305; the season number multiplied by two and added to one is $29 \times 2 + 1 = 59$.

Hence $305 \times 59 = 17995$.

Now one sidereal revolution (Nakshatraparyāya) = 3660.

$\therefore$ 4 revolutions = 14640.

Hence $17995 - 14640 = 3355$.

Deduct from this 3225, being the correction for stars from Abhijit up to Mūla. Then there remains 130. That is the moon completes the 30th season after having traversed $\frac{130}{134}$ parts of Pūrvāshāḍha.

Likewise for the sun :—

$305 \times 1 - (88$ for Pushya $+ 67$ for Āślesha $+ 134$ for Magha$) = 16$. Hence we say that after having traversed $\frac{16}{134}$ parts of Pūrvaphalguni the sun completes the 1st season.

Likewise for the second season :—

$305 \times 3 - (88$ for Pushya $+ 67$ for Āślesha $+ 134$ for Magha $+ 134$ for Pūrvaphalguni $+ 201$ for Uttaraphalguni $+ 134$ for Hasta $+ 134$ for Chitra$) = 23$. Hence we say that having traversed $\frac{23}{134}$ parts of Svāti the sun completes the 2nd season.

Now for the 30th season :—

$305 \times 59 - (4 \times 3660 = 14640) = 3355$.

Now $3355 - (88$ for Pushya $+ 3258$ for stars from Āślesha to Mrigaśirah$) = 9$.

Hence we say that having finished $\frac{9}{134}$ parts of Ārdra the sun completes the 30th season.

Lunar Seasons.

Now in one sidereal revolution of the moon, the lunar seasons are six. Hence in a cycle of 5 years which is equal to 67 sidereal revolutions of the moon there are $6 \times 67 = 402$ lunar seasons.

In one lunar season there are $4 \frac{87}{67}$ days.

The reason for this is as follows :—

One sidereal revolution of the moon = 6 seasons.

One revolution is $= 27 \frac{21}{67}$ days.

$\therefore$ One season $= 27 \frac{21}{67} \div 6 = 4 \frac{87}{67}$ days, as stated in the Kāraṇa verse of the ancient teachers.

The formula to determine the lunar seasons is as follows:—

Multiply by 15 the number of parvas that has elapsed from the beginning of the cycle. Then add the remaining number of days above the parvas, if any. Then deduct Avamarātras at $\frac{1}{61}$ per day. Then multiply the remainder by 134 and add to the product 305 and divide the sum by 610. The quotient is the number of Ṛitus.

For example, we may desire to know the Ṛitu on the 5th day of the 1st parva from the beginning of the cycle. No parva has as yet been completed here. Hence take only the days, *viz.*, 5. Deduct one from it. Remainder is 4. Multiply it by 134.

$\therefore 4 \times 134 = 536$.

Add to this 305. $\therefore 536 + 305 = 841$. Dividing this by 610 we have $\frac{841}{610} = 1 \frac{231}{610}$. Here 1 stands for the 1st season.

Taking the remainder 231, divide it by 134.

$\therefore \frac{231}{134} = 1\frac{97}{134}$. Here 1 stands for days.

i.e., one day.

Now dividing 97 by 2 we get $48\frac{1}{2}$ which stands for so many sixty-seventh parts. Hence we say that on the 5th day the Prâvṛit Ṛitu has expired and that one complete day of the second season and $48\frac{1}{2}$ sixty-seventh parts of the second have also elapsed.

If it is desired to know what season there will be on the 11th day in the 2nd parva from the beginning of a cycle, we proceed as follows :—

1 parva elapsed $\times$ 15 + 10 days elapsed upto the 4th day=25. $25 \times 134 = 3350$. Adding to this 305 we have 3655. Dividing this by 610, we have $\frac{3655}{610} = 5\frac{605}{610}$, where 5 stands for Ṛitus.

Now $\frac{605}{134} = 4\frac{69}{134}$, where 4 stands for days.

$\frac{69}{2} = 34\frac{1}{2}$ sixty-sevenths of a day.

That is, 5 seasons and 4 days and $34\frac{1}{2}$ sixty-sevenths of a day have elapsed.

In order to determine the closing day of a lunar season the following method is taught :—

As in the case of solar seasons, multiply the constant $\frac{305}{134}$ by one for the first and by (2 $\times$ number of seasons + 1) for the 2nd and other seasons up to the last season ; and divide the product by 134. The quotient is the number of lunar seasons expired.

If, for example, the day on which the 1st lunar season expires is sought to be known, we proceed as follows :—

The constant is $\frac{305}{134}$. Multiplying it by 1 we have $\frac{305}{134} = 2\frac{37}{134}$. Divide 37 by 2. We have $18\frac{1}{2}$.

Hence we say that after 2 days and $18\frac{1}{2}$ sixty-sevenths of the third day the 1st lunar season attains completion.

Likewise for the 2nd Ṛitu :—

$\frac{305}{134} \times 3 = \frac{915}{134} = 6\frac{111}{134}$ (i)

$\frac{111}{2} = 55\frac{1}{2}$ (ii)

That is, that after 6 days and $55\frac{1}{2}$ sixty-sevenths of the 7th day the second season attains completion.

Similarly for 402nd season :—

$\frac{305}{134} \times 803 = \frac{244915}{134} = 1827\frac{97}{134}$ (i)

$\frac{97}{2} = 48\frac{1}{2}$ (ii)

That is, the 402nd season will be completed when 1827 days and $48\frac{1}{2}$ sixty-sevenths of the day after those days have elapsed.

There is also a formula taught by ancient teachers to determine the star with which the moon completes any one of his seasons.

The same constant $\frac{305}{134}$ is multiplied by one for the 1st and by 1 + 2 $\times$ (number of seasons *minus* 1st) for the 2nd and other seasons. Then corrections for stars from Abhijit onwards are made. What remains then indicates the portion of the star.

Now for the star on the last day of the first season we proceed as follows :—

$\frac{305}{134} \times 1 = \frac{305}{134}$.

Then deduct from this 42 for Abhijit ; then 134 for Śravaṇa. Then there remains 129. Dividing this by 2 we have $64\frac{1}{2}$.

That is, the 1st season is completed by the moon when $64\frac{1}{2}$ sixty-sevenths of Dhanishṭha are passed.

Likewise for the 2nd season :—

$\frac{305}{134} \times 3 = \frac{915}{134}$. Deducting from this 42 for Abhijit, 134 for Śravaṇa, 134 for Dhanishṭha, 67 for Śatabhishak, 134 for Pūrvābhādra, 201 for Uttarābhādra and 134 for Revati then there remains $\frac{69}{134}$. That the moon completes the 2nd season when $\frac{69}{134}$ parts of Aśvini have elapsed.

Likewise for 402nd season :—

$\frac{305}{134} \times 803 = 244915$.

Now one paryāya or turn for all the 28 stars is 3660. Hence $\frac{244915}{3660} = 66\frac{3355}{3660}$.

Now from 3355 we deduct 42 for Abhijit and 3082 for stars from Śravaṇa to Anūrādha. Then there remains 231. Deduct from this 67 for Jyēshṭha + 134 for Mūla. There remains 30. Hence we say that after having traversed $\frac{30}{134}$ parts of Pūrvāshāḍha, the moon completes the 402nd season.

(To be continued.)

SURYAPRAGNAPTI.

By Dr. R. Shama Sastry, B.A., Ph.D., M.R.A.S.

(*Continued from Vol. XVIII, No. 3.*)

We have said that one paryāya for all the stars is 3660. The proof of this is as follows :—

For six stars of half area the amśas are		$67 \times 6 = 402$
For six stars of $1\frac{1}{2}$ area	„	$6 \times 201 = 1206$
For 15 stars of one whole area	„	$15 \times 134 = 2010$
For Abhijit	„	42
	Total of the amśas	$= 3660.$

Thus the astronomical measure of the lunar seasons has been dealt with. But, according to popular conception, the measure of a lunar season is quite different. According to it, two lunar months make one lunar season.

The lunar year $= 354\frac{12}{62}$ days.

Hence one season $= 354\frac{12}{62} \div 6 = 59\frac{2}{62}$ days.

Now a Karma month is of 30 days. Hence in one Karma season of two Karma months there are 60 days. Hence compared with this it is usual with the people to consider the lunar season to be short of 1 day. Hence compared with one Karmasamvatsara, the lunar year is nearly 6 days less. These six days are called Avama days.

There is nothing in the time itself to distinguish it as consisting of Avama or Atirātra days. These distinctions are all due to our conception of various forms of months. This is what ancient teachers have taught us of Avamarātras :—

The Karmamāsa is $= 30$ days.

The lunar month is $= 29\frac{32}{62}$ days.

The difference between these two is $30 - 29\frac{32}{62} = \frac{30}{62}$.

This is the fraction which makes Avamarātras. Hence if $\frac{30}{62}$ parts of a day is the difference between one Karmamāsa of 30 days and lunar māsa of $29\frac{32}{62}$, the difference due to one day is $\frac{1}{62}$. Hence in 62 days there will be one complete Avamarātra. On the same day (62nd day) the lunar day (tithi) will be 63rd day. Hence on the 61st day, both the 61st and the 62nd tithis will expire. Hence 62nd tithi is, according to popular parlance, as an omitted tithi.

Now, the rainy season consists of 4 months. Hence in this season the 1st Avamarātra will occur in the 3rd parva from Śrāvaṇa and the 2nd Avama

in the 7th parva. Then in the cold season of 4 months, the third Avama will occur on the 11th parva from the first parva of the cycle or in the 3rd parva in the season itself will occur and the 4th in the 15th or 7th parva. Then in the summer season the 5th Avama will happen on the 19th parva and the 6th Avama on the 31st parva. This is according to ancient teaching. But really the 1st Avama will happen on the 4th parva.

Now, regarding the question which tithi will be completed on the 1st Avama day and on what parva, the following ancient verse supplies the formula :—

The formula is of two kinds: one for odd number of tithis; and another for even number of tithis.

(i) In the case of odd number, add one to it, and double the sum. The product shows the number of the parvas.

(ii) In the case of even number, add one to it and double the sum. Again add 31 to the product. The sum is the number of parvas.

Now let the question be as follows :—

In what parva or paksha will the pratipath day be Avama and close with the second tithi ?

Now the tithi being one, we take 1; and add 1 to it; $1 + 1 = 2$. Doubling this we have 4.

Hence we may say that in the 4th parva or paksha, the pratipath will be Avama and close with the second tithi on the same day.

The reason for this is as follows :—

Now 4 parvas $\times$ 15 tithis $= 60$ tithis.

Add to it the Pratipath and the second, the two tithis falling on the same day. The sum is 62. This gives no remainder when divided by 62. Hence the 1st Avama day will be the Pratipath.

Or let the question be regarding the second Avama day on the second day closing with the third on the same day.

Here we take 2, the number that is asked.

Adding one to it and doubling it we have $1 + 2 = 3$; $3 \times 2 = 6$. Add 31 to this. Hence $6 + 31 = 37$.

That is, in the 37th parva or paksha the second lunar day will be the second Avama day and close with the third day on the same day.

Here also 37×15 tithis $= 555$ tithis.

The second is lost and the third also closed with the second day. Hence adding 3 to it, we have 558 tithis. This divided by 62 leaves no remainder.

Likewise in the case of other tithis, as follows :—

The 3rd Avama	with	4th tithi	will happen in	8th parva.
The 4th	„	5th	„	41st „
The 5th	„	6th	„	12th „

The 6th	Avama with	7th	tithi will happen in	45th	parva.
The 7th	„	8th	„	16th	„
The 8th	„	9th	„	49th	„
The 9th	„	10th	„	20th	„
The 10th	„	11th	„	53rd	„
The 11th	„	12th	„	24th	„
The 12th	„	13th	„	57th	„
The 13th	„	14th	„	28th	„
The 14th	„	15th	„	61st	„
The 15th	„	1st	„	32nd	„

Thus in the first half of the cycle, and likewise the same can be found out in the second half.

Now the teacher goes to explain the occurrence of the Atirātras :—

Now if we compare the solar month with the Karma month, we find the difference of a day between a solar and a Karma season ; for

One Karma month = 30 days.

„ solar „ = $30\frac{1}{2}$ „

$\therefore$ Two Karma months = One Karma season $\}$ = 60 „

Two solar months = One solar season $\}$ = 61 „

The solar season commences with the Āshāḍha month. Hence in the 4th parva from Āshāḍha there will be one Atirātra day.

The 2nd	Atirātra will be at the close of the			8th	parva.
The 3rd	„	„	„	12th	„
The 4th	„	„	„	16th	„
The 5th	„	„	„	20th	„
The 6th	„	„	„	24th	„

The Avamarātras are due to the lunar year, and the Atirātras are due to the solar year, both being compared with the Karma year.

Now in a cycle of 5 years there are ten Ayanas of the sun and 134 Ayanas of the moon.

The sun moves southward for 183 days
and northwards for 183 „

$$\text{Hence } \frac{1830 \text{ days of a cycle}}{183 \text{ of an Ayana}} = 10 \text{ Ayanas.}$$

The moon moves southward for $13\frac{44}{67}$ days
and northward for $13\frac{44}{67}$ „

$$\text{Hence } \frac{1830}{13\frac{44}{67}} = 134 \text{ Ayanas.}$$

The solar Ayana days in each year of the cycle are :—

1st	Ayana in the	Śrāvaṇa month.
2nd	„	Māgha.
3rd	„	Śrāvaṇa.
4th	„	Māgha.
5th	„	Śrāvaṇa.
6th	„	Māgha.
7th	„	Śrāvaṇa.
8th	„	Māgha.
9th	„	Śrāvaṇa.
10th	„	Māgha.

The formula to find out the parva and the tithi of the solar Ayanas is as follows :—

Take the Ayana number in question. Deduct one from it. Then multiply the remainder by 183 and add to the product thrice the Ayana number *plus* one. Then divide the sum by 15. The quotient will be the number of parvas that have passed and the remainder the number of days in the current parva, the last of that number is the lunar day.

Now, for example, take the 1st Ayana.

$\therefore$ $1 - 1 = 0$. Hence we take the 10th Ayana of the past cycle ; *i.e.*, number 10.

Now $10 \times 183 = 1830$ ... (i)

$10 \times 3 + 1 = 31$ ... (ii)

$1830 + 31 = 1861$ ... (iii)

$\frac{1861}{15} = 124\frac{1}{15}$.

Hence we say that the 1st Ayana will occur on the pratipath day after 124 parvas of the previous cycle.

Similarly for the 2nd.

$2 - 1 = 1$

$1 \times 183 = 183$

$1 \times 3 + 1 = 4$

$183 + 4 = 187.\quad \frac{187}{15} = 12\frac{7}{15}$.

That is, the 2nd Ayana will be on the 7th day of Māgha Bahula after 12 parvas in the cycle.

Likewise the 3rd.

$3 - 1 = 2$

$2 \times 183 = 366$

$2 \times 3 + 1 = 7$

$$\frac{366 + 7}{15} = \frac{373}{15} = 24\frac{18}{15}.$$

That is, the 3rd Ayana will be after 24 Parvas, *i.e.*, one year; hence in the Śrāvaṇa month on the 13th day, Bahula.

Similarly in other cases also.

The tithis and the months for all the ten Ayanas are thus enumerated:—

Śrāvaṇa	Bahula	1	The five Ayanas in the Śrāvaṇa month.
,,	,,	13	
,,	Śukla	10	
,,	Bahula	7	
,,	Śukla	4	
Māgha	Bahula	7	The five in Māgha.
,,	Śukla	4	
,,	Bahula	1	
,,	,,	13	
,,	Śukla	10	

The formula for finding out the stars on these Ayana days is stated as follows:—

The constant used here is $573 + \frac{36}{62} + \frac{6}{67}$ muhūrtas.

This constant is found as follows:—

10 solar Ayanas = 67 sidereal months.

$\therefore 1 \quad = \frac{67}{10} = 6\frac{7}{10}$.

In order to reduce $\frac{7}{10}$ to muhūrtas we proceed as follows:—

$\frac{1}{10}$ of an Ayana = $27\frac{21}{67}$ days.

$\therefore \frac{7}{10}$ ths $= \dfrac{27\frac{21}{67} \times 7}{10}$ days.

$\dfrac{1830 \times 7 \times 30}{10 \times 67} = 573\frac{39}{67} = 573$ muhūrtas, $\frac{36}{62}$ of a muhūrta and $\frac{6}{67}$ of sixty-secondth of a muhūrta.

Multiply this constant by the number of Ayanas *minus* one.

Then deduct from the product $9 + \frac{24}{62} + \frac{62}{67}$ muhūrtas for Abhijit, 30 for Śravaṇa, 30 for Dhanishṭha, 15 for Śatabhishak, 30 for Pūrvābhādra, 45 for Uttarābhādra; then 30 for Revati, 30 for Aśvini, 15 for Bharaṇi, 30 for Krittika, 45 for Rohiṇi, 30 for Mrigaśirah, 15 for Ārdra, 45 for Punarvasu, 30 for Pushya, 15 for Āślēsha, 30 for Māgha, 30 for Pūrvaphalguni, 45 for Uttaraphālguni, 30 for Hasta, 30 for Chitra, 15 for Svāti, 45 for Viśākha, 30 for Anūrādha, 15 for Jyeshṭha, 30 for Mūla, 30 for Pūrvāshāḍha, 45 for Uttarāshāḍha, as far as possible. Then what remains is the star.

For example, let us take the first Ayana and find the star on the day.

Take 1 and deduct 1 from it. The result is 0. So take the number of the Ayanas in the previous cycle. It is 10.

Then multiply the constant $573 + \frac{36}{62} + \frac{6}{67}$ by 10.

Deducting from this 819, being the correction for stars from Abhijit to Uttarāshāḍha, *i.e.*, for one revolution.

Now 819×7 revolutions = 5733.

$5735 - 5733 = 2$.

Hence the remainder is $2 + \frac{50}{62} + \frac{60}{67}$.

Deduct from this the fraction of correction for Abhijit, multiplying it by 7 times.

Hence $2 + \frac{50}{62} + \frac{60}{67} - (\frac{24}{62} + \frac{62}{67}) \times 7 = 0$.

Hence we say that the moon completes the Uttarāshāḍha when the Ayana begins.

Similarly for other stars for other Ayanas.

Now with regard to the stars in which the sun completes the several Ayanas of a cycle:—

The sun will have traversed $19 + \frac{48}{62} + \frac{30}{67}$ muhūrtas in the Pushya where the 1st Ayana is completed.

This is worked out as follows:—

10 Ayanas are made in 5 years.

1 $\quad \frac{5}{10}$,, $= \frac{1}{2}$ a year.

(i) Now 6 stars from Śatabhishak onwards are of $\frac{1}{2}$ area.

$\therefore$ each being $33\frac{1}{2}$ sixty-seventh parts, $33\frac{1}{2} \times 6 = 201$ sixty-sevenths.

(ii) 6 stars from Uttarābhāḍra onwards are of $1\frac{1}{2}$ area.

$\therefore 6 \times \frac{3}{2} \times 67 = 603$ sixty-seventh parts.

(iii) The remaining 15 stars are of one whole area.

$\therefore 67 \times 15 = 1005$ sixty-seventh parts.

(iv) For Abhijit $\frac{21}{67}$ parts.

$\therefore 201 + 603 + 1005 + \frac{21}{67} = \frac{1830}{67}$ parts.

This is equal to one whole sidereal revolution.

Half of this = 915.

Deducting from this 21 for Abhijit, we have 894 parts or Amśas.

Now $\frac{894}{67} = 13\frac{28}{67}$.

Now $\frac{28}{67}$ multiplied by 30 gives the parts in terms of muhūrtas. $\frac{28}{67} \times 30 = \frac{690}{67} = 10\frac{20}{67}$.

Again $\frac{20}{67} \times 62 = 18\frac{84}{67}$ sixty-second parts of a muhūrta.

Hence we say that when 10 muhūrtas, 18 sixty-second parts of a muhūrta and $\frac{84}{67}$ of one sixty-secondth of a muhūrta have elapsed, the 1st Ayana commences.

Now regarding the question, in which star does the moon commence the 2nd Ayana in Śravaṇa in a cycle? We proceed as follows :—

The 2nd in Śravaṇa is really the third from the 1st in the cycle. Hence we take 3 and deduct one from it; then we multiply the constant by 2, as, $(573 + \frac{36}{62} + \frac{6}{67}) \times 2 = 1146 + \frac{72}{62} + \frac{12}{67}$.

Deduct from this as much as = one revolution.

$\therefore (1146 + \frac{72}{62} + \frac{12}{67}) - (819 + \frac{24}{62} + \frac{66}{67}) = 327 + \frac{47}{62} + \frac{13}{67}$.

Deduct from this $309 + \frac{24}{62} + \frac{66}{67}$ being the correction for stars from Abhijit to Rohiṇi. Then what remains is $18 + \frac{22}{62} + \frac{14}{67}$; that is, that when out of 30 muhūrta parts of muhūrta there have elapsed $18 + \frac{22}{62} + \frac{14}{67}$ and $11 + \frac{39}{62} + \frac{53}{67}$ muhūrta parts remain to be passed by the moon, the 2nd Ayana occurs.

Likewise in the case of the sun :—

Here the sun makes 10 Ayanas and 5 of his sidereal revolutions. Hence 2 Ayanas in one revolution. Of these the Uttarâyaṇa always occurs in the Abhijit and the Dakshināyaṇa when there remain in Pushya $19 + \frac{48}{62} + \frac{38}{67}$ muhūrta parts.

Now the moon makes the 3rd Ayana in the month of Śrâvaṇa in Viśākha when in that star there still remain $13 + \frac{54}{62} + \frac{40}{67}$ muhūrta parts. As in the 2nd Ayana, here also the sum is worked out as follows :—3rd in Śrâvaṇa means 5th from the beginning. Hence deducting one from it, we multiply the constant :—

$\therefore 4 \times (573 + \frac{36}{62} + \frac{6}{67}) = 2292 + \frac{144}{62} + \frac{24}{67}$.

Deduct from this $2 \times (819 + \frac{24}{62} + \frac{66}{67})$ revolutions.

Then there remain $654 + \frac{94}{62} + \frac{26}{67}$ muhūrta parts.

Deduct from this $549 + \frac{24}{62} + \frac{66}{67}$ being the correction for stars from Abhijit to Uttaraphalguni.

Then there remains $106 + \frac{7}{62} + \frac{27}{67}$.

Deduct again 75 for stars from Hasta to Svâti.

Then the remainder is $31 + \frac{7}{62} + \frac{27}{67}$, *i.e.*, when so much has elapsed in Viśākha leaving still $13 + \frac{54}{62} + \frac{40}{67}$ muhūrta parts the third Ayana in Śrāvaṇa commences.

Likewise, following the same method, it can be ascertained that the moon commences the 4th Ayana in Śrāvaṇa when there remain in Revati $25 + \frac{32}{62} + \frac{26}{67}$ muhūrta parts.

Similarly the 5th Ayana in Śrāvaṇa commences when the moon has yet to traverse $12 + \frac{47}{62} + \frac{13}{67}$ muhūrta parts in Pūrvaphalguni.

Likewise the moon will have to traverse yet $5 + \frac{50}{62} + \frac{60}{67}$ in Hasta when the first Ayana (*i.e.*, Uttarāyaṇa in Māgha) in Māgha in a cycle commences.

At this time the sun will be in the Abhijit.

Proof :—

10 Ayanas occur in 5 revolutions.

1 Ayana occurs in $\frac{5}{10}$ revolutions.

$\frac{5}{10}$ revolutions $= \frac{1}{2} = \dfrac{1830}{2 \times 67}$ days or 915 sixty-seventh parts.

Now in the previous Ayana $\frac{23}{67}$ parts of Pushya were passed, leaving $\frac{44}{67}$ parts behind.

Deducting this from $\frac{915}{67}$ we have $\frac{915}{67} - \frac{44}{67} = \frac{871}{67} = 13$ stars, from Āślesha to Uttarāshāḍha. The next star is Abhijit where the Ayana commences with the sun.

The second Ayana in Māgha with the moon commences when in Śatabhishak there remain $2 + \frac{28}{62} + \frac{46}{67}$ muhūrta parts.

Likewise the third Ayana with the moon in Māgha commences when $19 + \frac{48}{62} + \frac{38}{67}$ muhūrta parts remain in Pushya.

The fourth when $6 + \frac{58}{62} + \frac{20}{67}$ muhūrta parts remain in Mūla.

The fifth when $18 + \frac{36}{62} + \frac{6}{67}$ remain in Kṛittika.

It must be borne in mind that the moon commences the northern or southern movements in those stars in which the sun does; the northern in Abhijit and the southern in Pushya.

Thus while the sun makes ten Ayanas in a cycle, the moon does 134.

Hence by making 134 Ayanas, the moon makes 67 revolutions (complete).

Hence in one Ayana he makes $\frac{67}{134}$ revolutions $= \frac{1}{2} = \dfrac{1830 \text{ days}}{2 \times 67} = \frac{915}{67}$ stars. Here when $\frac{23}{67}$ of Pushya have elapsed, the southern Ayana was made by the moon.

$\therefore$ There remained $\frac{44}{67}$ star-parts.

Deducting this from $\frac{915}{67} - \frac{44}{67}$, we have $\frac{871}{67} = 13$ stars from Āślesha to Uttarâshāḍha. Hence we conclude that he makes the Uttarâyaṇa in Abhijit.

Likewise he makes Dakshināyana in Pushya when there remain $10 + \frac{20}{67}$ muhūrta parts. This is found as follows :—

Now in 134 Ayanas there are 67 complete revolutions of the moon.

$\therefore$ 1 $\frac{67}{134} = \frac{1}{2} \times \frac{1830}{67}$ or 915 sixty-seventh parts.

Deduct from this $\frac{915}{67} - \frac{21}{67}$ for Abhijit.

There remain $\frac{894}{67}$ parts $= 13\,\frac{23}{67}$ stars.

Deducting 13 stars from Abhijit to Punarvasu we have $\frac{23}{67}$ stars $= \frac{23}{67} \times 30$ muhūrtas $= 10 + \frac{20}{67}$ muhūrtas passed in Pushya, when the southern movement of the moon occurs.

Yogas in a Cycle.

There are ten yogas in a cycle.

(1)	Vrishabhanujata	(6)	Chhatrātichhatra
(2)	Venukanujata	(7)	Yuganaddha
(3)	Mancha	(8)	Ghanasammarda
(4)	Manchātimancha	(9)	Prinita
(5)	Chhatra	(10)	Mandukapluta

These yogas are said to occur when the sun, the moon, and the star in conjunction, appear to take such form as is implied by the names. Except the 6th which occurs rarely in some particular country the rest happen in all countries. The Chhatrātichhatra or umbrella-above-umbrella occurs when the moon, the Chitra star, and the sun appear one below the other in the Dakshināyana. Divide the ecliptic circle into 4 parts by drawing vertical and horizontal diameters. Divide each of the four quadrants into 31 divisions. But in the south-eastern quadrant divide the 28th division into 20 minor divisions, leaving the 29th, 30th and 31st divisions as before. When the moon is just arriving at the 19th minor division after traversing 27 big divisions and 18 minor divisions of the 28th, the Chhatrātichhatra yoga occurs on some occasions.

The Two Halves of a Lunar Month.

One lunar month $= 29 \frac{32}{62}$ days $= 885 \frac{30}{62}$ muhūrtas. Of this the white half contains $442 \frac{46}{62}$ muhūrtas and the dark half also $442 \frac{46}{62}$ muhūrtas.

The moon is divided into sixteen parts. Of these 15 parts are completely covered by the dark disc of Rāhu on the 15th lunar day and on the Pratipath day one part, on the 2nd day two parts, and so on, 15 parts on the 15th day.

The number of diurnal circles of moon in a parva:—

The moon moves through $14 \frac{16}{62}$ diurnal circles in half a lunar month or 1768 circles in 124 parvas.

The teacher goes on to speak of two moons and the day in which they move through their diurnal circles and of the distinction between sidereal and lunar months.

Velocities of Planets and Stars.

Among the four, the moon, the sun, the Grahas and the Nakshatras, the sun is quicker than the moon, the planets than the sun, and the stars than the planets. This is ascertained by considering their motions through ecliptic circles. Imagine that the circumference of the circle is divided into 1,09,800 divisions. Now we have to understand the moon's velocity per muhūrta in terms of such circle divisions before we can find the difference in the rates of velocities of the moon, the sun and the stars.

Now the moon completes 1768 half circles * in 1830 days.

$\therefore$ One circle ,, ,, $\frac{1830 \times 2}{1768}$ days.

$= \frac{3660}{1768} = 2$ days $+ \; 2 \frac{28}{221}$ muhūrtas.

That is, the moon moves through one circle in so much time.

From this we can deduce the moon's velocity in a muhūrta.

Now one circle is divided into 1,09,800 parts.

The moon goes through 1,09,800 parts in 2 days + $2 \frac{28}{221}$ muhūrtas.

Hence in a muhūrta $\frac{109800}{60 + 2 \frac{28}{221}}$ parts.

$= \frac{109800}{13725} \times 221 = \frac{24265800}{13725} = 1768$ parts.

That is, the moon moves through 1768 parts of the circumference of a circle divided into 1,09,800 parts in one muhūrta. (i)

Now the sun moves through 1830 such parts in one muhūrta. (ii)

for he completes one circle of 1,09,800 parts in two days or 60 muhūrtas.†

Hence in one muhūrta $\frac{109800}{60} = 1830$ parts.

Now the Nakshatra velocity per muhūrta is ascertained as follows:—

Now each of the stars takes to complete 1835 half circles in 1830 days.

$\therefore$,, ,, ,, 2 ,, $\frac{1830 \times 2}{1835}$ days.

$= 1$ day $\times \; 29 \frac{307}{367}$ muhūrtas.

Now in $59 \frac{307}{367}$ muhūrtas 109800 parts of one circle are completed.

Hence 1 ,, , ,, $\frac{109800}{21960} \times 367$

$= \frac{40296600}{21960} = 1835$ parts. (iii)

Accordingly we say that the moon going through 1768 parts per muhūrta is slower than the sun who goes through 1830 parts per muhūrta and that the stars moving each through 1835 parts per muhūrta are quicker than the sun.

As to grahas, they are of unsettled velocities, as they are liable to retrograde movements (Vakra).

Now it is evident that the sun moves $1830 - 1768 = 62$ parts more per muhūrta than the moon; (i)

that the stars, $1835 - 1768 = 67$ parts more per muhūrta than the moon; (ii)

and that the stars $1835 - 1830 = 5$ parts more per muhūrta than the sun. (iii)

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* On the supposition of two moons. † On the supposition of two suns.

The moon's diurnal circles and the sidereal month.

The moon makes in 67 sidereal months 884 circles.

Hence „ 1 „ $\frac{884}{67} = 13\,\frac{13}{67}$ circles.

Likewise the sun makes in 67 „ 915 circles.

Hence „ in 1 „ $\frac{915}{67} = 13\,\frac{44}{67}$ circles.

Similarly the stars make in 67 „ 1835 circles.

Hence „ 1 „ $27\,\frac{26}{67}$ half circles.

or $13\,\frac{46\frac{1}{2}}{67}$ whole circles.

Changing the month, and taking the lunar month, the moon makes in 124 parvas 884 circles.

Hence „ 2 parvas $\frac{884}{124} \times 2 = 14\,\frac{32}{124}$ circles.

Similarly the sun makes in 124 parvas 915 circles.

Hence „ 2 parvas $915 \times \frac{2}{124} = 14\,\frac{94}{124}$.

Likewise the stars 124 „ 1835 circles.

Hence 2 „ $\frac{1835}{124} \times 2 = 14\,\frac{94}{124}$ circles.

Now taking a karma-māsa, we see that the moon makes in 61 karma months 884 circles.

Hence 1 karma month $\frac{884}{61} = 14\,\frac{30}{61}$ whole circles.

or twice the number of half circles.

Likewise the sun makes in 61 karma months 915 circles.

Hence „ 1 „ $\frac{915}{61} = 15$ circles.

Similarly the stars make in 122 „ 1835 circles.

Hence „ 1 „ $\frac{1835}{122} = 15\,\frac{5}{122}$.

Note:—In all these cases, it must be borne in mind that these conclusions are made on the supposition of two moons, two suns, and two stars, making each pair a complete circle a day. Hence these half numbers refer to one of these pairs, *i.e.*, half the number of circles per month.

Now taking the solar month, we see that the moon makes in 60 solar months 884 circles.

Hence „ 1 „ $\frac{884}{60} = 14\,\frac{11}{15}$ circles.

Likewise the sun „ 60 „ 915 circles.

Hence „ 1 „ $\frac{915}{60} = 15\,\frac{15}{60}$ circles.

Similarly the stars make in 120 solar months 1835 circles.

Hence „ 1 „ $\frac{1835}{120} = 15\,\frac{15}{120}$ circles.

Likewise we can find out the exact number of circles which the moon makes in an intercalary month. But in doing so we cannot use the ordinary cycle of 5 years without involving ourselves in long fractions; for a Yuga consists of 57 months, 7 days 11 muhūrtas and $\frac{23}{62}$ of a muhūrta, if all the months of a Yuga are converted into intercalary months. (An intercalary year of 13 lunar months is $= 383\,\frac{44}{62}$ days. This divided by 12 gives 31 days, 29 muhūrtas and $\frac{17}{62}$ of a muhūrta, as the measure of an intercalary month. Hence in a Yuga there are 57 such intercalary months, 7 days, 11 muhūrtas, and $\frac{23}{62}$ of a muhūrta). So we use the major cycle of 780 years or 156 cycles of 5 years each. Such a cycle converted into intercalary months of the said length will be=8928 intercalary months.

Now the moon makes in 8928 inter months 137904 circles.

Hence „ 1 „ $\frac{137904}{8928} = 15\,\frac{88}{186}$ circles.

Likewise the sun makes in 8928 inter months 142740 circles.

Hence „ 1 „ $\frac{142740}{8928} = 15\,\frac{245}{248}$ circles.

Similarly the stars make in 8928 inter months 143130 circles.

Hence „ in one „ $\frac{143130}{8928} = 16\,\frac{47}{1488}$ circles.

We may also find out the number of circles which the moon, the sun and the stars make in a whole day.

Now the moon makes in 1830 days 1768 half circles.

Hence „ 1 „ $\frac{1768}{1830} = \frac{884}{915}$ half circles.

Likewise the sun makes in 1830 days 1830 half circles.

Hence „ 1 „ $\frac{1830}{1830} = 1$ half circle.

Likewise the stars make in 1830 days 1835 half circles.

Hence „ 1 „ $\frac{1835}{1830} = 1\,\frac{2}{732}$ half circle.

For one complete circle the same process may be employed.

The moon makes one complete circle in $1\,\frac{31}{442}$ days.

The sun „ „ 2 days.

The stars „ „ $1\,\frac{365}{367}$ days.

Likewise we may find out the number of circles which the moon, the sun and the stars make in a cycle.

The moon traverses in a muhūrta 1768 parts of the ecliptic circle divided into 1098 parts.

There are in a Yuga 54900 muhūrtas.

Hence in a Yuga he traverses $54900 \times 1768 = 97063200$ parts.

Hence $\frac{97063200}{109800} = 884$ circles.

Likewise the sun traverses in 2 days one circle.

Hence „ „ in 1830 days $\frac{1830}{2} = 915$ circles.

Similarly the stars move in one muhūrta through 1835 parts of the ecliptic circle divided into 109800 divisions.

Hence in a Yuga 1835 × 54900 = 100741500 divisions.

These divided by 109800 = 1835 half circles.

The author goes on to refer to the views of 25 astronomical schools on the disappearance of old moons and the reappearance of new moons, muhūrta after muhūrta; on the situation of the sun about 1000 yojanas above the earth, the moon 1500 yojanas above; the diametrical measure of the spheres of the sun and the moon; the number of suns, moons, their wives, their satellites the number of stars.

Then referring to eclipses of the sun and the moon, he criticizes the views of others who say that Rāhu swallows either of them in part or as a whole and that the planets tearing out Rāhu's belly, come out of it. In his own view eclipses are nothing but the covering of the sun's or the moon's disc partially or wholly by the dark vimāna or car of Rāhu. This Rāhu is called Parva Rāhu as distinguished from Nitya Rāhu who causes the phases of the moon by covering 1/16th part of the moon's disc every day upto 15/16 parts on the 15th lunar day in the dark half of the month and again disclosing those parts upto 15/16th parts on the 15th in the white half of the month.

The least interval between one solar or lunar eclipse and another is six months and the greatest is 32 months for the lunar and 48 years for the solar eclipse.

Referring to Grahas or planets, he says that they are 88 in number. Their names are :—

1. Angāraka
2. Vikalaka
3. Lohityaka
4. Sanischara
5. Adhunika
6. Pradhunika
7. Kana
8. Kanaka
9. Kanakanka
10. Kanavitanika
11. Kanasantanaka
12. Soma
13. Sahita
14. Asvasana
15. Karyopaga
16. Karbataka
17. Ajakaraka
18. Dundubhaka
19. Sankha
20. Sankhanabha
21. Sankhavarnabha
22. Kansa
23. Kansanabha
24. Kansavarnabha
25. Nīla
26. Nīlāvabhāsa
27. Rūpi
28. Rūpyāvabhāsa
29. Bhasma
30. Bhasmarāśi

31. Tila
32. Tilapushpavarnaka
33. Daka
34. Dakavarna
35. Kaya
36. Vaudhya
37. Indrāgni
38. Dhūmaketu
39. Hari
40. Pingala
41. Budha
42. Śukra
43. Brihaspati
44. Rāhu
45. Agasti
46. Manavaka
47. Kāmasparśa
48. Dhura
49. Pramukha
50. Vikata
51. Visandhikalpa
52. Prakalpa
53. Jatala
54. Aruna
55. Agni
56. Kāla
57. Mahākāla
58. Svastika
59. Sauvastika
60. Vardhamanaka
61. Pralamba
62. Nityaloka
63. Nityodhyota
64. Svayamprabha
65. Avabhāsa
66. Śrēyaskara
67. Khemankara
68. Abankara
69. Prabhankara
70. Arajā
71. Virajā
72. Aśōka
73. Vītaśoka
74. Vivarta
75. Vivastra
76. Viśāla
77. Sāla
78. Suvrata
79. Anivritti
80. Ēkajāti
81. Dvijāt
82. Kara
83. Karika
84. Raja
85. Argala
86. Pushpa
87. Bhava
88. Kētu