Hindu-Aryan Astronomy

AND

Antiquity of Aryan Race.

BY

Pandit BHAGWAN DAS Pathak,

Retired Head Clerk, Aligarh Collectorate.

CONTENTS.

—:o:—

ERRATA.

—:o:—

PAGE	LINE	FOR	READ
11	3 & 7	religeous	religious
111	20	co-religeonists	co-religionists
111	28	religeon	religion
3	9	equel	equal
5	19 & 26	religeous	religious
6	6 & 9	religeous	religious
9	12	tha	that
10	25	religeons	religious
11	5	the	...
12	5	sidercal	sidereal
12 & 13	16	religeous	religious
14	12	,,	,,
16	9	,,	,,
18	19	,,	,,
19	28	,,	,,
20	29	taditions	traditions
20	30	religeous	religious
33	17	,,	,,
34	33	referentces	references
40	20	ascension	ascension
43	23	ther	there
52	15	cf	of
53	19	Mahamaho-	Mahamaho-
54	24	padhya	padhyaya
73	2	Drancons.	Draconis
84	heading	Indian meridian	4-Indian meridian
98	14	differenoe	difference

PREFACE.

In this small book an attempt is made to give a brief account of the ancient Hindu Aryan Astronomy, to trace its antiquity as far as possible from the available ancient works and to verify by calculations the results of the observations made by the ancient Indian sages.

During the course of my researches, I was astonished to find the degree of accuracy with which the ancient Indian astronomers made their observations and I believe that if the western scientists had made use of the ancient Brahmanical works for determining some of the astronomical constants instead of the old Greek works, they would have received much valuable help but unfortunately the general tendency of the majority of the European scholars has been and still is to ignore the ancient Indian Civilisation and to attribute to foreign influence every mark thereof, which is brought to light either by study of the ancient Indian works or by Archaeological researches. The ancient civilisation was not the product of one country or nation, but of all the human nations which inhabited this earth from time to time. It is therefore idle to suggest specially, in the absence of any authentic ancient history that a nation borrowed an art or a science from another nation. As regards astronomy, there is a work called Romak Sidhanta which was of course, based on the Greek system of the science but there was no attempt on its' author's part to conceal the source of its' origin. Its' name is a clear indication of its origin, but to clear the point still further its' author used the meridian of Yawanpura, and stated the difference in time between that place and the Indian meridian. The ancient Indians were honest people and never concealed the real facts.

It is a well known fact, that a considereble number of old Sanscrit works were lost in political changes and destroyed by religeous fanatics. It is in fact very creditable to our forefathers that they could preserve for their descendants a remnant of the ancient treasure in those troublous and stormy times. With the exception of some religeous works, hardly any book of pre-Budhistic period still exists. I have however tried my best and my researches have led me to the following important discoveries.

1. The beginning of Yudhistara's era in 2448 B. C.

2. The reckoning of the Indian meridian from Kurukshetra was fixed by Maharaja Yudhishtara, in commemoration of his victory at that place.

3. The meridian of Avanti or Ujjain was subsequently fixed by the author of Vashishta Sidhanta in 1905 B. C.

4. The antiquity of the Indian constellations, numbering 28, is traceable from Astronomical and Astrological works, up to the time when the vernal equinoctial point was retrograding through Adra Nakshatra *i. e.* about 5000 B. C,

5. Their further antiquity is traceable from the Vedic theological works to a very remote period.

6. The changes in the Indian constellations caused by unequal motions of the Principal Stars of Nakshatras in their right ascension.

7. The antiquity of Surya Sidhanta.

8. The antiquity of the Vedas.

9. The antiquity of the Indian Yugas, Calendars, etc.

10. Planets known to the ancient Aryan race.

11. The variations in the tropical motions of the sun and it's perihelion.

12. The variations in the Sidereal motions of the moon, its perigee and its node.

The moon's variation as determined by me is 8.44 sec. in a century, while it is 8.8 sec. according to Professor New Comb. The variation in the tropical year is 0.005313041 seconds per year as against 0.00539 and 0.0053675 as determined by some of the European astronomers. The tropical variation in the sun's perihetion is '00036465 sec. in a year, as against, '0003646 as determined by M. Leverrier.

The strongest proof that I can give in support of the accuracy of the moon's variations is the fact that though they are based on the observations of 1905 B. C., 1183 A. D. and 1850 A. D. the moon's sidereal motion, if calculated according to my figures for the year 1850 A. D. exactly sgrees with that determined by the European Astronomers.

One of my objects in writing this work is to contribute my humble quota to the efforts of my co-religeonists who are trying to find out some convenient method to rectify the present Hindu Calendar, which is based on the rules framed about two thousand years ago, and though they were revised from time to time in remote periods, yet no attempt was made in this direction during the past 400 years, and the result is, that the present Hindu calendars are generally unreliable. The science of astronomy plays an important part in the Brahmanical religeon, as the observation of the various ceremonies and rites depends entirely on calendar. It is therefore a matter of great importance that some effective steps should be taken to remove the defects and errors, and to revise the old rules. This book

will show how calendars were revised in ancient time but whether the methods adopted by old astronomers are convenient and suitable to the present time, with due regard to the natural inclination of the present generation, to preserve intact the ancient Indian constellations (Nakshatras) and other ancient relics, is a matter for the serious consideration of my co-religionists.

For the benefit of those of my readers who are unaquainted with Astronomical terms, I have defined those which are used in this work in the first chapter thereof.

I conclude this preface with a few personal remarks. I had a taste for the Indian astronomy from my early youth, which perhaps, I inherited from my lamented father Pandit Bhikshanand of Najibabad in the Bijnor district, who was a very learned Sanscrit scholar and a reputed mathematician of the old Sanscrit school. During my long service under the British Government in the Revenue Department, I carried on my research work in my leisure hours, but I could not find time to collect materials and publish them in a book form. When I retired from the post of the head clerk of Aligarh collectorate in 1914 A. D. I found myself quite incapacitated for any work and was reluctantly obliged to leave my work unfinished. I am still suffering from ill health and therefore ask my reader's indulgence for any error which they might find in this book, as it has been written very hurriedly owing to the rapid decline of my health. In fact, I would have given up the work altogether, had I not been urged and prompted by my affectionate son Pandit Harswarup Pathak, a tahsildar in the district of Moradabad.

I have tried my best to avoid controversial points but in a book of this kind, I have found it impossible not to mention the results of my investigations in connection with such topics. I assure however my readers that I have stated the results without any biassed mind.

DEHRA DUN, U.P.
The 1st March 1920.

BHAGWAN DAS,

CHAPTER I.

Definitions of certain Astronomical terms.

—:C:o:C:—

Stars are the objects in the heaven which appear as points of light to the inhabitants of the earth. They appear to move owing to the earth's diurnal rotation about its axis, but their relative positions in the firmament as regards one another undergo only very insignificant changes which are called proper motions. The ancients classified the stars in the heaven by groups, which were called constellations or Nakshatras. They are also classified according to their different degrees of brightness. The brightest stars are said to be of the first magnitude. The stars of each magnitude are about $2\frac{1}{2}$ times brighter than those of the next magnitude.

The sun is the most important heavenly body to the inhabitants of the earth. With the exception of a very slight motion of its own, which is not perceptible, it appears to change its position from North to South and vice versa and to revolve daily round the earth owing to the latter's diurnal rotation about its axis and its annual movement round the sun.

The planets are the heavenly bodies which like our earth move round the sun. Five of them viz, Mercury, Venus, Mars, Jupiter and Saturn were known to the ancients but many more have been discovered by the Western Astronomers.

The Satellites are the heavenly bodies which move round the planets, as the moon does round our planet (the earth.)

The ecliptic is the apparent path of the sun among the stars.

The zodiac is an imaginary zone in the heaven extending about 8 degrees on both sides of the ecliptic.

The perigee is the point in the orbit of the moon at it's least distance from the earth.

The apogee is the point in the orbit of the moon at it's greatest distance from the earth.

The aphelion is the point in a planets' orbit (path) where it is farthest from the sun.

The perihelion is the point in a planet's orbit where it is nearest to the sun.

The apparent displacement of the heavenly bodies caused by the earth's atmosphere is termed refraction. It causes a celestial body to appear higher above the horizon than it really is.

The node is the point in the orbit of a planet or the moon where it crosses the plane of the earth's orbit.

The nutation is an oscillatory motion of the earth's axis by which it periodically increases and diminishes the earth's inclination to the plane of the ecliptic. The period corresponds to the revolution of the moon's node.

The celestial meridian is the great immaginary circle, which passes through the North and the South points of the horizon and through the Zenith.

The equinoxes are two moving points on the ecliptic. The sun when at these points makes day and night equal all over the world. These are called vernal (spring) and the autumnal equinoxes. There is a retrograde motion of these points which is called the precession of equinoxes. The equinoctial points move completely round the ecliptic and regain their original positions in about 26000 years.

The plane of the ecliptic is inclined to the plane of the equator by an angle, which is called the obliquity of the ecliptic.

The apparent displacement of a celestial body caused by the earth's motion is called the aberration of light. It causes a heavenly body to appear behind it's actual place.

The ecliptic is devided into 360 equal parts called degrees, each degree into 60 minutes and each minute into 60 seconds, Thirty degrees are equel to a sign.

The measurement of a heavenly body by means of the celestial pole and the celestial equator are termed the declination and the right ascension. The measurement by means of the ecliptic and its pole are called the longitudes and the lattitudes.

A Sidhanta is a standard work on the Hindu Astronomy.

Ahargan is the number of aggregate days from the commencement of an epoch. Kali Ahargan is the number of days from the beginning of Kaliyuga, according to Surya Sidhanta.

According to the various Hindu Astronomers a day begins from midnight, sunrise, midday, afternoon and evening.

CHAPTER II.

Antiquity of the Indo-Aryan Race.

General Remarks.

Since the advent of the British Government in India, both Western and Indian Scholars have tried to solve the problem of the ancient Indo-Aryan Civilisation and collected a lot of useful information about different subjects including the Hindu-Aryan Astronomical science, but as far as I gather from their writings, most of them have arrived at no satisfactory conclusions, which can convince an unbiassed mind of their correctness. They have generally differed from one another's views and have assigned various periods to the antiquity of the ancient Indo-Aryan Civilisation. The reasons for all this chaos are many, but I mention below only those which are important.

(*a*) The present state of the ancient Sanscrit works which have come down to the present time. is that most of them were amended and enlarged from time to time while many old works of remote antiquity were reproduced in some later periods in the present classical Sanscrit, with the necessary additions to suit the time. This is the reason that different and sometimes contradictory views are expressed in them. These books are however very useful because they show the different stages of the Indo-Aryan Civilisation but they have misguided the judgment of many scholars who were ignorant of the fact.

(*b*) Religious, or natural prejudices or personal convictions of researchers who could not divest themselves of these defects owing to the first mentioned cause.

(c) The researchers have completely ignored the Indo-Aryan astrological science which has been of great help to me, as many works on that subject contain many valuable information. The existence of this science among the Indo-Aryans has been traced by me to a very remote antiquity.

The Hindu nation, I think, is the only one in the present world which braved numerous oppressive onslaughts, but escaped extinction and somehow managed to outlive other old nations and preserved the remnant of their ancient literature. The credit for this is chiefly due to the priestly caste or Brahmans and I think they have thus atoned for all the faults which are attributed to them. Whether this old nation which now shows signs of decay under its present environments will continue to exist, is a matter which only the futurity will show.

Unfortunately, the Brahmans could generally preserve some of their religeous works which they esteemed much, and all other works, with a few exceptions, have been lost. The result is, that there is no reliable history of the ancient vast period. In these circumstances, a researcher must try to gather his information from all the available sources.

In the absence of any ancient Indian history it is only by means of Indian Nakshatras, divisions of time and old traditions narrated in the Indian religeous works that the antiquity of the Indo-Aryan race can be traced. The solution of these points, however, depends to a considerable extent on the discovery of the ancient abode of the Aryan race. I intend, therefore, to deal with these matters in the following paras of this Chapter.

Before proceeding further, I wish to draw special attention of researchers to the fact, that the Vedas and the works called Brahmans are the only ancient books now existing in the world, which contain a mass of useful information on the past history of the Aryan race and that they should be studied thoroughly without any religeous bias.

2. *The original home of the Ancient Aryan race.*

According to the Indo-Aryan religeous works, the Creator had a son called Kashyap, who had two wives named Aditi and Diti. It is stated in the Rig Veda (X-72-8), that Aditi gave birth to 8 sons. With seven, she went up to the heavens and cast away the 8th called Martand, which is a name of the sun. In the next verse (X-72-9), it is stated that the seven sons of Aditi were born in a former Yuga but as the 8th son (Martand) used to die and again spring to life, she again gave birth to it. The sun was supposed to die, while fighting with Asuras, at evening, and spring to life daily, vide Vishnu Puran II-8-45 & 46. Aditi was Devas' mother and Diti of Daityas or Asuras (Rig Veda I-113-19 & V-62-8.) According to the Rig Veda (IX-114-4) the seven Aditya Dewas (*i.e.* the Dewas, the sons of Aditi) were called Vasus. According to Taitraiya Brahman (I-5-2-5) the Nakshatras or constellations were the Dewas' abodes. The root meaning of the word 'Dewa' is a shining object and it is therefore clear that the visible heavenly bodies were originally called Dewas. According to Amarkosh, an ancient Sanscrit dictionary, Asuras were also called Daityas (Sons of Diti) and *Purva* Dewas or *former* Dewas.

It is stated in the Rig Veda (I-22-18) that Vishnu traverses the heaven with three steps. The sun was also called Vishnu, Vide Nirukt (IV-2-37), an ancient Vedic dictionary.

According to Surya Sidhanta and other Astronomical and religious works, a Dewa's day is equal to six months corresponding to a night of Asuras and vice versa.

It is stated in the Rig Veda (IX—42—1) that Aditi begot heavenly bodies and the sun in waters.

In conneetion with the 48 ancient constellations, which have come down to the European nations through the ancient Greeks, it is noticeable that all the constellations having high North celestial latitudes, with the single exception of that called Delphinus, are figured and named as birds, land animals including man and reptiles and objects pertaining to land, *viz.*, The Bears, The Eagle, The Dragon, The herdsman, The Swan, The Kneeler, The Serpent holder, The Serpent, The Maiden (Andrameda) and her deliverer (Perseus), The lady on her throne and her husband, The Charioteer, The Crown, The harp and The flying horse.

As regards Delphinus, it is quite possible, that its name was changed at some time when it was close to the heavenly equator and included the stars now formed into a separate constellation called Equuleus.

On the other hand several of the remaining constellations are figured and named as marine animals and rivers.

In consideration of the above mentioned facts, I have come to the following conclusions.

(*a*) The celestial sphere was called Kashyapa.

(*b*) The invisible and the visible parts of the heaven were called Diti and Aditi respectively.

(*c*) The heavenly equator was the horizon.

(*d*) The movement of certain stars into the invisible part of the heaven and vice versa which was of course caused by the retrograde motion of the vernal equinoctial point, caused the ancient Aryans to name the visible stars as Dewas (Sons of Aditi) and the invisible but formerly visible stars as Daityas (Sons of Diti) as well as Purva Dewas or former Dewas.

(*e*) The stars marking the half of the ecliptic were Vasus. They were considered the best of all the Dewas, vide the Rig Veda (I-43-5). They were seven in number because the three marked the equinoctial and the North Solstitial points and the rest the intervening signs. Every sign was equal to a step of Vishnu or the sun. Thus Vishnu moved upwards with three steps and downwards with three. The North Circumpolar stars and Jupiter, which was the only planet first known to the ancient Aryans, must have appeared as making about 180 revolutions in a night near the pole. In a day and a night of the arctic region Jupiter's movement on the ecliptic must have been nearly equal to a sign. These facts must have led the ancient Aryans to devide the ecliptic into 6 parts and each part into thirty degrees, corresponding to about thirty sidereal revolutions. Similarly the moon's revolutions in the six signs which numbered about 14 caused the ancient Aryans to devide the half of the Zodiac into fourteen constellations which were called Nakshatras. When the Aryan race migrated southward and the whole of the ecliptic and the Zodiac were known, the signs and Nakshatras were doubled.

(*f*) The invisible part of the heaven was supposed to have been filled with water and inhabited by Daityas, snakes &c. Hence, it was presumed that the sun, the moon &c. were born in waters.

(*g*) A Yuga, which means a couple, was originally equal to a day and a night of the arctic region.

(*h*) The North portion of the ecliptic was the Aryaman's or the Sun's path, vide (Rig Veda I-105-6, & Taitraiya Brahman I-7-6-6). It appears from the Rig Veda (VIII-85-13) and Atharva Veda (XIII-2-42 to 43) that the ancient Aryans must have discovered at some later period tha half of the ecliptic was below their horizon, as it is inferred from these quotations that the southward half of the ecliptic was called Ansumati and the sun when moving in that part was called Krishna or dark. It was also called Rama, vide the Yajur Veda XXIX-19-58 and Nirukt I-7.

(*i*) The facts stated above about the 48 ancient constellations, show that the most of them were originally designed by the Aryan race but some of them were revised by different tribes of that race when they migrated southward and settled in different parts of the earth.

It will appear from the above mentioned facts that the original home of the ancient Aryan race was in the North arctic region, though it is not understood how they managed to live there. It is however, quite possible that the region was formerly warmer than at present. There are also other facts which support the above conclusion and I mention below some of them.

(a) It is noticcable that in the Vedas, there are numerous hymns praying for a life of 100 Sharats (winter) or Hima (Him means snow). The former word means winter but came to be regarded in the post vedic period as a synonym of the word 'year' but the second word *i.e.* 'Hima' clears the point beyond doubt. These facts show that winters were long and rigid in the regions where the ancient Aryans lived. Atleast, they show that the original home of the Aryan race was in some snowy region and importance to this season was given, because the human life was considered precarious in the winter season. The author of Vrihat Arayanak Upnishad, expressed some old idea when he said, that in Salvation there was neither grief nor *snow*.

(b) The numerous hymns in the Vedas about Indra's (a name of the Sun) fighting with Asuras and especially Vritta (darkness) and those praising dusk and dawn, would simply appear childish and nonsense, unless they were based on some special circumstances.

(c) It appears from Grahya Sutras, the Vedic theological works, that performance of social and religeons ceremonies including that of marriage was forbidden in a dark fortnight and in Dakshnayan. The former restriction is no longer observed but the latter is still followed. The latter term actually means the Sun's position in the southern Solstice or when fhe Sun is in the southern hemisphere, but according to the present practice the period of the southward course of the Sun is meant. There is some special reason for

every custom but I have been unable to find out any satisfactory reason for these prohibitions. In India, of course, three or four months of the rainy season are somewhat inconvenient but not the the whole period now called Dakshnayan. As regards the lunar fortnights, they are practically the same as regards the general convenience, and this is probably the reason for the discontinuance of this restriction. In the Arctic regions the circumstances are, however, different and the prohibitions for those regions, are reasonable.

(*d*) Pitri's ceremony are now performed for the satisfaction of departed souls. The proper time for their performance is evening or afternoon and the first fortnight preceding the autumnal equinox. The origin of these practices could satisfactorily be explained, if it were supposed that the original home of the ancient Aryan race was in the Arctic region. I think they were originally performed for the departing sun when it was nearing the Autumnal equinox. As according to the verses of the Rig Veda and Vishnu Puran, the sun was supposed to die and born again, it is very probable that this belief was the origin of the Pitri's ceremony and the doctrine of transmigration of soul. According to Vishnu Puran (II-8-80), the abode of Pitris was beyond the south solstitial point. This fact also explains satisfactorily the statement in Purans, that Pitris have to cross a vast river or ocean befor they reach their destination, as the region beyond the arctic horizon was believed to have been filled with water.

(e) In chapter XIV of Surya Sidhanta, 9 kinds of divisions of time are mentioned. Of these, the following are noticeable in connection with this subject.

Sidereal day which was equal to one Sidereal revolution.

Jupiter—year which commenced from the planet's rising and setting.

Manwantra, probably based on the revolutions of Pole Stars.

The adoption of such a day and a year for ordinary purposes is strange, but in the arctic region it might have been the practice to reckon time during long nights by means of Star's and Jupiter's revolutions around the Pole Star, for details see part 4 of this chapter.

(f) The legend of the great flood, which is also narrated in the ancient Indian religeous works, probably refers to the time when the ancient Aryans were forced to leave their arctic home, owing to some serious flood caused perhaps by glaciers.

(g) The legend in Mahabharat, Valmiki Ramayan and some other works about the creation of Stars, in the southern region by Vishwamitra, is apparently based on the fact that he was the astronomer, who formed these clusters of Stars, when the Aryan race migrated downwards.

(h) Now I proceed to mention a very important point on this subject. Among the 48 constellations which have come down from the extremely ancient time and are still used by the westernastronomers, there is one which is called

Hydra and is the longest of them, *i.e.* about 100 degrees. Now the question arises, as to why this constellation was figured and named as a *water* snake. I have already qnoted above the Vedic hymns in support of the fact, that the invisible part of the heaven was supposed to have been filled with water or most probably that part which was between the south solstice and the antumnal eqninoctial point, as the rest was the abode of Pitris. When the precession of the vernal equinoctial point caused the invisible stars to appear on the horizon of the arctic region they were figured into clusters representing marine animals, &c. In support of this fact, I mention a legend narrated in the ancient Indian religeous works. At some remote past time, Dewas and Asuras churned the ocean out of which fourteen jewels were produced, including nectar. Vishnu, so arranged the distribution of the nectar that only Dewas should drink it. But a cunning demon managed to mingle with the Dewas and drank the nectar. When found out, his head was cut off by Vishnu. As the demon could not die, because he had drunk the nectar, his head passed into Dewas' and his tail into Asuras' regions as separate bodies.

This legend apparently refers to an astronomical event which necessitated a rearrangement of Nakshtras, owing to the appearance of some new stars on the heavenly sphere in the arctic region. The legend is supported by the following facts.

Among the Indian Nakshatras there is one which is called 'Ashlesha'. The word means an object which has lost its connection with its body. The Nakshatra is figured

as the head of a dragon and its presiding deity is 'sarp' or serpent. The Nakshatra is the head of the constellation called Hydra by the ancient Greeks. As it was a water snake, its presiding deity was a land serpent called Draco. It is noticeable that the longitude of Delta Hydrae and Lambda Draconis is nearly the same. The former star marks the commencement of Hydra's head, while the latter of Draco's tail. Draco is a North circumpolar constellation and is situated very high above Hydra. It appears from the above mentioned facts that these constellations were purposely designed and that the above legend, as narrated in the Indo-Aryan religeous works, was based on an actual astronomical event.

(*i*) It is noticeable that the old principal stars of Chitra Nakshatra *i.e.* Delta and Theta Virginis, which are referred to in the Indian astronomical works and even in the Rig Veda (II-35-3) were called 'Apa' (water) and Apam Napat or Apam Vatsa (child of water), while the constellation beyond 180 degrees or half of the zodiacal sphere was called Revti, Min or Fishes. According to Rig Veda (VI-55 4 and 6, VI-53-1) Pushan, which was a name of the sun and of the presiding deity of Revti or the Fishes, was the lord of the sun's path and had goats (Pegasus) for the team he drove and had other bay steeds (Aries) at hand and with the aid of both of them he slew Vritta or darkness. It appears, that Delta and Theta Verginis were named 'water' and 'child of water' when they appeared for the first time on the horizon of the arctic region.

CHAPTER III.

3. Antiquity of Indian Nakshatras.

At the outset, I may note with a view to avoid any misunderstanding that I shall use the word 'Constellation' only for those groups of stars which are not the Indian Nakshatras.

When the ancient Aryans were living in the arctic region they had naturally much regard for the sun and fire, which were the chief objects of their comfort. I belive, in fact, that the ancient Aryans were originally the sun and fire worshippers. They called the suu by various names, some of which were subseqnently assigned to certain groups of stars wlth regard to their position in respect to the sun. It appears, however, that in course of time the origin of such names was forgotten and stars were ranked as superior and inferior Dewas. When the ancient Aryans came to know that certain stars were not subject to periodical disappearance from the arctic horizon, they were even deified and specially those whieh had very high altitudes. According to the Vedas the chief work of Indra was the killing of Vritta or the demon of darkness and it appears therefore that the rising sun was called by that name. The setting sun was probably named Rudra, because it was the forerunner of a terribly cold long winter in the arctic region and the ancieuts used to mourn for the departing sun. The word Rudra is derived from the root 'Rud' to weep and in secondary sense a terrible object is also called Rudra. The midday sun was probably called Prajapati or Brahma. The sun's position at the south solstitial point or the midnight sun was named Vishnu or Krishna. This is the reason that these deities are figured as having dark complexion. As far as I have been able to ascertain the above mentioned names of the Sun were subsequently assigned to the following constellations.

Indra—Ophiuchus and Hercules.
Rudra—Ursa Minor.
Brahma—Lyra and Auriga.
Vishnu—Cygnus.

The longitudes of Alpha and Epsilon scorpii, the present and the former chief stars of Jyeshta Nakshatra, the presiding deity of which is Indra nearly agree with those of Epsilon and Alpha Hercules respectively. According to a legend which is narrated in several Indian religeous works, there was a hero called Vali or a mighty one. He conquered Dewas and became their lord or Indra. He had a celestial necklace, vide Mahabharat (XIV-223-23). Subsequently he was deprived of his position by Vishnu and another Deva became Indra. Vali was granted a boon by Vishnu that the latter would guard the former's new abode in Patal or lower region in the shape of a dwarf. It appears that originally there was a constellation called Vali, which included the present three groups of stars, now known as Ophiuchus, Corona and Serpens. Apparently owing to its size it was called Vali or a mighty one, When a part of it disappeared from the arctic horizon in consequence of the polar movements, the constellation known as Hercules was appointed as the successor of Vali and the latter was divided into three parts called Corona, Serpens or Serpent and Ophiuchus or Serpent holder. From the nature of the boon granted to Vali, it appears that Hercules was named Indra, when Alpha Ophiuchi marked the Sun's south Solstitial position. This is also supported by the fact, that Alpha Aurigae marked at the time the North solstitial point and that the constellation of Auriga is still called Brahma Rasni or the sign of Brahma. Brahma is also the presiding deity of Abhijit Nakshatra and apparently Auriga succeeded to the position when a new Indra was appointed. Thus in a complete revolution of the vernal equinoctial point, there were 2 Indras and 2 Brahmas, vide the last part of this chapter.

Rudra is the presiding deity of Ādra Nakshatra, the principal star of which is Alpha Orionis. Its longitude is almost the same as that of Alpha Ursae Minoris. The latter constellation was therefore called Rudra. Moreover, this deity is associated with serpents and in fact the constellation called Draco almost encircles Ursa Minor or Rudra.

When the abode of the Aryan race was in the arctic region the half of the Zodiac Northward of the heavenly equator was divided into 6 signs and 14 Nakshatras.

Some other constellations were also designed for determining the Sun's probable movements below the arctic horizon, which the ancient Aryans might have been able to find out by means of a full moon. At least they might have been, able in this way to ascertain the Sun's position at the South solstitial point for the purpose of finding out the time of their midnight. In this connection it is noticeable that the chief stars of the Indian Nakshatras are with a few exceptions neither the most brilliant stars of their Nakshatras nor do they mark the limits of the latter, but the majority of them were so selected that two of them must have marked approximately the North and South solstitial points at a time. I believe that this was the case originally with all the principal stars but some of them have undergone changes in course of time. The above, of course, appears very strange, considering the fact that the Indo-Aryans used to measure longitudes of stars on polar circles or declination and not on latitudinal circles. Vide Whitney's Surya Sidhanta. Under these circumstances, I am of opinion that originally it was the practice among the ancient Aryans to note down the stars, which from time to time marked the North and South solstitial points. Such stars numbered 120 which were called Asuadityas. When the Nakshatras were formed, certain Asuadityas were fixed as the principal stars of the former.

It is very strange, that there are some principal stars of the Indian Nakshatras which have almost the same longitudes, if measured on latitudinal circles, as those of Alpha Ursae Minoris, Delta Cygni and Gamma Cephei which must have served the purpose of a pole star in the past ages. Alpha Lyrae the chief star of Abhijit Nakshatra must have been also at some time close to the pole. The above coincidence cannot be a mere chance, but must have been due to the fact that the principal stars of the Nakshatras concerned (Alpha Orionis, Beta Delphini and Eta Tauri the chief stars of Adra, Dhanishta and Kritika respectively) were selected when Alpha Ursae Minoris, Delta Cygni and Gamma Cephei were either pole stars or situated at the time near the pole. It is however, remarkable that longitude of Alpha Draconis which was the pole star about 5000 years ago, does not coincide with that of any principal stars of the Indian Nakshatras. This is probably due to some change in the chief star of Purva Phalguni, the Nakshatra concerned.

It is stated in the Indo-Aryan religeous works, that at the beginning of the Creation, Vishnu or the Sun was sleeping on a Nag (water snake) and Brahma was sitting in a lotus flower, the plant of which grew from the navel of Vishnu. Nag was, of course, the constellation subsequently figured and named as Ashlesha or the head of Hydra, Vide the preceding part of this chapter. As already stated, the presiding deity of Abhijit Nakshatra is Brahma and its principal star is Alpha Lyrae. It appears, however, from the legend that the star referred to was not the pole star at the time, but it was not very far from the pole. Apparently the time alluded to was the period when the South solstitial point was marked on the Arctic horizon by Alpha Ursae Majoris, a star of the constellation of Bears. The abode of Pitris or departed souls which was, according to the belief of the ancient Aryan race, beyond the South

solstitial point, was marked on the Arctic horizon by Delta Ursae Majoris. There is only a difference of about a degree in the longitude of this star as compared with that of Alpha Leonis, the principal star of Magha Nakshatra. This is the reason that Pitris were fixed as the presiding deities of this Nakshatra when it subsequently appeared on the Arctic horizon and was designed as a Nakshatra. The followiug facts strongly support the above conclusion.

Accordine to the Rig Veda, the Bears or the Sapt Rishis were the old Dewas of Pitris, Vide (X-109-4). The dead used to go to them (X-16-1) and they punished Pitris for their sins (X-15-6). Subsequently, Yama was appointed as Deity of Pitris. Either Cassiopeia or Triangulam was Yama but most probably the latter.

When Alpha Ursae Majoris marked the South solstitial point on the Arctic horizon the constellation called Draco or land serpent was designed as a contrast to the supposed Nag or water snake below the horizon. It was called Nahush by the ancient Indo-Aryans and was figured, as if it was riding on a chariot, vide Rig Veda (III-53-6 & VIII-46-27). The constellation of Bears and Auriga were then named chariot and charioteer respectively. When in the course of time the *North* solstitial point was marked by Ashlesha Nakshatra or the head of Hydra, the latter was figured as a water snake and the constellation of Draco or sarp was fixed as its presiding deity. The Bears were renamed as Sapt Rishis or the seven saints, owing to their changed position. It is stated in the Indian religeous works, that Nahush became a serpent with his head downward, as was his position at the time, owing to his former sin, which he had committed by making Sapt Rishis as his chariot. Of course the legend was devised to account for the changed positions of the constellations concerned. Subsequently Auriga was also named Brahma, as already stated.

From the above mentioned facts, I have drawn the following conclusions.

(*a*) When the Nakstatras and Constellations were formed in the Arctic region, the star called Beta Delphini, which is the chief star of Dhanishta marked the North solstitial point. Delta Cygni, the longitude of which is almost the same as that of the former, was the pole star. Alpha Lyrae was also not very far from the pole and the position of the midnight Sun was marked by Alpha Ursae Majoris.

(*b*) Since the formation of Nakstatras, the ancient Aryans continued to live in the arctic region till at least the time when the North solstitial point was marked by Alpha Aurigae.

There is however a strong evidence to show that they continued to live in the arctic region, even after the time alluded to above. The stars Delta and Theta Virginis were called by the Indo-Aryans as Apa (water) and Apam Vatsa (child of waters), respectively. It is quite clear therefore that they were so called when they last appeared on the arctic horizon *ie* when they coincided with the vernal equinoctial point. In this connection it is noticeable, that at the time referred to the Autumnal equinox was in Revti Nakshatra, which is still called the Fishes. Probably the Aryan race migrated South ward at about this period, owing to some serious flood in the Arctic region caused perhaps by glaciers. I think it was the great deluge, which is alluded to by Hebrew and Babylonian traditions. The legend about it, as narrated in the Indo-Aryan religeous works refers to a great fish, which helped the ancients at the time. It is quite possible that the constellation of Fishes might have some connection with the great fish or the asterism was so named in commemoration of the deluge.

According to the Indian astrological works, a death in a family when the moon is in the five Nakshatras, commencing from Dhanishta (Dolphin) forebodes successive deaths in that family. This superstition, apparently originated at the time when the abode of the Aryan race was at some place where the part of the Zodiac marked by these Nakshatras was below the horizon. The superstition was most probably due to the fact that a death in a family during a long cold night and specially when there was no moon, must have been very inconvenient and dangerous to other members of that family. In this connection, it is noticeable that the constellations corresponding to these five Nakshatras, are figured as marine animals among the 48 constellations which have come down through the ancient Greeks.

When the South solstitial point reached the Indian Nakshatra, now called Mul, the abode of the Indian branch of the Aryan race, was in some place the latitude of which was about 50 degrees North. The position of this Nakshatra at the time is clearly referred to in the Vedic theological works. It appears from Taitraiya Aranyak (II-6-1 and the Atharva Veda (III-2-7-4) that there were two stars which were called Vrichritrau. It is stated in the Atharva Veda (VI-110-2) that one of them was detached from Jyeshta, that they were formed as a Nakshatra, which was called Mul Varhni and that they belonged to Yama, the present deity of Pitris or departed souls. The present Nakshatra Mul, which is next to Jyeshta was formerly called Mul Varhni, Vide Taitraiya Brahman (I-5). The word means a destroyer of its race or its lower body. These stars were probably also called Shablau and Kal Kunjas. It is stated in the Rig Veda (X-14-10-11) that the two dogs named Shablau guarded the Pitris' path to Yama's abode.

According to Taitraiya Brahman (I-1-2-4 to 6) some demons called Kal Kunjas constructed a fire altar (probably

the tower of Babel referred to in the holy Bible) to go up to heaven. Indra the head of Dewas also put a brick called 'Chitra' which is at present a name of a Nakshatra (Virgin). They climbed up to heaven, but Indra pulled out his brick and they tumbled down, but two of them flew up to heaven and the rest were killed by Indra. The two, who flew up to heaven, were called heavenly dogs, vide also Shatpath Brahman (II-1-2-13 to 17). In the Atharva Veda three heavenly dogs called Kal Kunjas are mentioned Vide VI-80. According to Mr. Robert Brown, the 27th Babylonian asterism consisted of Theta, Iota, Kappa, Lambda and Upsilon, Scorpii and its presiding deity was a leader of the dogs. The stars stated above are situated in the present Indian Nakshatra called Mul. According to astrological works and Valmiki Ramayan, the birth of a child when the moon is in the above Nakshatra foreboides the destruction of the child's family. The birth of a child at the end of Jyeshta is also inauspicious.

It is clear from the above mentioned facts, that the Nakshatra now called Mul lost, at some time, its lower body and that the Nakshatra was replaced by an asterism called Mul Varhni, which was formed by detaching a star from Jyeshta. Its other name Vrichritrau shows that the new Nakshatra consisted only of two stars, as the word was used in its dual form. This shows that only one star of the old Nakshatra did not disappear. The Nakshatra's position at the South solstitial point at the time is proved by the facts, that it belonged to Yama the god of Pitris and that the two stars consisting the Nakshatra guarded the Pitris' path to Yama's abode. Foreign evidence on the point is furnished by the Babylonian scheme of asterisms. There can be no doubt that the stars referred to are Epsilon and Upsilon Scorpii. The former was originally the principal star of Jyeshta and was replaced at the time by Alpha Scorpii, the present chief star of that Nakshatra. There is another

star called Lambda Scorpii which is very close to Upsilon Scorpii. It must have been included later in Mul Varhni Nakshatra, thus increasing the number of heavenly dogs to three, as stated in the Atharva Veda. Now the question arises as to how the old Nakshatra lost its lower portion. It must have been due to the fact that the latter had disappeared from the horizon of the then abode of the Aryan race.

About 900 years later when the South solstitial point reached Jyeshta, this Nakshatra was named Rohni, because the Sun's Northward movement then commenced from Jyeshta. It is no longer called Rohni, but it appears from Taitraiya Brahman [I-5] that at least up to the time when that work was composed, the two Nakshatras, the chief stars of which are Alpha Tauri and Alpha Scorpii, were called by that name.

Iota Aurigae was probably the original principal star of the Nakshatra now called Mrigshira. Beta Orionis was substituted for it and the Nakshatra was named Mriga or deer, as appears from the Rig Veda [VII-93-14]. Mriga is also mentioned in Taitraiya Brahman [I-5], not as a Nakshatra, as in the Rig Veda, but as a constellation situated close to the present Nakshatra Mrigshira. It is therefore quite reasonable to suppose, that the latter was substituted for the former Nakshatra Mriga. This was not however the actual fact, as appears from the Rig Veda (X-61-59) and Aitraiya Brahman (III-33). In the Rig Veda hymn, it is stated that Prajapati or Brahma approached his own daughter. This hymn is explained as stated below by the auther of Aitraiya Brahman.

"Prajapati fell in love with his own daughter. He transformed himself into a buck, while his daughter assumed the shape of a female deer. The Dewas then became angry and produced a horible Dewa and ordered him to kill

Prajapati. The former then pierced the latter with an arrow. Then Prajapati became Mriga, the killer Mrig Vyadh, the female deer which had been called Rohit became Rohni and the arrow was named the three knotted arrow." Vide also shatpath Brahman (II-1-8).

According to Surya sidhanta, Delta Aurigae, Alpha Aurigae and Sirius are respectively called Prajapati or Brahma, Brahma Hriday or the heart of Brahma and Mriga Vyadh or the hunter of deer. Alpha Aurigae is the brightest star of the constellation and must have been originally called Prajapati instead of his heart. Moreover, its right ascension nearly coincides with that of Alpha Tauri, the chief star of Rohni Nakshatra, when these stars mark the vernal equinoctial point. This was most probably the reason, that Alpha Aurigae was fixed as the presiding deity of Alpha Tauri and was therefore cosidered as the latter's father.

From the above mentioned facts, I have come to the conclusion that the star Alpha Tauri was originally called Rohit, on account of its colour, that it became Rohni when it began to move Northward from the South solstitial point, as its present name (Rohni) shows, that Mriga Vyadh or Sirius became visible for the *first* time when the right asceusion of Alpha Aurigae coincided with that of Beta Orionis, the principal star of the old Nakshatra Mriga, that Prajapati was then substituted for the former and the belt of the Orion was named as Ishu trikanda or a three knotted arrow. When Alpha Aurigae no longer served the purpose of Mriga Nakshatra, the present Nakshatra Mrigshira or the head of the deer was formed. It appears therefore that the abode of Indo-Aryans was in 33 or 34 latitude North when Alpha Tauri marked the South solstitial point, *i.e.* more than 11000 years ago.

It is stated in Puranas, that a Dewa called Skand, whose foster mothers were Kritikas or Pleiades was

born for destruction of demons and was appointed by Indra to the command of Dewas' army, vide also Mahabharat (III-Chapters 223 to 229). It is qiute possible that this Dewa was Beta Orionis and was so named when, at the antumnal equinoctial point, there was a slight difference between its right ascension and that of Eta Tauri, the principal star of Kritika. It is also quite possible, that the latter star was called Skand, when it was fixed as the chief star of that Nakshatra. There is, however, one strong evidence, which does not support either of the above suppositions. In Yajur Veda, the Kali Yuga is called Skand. Another name of this Yuga is Tishya or Pushya, and Skand must have had some connection with that Nakshatra. Skand was either Alpha Canis Minoris or it was another name of Sirius. Most probably it was the latter, as right ascension of Sirius coincided with that of the chief star of Tishya, when Alpha Tauri marked the South solstitial point vide the legend about Prajapati.

So far, I have dealt with the Vedic Theologieal works, which of course, are very ancient. I now proceed to give some information bearing on the subject of the Indian Antiquity, which I have gathered from astrological and other works of later period. The works on the Indian astrology, are very important, because they contain some valuable information abont the history of the Indian Nakshatras, since the time when the vernal equinoctial point began to retrogade through the Indian Nakshtra called Adra, the principal star of which is Alpha Orionis. As these works contain no reference to any obsolete Nakshatras, I must presume that this was the time, when the science of Astronomy began to be used for Astrological purposes, though there are some indications in those works which certainly show, that Astrology in primitive form was in vogue, even in a very remote period. Periods of planets were fixed from time to time for the purpose of fortelling a man's

fortune during his life time. These were called Dashas and they were of several kinds. I propose to mention a few of them in the order of their antiquity. The oldest of them is called Ashtotri, aggregating 108 years. Perhaps this period was considered at that time the maximum duration of the human life and this fact, probably accounts for the practice of using a string (Mala) of 108 beads for the purpose of a prayer. The period was divided into 8 unequal parts and they were allotted to the Sun, the moon, five major planets and to the moon's node, which was called Rahu. Four were considered good and the rest bad, but it is significant, that the order, in which they follow one another, is not in accordance with the practice of the Indian Astronomers, whose works are still in existence. It does not even agree with the names of the heavenly bodies, assigned to week-days. The order in which the *Dashas* are stated is the following. Sun, Moon, Mars, Mercury, Saturn, Jupiter, Rahu and Venus. The number of Nakshatras used is 28, of which the first is Adra, which is the sixth of the present arrangement of 27 Nakshatras. This shows that the *Dashas* were designed when Adra Nakshatra headed the list or the Vernal equinoctial point was retrograding through it. It is also a proof beyond doubt of the fact, that the five major planets were known to the Hindu Aryans at the time. As regards Rahu, it cannot be said positively that it was even at that time the name of the moon's node, as is the case at present. It is quite possible that the Indians of that period gave that name to a supposed demon, who caused eclipses of the Sun and the moon.

The second *Dasha* is called Yogni of 36 years, a period which shows that the maximum age was still considered of 108 years, and every Dasha was to run thrice in a full age. This *Dasha* also begins from Adra Nakshatra.

The third Dasha is called Binsotri, aggregating 120 years, which commences from Kritika Nakshatra, *i.e.* the third

constellation of the present arrangement. The number of the Dashas is nine, *i.e.* one more Dasha for the moon's second node. It is therefore probable, that the Indians of that period knew the true cause of eclipses. The Dasha was designed when Kritika headed the list of Nakshatras, and the vernal equinoctial point was retrogading through it. As regards the works on the *Muhurtas*, a careful study of the various groups in which the Nakshatras were formed from time to time, gives very valuable information on the subject. The oldest classification which is even referred to in Grahya Sutras, the ancient works on the Vedic rituals, is the division of Nakshatras into three groups, namely female, neuter and male beginnig with Adra Nakshatra, as is the case with the above mentioned *Ashtotri* and *Yogni* Dashas. This division was therefore made, when the vernal equinoctial point was in that Nakshatra. When it retrograded to Rohni, the fourth constellation of the present arrangement, the Nakshatras were formed into 4 groups of 7 constellations each, which were termed blind &c and commeneed from Rohni. It also appears probable that another division of 28 constellations into 7 groups, corresponding to week days and called Dhruva &c was also made at about the same time, as Rohni is placed in the first group. This is the oldest reference to the week days in the Indian books which have come under my notice. When the vernal equinoctial point retrograded to Kritika Nakshatra, the Nakshatras were again formed into several groups commencing from Kritika for various astrological purposes, including the marriage ceremony and suitability of brides and bridegrooms on astrological points of view. Of these, I may mention Yoni, Panch Shalaka, Yamitra, Shani Chakra, Aikargal and Sapt Nadi Chakra.

A curious way of naming children still exists among the Hindus, which was apparently devised for the sake of facility in foretelling events. It was first designed when the vernal equinox was either in Adra or Kritika. Every Nakshatra was divded into 4 parts and one alphabet was

allotted to every part. This is calld *Avak Hora Chakra*. It at present begins from the first quarter of Ashwani (Aries), which now heads the list of Nakshatras, with the letter '*Chu*'. But why it is called *Avak* and why it begins from '*Chu*' and not from the letter '*Cha*'. The reason is simply this, that the method of thus naming children was devised long before the Vernal equinoctial point retrograded to Ashwani Nakshatra, as will appear from the following circumstances. The first part of Kritika is represented by the Vowel '*a*'. Then 4 short vowels follow. Then the first consonant is '*va*' with its inflections according to the sound of every vowel. The next consonant is '*Ka*' and so on. For facility of reference, the first three Alphabets were grouped in naming the design. It is also noticeable, that the letter '*Cha*' and its inflections are partly allotted to the first Nakshatra Ashwani and partly to Revti, the last Nakshatra of the present arrangement. These facts very clearly show, that this method of naming children was adopted, when Kritika was the first Nakshatra and when the Vernal equinoctial point was retrograding through it, but a further scrutiny of the arrangement of Alphabets, produces an impression, that the origin of the method was earlier and that it was revised during the Kritika period. There being 112 parts of 28 Nakshatras, 5 vowels and 19 consonants were allotted to 100 parts (5 parts for vowels and 95 for 19 consonants with their inflections) and the remaining 12 consonants *without inflections* to the rest. These 12 letters were allotted to the second, third and fourth parts of only 4 Nakshatras, situated at intervals of six Nakshatras, commencing from Adra. It is also noticeable that the arrangement of Alphabets neither agrees with the present classification nor with that of the renowned grammarian Painini, though there would not have been the least inconvenience, if either classification were followed. This shows that the Indian classification of Alphabets have undergone many changes.

The above facts also prove beyond doubt, that Alphabets with their classification into vowels and consonants, with their inflections, were known to the ancient Indians, at least in the Kritika period, if not earlier.

When the Vernal equinoctial point retrograded to Bharni, the 27 Nakshatras (the number was reduced to 27 during the Kritika period) were divided into 3 parts of 9 each, commencing from Bharni, for foretelling events, according to the positions of Venus, vide chapter 9 of Varahi Sanhita. When the Vernal equinoctial point reached Ashwani (the aries), the first Nakshatra of the present arrangement, the Indian Astrologers made some further divisions of 27 Nakshatras, commencing from Ashwani (The Aries), as for an instance, the Trinadi chakra. I have now traced the Indo-Aryan antiquity by means of Nakshatras, but I think it would not be out of place to mention here, some other facts which are connected indirectly with the above subject.

The Sanscrit word for Sign is Rash or Rashi, vide Indian Astronomical works and Amarkosh dictionary. The word is also used in this sense in Mahabharat, vide Ban Parva, chapter 190 verses 90 & 91. This word has been used in connection with the constellation of Auriga, which was called Brahma Rashi, vide Mahabharat Bhishma Parva, chapter 3 and Valmiki Ramayan VI-4-48. It is strange, that the ancient names of Alpha Herculis and Alpha Ophiuchi should begin with the word 'Ras' *ie* Ras-al-Gathi and Ras-al-Hague. The difference between the longitude of Alpha Ophiuchi and that of Alpha Aurigae, the most brilliant star of the constellation called Brahm Rashi, is almost equal to 180 degrees or one half of the sphere. I have already stated that the latter constellation, which had been originally named charioteer was called Brahm Rashi, when its chief star Alpha Aurigae marked the North solstitial

point. The longitude of the former principal star of Jyeshta Nakshatra (Epsilon Scorpii) is nearly the same as that of Alpha Herculis and they both marked therefore the North solstitial point at some time. I have already stated that the former was transferred to Mul, when South solstice was in that Nakshatra.

The Indian Nakshatras, with their presiding dieties and the 48 constellations which have come down to the European nations through the ancient Greeks, appears to have had a common origin. In support of this conclusion, I have already referred to the similarity in the names of the constellations, called Ursa Major, Draco and Hydra, as well as in their positions. There are however, some other important points in connection with this subject. Among the 48 constellations there is one which is called Aquila or the eagle. It corresponds to the Indian Nakshatra, called Shrawan, the presiding deity of which is Vishnu. The riding bird of this divinity is Garur or Eagle.

Another Sanscrit name of Kritika Nakshatra is Vahula, which means 'many'. Its Greek name Pleiades also means 'Many'. Its Hebrew name 'Kimah' means cluster, and its Babylonian name 'Kimtu' means 'family'. It may, however, be argued, that the Indians borrowed the name from the ancient Greeks. Fortunately, there is a clear evidence rebutting the above argument. As far as I know, there is no explanation for assigning such a name to this asterism in any foreign work. This is, however, not the case with the ancient Indian works. It is clearly stated in Shatpath Brahman (II-1-8-2), which is a very ancient work and was composed when the Vernal equinoctial point was retrograding through Kritika Nakshatra, *ie* more than 4000 years ago, that other asterisms consist of one, two, three or four stars, but the stars in Kritika are more than in any Nakshatra. The above

facts clearly show, that originally, the zoadical constellations among the Aryan races were like those of Indo-Aryans. It appears therefore, that these constellations were grouped together to represent the twelve signs of the zodiac, most probably, when the Vernal equinoctial point was in Pleiades and figured according to some old name of one of the components or according to the whim of the designer. I have seen it stated, that because tiger, elephant, &c are not represented in these figures, these constellations were not formed in India. In this connection, I may refer to the Rig Veda hymn X-28-4 in which Lion or Tiger and Fox are mentioned. Moreover, in the calendar of Paras Ram, which was started in 1176 B.C. commencing from the then North solstice, the months are named after the signs and these agree with the present Sanscrit names of the twelve signs. It will however appear from the facts stated above in connection with the word 'Ras or Rashi' that this was not the first attempt for grouping of constellations but there had existed some former groups which were revised to suit the time in the Kritika period.

4-Cycles, Yugas and Kalpas.

A-General Information.

Among the different kinds of days, months and years, as mentioned in the Hindu astronomical works, the following are noticeable :—

Nakshatra day	...	A Sidereal revolution.
Pitri's day	...	One lunar month.
Dewa's day	...	One Tropical year.
Dewa's year	...	360 Tropical years.
Nakshatra year	...	A Synodical revolution of Jupiter.

The first was based on the revolution of stars which is caused by the earth's rotation on its axis.

The modern scholars believe that the second was based on the discovery made by the ancient Indo-Aryans about the Moon's rotation on its axis once in a lunar month. According to their belief, a full Moon is Pitri's Midday. It is therefore very probable, that the ancient Aryans when living in the arctic region used to determine the Sun's South Solstitial position, which was according to their belief the abode of Pitris or departed souls, by means of a full Moon.

The third was apparently a day and a night of the arctic region.

The fourth is not mentioned in Mahabharat and was probably designed for astronomical purposes.

The fifth is mentioned in Surya Sidhanta, Vide Chapter XIV, and was based on Jupiter's rising or setting.

According to the Indo-Aryan astronomical works and Manusmriti, there were the following kinds of Yugas and Cycles.

(*a*) Jupiter's Yuga, which consisted of twelve Synodical revolutions of the planet and commenced from its rising or setting. This is the oldest of all the Yugas and is mentioned even in the Rig-Veda.

(*b*) Five years Yuga, consisting of 62 lunar months, viz, 60 ordinary and two *additive* lunar months.

The Yuga was divided into five years of 366 days each.

(*c*) A Cycle of 60 years, based on five revolutions of Jupiter and two of that of Saturn, Vide Bhishma Parva of Mahabharat, Chapter 3. It is stated therein that the Indian year, used at the time, was based on these two planets.

(*d*) A Cycle called Kalpa or a day of Brahma but *exclusive* of night. It consisted of a very long period, as per details given below :—

DEWA'S YUGA.

Krit yuga ...	4800	Dewas years.
Treta do. ...	3600	do.
Dwapar do. ...	2400	do.
Kali do. ...	1200	do.
Dewa's Yuga ...	12000	do.

1000 Dewa's Yugas or 4320000000 tropical years were equal to a day of Brahma and a night was also of the same duration. A day of Brahma was divided into 14 parts, called Manwantras.

According to the Hindu Astronomical works, the present period is the 28th Kali Yuga of the 7th Manwantra. It commenced from the first day of the month of Chaitra in 3101 B.C. According to these works, every Yuga commences from the first day of the bright half of the month of Chaitra, *i.e.* from a new Moon of that month.

Now, I quote below the Indian religeous works, which differ on some points from the astronomical works. In this connection, it may be noted that all those works in which astronomical calculations are based on the above mentioned figures of Kalpa and Yugas, were composed after the commencement of the Christian era (see also note about Surya Sidhanta).

In the Mahabharat, the periods of the four Yugas are stated in Ban Parva, chapter 188 and Shanti Parva, chapter 231, but in the text, the word 'year' is simply used. In the latter Parva, however, the description of Brahma's day is preceded by some explanatory words, which clearly show, that the periods are expressed in human years. In fact, there is no mention of a Dewa's year but only a Dewa's Yuga of 12000 years is stated.

In the Atharva Veda (VIII-1-2-21), the figures 432 × 10000 × 100 are mentioned in words, which probably

refer to the number of years in a Kalpa, but the last multiplier should be 1000, instead of 100 to give the figure, as mentioned in the Surya Sidhanta. The word used is 'Shat', which ordinarily means 100.

It is stated in Brahmand Puran, that the present Kali Yuga *commenced* from a *full* Moon in the month of Magh, while according to Muhurt Chinta Mani (an Astrological work), Kali Yuga began from a *new* Moon. The disagreement between these two works is, however, not of any importance, considering the fact that two kinds of calendars were once prevalent in India. One of them used to commence from a full Moon and the other from a new Moon. According to Ban Parva of the Mahabharat (chapter 190 verses 90 and 91), Kali Yuga was to end when the conjunction of the Sun, the Moon and Jupiter was to take place in *Tishya* or Pushya Nakshatra in one *Sign*. The use of the word Rashi or Sign is noticeable specially, because Pushya is in the sign of Cancer, according to the present arrangement of Nakshatras commencing from Ashwani. The use of the word, therefore clearly shows that the Nakshatra was not in one sign, at the time when the Mahabharat or at least the chapter referred to was composed, and that the word Rashi meant a *Tropical* sign and not a *Sidereal* one, as is the practice at present. This practice is not supported even by Surya Sidhant, Vide Chapter XIV of the work.

It was stated by Garga and Parasar astronomers, that if the Sun should turn to the North without reaching the end of Shrawan or to the South without reaching the middle of Ashlesha, then there would be much danger to the world, Vide Bridh Garga Sanhita. This statement simply meant, that in the circumstances referred to, Kali or dark Yuga would commence.

It is clear from the above quoted referentces, that Kali Yuga actually commenced when the North

solstitial point began to retrograde from the middle of Ashlesha and ended, when the conjunction of the Sun, the Moon and Jupiter took place in Pushya Nakshatra in one sign, at about the North solstitial point.

In certain Astrological works, the lunar days from which the past four Yugas commenced, are stated as follows :–

Krita .. 9th day of the bright half of the month of Kartik.

Treta ... 3rd day of the bright half of the month of Vaisakh.

Dwapar... Full Moon of Phalgun, according to Muhurt Ganpati and some other works, while according to some books new Moon of Magh.

Kali ... New Moon of Magh, full Moon of Magh and 13th day of Ashwin.

The variations in the dates of the last two Yugas were, ofcourse, due to the revision of the periods of the four Yugas and to the changes in the Calendars. But these dates clearly show, that the assumption of the author of Surya Sidhanta and of the other Astronomical works of the same type, that all the four Yugas commenced from the new Moon of the month of Chaitra, is quite wrong. The first two Yugas did not commence even from a full or a new Moon.

It was believed by the ancient Indo-Aryans at about the period of the great war of Mahabharat, that prosperity and good actions were supreme in Krita Yuga, that in the next Yuga, they were three fourths, that in Dwapar one half and that in Kali Yuga one fourth. This belief is still held by the orthodox Hindus, but I shall shortly show that, originally these Yugas were simply designed for Astronomical purposes. When the general condition of the world

did not improve after the end of the last Kali Yuga, as had been anticipated, the period of the Kali Yuga was increased under the pretext, that in older works the periods of the four Yugas had been stated according to Dewa's years and not human years. It appears, however, from the hymn of the Atharva Veda, already referred to, that a Kalpa did not correspond to a day and a night of Brahma but was equal to the period stated in the hymn. The Dewa's Yuga and its division into 4 parts were based, in fact, on the movement of the North solstitial point, as per details given below.

Treta ...	The period during which the North solstitial point retrogrades through Visakha, Swati, Chitra, Hasta ($12\frac{6}{7} \times 4 = 51\frac{3}{7}$ degrees) and $2\frac{4}{7}$ degrees of Uttra Phalguni Nakshatra ...	54 degrees.
Dwapar	Uttra Phalguni $10\frac{2}{7}$, Purva Phlaguni $12\frac{6}{7}$ and Magha $12\frac{6}{7}$	36 do.
Kali ...	Ashlesha $12\frac{6}{7}$ and Pushya $5\frac{1}{7}$	18 do.
Krita ...	Pushya $7\frac{5}{7}$, Punarvasu $12\frac{6}{7}$, Adra $12\frac{6}{7}$ Mrigshira $12\frac{6}{7}$, Rohni $12\frac{6}{7}$ and Kritika $12\frac{6}{7}$	72 do.
Total of 14 Nakshatras		180 do.

When a full Moon occurs either in Ashlesha or Magha, the month is called Magh. The last Kaliyuga therefore commenced from the month of Magh. Similarly, Treta began in the month of Vaisakh and Dwapar in that of Phalgun. Krita Yuga must have begun from Paush and ended in

Kartik, So the date given in Astrological works is actually the one on which a Treta began and a past Krita Yuga came to its end. I think, the date was purposely preserved to show the period of an entire Dewa's Yuga of 12000 Jupiter's years. Thus, a Treta Yuga commenced from 9th of Kartik and the next on 3rd of Vaisakh. This shows that the number of lunations during the period were not full, but were short of five days. Kali Yuga commenced from Ashlesha (Water Snake or Hydra) Nakshatra and was therefore called a dark Yuga. It was also named Tishya, because it ended when the North solstitial point was in that Nakshatra. Dwapar and Treta were so named, because their periods were double and treble of the shortest Yuga respectivefy. According to Astronomical works, the word 'Krit' means four and it appears therefore that the first Yuga was also called on the same principle. The last Kali Yuga commenced when the North solstitial point was in the middle of Ashlesha, because prior to its commencement, the number of Nakshatras was reduced from 28 to 27.

When the ancient Aryans were living in the arctic region, they adopted a Yuga which was equal to 12 Synodical revolutions of Jupiter. It appears that in course of time, they were able to find out by experience, that 1000 of these Yugas were equal to a Dewa's Yuga or the period during which the North or the South solstitial point moved 180 degrees. They divided this Dewa's Yuga into four parts, apparently for the sake of convenience. By calculating the periods according to the mean rates of motions, as stated in Herschel's Astronomy for the epoch of 1850 A.D., I found that 12 Synodical revolutions of Jupiter were equal to 4786·60908 days and 162.08986 lunations and that a Dewa's Yuga was equal to about 13104·8 Sidereal and 13105·3 Tropical years, according to the present rate of the precession. It appears that, the ancient Aryans divided

the Dewa's Yuga into 4 parts with regard to lunations, as per detail below:—

Kali ...	1200	Jupiter's years	...	16208.986	lunations.
Dwapar ...	2400	do.	do. ...	32417.972	do.
Treta ...	3600	do.	do. ...	48626.958	do.
Krita ...	4800	do.	do. ...	64835.943	do.
Total	12000			162089.859	do.

A Dewa's Yuga consisted therefore of 162090 lunations, minus about 4 or 5 days, and the fraction is almost the same as deduced from the above mentioned dates of the Yugas. The rate of the precession is 54 seconds per Jupiter's Synodical revolution. This rate was apparently taken by the author of Surya Sidhanta from some ancient work and he adopted it under the misapprehension that it was for a Sidereal year. The mean rate per Sidereal year amounts to nearly 49.45 seconds, instead of 50.44 as determined by Mr. Stockwell. According to the ancient Aryans the obliquity was equal to 24 degrees. I think it was the mean quantity, as was the case with the rate of the precession of equinoxes. According to my determination, the rate of the precession varies *twice* between 52.5266 and 55.4334 seconds per Jupiter's Synodical year during a complete revolution of the vernal equinoctial point *i.e.* in 24000 Synodical years of Jupiter.

As regards the period of a Kalpa stated in the Atharva Veda, I am of opinion that a Dewa's Yuga consisting of about 162089.85894 lunations was multiplied by 36000, with a view to avoid the fraction by designing a year of Brahma and by assuming 100 of his years as the duration of his age. Brahma's year and his age are also mentioned in Surya Sidhanta, but the author of that work has increased even this period of Kalpa.

When the ancient Aryans were living in the arctic region, the only heavenly bodies known to them which moved from one star to another during the night time, were the Moon and Jupiter, as Venus and other planets were discovered long afterwards. By means of these two, they designed the constellations, the lunar months and the Yuga, based on twelve Synodical revolutions of Jupiter. It is noticeable, that a revolution is nearly equal to 13½ lunations and that 67 revolutions are almost equal to 905 lunations. I think, this was the reason which led the ancients to adopt two kinds of calendars *i.e.* one beginning from a full Moon and the other from a new Moon. Probably it was also due to the above mentioned facts, that Jupiter was called Dewa's priest and guide. When Venus was discovered, it was first named Ushna, as it was visible only at dusk or dawn. This planet was made the priest of Asuras, because it remained generally in their region, *i.e.* below the arctic horizon.

The word Yuga actually means a couple, and a day and a night of the arctic region was called a Yuga, Vide the Rig Veda (X-72-9). Similarly the Yuga of Jupiter was so named, because during a revolution the planet remained partly above and partly below the arctic horizon.

When the ancient Aryans found in course of time, that their pole star was also moving, they designed a Dewa's Yuga, based on a half of the revolution of a pole star. The polar movement is clearly referred to in Yog Darshan, which is a Philosophical work.

When the Aryan race migrated southward, a Yuga of 5 years and a cycle of 60 years were designed apparently to suit the changed circumstances. The former was called a Yuga, because it consisted of two additive lunar months. The cycle was based on five Jupiter's and two Saturn's revolutions, Vide Mahabharat Bhishma Parva chapter 3. It is stated therein, that the Indian calendar was based on the movements of these two planets.

B—Antiquity of the Yugas.

Dewa's and human Yugas are mentioned in the Rig Veda (X-72-3), (I-92-11) and (VII-9-4). In the Rig Veda hymn (I-158-6), the words 'Dashme Yuge' are stated. This shows that the number of Yugas was not less than ten. The hymn most probably refers to the Yuga of Jupiter, based on its twelve Synodical revolutions.

Five years Yuga is mentioned in the Mahabharat (Virat Parva chapter 52), Panch Sidhantika, Shushrut, Chanakya Arth Shastra &c. The years of this Yuga were called by different names, which are mentioned in several works and even in the Yajur Veda (XXVII-45). The words Krita, Treta, Dwapar and Askand are stated in the Yajur Veda (XXX.18). The first three are the names of the first three parts of Dewa's Yuga and the last was most probably another name of Kali Yuga. As already stated, Kali Yuga was also called Tishya Yuga, because it was to end when the North solstitial point was to reach that Nakshatra. There are no prominent stars in this asterism and it is very probable that some brilliant star, the right asceusion of which coincided with a star of this Nakshatra, when it was at the vernal equinoctial point, was selected as the principal star of the asterism. In Mahabharat and several other works, a legend about the birth of Skanda is narrated, from which it appears that the star so selected, was either first seen by the ancients above their horizon or was not included formerly in any Nakshatra. But the former fact is more probable than the latter from the context of the legend. This star might have been either Alpha Canis Majoris or Sirius.

5. The Vedic period.

No astronomical work of this period has come down to the present time and it is only from the religious works generally that some information about the time can be drawn. The most sacred books of the Hindu Aryans are

the four holy Vedas, Viz Riga, Sam, Yajur and Atharva. Opinions differ as to the time, when they were composed, but there is not the least doubt that they are the oldest books in the world, a fact not contested even by the Western Sanscrit scholars. The followers of the Vedic religion, of course, believe that the Vedas are the revealed works, and have existed since the beginning of the human creation. The word 'Veda' means kowledge, and the true knowledge is of course eternal, but this fact does not imply that the books called the Vedas have existed in their present form since the creation. They are composed in verses in a cultivated and perfect language and metres used are based on a scientific system of music. Every word is marked with a particular sign for its proper pronouncement. They were therefore not composed by a primitive nation. The Vedas are generally the collections of hymns and consequently do not give much information about the state of the nation's civilisation. Moreover, the Vedic scholars are not unanimous in their interpretation of the Vedic text and therefore no implicit reliance can be placed on the existing translations of the Vedas. There are, however, clear passages in the works which are generally free from controversial points and they show the advanced state of civilisation existing in the Vedic period. In the Vedas the following particulars are given at the commencement of each prayer. At least this is the case with the first three Vedas, but these particulars are not given in the copy of the Atharva Veda, which is in my possession.

(*a*) Name of composer and often his parentage and family name.

(*b*) Metre used.

(*c*) Name of the deity to whom the hymn is addressed.

A Scrutiny of the family names show that family prayer songs composed at different periods formed the

nucleus of the Vedas. Many hymns are repeated in two, three or all the Vedas and in a few cases with changed *wordings*. As for an instance, in the 13th hymn of the Rig Veda X-85, the words 'Agha' and 'Arjuni' occur. This hymn is repeated in the Atharva Veda (VIII-1-2-21) but the above words are replaced by 'Magha' and 'Phalguni' respectively, which are the present names of the 10th and 11th Indian Nakshatras, beginning with Ashwini (Aries). The former word 'Agha' is so archaic that it is not traceable in any other work. This is apparently the reason that the compiler of the Atharva Veda, thought it advisable to repeat the hymn in the book with changed wording. The hymn therefore is a very old one. In the previous parts of this chapter, I have already quoted several hymns bearing on the subject of the Indo-Aryan antiquity : it is needless for me to refer to them again. The latest astronomical event which is alluded to in the Rig Veda, concerns Rohni Nakshatra. It refers to the period when Alpha Tauri marked the South solstitial point about more than 11000 years ago. The present names of the Indian lunar months are not mentioned in the Vedas, with the probable exception of the verses XIII-25 and 26 of the Yajur Veda, in which the words Jyeshta and Asharha occur in connection with the spring season: they might have reference to the Indian months of the same names. Obsolete names of the Indian months, which were based on the seasons, are detailed with the seasons concerned in the Yajur Veda, vide chapter XIII and XIV and some of them are also mentioned in the Rig Veda (VII-14-1 and VII-56-19). This fact show that these hymns were composed before the Indian months were named after Nakshatras.

It should, however, be borne in mind that the existing Sanscrit dictionaries are no guide in this matter. They were composed at about the time, when the months of

Chaitra and Vaisakh corresponded to the spring season and the authors thereof naturally concluded that the months of Madhu and Madhava mentioned in the Yajur Veda, as the months of the spring season meant Chaitra and Vaisakh. This however, was not the actual fact, as the former were based on a Sidereal and the latter on the Tropical year. But it is certain that the lunar months are very old, vide part 4 of this chapter, though it cannot be said with certainty when they were named after Nakshatra. There are however, reasons to believe that the present names were designed when the Vernal equinoctial point was retrograding through Adra or Mrigshir Nakshatra.

It is stated in Mahabharat, that some of the hymns of the Yajur Veda had been lost and a sage named Yagyavalka obtained them from the Sun god, vide Shanti Parva chapter 318. So it is quite possible, that the verses of the Veda referred to above in which the words Jyeshta and Asharha occur, in connection with the spring season, were composed by Yagyavalka.

As regards the number of the Vedas, there was difference of opinion even in the time, when Mahabharat or at least the chapter 43 of Udyog Parva was composed. It is also stated in Ban Parva chapter 149, that ther was only one Veda, and one caste in Krit Yuga and four Vedas and 4 castes in Dwapar Yuga. According to Adi Parva of the same work, a Sage named Vyas arranged and divided the Veda into four parts. It is also noticeable, that in the country of Siam, the persons professing the Vedic religion recognise only some parts of the first three Vedas, viz, most part of the Sam Veda and parts of the Rig and Yajur Vedas. There are many hymns in which the Vedas are mentioned by their names, but it is noticeable that when only two Vedas are stated, they are generally the Rig and the Sam, when three, they are the Rig, the Sam and the Yajur, and the

name of the last Veda is mentioned only, when all the four Vedas are stated by name.

Only 3 Vedas are mentioned in Manusmriti, Atrismriti, Gita and several other ancient works. In Vrihat Arnyak, Chhandogya, and Taitriya Upnishadas and Katyayan and Vyas Smritis, a work called Arthavangiras is mentioned after the three Vedas. An Atharva sect is mentioned in Amarkosh dictionary.

Under the above circumstances, I have come to the following conclusions :—

(*a*) That family prayer songs formed the nucleus of the original Veda and that it was enlarged from time to time.

(*b*) That the hymns best suited to singing were collected together and named the Sam Veda.

(*c*) That when sacrifices came into much vogue and were considered as the best means of securing salvation, the Veda called Yajur, which specially treats this subject, was compiled from the theological works existing at the time.

(*d*) That some portion of the existing Yajur Veda was composed by Yagya Valka, who thus enlarged the original work.

(*e*) That the last Veda, which was originally named Arthavangiras, was probably composed by a physician named, Atharva, as appears from the following facts :—

1. The Indian Medical Science is treated occasionally in this work.

2. Preference was given to this Veda and to the Brahmans versed in it by the author of Charak, the well known ancient medical work.

3. A sage named Bhishag Atharva and some other sages bearing the same family names composed some hymns which are now found in all the Vedas, They were apparently incorporated in the first three Vedas by their composers or by Vyas who arranged the Vedas.

It appears that Arthavangiras was formerly not recognised as a Veda, except by the Brahmans of the medical profession. Probably the majority of the priesthood viewed it contemptuously, as appears from the facts that according to Manusmriti (XI-38), the hymns of Atharva were used for evil purposes and the Brahmans versed in it were not allowed to participate in Shradh (Pitris) ceremonies, vide Atri smriti verse 382. In course of time, the prejudices against it wore off gradually, as is apparent from the fact that in certain Upnishadas and Smritis, its teaching is recommended but it is called by its original name *i.e.* Arthavangiras. I think, the sage named Vyas formally recognised the work as one of the Vedas. He arranged the Vedas and numbered their hymns, chapter &c, and I believe there have been no further additions to the works.

As regards the antiquity of the Vedas, I have already stated that they are the collections of the hymns composed at different periods. The Rig Veda hymns (X-72-8 & 9, IX-114-4-&c), which refer to seven Vasus and to the Yuga consisting of a day and a night of the arctic region, are apparently the oldest. The Atharva or the last Veda was composed after the war of Mahabharat *i.e.* about 2400 B.C. as will appear from the following facts:—

(*a*) The Ayan or the North solstitial point was in Magha Nakshatra, vide the Atharva Veda XIX-1-7.

(*b*) In the above quoted hymn, a complete list of 28 Nakshatras beginning with Kritika is given

in their regular order. This hymn clearly shows that Magha marked the North solstitial point and that the vernal equinoctial point was retrograding through Kritika.

(*c*) King Parikshit of Kuru race is mentioned in the Atharva Veda, vide chapter XX. He was the grandson of Arjun of the Mahabharat war and ruled India after Yudhishtara's death. The work was therefore composed probably in the time of Parikshit and certainly before the reduction in the number of Nakshatras, *i.e.* before 1905 B.C.

The last fact clearly shows, that the Atharva Veda was *not* composed in any *previous* revolution of the vernal equinoctial point.

6–The War of Mahabharat.

This war is described in the epic poem called Mahabharat, but unfortunately the following extracts from the work about the time when it occurred, are vague and unsatisfactory.

(*a*) Ban Parva, chapter 121 verse 20.

The time was the conjunction of the Treta and Dwapar Yugas.

(*b*) Ban Parva, chapter 149 verse 38.

The present is the Kali Yuga, which has lately commenced.

(*c*) Gada Parva, chapter 60 verse 23.

"Know that Kali Yuga has commenced."

(*d*) Shanti Parva, chapter 339.

Shri Krishna was born in the period of conjunction of Dwapar and Kali Yugas.

There are, however, other works which give the information in question. The author of Panch Sidhantika (Varah Mihr) composed another work called Varahi Sanhita. It is stated therein, on the authority of Bridh Garga, that Maharaja Yudhistar was the ruler of India 2526 years before the commencement of the Shaka era, when the Sapt Rishis were in the constellation of Magha. A similar statement is met in Raj Tarangni, an ancient history of Kashmir. It is noticeable that the number of years is not mentioned in round figures, *i.e.* in hundreds or even tens, which might have been the case, if these gentlemen had any doubt about the accuracy of their statements. This clear evidence is however, not generally accepted, as I have discovered from discussions on the subject in several papers. One of them has tried to prove that the era meant by Varah Mihr was that of Lord Budha. I think this is the view of the orthodox people who try to reconcile in this way the statement of Varah Mihr with the vague expressions in Mahabharat on the subject. But there is not the least evidence in support of this argument, as the era of Lord Budha is nowhere used by the Hindu astronomers, including Varah Mihar. It is therefore absurd to believe that the latter used that era in this particular instance. Moreover, the word used is 'Shaka.' No other era than that of Salivahan is generally meant by that word. Other scholars of advanced views disbelieve Varah Mihra's statement, owing chiefly to the apparent absurdity of the latter part of it and partly to the fact that the period is irreconcileable with the geneologies of the Indian kings, given in the Puranas. As regards the first point, they have ignored the fact, or probably they had no idea, that the principal stars of the Indian Nakshatras had been arranged according to their places in their right ascension, as is the present practice of modern astronomers, vide star cotalogues, nautical almanacs, &c. The apparent movement of stars in their right ascension is not uniform, but varies in case of

every star, according to its position in the heaven at different periods. A reference to chapter 230 of Ban Parva of Mahabharat, will show that a calendar beginning from Dhanishta was brought into use, that prior to its adoption the time was calculated from Rohni and that the change in the calendar was made owing to the fact that the star Abhijit (a. Lyrae) had left its former position among the Nakshatras. This fact clearly supports the above statement, that the principal stars of the Indian Nakshatras were arranged according to their right ascensions. As regards the Sapt Rishis (The Bears), the change in their position was simply due to their present faster motions in their right ascension than that of the principal star of Magha (a. Leonis). The ignorance of the real cause led the Indian astronomers to ascribe fanciful movements to Sapt Rishis, with a view to reconcile their positions in their (astronomer's) time, with those at the time of the war.

As regards the geneological tables of the Indian kings in the Puranas, I may state that they are not reliable, considering the mutilated state of the existing works which differ from one another on numerous points. Some gentlemen have tried to amend in places the various statements in these works, bearing on the point in question, in order to reconcile them to their views. As for an instance, they have modified some unreasonable long durations of certain dynasties, with reference to the number of their kings. They have, however, quite ignored the fact, that it was more probable that the errors were in the number of kings, because it was the tendency of the authors of Puranas to show that the human life lasted for longer periods in past ages than at present.

On the other hand, a clear statement of Garga, who is even mentioned in Mahabharat as an astronomer, (Shanti Parva chapter 59) and that of the author of the ancient

history of Kashmir, cannot be lightly treated, especially when there is a strong corroborative evidence on the point in the Atharva Veda, vide the Vedic period. It appears also from many astronomical works, that Yudhishtara's era was once prevalent in India and there is therefore no reason to suppose, that all records about it were lost before Garga's time, who lived before Mahabharat was composed and long before the time when the country was convulsed with serious and hostile foreign invasions. It is therefore, quite clear that his statement was based on some authentic records. It will appear from my calculations, that Yudhishtara's era commenced in 2448 B. C. (2526+Shaka era minus the Christion era) from the vernal equinox, which occurred on a full Moon at the end of the Indian month called Vaisakh, that the first month of the era was Jyeshta, that the time of commencement was afternoon and that the starting place of the meridian, which suits the calculation, was some place near Kurukshetra, the battle field of the war. It also appears that the old limits of the Nakshatras were revised, commencing from the vernal equinox at the time, that Rohni was the first constellation, that the time was reckoned from that Nakshatra, as stated in Mahabharat, and that a sphere was started from a point, which was *exactly* at a distance of $3\frac{1}{4}$th of a Nakshatra from the star Zeta Piscium, the principal star of Revti. It is noticeable that according to this sphere, the longitude of Chitra (a. Virginis), as reckoned from the beginning of Ashwini was 180 degrees, as stated in Surya Sidhanta.

All these facts cannot be considered as the result of a mere chance. There can therefore, be no doubt about the facts, that Raja Yudhishtar started an era after his accession to the throne, which commenced from the vernal equinoctial day on the full Moon and from the beginning of an Indian lunar month (Jyeshta), and that the meridian started from a place near Kurukshetra, which was fixed in commemoration of his victory at that place.

The various statements in Mahabharat, about the time of the great War, were due to the changes in the periods of the four Yugas, referred to in part 4 of this chapter and to the enlargement of the book at different periods.

It appears from Mahabharat chapter 230 verses 7 and 8, that the calendar beginning from Dhanishta Nakshatra was prevalent when the chapter referred to was composed and that the calendar was substituted for the one beginning with Rohni Nakshatra. The latter was apparently Yudhishtra's calendar. It is also referred to even by Jains, vide Jin Vijaiva Kavya, in which it is stated that Kumaril Bhatta was born in 2077 of Yudhishtra's era.

7—State of Indian Civilisation in the Vedic and post-Vedic period.

As this subject is quite distinct from the scope of this work, I shall briefly state the facts which have come to my notice, while making astronomical researches.

The state of the Indian civilisation when the Yajur Veda was composed, can be inferred from the fact, that a considerable number of professions and industries are stated therein, vide chapter XXX-5 &c. Some of them I mention below. Iron arms holders, priests, soldiers, dancers, singers, carriage builders, carpenters, potters, jewellers, rope makers, physicians, star gazers, syce, elephant keepers, cowherds, *character builders*, bankers, iron and gold smiths, drivers, &c.

The mathematical knowledge of the ancient Indo-Aryans can be judged from chapter XVII of the Yajur Veda, the works of Arya Bhatta, Brahma Gupta, &c. and from the skill they displayed in making their sacrificial grounds of numerous geometrical figures. There are numerous works on the medical science which is also treated in the Atharva Veda. The Musical science can best be judged from the various metres adopted in composing the Vedic songs. The ancient

Aryan's knowledge of astronomy can be ascertained from the information contained in this work. They were aware of the fact, that the Moon shines with the Sun's light, vide the Rig Veda IX-97-41 and Nirukt XI-1-8.

The earth's rotation about its axis and around the Sun was discovered by some of the Indian astronomers, as appears from Arya Bhattiya (498 AD) and Panch Sidhantika. The ancient Aryans were aware of the movements of the celestial poles, vide Yog Darshan.

8—Indo Aryan Religion.

As in the case of the Ancient Indian civilisation, I shall confine myself to a few general remarks on the subject. The religious beliefs of the ancient Indo-Aryans are embodied in the Vedas, but unfortunately there is much controversy about the interpretation of the Vedic terminology. Some state, that the Vedic Aryans were worshippers of elements, while others believe, that they were pure monotheists. In fact, some of the hymns are so clear, that even the western scholars had to admit that those were addressed to the Almighty God. As regards the existing religion, I think there can hardly be any kind of spiritual belief, which is not to be found in the religion called Hinduism. This is most probably due to the fact, that the Vedic religion is a very ancient one, dating back to thousands of years; that during this long period it came into contact with numerous faiths and that its followers had no idea of fanaticism but had, even among themselves, the full liberty of holding religious views. It was apparently due to this fact, that even atheists were tolerated, as appears from Mahabharat and Valmiki Ramayan. Even to this day, marriages are allowed between Hindus and Jains, though the latter hold quite different religious views. Lord Budha, the founder of the Budhist religion, was one of the ten incarnations of Vishnu, according to Hindu belief. Under these circumstances, it seems very strange that

among the Hindus there are numerous classes of peoples, who are called untouchables. The real fact is that there has always been an inherent racial pride in the Aryan race. They easily tolerated different religious beliefs, but could on no account allow any union by marriage or otherwise, with persons of different race. To carry out this principle, they had to prescribe very hard rules and incorporated them into religious works. As appears from Mahabharat, there was originally one caste, but subsequently for economic reasons, the people were divided into three castes, based on professions. When the ancient Aryans came into contact with other races, probably as conquerors, they classed them as Shudras or the serving caste. It was purely a colour question, as according to chapter XVIII of Vashishta smriti, Shudras were black people. In course of time, the rigidness of the caste system increased and persons born of intermarriages between the three original castes of the Aryan blood were also classed as Shudras, but of a superior status. But persons of Aryan race who contracted alliances with Non-Aryan races and their issues were classed as untouchables, as a deterring punishment.

9—Antiquity of the Indian Astrology.

I have already traced the antiquity of the Indian superstitions about the five Nakshatras, begining with Dhanista and the Nakshatras called Jyeshta and Mul.

The present system of foretelling a man's fortune by means of a horoscope was most probably devised by the ancient Greeks and was adopted by the Indo-Aryans, between 300 and 100 B.C. It is referred to in Valmiki Ramayan, but no trace thereof is to be found in Mahabharat and earlier works. The use of many Greek words, such as Hora, Leo &c in the Indian astrological works, also supports the above conclusion. The original Indian system of astrology was based on the Moon's Nakshatras. The antiquity of this

system is traceable to the time, when the vernal equinoctial point was in the constellation of Orion, vide Ashtotri Dashas, already referred to. In this connection it is noticeable, that according to Ashtotri, Binsotri and Yogni Dashas, a man's fortune is foretold irrespective of the positions of the heavenly bodies in the 12 houses of horoscope. This is simply due to the fact, that when those Dashas were designed, the system of foretelling events by means of a horoscope was not in vogue among the Indo-Aryans.

CHAPTER III.

A-Notes about certain Astronomical works.

Panch Sidhantika. Epoch 505 A.D.

This book was composed by Varah Mihar of Ujjain about the beginning of the sixth century A.D. It is an epitome of 5 important astronomical works. Its author adopted the epoch of Lat Deva, who had revised the Paulis and the Romak Sidhantas, which were also treated by Varah Mihar in Panch Sidhantika. This book was published by the late Dr. Thebaut and Mahamahopadhya Pandit Sudhakar, with an English translation and a Sanscrit commentary. Unfortunately, the book is based on defective manuscripts and there are many verses which are left unexplained. It appears, that Varah Mihar selected the five Sidhantas or astronomical standard works, which he treated in Panch Sidhantika, out of the works which were in existence in his time, as the best specimen of every type. The works treated by him are Vasishta, Pita Maha, Paulis, Romak and Surya Sidhantas. Romak is based on the Greek system of astronomy and Surya Sidhanta is one of the type of the astronomical works, in which religious division of time into very long periods called Kalpas, Yugas &c is used and calculations are started from the assumed beginning of the Creation. Paulis does not mention any such period, while

a Yuga of 5 years is used by the author of Pita Maha Sidhanta. In Vashishta Sidhanta nothing is said about Yugas and calculations are made on a somewhat peculiar method. Pita Maha Sidhanta is of the same type as Jyotish Vedang, a very old astronomical work, which forms a part of the Vedic theological literature. According to the latter work, the Southern course of the Sun used to commence from the middle of Ashlesha Nakshatra and the book was therefore composed in the twelfth century B.C. The shortest day according to both these works was 12 Muhurtas or $9\frac{3}{5}$ hours, which shows that these works were composed at some place or places situated in 35°-50′ North latitude. According to Pita Maha Sidhanta, the calendar commenced from the first day of the bright half of the month of Magh and the Sun's and the Moon's positions were calculated from the beginning of Dhanishta Nakshatra. The rules are very rough and show a primitive knowledge of astronomy. I therefore long continued under the impression, that the Hindu-Aryan's progress in this science was due to their contact with the ancient Greeks, as is generally supposed by Western Scholars. I had however, to change my opinion and I am going to explain how it happened. While pondering over the first verse of chapter II of Panch Sidhantika, which was left unexplained by Dr. Thebaut and Mahamahopadhya Pandit Sudhakar Dwivedi, I was struck with the figures given in the latter part of it. This chapter contains rules based on Vashista Sidhanta. The first part of the verse probably gives a rule for calculating the Moon's position, as appears from the word 'Shashi' Moon at the end of the sentence. Then 689947200 are stated in words and the verse is completed by a word which is not understood and appears to be a mistake in the manuscript. The author must have used some different word explaining the nature of the figure. From the next verse, it appears that the original word meant 'Kendrausha' appertaining to the anomalistic

revolution of the Moon. The figure above mentioned is divisible by 27 (the total number of Nakshatras) and 800 (the number of minutes in a Nakshatra). This shows that the Moon had completed 31942 anomalistic revolutions, since the Epoch of Vashishta Sidhanta, but the question arises as to when those complete revolutions ended.

According to the rules of this work, the Moon performs 110 anomalistic revolutions in 3031 days and therefore 31942 revolutions must have been completed in 880147 $\frac{32}{110}$ days. In the next verse, calculations are based on the entire periods of 3031 days, and it is stated that 1936 days are to be added to the number of days since the beginning of Varah Mihra's epoch to make a complete period of 3031 days. If 31942 revolutions were divided by 110 it would appear that 1873 $\frac{78}{110}$ days were wanted to make a complete period of 3031 days. Thus there was a difference of 62 $\frac{32}{110}$ days, between the epoch of Varah Mihar and the time when 31942 revolutions ended. By deducting 62 $\frac{32}{110}$ days from the period of these revolutions $\left(880147 \frac{32}{110} \right)$, the number of days that passed since the beginning of Vashista's epoch to the commencement of Varah Mihra's epoch are found, viz 880085 days. It appears therefore that Varah Mihar first stated the complete anomalistic revolutions of the Moon, according to Vashishta Sidhanta and then stated a rule to calculate its position, in accordance with that work for the beginning of his own epoch. To assure myself as to the accuracy of these figures, I calculated the Moon's position at the beginning of Vashishta's epoch (1905 B.C.) according to the Moon's rate of motion, as determined by the western astronomers for the epoch of 1850 A.D. and found that there was a slight difference, which would disappear if the rate of the accelerated motion of the Moon, as determined by

Professor Newcombs, were reduced from 8·8″ per century to about 8·44″. To further assure myself as to the accuracy of my figure, I calculated the Moon's position at this rate for the epochs of Arya Bhatta and Bhashkar Acharya and found that the results agreed with those stated by these astronomers. The western astronomers have differed considerably from one another in their determination of the increase in the Moon's motion, apparently because they had no opportunity to test their rates by comparing the Moon's positions at such long intervals, as I had means to do. (For details of calculations see chapter V-2). It may be argued, that Varah Mihar stated the figures of the Moon's complete anomalistic revolutions by calculations, in order to make the work appear older than it really was. Though the objection is preposterous and insulting to our respected astronomer's memory, yet its fallacy is obvious, considering the fact, that neither Vashista's rates could give accurate results for the time of Varah Mihar nor was the latter aware of the fact, that there was an accelerated motion in the Moon's movement. Moreover, the accurate sidereal motion of the Moon was not known to the ancients and any slight error in it could not give correct results for such long periods. Therefore, there is not the least doubt about the epoch of Vashishta Sidhanta, which commenced from the noon of the full Moon of the month of Ashwin in 1905 B.C. or from the beginning of Kartik, when the Moon was in its perigee at the beginning of Ashwani Nakshatra at the meridian of Ujjain or some place close to it (vide calculations). It is therefore the oldest work that has come down to the present time. To remove any lingering doubt, I may mention that the work is so old that according to it the Moon's equation of the centre was only 4°-47·6′ at the time. No rules are given in the work for calculating the Sun's position, which used to be determined by means of observations on the principle, that a gnoman

threw no shadow on the noon of the day, when the Sun used to reach the limit of its northern course in the latitude of 24 degrees North.

This startling discovery about Vashisht Sindhanta's epoch proves beyond boubt, that the Indo-Aryans were comparatively far advanced in their astronomical science at so remote a period as 1905 B.C. considering the fact that rules are given in the work for calculating the Moon's and the planets' positions. The periods of the Moon's anomalistic and the sidereal revolutions as given in the work are so nearly accurate as to tend to a strong presumption, that they were based on some records of the Moon's movements of many past centuries. This Sidhanta is the oldest of the available works, which gives rules for the determination of the planets' positions. The author has used the synodical revolutions for the purpose and not the sidereal revolutions, as has been the practice of the Indian astronomers since the time when the Surya Sidhanta was composed. As I have already stated, the major planets were known to the ancient Indians since at least the Adra period. At the time of the war of Mahabharat, there were 28 constellations. The author of Vashishta Sidhanta apparently reduced the number to 27, probably because there must have occurred some important changes in situations of the principal stars, owing to their unequal movements in the right ascension, since their last revision in 2448 B.C. He of course, could remove the defect otherwise without reducing the total number of Nakshatras, but I think he did so purposely for the sake of convenience, with a view to make a Nakshatra equal to 800 minutes. He did not adopt the Yudhistara's meridian of Kurukshetra, but fixed another starting from Ujjain or some place near it, for facility of astronomical observations. He apparently established an observatory at a place called Avanti, the latitude of which was 24 degrees North, as according to his work a gnoman threw no shadow

at noon of that place when the Sun used to enter the sign of Cancer. The obliquity of the ecliptic was 24 degrees or nearly so during this period. It has been decreasing slightly and was 23°-27′-8″ in 1908.

The author of Vashishta Sidhanta so contrived the revision of Nakshatras, that it caused the least possible disturbance in the position of the North solstitial point according to the old limits. At Yudhishara's epoch, the point was at the end of Magha, which was at a distance of 131°-47′-8″ or 10¼ Nakshatras from the star Zeta Piscium. It receded by 7°-28′-4″ up to Vashishta's epoch and the North solstitial point was therefore 124°-19′-4″ from Zeta Piscium and 5°-23′-22″ beyond the old limit of Ashlesha, which was 118°-55′-42″ from the star referred to or $118^{\circ}\frac{13}{14}$. He slightly changed this figure and took 119,° thus avoiding the fraction. His new Nakshatra consisted of $13^{\circ}\frac{1}{3}$ and at this rate the end of Ashlesha was 120° from the star Zeta Piscium instead of 119.° So he extended the limit of Ashwani Nakshatra 1° beyond the star. There was also another reason for his compounding the fraction and not exactly adhering to the old limit of Ashlesha. This was the fact that the Moon's position at the time happened to coincide with its perigee at 1° beyond the star. This was also the reason for his adopting a new sidereal sphere commencing from that point, It was apparently designed for observations of lunar movements and for calculating the Moon's position from the beginning of the Sidhanta's epoch, but it seems probable that the sphere was used by him for all astronomical purposes, as it appears from Surya Sidhanta that long before the vernal equinoctial point reached the commencement of Ashwani Nakshatra, the latter was adopted as the starting point of the Indian sphere. Such apparently was the practice among the ancient Greeks, as the modern European astronomers, who have followed the

Greek system, still call the vernal equinoctial point as the beginning of Aries or Ashwani, irrespective of its actual position. I think the circumstances stated above explain the origin of this practice. As regards the Indian astronomers, who followed Vashishta there were at least, some who did not adopt his sphere, as for an instance, the author of Pita Maha Sidhanta,

Vashishta probably started a new calendar, commencing from the month of Kartik, which is also referred to in Surya Sidhanta.

Pita Maha Sidhanta.

This is a work of the type of Jyotish Vedang. Such works were called Sanhitas (vide Brahm Sphut Sidhanta). Their rules are very rough and they treat only of the Sun and the Moon. It is clear, as the term 'Sanhita' shows, that these works were merely intended for the Vedic scholars engaged in the performance of the Vedic rituals and ceremonies, for whom no advanced knowledge of astronomy was needed for their practical purposes. It is remarkable, that Pita Maha Sidhanta was composed in the country of Afghanistan, at some place about $1\frac{1}{3}$ degrees North and 57' west of Kabul. The epoch of Jyotish Vedang is not known, but I have tried to discover it by means of calculations.

Surya Sidhanta

This work is held in great esteem by the Indian astronomers. It is stated in the existing work, that its subject matter was revealed to a person named Maya by the Sun god at the end of the last Krityuga. Some of the western scholars of the eighteenth century A.D. were of opinion that the book was composed in the 12th century A.D. It was an erroneous opinion, as Surya Sidhanta is mentioned in Bhattotpal's commentaries of Vrihat Sanhita and Vrihat Jatak. The latter commentary was composed in 888 Shaka or 966 A.D. as stated by the author. It has now

been found by the discovery of Panch Sidhantika, edited by Varah Mihar, that a work called Surya Sidhanta existed in the sixth century A.D. It appears from the rules of that work, as stated by Varah Mihar, that it differed from the existing work on several important points. Dr. Thebaut who translated Panch Sidhantika came to the conclusion that Surya Sidhanta had undergone many changes. He based his opinion on certain facts, which led him to believe that Varah Mihar reproduced strictly the doctrines of all the five Sidhantas treated by him. I am, however, of opinion that Varah Mihar did so with the single exception of Surya Sidhanta. I briefly state my reasons for differing from Dr. Thebaut's conclusion. In verse 2 of chapter I, Varah Mihar has stated that he would apply corrections to the planetary motions. In verse 4 of the same chapter, he has expressed his opinion that Surya Sidhanta was the most accurate of all the Sidhantas. He has only applied corrections to the planetary positions as calculated according to Surya Sidhanta in the form of certain additions and reductions per year *from the time of his Epoch*. In the case of Jupiter, he has made a further deduction of 1400 seconds in addition to an annual reduction of 10 seconds. In this connection, it may be noted that his Surya Sidhanta agrees with the existing work concerning the revolution of only Jupiter. He has applied a slight correction to the Moon's motion, but apparently none to that of the sun. This looks rather strange, considering the fact that the Sun's motion according to Varah Mihra's Surya Sidhanta was slower than the actual figure by 8'362864617056 seconds per year. In these circumstances, I have come to the following conclusions :—

1. That Varah Mihar applied corrections to the planetary motions of Surya Sidhanta, with the exception of that of Jupiter by altering the figures of the total number of revolutions in a Kalpa as stated in the existing Surya Sidhanta.

2. That for the above purpose, he generally adopted the figures of Arya Bhatta, who 6 or 7 years before Varah Mihara's epoch composed *two* works, vide Brahma Gupta's statement in his Brahma Sphut Sidhanta.

3. That he did not adopt Arya Bhatta's figure in the case of Jupiter apparently, because it did not suit the time when Varah Mihar composed Panch Sidhantika and that he therefore retained the figure of Surya Sidhanta and adjusted the planet's position at his time by making the additional correction referred to.

4. That by adopting Arya Bhatta's figures of the number of days in a Kalpa and of the Sun's revolutions and by slightly changing the starting point of the sphere, Varah Mihar adjusted the Sun's position suited to his time.

5. That Varah Mihar adopted the figures of that work of Arya Bhatta, which has not come down to the present time, but which is referred to by Brahma Gupta and that the figures of the numbers of planetary revolutions in a Kalp, according to that work did not differ from those employed in the existing work of Arya Bhatta, except in the case of Mercury, as appears from the figures of Varah Mihra's Surya Sidhanta.

6. That it is inferred from the longitudes of certain stars, as stated by Varah Mihar, that his starting point of the Sphere was one degree from the star Zeta Piscium.

7. That Varah Mihra's statement to the effect that Surya Sidhanta was the most accurate of all the five sidhantas treated by him, can be accounted for by the facts, that the Epoch of 505 A. D. adopted by him was not his own, but that of Lat Deva who revised Paulis and Romak sidhantas and whose figures give the strictly accurate results for his epoch, as will appear from my calculations and that Varah Mihra's statement was apparently applicable to the time when he composed his Panch Sidhantika.

8. That in consideration of the fact that Arya Bhatta's rate of the Sun's motion which was slow by about 8·36″ per year suited Varah Mihar, it appears that the latter composed Panch Sidhantika in 570 A. D, *i.e.* 72 years later than the epoch of Arya Bhatta, vide para 6.

9. That the last conclusion is also supported by the facts, that Varah Mihar referred to the works of Arya Bhatta and his opinion about the rotation of the earth on its axis in Panch Sidhantika and that according to a passage quoted by the late researcher Bhau Daji, Varah Mihar died in 587 A. D. It is noticeable here, that Arya Bhatta composed his works in 498 or 499 A. D. It is, therefore, hardly possible that Varah Mihar of Ujjain could have found it possible to refer to the works of Arya Bhatta of Kusampura (near Patna) in Panch Sidhantika, considering the means of communications existing at the time.

10. That there are of course some reasons to believe that Surya Sidhanta has undergone some changes, but they were not surely of such an extensive nature as is suggested by Panch Sidhantika.

Now I proceed to find out the time when Surya Sidhanta was most probably composed. By calculating the Sun's mean position at the commencement of Kaliyuga at midnight, it will appear that the Sun's position was actually 11°-22° 18′-33″ *ie* 7°-41′-27″ less than that assumed by the author of Surya Sidhanta. The Sun's motions, according to Varah Mihra's Surya Sidhanta and the existing work being 8·362864617056″ and 8·3858620129055″ slower per year respectively, than the actual figure, the difference of 7°-41′-27″ is adjustable in 3311 and 3302 years, by assuming Kurukshetra, as the starting place of meridian instead of Ujjain. These figures are of course, based on the assumption that the starting point of the sphere as stated in the existing work is correct. It is however, quite possible that the starting

point of the sphere, as fixed by the author of Surya Sidhanta, might have been subsequently changed to reconcile the error caused by the slow rate of the Sun's motion. In fact, this error is adjustable after a period of 72 years, by altering the starting point of the sphere by 10 minutes. This uncertainty can be removed by means of the Sun's perihelion. I may, however, mention that the fixed position of the perihelion, as stated by Varah Mihar (80 degrees) does not agree with that calculated according to the rules of the existing Surya Sidhanta for the epoch of Varah Mihar. The former figure is, however, so absurd that it can only give correct results at some remote future period, *i.e.* about more than 1000 years hence. Such an inaccurate figure is either due to some mistake in the manuscript of Panch Sidhantika or to the fact, that Varah Mihar in fixing the longitude of perihelion for future use, did not take into consideration the Sun's slow rate of Surya Sidhanta, which reduces the progressive motion of the perihelion to a considerable extent. I therefore used the figures of the existing work and found by calculations that 129 or 138 A.D. were the years when Surya Sidhanta was composed (for details see calculations) and that the sphere started from the star Zeta Piscium. The statement in the existing work to the effect, that Surya Sidhanta was composed at the end of Krit Yuga is therefore quite wrong. In support of this conclusion, I may also mention the following facts.

1. The error in the rate of the Sun's motion of Surya Sidhanta is so considerable that it is quite impossible that it was composed at the end of Krit Yuga. In fact, the error was caused by an erroneous assumption that Kali Yuga commenced when the Sun entered Ashwani, the first Nakshatra.

2. According to the Indian theory, a Yuga must commence when the Sun is on the first point of Ashwani

and its tropical and sidereal positions are the same. This was, however, not the case. The Sun's sidereal and tropical positions at the beginning of Kaliyuga were respectively 11ˢ-22°-29′-1″ (sphere starting from the star Zeta Piscium) and 10ˢ-1°-44′-45·76″ respectively. These figures will show that Surya Sidhanta's Kaliyuga commenced neither with the beginning of a sidereal nor a tropical year.

Paulis Sidhanta (Original).

This work is not now available, but it was revised by Lata Deva in 505 A.D. (Kali Ahargan 1317122) and treated by Varah Mihara in his Panch Sidhantika. The author of Paulis Sidhanta did not adopt the system of employing Kalpas and Yugas for the purpose of astronomical calculations, but calculated Ahargan from the number of solar days passed since his epoch. The method for calculating the moon's position is similar to the one used by the author of Vashishta Sidhanta. Though this method is still used, I believe, in some parts of the Madras Presidency, yet it was discontinued in other parts of India long ago and no astronomer from the author of Surya Sidhanta down to the present time has employed it. The author of Paulis Sidhanta also used the obsolete system of Vashishta Sidhanta for finding out the planets' positions by means of their synodical revolutions.

In chapter I of Panch Sidhantika, Varah Mihar has mentioned the figure of 203279 in connection with the rule for calculating Ahargan according to Paulis Sidhanta, as revised by Lat Deva. The figure, however, appears to be slightly wrong and, considering the state of the work's manuscript, it is not strange. The correct figure was apparently 203079 which is completely divisible by 365¼ the number of days in a Julian year. This figure shows that the work was composed in 51 B.C. From the verses 35 & 36 of chapter III, it appears that the epoch of Paulis

Sidhanta commenced from the ninth lunar day of the bright half of the month of Chaitra and from the moon's Nakshatra of Punarvasu. By calculations, I have found that the tropical year commenced from the noon of that day. The author of Paulis Sidhanta therefore purposely commenced his epoch from the anniversary of Shri Ram Chandra's birth day, as it is noticeable that the month, the fortnight, the lunar day, the spring season, the moon's Nakshatra and even the time of the epoch were the same, which are mentioned in Valmiki Ramayan, as marking the birth time of Lord Ram Chandra.

It is therefore quite clear that the author of Paulis Sidhanta was a follower of Lord Ram Chandra's cult. It is also evident from the verses referred to above, that the author of Paulis Sidhanta was of opinion, that the use of Romak Sidhanta for the religious purposes was improper, but it is also quite possible that it was the opinion of Lat Deva who revised the work. Though the author of Paulis Sidhanta commenced his epoch from the beginning of a tropical year for the reason already mentioned, yet he used a sidereal sphere, according to the Indian practice, as appears from the fact that the length of his year (365·25833 days) does not correspond to the tropical year of Romak (365·2466 days). The rate of the Sun's daily motion according to the year of Paulis Sidhanta was, however slower than the actual Indian sidereal rate by 0·01884816975″ per day. Therefore the Sun's position by the time of Lat Deva (505 A. D.), who revised Paulis Sidhanta must have shewn an error of 1°-3′-47·57″, if calculated according to the rate of that work. It appears that Lat Deva adjusted 14′-47·05″ by changing the astronomical time from noon to evening. This leaves a difference of 49′-0·52″. The sphere of Lat Deva's revised work commenced from the point 50 minutes from the star Zeta Piscium. It is, therefore, evident that the sphere of Paulis Sidhanta coincided with

the above mentioned star and the difference of $59{\cdot}48'' = 60{\cdot}35$ Palas is due to the change in the starting place of the meridian. As Lata's meridian was 100 Palas west of Benares, the meridian of Paulis must have started from some place 39·65 Palas west of Benares. It is noticeable, that Bhaskaracharya also adopted nearly the same meridian. The latter was a resident of Southern India and it is therefore quite probable that Paulis was also the resident of the Deccan.

There is a way by which the accuracy of the above mentioned facts can easily be tested. According to the rule of Paulis Sidhanta, the Sun's sidereal position is calculated by multiplying the number of days passed since the epoch by 120 and dividing the product by 43831, after adding to or deducting from the product some number, which represented the Sun's position at the beginning of the epoch. It is, therefore, clear that the Sun's position at the commencement of the epoch of the original Paulis Sidhanta must have been represented by some figure, which was completely divisible by $\frac{1}{43831}$ of a revolution. My calculations will show, that the Sun's sidereal position at the commencement of the epoch was $0^s\text{-}8^\circ\text{-}43'\text{-}50{\cdot}89''$, which is equal to $\frac{1063}{43831}$ of a revolution. Then the quotient 1063 denoted the Sun's position at the epoch. It appears from the introduction to the translation of Panch Sidhantika, that Dr. Thebaut was at a loss to account for the startling difference between the two sets of the rules given in chapter XVIII of the book for calculating positions of the five major planets, on the basis of their synodical revolutions and he found himself unable to propose any definite views as to the source of that chapter. In my opinion, the first set of the rules were based on Vashishta and the second on Paulis Sidhantas. The difference between the two sets of the rules is simply due to the fact, that in the second set, solar days were used and not ordinary or Sawan days as in

the first. The periods of synodical revolutions of the 5 major planets, as determined by the European astronomers, exceed the figures of Paulis nearly by the ratio which a year of 365·25 days bears to a solar year of 360 solar days *i.e.* by about 1·44 percent. It is also clearly stated in Bhatotpal's commentary of Vrihat Jatak, that Paulis made use of solar days.

B—Notes on some ancient religious works of Post-Vedic period.

Taitraiya Brahman.

This is the only ancient work, now available, which gives a good deal of information about Indian Nakshatras. In part I chapter 5 thereof, all the Nakshatras are stated, beginning with Kritika, with their presiding deities, as well as some other constellations, adjoining those Nakshatras, for facility of the latter's identification. It is stated therein, that Kritika to Visakha were Dewa's Nakshatras and Anuradha to Bharni were called Yama Nakshatras. According to this chapter, Rohni and Jyeshta were both called Rohni. Invaka and Vahu are mentioned in place of the present Nakshatras Mrigshira and Adra. Swati was called Nishtya. Indra is mentioned as presiding deity of Chitra and Shatvisha, instead of the present deities Twashta and Varun.

Aryaman and Bhag are stated as the presiding deities of Purva Phalguni and Uttra Phalguni Nakshatras respectively, while according to some later works, the reverse is the case. Abhijit Nakshatra is mentioned separately and not in its proper place. This fact shows that at least this chapter was composed when the number of Nakshatras was reduced to 27, but the vernal equinoctial point was retrograding through Kritika. It is however, very strange that in chapter I of Part III of this work, all

the 28 Nakshatras are stated in regular order, beginning with Kritika.

In I-4-10 five seasons are mentioned, instead of 6 and Shishir is omitted.

In 1-5-11 Krita and Kali Yugas are mentioned.

It is stated in II-2-3, that there are 12 months, 5 Seasons, 3 lokas and 120 Asawadityas.

Shatpath Brahman.

Some Nakshatras are mentioned in this work, beginning with Kritika. Old names of Indian months are given in detail according to 6 seasons, commencing from spring. It is also stated that the first three are Dewa's seasons. This shows, that in the author's time the spring season commenced from the vernal equinox. In this connection it is noticeable, that according to Surya Sidhanta and the present practice, this season begins one month before the vernal equinox. It is stated in Mahabharat, that this work was composed by Yagyavalka, who obtained the lost portion of the Yajur Veda from the Sun god. As the first Nakshatra stated in the work is Kritika, it is reasonable to suppose that the book was composed when the vernal equinoctial point was retrograding through that Nakshatra.

Mahabharat.

This is a very important book, which gives much valuable information on various points, including the Indian antiquity and civilisation. Even the oldest traditions of the Aryan nation are found in the work; as for an instance, it relates the circumstances under which the rite of marriage was established among the Aryans. This work is in fact the only book, which may be called the thesaurus of early Indian civilisation and culture. The original work was composed by Vyas and was called Bharat Sanhita, containing 24000 verses, vide Adi Parva chapter I verse 102.

This Sanhita was the basis of the present work, which I believe is not the production of one man, but appears to have been enlarged by many persons in different periods. The book, however, even in its present form, is very old, as appears from the following facts.

(*a*) In such a big work the present Indian division of a day into 60 Ghatikas or Nadis is nowhere mentioned, while the old division into Muhurtas, Kasta's, Kalas &c is stated in Adi Parva chapter 25 verse 14, Virat Parva chapter 52 verses 1 to 3, Shanti Parva chapter 166 verse 14 and chapter 231 of the same Parva verses 12 to 14. The present division was used in Surya Sidhanta, Arya Bhattiya and all the subsequent astronomical works.

(*b*) The Dhanishta calendar, which has already been referred to was prevalent. In none of the astronomical works, mentioned above, this calendar was adopted. Even in Paulis Sidhanta composed in 51 B.C. the calendar commencing from Ashwani Nakshatra was used.

(*c*) Situations of heavenly bodies are generally referred to in Mahabharat by means of Nakshatras, which was a very ancient practice, and it was discontinued long before the above mentioned works were composed.

(*d*) The archaic words are frequently used.

Under the above circumstances, it appears, that the original work was composed after the adoption of Dhanishta calendar (1100 B.C.) There are reasons to believe that the book was chiefly enlarged in the Budhist period, though some changes were also made after Mohammadan invasions.

The Budhist term Nirwan (Salvation), is used in verse 47 chapter 261 of Ban Parva and animal sacrifice is forbidden in chapter 262 and 264 of Shanti Parva. In verses 35 and 36 chapter 188 of Ban Parva there is a prophecy, about the nationalities of rulers of India during Kaliyuga or the present age. The nations mentioned, are Andhra, Shak, Pulind, Yawan, Kamboj, Balhik, Shur and Abhir. This shows that at least these verses were incorporated in the chapter in the Mohammadan period. In this book a long list of countries situated in and outside of India is given. Of the foreign countries mentioned, Yawan, Barbar, Hun, Chin, Parsik, Rom, Balhik, Shak and Kamboj are noticeable.

Valmiki Ramayan.

This is also an important old work. This book is also based on some older work called Ramayan Sanhita, as appears from the last chapter of Yudh Kand. The original work was composed by Valmiki. The chapter referred to shows, that it was the last chapter of the original book and that Uttar Kand was added subsequently. These facts are also supported by the statement in the first Kand, that the work was composed by Valmiki *as well as Uttar Kand.* The composer of this verse must have been some person other than Valmiki as there was no use of adding the above words in Italics, if there was no doubt about the fact. This book was also enlarged. There are many chapters and numerous verses which, if omitted, would not break connection with the previous and the following chapters or verses :—

The work is not older than the Budhist period, as will appear from the following facts.

(*a*) In Amarkosh, a standard Sanscrit dictionary, which was composed in the Budhist period, a chapter is devoted to the names of all the

Hindu and Budhist deities. Names of deities of nearly all the faiths prevailng at present are given, but strange to say, that there is not the slightest trace of Rama, nor his brothers nor his devoted wife Sita. Names of Krishna, his brother, his sons and even of his weapons are given. The only explanation of this important omission must be the fact, that Rama's worship was not prevalent in the time of the author of Amarkosh. It is true that Rama's worship is referred to in the Mahabharat but the fact is no proof of the antiquity of this hero's worship, as the work was enlarged at different times.

(*b*) The situations of heavenly bodies are expressed by signs, as is the present practice, vide Balkand chapter 18.

(*c*) The lunar month Shrawan was the first of the four months of the rainy season, vide Kiskinda Kand chapter 26 verse 14.

(*d*) According to the work, Shri Ram Chandra was born in the spring season at noon in the month of Chaitra, which was then the 12th month of the calendar, on the 9th day of the bright fortnight and Punarvasu Nakshatra.

(*e*) The Sanscrit word for Budhist monasteries, is often mentioned with Hindu temples.

The work was, however composed before 51 B. C., as Paulis astronomer selected his epoch from the birth anniversary of Shri Ram Chandra. He was either a follower of this cult or possibly he composed the Ramayan, under the assumed name of Valmiki. Any how, the book was not composed much earlier than 51 B.C. The horoscope of Ram Chandra, as given in Valmiki Ramayan, also suggests

the idea that the work was composed after the Indian astrological science had been influenced by the Greek system, as I find no trace of foretelling events by means of a horoscope in the earlier periods.

CHAPTER IV-MISCELLANEOUS.

1. Indian division of the Zodiac.

A—Nakshatras and their number.

As already stated in chapter II, the Zodiac was divided into 28 Nakshatras. Their number is 27 at present; it appears therefore, that one Nakshatra was omitted in some past period. It will appear from the chapter referred to, that there were 28 Nakshatras, when the equinoctial point was retrograding through Adra Nakshatra. In the Atharva Veda (XIX-1-7), 28 Nakshatras are mentioned in regular order, beginning with Kritika. In Taitraiya Brahman (III-1), 28 Nakshatras are mentioned in the regular order, beginning with Kritika, while in another part of the same work (I-5), only 27 are stated. Abhijit (Lyra), the omitted constellation, is referred to separately in the next para. In chapter IX of Varahi Sanhita, 27 Nakshatras beginning with Bharni are referred to.

It is clear from the above facts, that the number of Nakshatras was reduced from 28 to 27, when the vernal equinoctial point was retrograding through Kritika Nakshatra.

B—The principal or the chief stars and presiding deities of Nakshatras.

I have partly dealt with this subject in chapter II of this book. Here I confine myself to those details, which I thought unnecessary for that chapter. There is not the least doubt, that the principal stars of Indian Nakshatras, were arranged according to their right ascensions, but it is very strange, that there should be a difference of only

about a quarter of a degree between the longitudes of Delta Hydrae and Lambda Dranconis and that these stars should mark the beginning and the end respectively of the constellations concerned. It is nearly the case with Alpha Leonis, the principal star of Magha and Gamma Ursae Majoris, a star of Sapt Rishis. The latter were the lords of Pitris at some past period according to the Rig Veda, and Pitris are the presiding deities of Magha Nakshatra. These facts clearly show, that the principal stars of Nakshatras were generally selected, when they marked the North solstitial point, as there was no difference then between the longitudes as measured on polar and latitudinal circles.

The presiding deities of Ashwini Nakshatra, which in the Vedic period consisted of Beta and Alpha Arietis, were Ashwinau or the two Ashwini. They were apparently Beta and Epsilon Cassiopeiae, as the difference between their longitudes and those of the above mentioned stars is very small.

The presiding deity of Bharni (33,35 and 41 Arietis) is Yama. The longitude of Delta Cassiopeiae is nearly the same as that of 41 Arietis. According to the description of Yama given in the Indian works, Gamma, Delta and Epsilon Cassiopeiae was the constellation called Yama. This constellation was probably formed in the arctic region, when Delta Cassiopeiae marked the position of the midnight Sun. As already stated, a star in the constellation of Ursa Major formerly marked that position and was consequently fixed as the head of Pitris. When circumstances changed, Yama was appointed as their divinity. It is, however, possible that when the Aryan race migrated southward and the South solstitial point was known, Alpha Ceti might have been called Yama, which appears likely from the tradition of the ancient Greeks about the constellations of Cassiopeiae and Cetus. It is also posible, that the constellation of Triangulum was Yama.

The presiding deity of Kritika Nakshatra is Agni or fire. Its principal star is Eta Tauri, the logitude of which is almost the same as that of Gamma Persei and Gamma Cephei. The latter's latitude is about 66 2/3 degrees North. It was therefore, the pole star at the time when Eta Tauri was selected as the principal star of Kritika. The stars Zeta to Eta Persei appear like a flame of fire. I think, that this constellation after excluding some stars, was called Agni and its principal star was Gamma Persei. Some scholars have identified Beta Tauri as the star Agni, referred to in Surya Sidhanta, but it cannot be the star in question, because its maguitude, as stated in that work, does not correspond to that of Beta Tauri.

The presiding deity of Rohni Nakshatra is Prajapati; its chief star is Alpha Tauri. When at the vernal equinoctial point, the right ascension of this star nearly coincided with that of Alpha Aurigae, which was therefore Prajapati, vide chapter II.

The presiding deity of Mrigshir Nakshatra is Soma or the Moon. At present this Nakshatra consists of Lambda, Phi-1 and Phi-2 Orionis, but it had undergone many changes. It was once called Mriga or deer, vide chapter II. In Taitraiya Brahman (I-5), Iuvaka (or the stars called Pi Orionis) is substituted for it.

The presiding deity of Adra Nakshatra is Rudra; its chief star is Alpha Orionis. Its longitude is nearly the same as that of Alpha Ursae Minoris, the latitude of which is about 66° North. It was therefore the Pole star, when Alpha Orionis was selected as the principal star of Adra. The constellation of Ursa Minor was most probably called Rudra, as the divinity is associated with serpents and the former is nearly encircled by the constellation called Draco or serpent. Vahu, which was at some period substituted for Adra Nakshatra (Taitraiya BrahmanI-5), was probably Mu Geminorum.

The presiding deity of Punarvasu Nakshatra is Aditi, the mother of Dewas or the visible part of the heaven in the arctic region. The principal star is Beta Geminorum. The presiding deity of Pushya Nakshatra is Jupiter. The chief star is either d Cancri or Delta Cancri. Most probably, it was the former according to its magnitude, as stated in Surya Sidhanta.

The presiding deity of Ashlesha or the head of Hydra is Sarp or Serpent; its principal star *at present* is Epsilon or Zeta Hydrae. The longitude of Alpha Ursae Majoris and the latter star is nearly the same. The former therefore marked the midnight Sun, when the constellations were formed in the arctic region. The presiding deity is Draco. There is only a difference of about a quarter of a degree in the longitudes of Delta Hydrae and Lambda Draconis, and it is therefore very probable, that the original principal star was the former.

The presiding deities of Magha Nakshatra, are Pitris; its principal star is Alpha Leonis. There is a difference of about a degree in the longitude of Alpha Leonis and those of Gamma and Delta Ursae Majoris, the old gods of Pitris, vide chapter II.

The presiding deity of Purva Phalguni Nakshatra is Bhag; its principal star is Delta Leonis. I think, it has undergone some changes. There is a differenec of about 4 degrees in its longitude and that of Alpha Draconis. In this connection it may be noted, that Bhag and Sarp are among the eleven Rudras.

The presiding deity of Uttra Phalguni Nakshatra is Aryaman, a name of the Sun; its principal star is Beta Leonis.

The presiding deity of Hasta Nakshatra is Savita, a name of the Sun; its principal star is Delta Corvi.

The presiding deity of Chitra Nakshatra is Twashta; its present principal star is Alpha Virginis. It has undergone several changes in the past periods. Delta and Theta Virginis were once its principal stars and are referred to in the Rig Veda (II-35-3). This is the reason, that the author of Surya Sidhanta has erroneously stated their longitudes as the same, as that of Alpha Virginis. They cannot correspond even according to the Indian method of measurement of longitudes. The presiding deity was either Gamma or Alpha Bootis.

The presiding deity of Swati Nakshatra is Vayu; its *present* principal star is Alpha Bootis. Its longitude is nearly the same as that of Alpha Virginis. Though it might have served the purpose at some time according to the Indian method of measurement, yet it was certainly not the chief star of that Nakshatra, when marking the North or South solstitial point. I think Kappa Virginis was originally the principal star of Swati Nakshatra, then called Nishtya (vide Taitraiya Brahman I-5) and the asterism consisted of Iota, Kappa and Lambda Virginis, as was the case with Babylonion asterism and Delta Bootis was the presiding deity. Alpha Bootis was apparently substituted for Kappa Virginis, owing to its brilliancy, when it coincided with the latter according to its right ascension, at the autumnal equinoctial point.

The presiding deity of Visakha Nakshatra is Indragni. Its principal star is Alpha Librae. There is a difference of two degrees or thereabout in the longitude of this star and that of Alpha Coronae. Carona was apparently called Indragni.

The presiding deity of Anuradha is Mitra; its principal star is Delta Scorpii. There is a difference of only about a quarter of a degree between the longitude of this star and that of Delta Ophiuchi. The constellation of Ophiuchi was therefore the presiding deity (see chapter II).

The presiding deity of Jyeshta Nakshatra is Indra; its chief star at present is Alpha Scorpionis. Formerly, it was Epsilon Scorpionis, but when the South solstitial point was marked by that star it was detached from Jyeshta and included in the Nakshatra, called Mul, vide chapter II. There is only a difference of less than a degree between the longitude of Epsilon Scorpionis and Alpha Herculis. The constellation of Herculis was Indra.

The presiding deity of Mul Nakshatra is Niriti; its principal star is Lambda or Upsilon Scorpionis. The difference between the longitude of these stars and that of Xi, Draconis is very slight; apparently, the mouth of Draco, *ei.* Xi, Gamma, Beta and Nu Draconis, was called Niriti. This deity was apparently selected, when Mul marked the South solstitial point.

There is not the least doubt, that there have been some changes in the principal stars of the Nakshatras, called Purva and Uttra Asharas, as the difference between their longitudes is only ab out 5 degrees. The present principal stars are Delta and Phi Sagittarii.

The presiding deity of Abhijit Nakshatra is Brahma; its present principal star is Alpha Lyrae. I think, Tau Sagittarii was the principal star of this Nakshatra, when Alpha Lyrae was close to the pole. When the latter was made the principal star, some changes had to be made in other Nakshatras. The changes were made when Alpha Lyrae marked the autumnal equinoctial point and its Indian longitude was the greatest. The result was, that an old Nakshatra called Shardul, the principal star of which was Alpha Aquarii, had to be omitted. The necessary changes were also made in the chief stars of the Nakshatras called Asharas.

The presiding deity of Shrawan Nakshatra is Vishnu, a name of the Sun and its chief star is Alpha Aquilae. The

difference between the longitude of this star and that of Beta Cygni is very slight. The constellation of Cygnus was therefore called Vishnu.

The presiding deity of Dhanishta Nakshatra is Vasu; its principal star is Beta Delphini. This was selected, when Delta Cygni was the pole star or close to the pole. The difference between the longitudes of these stars is very slight.

The presiding deity of Shatvisha Nakshatra is Varun; its present principal star is Lambda Aquarii. Varun is the God of waters. It was probably selected, when the Nakshatra was just at the horizon.

The presiding deity of Purva and Uttra Bhadrpada Nakshatras, are Ajek Pada (one legged goat) and Ahir Badhna respectively; their principal stars according to the magnitudes stated in Surya Sidhanta were probably Lambda and Phi Pegasi. Probably, some stars in the constellations of Lacerta and Andromeda were their presiding deities.

The presiding deity of Revti Nakshatra is Pushan; its present principal star is Zeta Piscium. When Delta Virginis and Theta Virginis marked the autumnal equinoctial point, Delta Piscium was the principal star. The presiding deity of this Nakshatra is Andromeda and was called Pushan. The longitude of Delta Piscium and Alpha Andromedae is nearly the same, while there is a difference of about only a degree in the longitudes of Zeta Piscium and Epsilon Andromedae.

C—Signs, degrees, ect.

The other division of the Zodiac used by the Indo Aryans was the same, as is now employed by modern astronomers, viz 12 signs of 30 degrees each, with a further sub-division of a degree into multiples of 60. As regards the antiquity of the heavenly division into Signs, I have already treated this matter in connection with the Indian

antiquity. Originally the 12 signs were divided into 120 parts, called Asuadityas, vide Taitraiya Brahman.

2—Indian Division of Time.

A—General.

As already stated detailed information on the subject is given in chapter XIV of Surya Sidhanta. According to this work, there were nine kinds of Indian division of time, which were called 'Man' or measures, viz Brahma, Prajapatya, Divya, Pitra, Varhaspatya, Chandra, Nakshatra, Sawan and Saur.

1. Brahma's day and night or Kalpa, was called Brahma Man, vide chapter II-4 of this book.

2. Manwantras were called Prajapatya Man.

3. Dewas' day and night of 6 months each, and Dewas' Yugas were called Divya Man, vide chapter II-4.

4. Pitris day, midday, night and midnight based on a lunation, were called Pitra Man.

5. Twelve Jupiter's years, commencing from rising or setting of that planet and named after Nakshatras, as well as Jupiter's cycle of 60 years, were called Varhaspatya Man.

6. Lunar days, Lunar fortnights and Lunar months, were called Chandra Man. These are also referred to in the Yajur Veda XXII-18.

7. Sidereal days which were based on stars' revolution around the Pole were originally called Nakshatra Man. When Lunar months were named after the Nakshatras they were termed as Nakshatra Man, as well as the period during which the Moon moves in a Nakshatra.

8. An ordinary day of 24 hours was called Sawan Man. Orginally it was divided into 30 Mahurtas; every Mahurta, into 30 Kalas; every Kala, into 30 Kashtas; and every

Kashta into 15 or 18 Nimesh, vide Shushrut chapter VI, Manusmriti verse 64 Mahabharat Shanti Parva chapter 231 and Amarkosh. Nimesh is also mentioned in the Yajur Veda (XXXII-2). In the Budhist period, a Sawan day was divided into 60 Ghatikas or Nadis; every Ghatika into 60 Palas. The latter division was used by the author of Surya Sidhanta and all subsequent astronomers.

9. The equinoxes, the solstices, the sun's 12 signs and degrees, the tropical months, the seasons and the calendar called Sharashtimukh, were called Saur Man. In the Rig Veda (X-90-6) and the Yajur Veda (XXXI-14) only three seasons are mentioned, viz Vasant, Grishma and Sharat. But in chapter XIII and XIV of the latter work, six seasons, with their respective months (2 for every season), are stated in regular order, viz Vasant (spring), Grishma (summer), Varsha (rains), Sharat (early winter), Hemant (winter) and Shishir (winter), vide also Shatpath Brahman (IV-3). In Taitraiya Brahman (I-4-10), the first 5 seasons are mentioned, and Shishir is omitted. These variations show, that the number of seasons was originally three; that it was revised from time to time to suit the local circumstances during Aryans immigration. According to Shatpath Brahman and the Yajur Veda the spring season used to commence from the vernal equinox, while according to Surya Sidhanta and some other works, it used to begin a month earlier.

According to chapter XIV of Surya Sidhanta, the divisions of time based on Saur Man, are defined as follows:- There are two equinoctial (Vishuwat) and two solstitial (Ayan) points. Between each Vishuwat and Ayan, there are two Sankrantis (the sun's signs, *i.e.* there are 12 signs. The first Sankranti between each Vishuwat and each Ayan, is called Vishnupadi or a step of Vishnu. There are 6 seasons. The period during which the Sun moves in two signs, commencing from Capricorn is a season. The first

season is Shishir. The period in which the Sun moves in twelve signs is called a year, commencing from Mesh or the Aries. Every year consists of twelve months. A tropical year, commencing from the autumnal equinox is called Sharashtimukh. (This is also referred to in the Atharva Veda, vide XI-2-3-21). This year is divided into 5 parts. The first four parts consist of 86 solar days each, and the fifth of 16 such days. The latter are solely used for performance of ceremonies of Pitris (departed souls). This period, which formerly corresponded to the last 16 days of Kanya or the sixth sign, is still called Kanagat or Kanyagate, though a tropical year is no longer used, nor does the period always correspond to the aforesaid Sun's degrees, even according to the sidereal reckoning. In fact, the ceremonies are now performed in these provinces in the last 16 days of the lunar month of Ashwin.

The periods, during which the Sun moves northward and southward, are respectively called Uttrayan and Dakshnayan. According to Shathpath Brahman (IV-3), the seasons during which the Sun moves northward of the equator, are called Dewas' and the rest Pitris' seasons. The words Uttrayan and Dakshnayan, literally mean the north and south solstitial points. It is therefore very probable, that when the ancients lived in the arctic region, Dewas' and Pitris' seasons were called by those names. According to Surya Sidhanta, there are 2 kinds of lunar months. One of them begins from a full Moon and the other from a new moon.

B—Indian Calendars.

When the ancient Aryans were living in the arctic region, they used to reckon their time by means of stars, the Moon, the planet Jupiter, and the autumnal equinox. Calendars, based on Jupiter's movements and tropical year, were used. Their oldest tropical calendar, called Sharasti-

mukh, has already been referred to. When the ancients migrated southward, they also adopted, at different periods, three kinds of tropical calendars, commencing from the vernal equinox and from the two solstices. The ancient Aryans generally used to change their calendar, when any of the equinoctial or solstitial points happened to coincide with the beginning of one of their Nakshatras. In fact, for the sake of convenience, they used to reckon their time by means of a sidereal year adjusting it to a tropical year, by means of Ayanansha, which is the difference between their sidereal and tropical positions of the Sun. With a view to avoid much disturbance in their seasons, they did not, however, allow the figure of Ayanansha to increase beyond reasonable limit. So it occasionally happened, that they had to start a new calendar coinciding with one of the points referred to, by slightly altering the limits of their Nakshatras.

Now, I proceed to mention the Indian calendars, about which some information is available.

When the vernal equinoctial point, began to retrograde in Adra or more probably in Mrigshira Nakshatra, the lunar months were named after Nakshatras. The last month of the calendar, commencing from the autumnal equinox, was therefore named Margshir. The month is still called Aghan, a corrupted form of Agrahayan. The Nakshatra Mrigshira is also called Agrahayan, vide Amarkosh dictionary. The month of Margshir was therefore held very sacred, owing to Pitris' ceremony, vide Gita. In Varahi Sanhita and some other works, two old calendars are mentioned. The first month of the one was Margshir and that of the other Kartik. The second was apparently substituted for the first, when the vernal equinoctial point began to retrograde through Kritika or Rohni Nakshatra. It appears from the Yajur Veda, (chapters XIII and XIV), that a spring calendar was also prevalent, at some time. When Maharaja Yudhistar

started his era, he made use of the spring calendar, vide the last chapter of this book. When the North solstitial point was in the middle of Ashlesha Nakshatra, two calendars commencing from the North and South solstices, were started. The former calendar is still prevalent in Tamil and Malayam of Madras Presidency and is called Paras Ram's calendar. The second is now no longer used, but it is referred to in Mahabharat and the epochs of Jyotish Vedang and Pita Maha Sidhanta, started from the commencement of this calendar, which was called Dhanishta calendar. There were, however, two such calendars, one commencing from a full Moon and the other from a new Moon. It appears from Valmiki Ramayan, that a calendar commencing from a full Moon of Chaitra was prevalent at the time, when that book was composed. The first month of this calendar was therefore Vaisakh. Owing to the retrograde movement of the vernal equinoctial point, this calendar had to be changed and a new one commencing from a new Moon of Chaitra or the middle of that month was adopted. This calendar was used by the author of Surya Sidhanta and all the subsequent astronomers.

3—Planets.

The five major planets were known to the ancient Indians, at least as far back as 5000 B.C., when the vernal equinoctial point was retrograding through Adra Nakshatra, the principal star of which is Alpha Orionis. This appears from the facts that a division of Nakshatras into 3 groups commencing from Adra and Ashtotri Dashas (planetary periods for foretelling events), beginning with that constellation are still in use. In these Dashas, their order of precedence is as follows. The Sun, the Moon, Mars, Mercury, Saturn Jupiter and Venus. This nearly corresponds to that employed in the week days. It appears therefore probable, that week days were named after the heavenly bodies at some time between 5000 and 2500 B. C. The order was subsequently changed as in Binshotri Dashas beginning

with the Kritika Nakshatra, the principal star of which is Eta Tauri, the following order of precedence, was adopted. The Sun, The Moon, Mars, Jupiter, Saturn, Mercury and Venus. This was probably, done in accordance with the situation of the orbits of the planets, with regard to the Earth's orbit. There are reasons to believe, that Jupiter and Venus were first discovered by the ancient Aryan race. Their rising and setting play an important part in religious and social functions of the Hindus, even upto this time. In fact, during the period of their invisibility, no auspicious ceremonies are performed, including marriage. In deciding dates for marriages on Astrological point of view, positions of the Sun, the Moon and Jupiter are taken into consideration. This fact suggests the idea, that Jupiter was held in greater importance, apparently, because it was first discovered. Of all the planets, Jupiter is the only one, which is the presiding deity of a Nakshatra.

Indian Meridian.

It is stated in Surya Sidhanta, that a line drawn from the city of Lanka, which was supposed to have been situated on the earth's equater, to the poles, was the Indian meridian and that it passed through Avanti, Rohtikam and Kurukashetra. Lanka is a mythical city and no body knows for certain, where it existed. As regards, the other places Avanti is said to be the old name of Ujjain, Rohtikam is perhaps the present town of Rohtak, in the Panjab and Kurukashetra is well known. Some subsequent astronomers mentioned certain other places, in addition to those stated above. Of these, Kanya Kumari is the Cape Comorin and Kanchi is Conjeveram.

All these places are, however, not situated on the same terrestrial longitude, vide details given below.

Ujjain	..	75°-47′	East of Greenwich
Kurukashetra	...	76-20	do. do.
Comorin	...	77-33	do. do.
Conjeveram	...	72-42	do. do.
Rohtak	...	76-35	do. do.

Under the circumstances stated, I could not form any idea about the exact place, from which the Indian meridian was reckoned. I therefore, made a search for any ancient work, which could give any correct information. The only book, which I have been able to find is Panch Sidhantika, in which the difference in time between Benares and Yawanpura and that between Avanti and Yawanpura, are stated, viz 9 gharis (3 3/5 hours) and 7 1/3 Gharis (2 14/15 hours), respectively. Of course, by the word Avanti the author's starting point of the meridian is meant, and not the town of Ujjain, as the actual difference in time between Benares and Ujjain is 1 1/5 Gharis and not 1 2/3, as appears from the above statement. Thus, I was able to find out the starting place of Lat Deva's meridian, which was 73°-1′ East of Greenwich and which he adopted in revising Romaka and Paulis Sidhantas. But the question remained, as to whether he followed the standard Indian meridian or devised a new one, for his convenience. To test this point, I worked out the Sun's positions, according to the rules of Arya Bhatta and Lat Deva, for their epochs of 498 and 505 A. D. respectively, and calculated the Sun's sidereal motion for the intervening short period by means of the *true* sidereal rate of motion. Thus, I found that the meridian adopted by Arya Bhatta, differed from that used by Lata Deva by about 40 Palas or 16 seconds. The difference is so small, that it cannot be accounted for by a possible change in the starting point of the sphere, which according to the practice of the Indian astronomers was limited to 5 minutes or its multiple. Moreover, such a change after so short a period of seven years, was not possible. In a similar way, I found that Bhashkaracharya started his meridian from a place, which was 79°-7′ East of Greenwich. Then, I worked out and compared the Sun's position in 1905 B. C. the Epoch of Vashishta Sidhanta, and found that its meridian started from a place, which was 75°-49′ East of Greenwich. Similarly, I

found that the starting place of the meridian adoped by Maharaja Yudhishtara's astronomers for his epoch of 2448 B. C. was Kurukshetra.

Under the above circumstances, it appears that Maharaja Yudhishatra started his meridian from Kurukshetra in commemoration of his victory at that place. Subsequently, Vashishta fixed Avanti, as the starting place of the meridian. This is corroborated by the fact, that according to Vishishta Sidhanta, the duration of a shortest day in a year was 1591 Palas, which nearly corresponds to the latitude of Ujjain. This place was selected probably, because its latitude nearly corresponded to the obliquity of the ecliptic. This is supported by the fact, that according to Vashishta Sidhanta, when the Sun entered the sign of Cancer, a gnoman threw no shadow at noon. Thus, the Indian meridian came to be known as Avanti.—Kurukshetra meridian, but it was not followed by several astronomers, as my calculations will show.

CHAPTER V CALCULATIONS.

1—The principal star of Revti and the Indian Sidereal motion of the Sun.

According to the late Bapu Deva Shastri, a renowned Indian astronomer of the modern period and certain European Scholars, who investigated the matter, Zeta Piscium is the principal star of the Nakshatra Revti. There are however, two stars bearing the same Greek Alphabet, but the description of the principal star of the Nakshatra, as given by various astronomers, leaves no doubt, that Zeta-1 Piscium is the star meant by them. By computing its longitudes for the years 1850 and 1890 A. D., as per Greenwich catologues of stars and by dividing their difference by 40, I got the star's rate of precession for 1st January 1870 A. D. viz 50'3645818". The duration of the tropical year, as determined by the western scientists for the epoch of 1850

A.D. and the rate of its annual decrease, are not strictly accurate, as appears from the fact, that these astronomers differ, though slightly, from one another's findings. The last determination is of Mr. Harkness (1891 A.D.), who apparently deduced his rates from the sun's tropical motion during the period 1850-1890 A.D. It is therefore, clear that whatever defects there might have been in his determination of the rates for the epoch of 1850 A.D., the duration of the tropical year at his rates must be quite correct for the year 1870 A.D. which is the mean of the period of 40 years, viz 1850-1890 A.D. The rate of the sun's Indian sidereal motion has thus been determined by me, vide details given below.

Longitude of Zeta Piscium on 1st January

1890 A.D. = 0-18-20-15·752763″

" " " 1850 A.D. = 0-17-46-41·169491

Difference 0-0-33-34·583272

Divided by 40 = 50·3645818″ in 1870 A.D.

The Sun's tropical daily motion according to the rates of Mr. Harkness for 1870 A.D. = 3548·33040886425″

Deducted

Daily rate of precession $\frac{50{\cdot}3645818''}{365{\cdot}2421986303 \text{ days}} = 0{\cdot}13789365519''$

The Sun's sidereal daily motion (Indian) 3548·19251520906″

There is not the least doubt about the strict accuracy of the Sun's sidereal daily motion, as it has given correct results even for the epoch of Vashishta Sidhanta (1905 B.C.)

2—*Variations in the motion of the Moon, its perigee and node and of the Sun (tropical) and its perihelion.*

It is only by means of comparing longitudes at long intervals, that exact rates of variations can be ascertained. Unfortunately the standard Indian works, called Sidhantas,

are useless for this purpose, partly because in majority of cases the time of their composition is not known and partly because of the elaborate system of calculation used, which is based on the epoch of Kalpa and fixed number of revolutions of heavenly bodies in that period. This fact creates suspicion in one's mind, that calculations based on these might not give strictly accurate results, even for the time when these works were composed. In fact, to remove such small errors, Brahma Gupta and the author of Maha Sidhanta have applied corrections, but unfortunately, the rules of the former on the subject are not clear and the time of the latter is not known. Under these circumstances, the only works, which can serve the present purpose, are those which have given positions of the heavenly bodies at the commencement of their epochs. The oldest of such works is Vashishta Sidhanta and the next available and reliable is the one composed by Bhaskaracharya in 1183 A.D. The works of Lat Deva, composed in 505 A.D. are not properly understood, as regards the Moon's position at the time, but they are very clear, as regards the Moon's node. As Vashishta Sidhanta is silent about the latter's position in his time, I have selected the works of Lat Deva for this purpose. Of the modern works, I have taken the figures of Mr. Hansen for the first January 1850 A.D. the commencement of his epoch, as they must be strictly accurate. I have converted the longitudes to the sphere, beginning with the star Zeta Piscium and added 4′-57·32″ the difference between the Indian and the European measurement, which is due to the fact, that the latter is based on observations made by means of telescopes, while the former is apparently the result of the naked-eye observations. The figures of the Indian works have also been converted to the sphere, starting from the star Zeta Piscium. As obviously the Indian figures for the Moon and its Perigee and Node represented positions, which are now termed "Corrected mean", I have converted them into actual mean,

according to the rules of the western astronomers To remove any possibility of doubt as regards the correctness of my results, I have tested them by means of Synodical and Anomalistic periods, which obviated the necessity of making any changes in the figures due to alterations in spheres and modes of measurement. The strongest proof, which I can offer in support of the accuracy of my results, is the fact that the Moon's daily motion calculated for the epoch of 1850 A.D. according to my figures, agrees in a remarkable degree, with that determined by the European astronomers, viz 47434'889438" according to the Indian sidereal motion as against 47434'889437" (vide Herschel's astronomy).

Vashishta Sidhanta.

Meridian 72 Palas west of Benares, time noon.

Moon at the beginning of his epoch *i.e.* Kali Abargan 437037 days	0°-0°-0'-0"
Deducted corrections −17'51707' + 8'66156	
Net − 8'85551 or 8'−51'33" minus	0-0-8-51'33
actual meam position	11-29-51-8'67
Converted to the sphere of Zeta Piscium	−0- 1- 0-0
	11-28-51-8'67
Converted to the meridian of Greenwich	+0- 2-46-29'21
	0- 1-37-37'88
According to Vashishta the Moon was in its perigee. It was therefore	0-0- 0- 0
Deducted correction	0-0-25-39'60
	11-29-34-20'40
Converted to the sphere of Zeta Piscum. −	0- 1- 0- 0
	11-28-34-20'40
Converted to the meridian of Greenwich +	0- 0- 1-24'44
	11-28-35-44'84

Bhaskaracharya.

Epoch, 1183 A.D.—Meridian, 39 Palas west of Benares—Time, morning of Kali Ahargan 1564737.

Positions as per work of Bhaskaracharya—Moon, $10^s - 29^\circ - 5' - 50''$: Perigee, $10^s - 15^\circ - 12' - 59''$: Node, $2^s - 12^\circ - 34' - 51''$.

Corrections to be applied—Moon, $+15'7814' - 23'5032'$ or $-7' - 43'30'$: Perigee, $+25' - 45'30''$: Node, $+8' - 27''19$ Add $2^\circ - 25'$ with a view to convert the figures to the sphere starting from Zeta Piscium. For making the figures applicable to the noon of Greenwich add $6^\circ - 11' - 22'72''$, $3' - 8'33''$ to the positions of Moon and Perigee respectively and deduct $1 - 29'61''$ from that of the Node. The net figures are :—Moon, $11^s - 7^\circ - 34' - 29''42$: Perigee $10^s - 18^\circ - 6' - 52'63''$: Node $2^s - 15^\circ - 6' - 48'58''$.

Epoch 1st January 1850 A.D.

Greenwich noon—Tropical positions according to Mr. Hansen viz Moon $4^s - 16^\circ - 15' - 33''70$: Perigee, $3^s - 9^\circ - 58' - 43'07''$: Node $4^s - 26^\circ - 10' - 25'11''$—With a view to alter the figures to the sidereal positions deduct the longitude of Zeta Piscium i.e. $17^\circ - 46' - 41.17''$. Add also $4' - 57'32''$ owing to the difference due to the method of measurement (vide, part V-3)—The net figures are :—Moon, $3^s - 28^\circ - 33' - 49''85$: Perigee, $2^s - 22^\circ - 16' - 59'22''$ Node, $4^s - 8^\circ - 28' - 4[illegible]''26$

Lat Deva.

Epoch 505 A.D. Kali Ahargan 1317122, Evening, Meridian 100 Palas or 40 minutes west of Benares—

Node, tropical position as per Romak Sidhanta	$7^s - 25^\circ - 48' - 57''96$
Added the difference between Romak and Paulis Sidhantas	$0 - 0 - 9 - 21'84$
Sidereal position	$7 - 25 - 58 - 19'80$

Added corrections to convert into mean	0-0-8-47·64
	7-26-7-7·44
Converted to the sphere of Star Zeta Piscium	+ 0-0-50-0
	7-26-57-7·44
Deducted 38·69" to convert to the meridian of Greenwich and added 47·69" for a quarter of a days' motion in order to convert it to Greenwich noon	+ 0-0-0-9·0
Position on Kali Ahargan 1317122 Greenwich noon ...	7-26-57-16·44

Moon.

(1) Kali Ahargan	1808293	3S-28°-33'-49·85"
do.	437037	0 - 1 - 37 - 37·88
	1371256	A 3 - 26 - 56 - 11·97

Revolutions $50189 \times 1296000''$ = 65044944000"
Added seconds of A = 420971·97"
65045364971·97"

Divided by 1371256 the difference of days = 47434·88084790148593''

This was the mean rate for the period and it was actually on Kali Ahargan 1122665 as per details below.

Kali Ahargan	437037
Added half of the difference of days i.e. 1371256/2	685628
	1122665

(2) Kali Ahargan	1564737 ...	11S-7°-34'-29·42"
do.	437037 ...	0 - 1 -37 -37·88
	1127700 ...	B 11 - 5 -56-51·54

Revolutions during the period
viz 41274 × 1296000 — 53491104000

Added seconds of B — 1209411·54

53492313411·54

Divided by the difference of days = 47434·87932210694333″

This was the actual rate on Kali Ahargan 1000887.

The difference of the two rates is divided by 121778 (i.e. by the difference of Kali Ahargans 1122665 and 1000887) and the result is 0·00000001252931188392″—This is the daily increment in the rate of the Moon's motion.

Perigee.

1—Kali Ahargan 1808293 = 2ˢ – 22° – 16′ – 59·22

,, 437037 = 11 – 28 – 35 – 44·84

1371256 2 – 23 – 41 – 14·38 = 301274·38

Added complete revolutions 424 × 1296000 = 549504000·00

549805274·38″

Divided by 1371256 days = 400·95013212704265″

2—Kali Ahargan 1564737 = 10ˢ – 18° – 6′ – 52·63″

,, 437037 = 11 – 28 – 35 – 44·84

1127700 10 – 19 – 31 – 7·79 = 1150267·79″

Added complete revolutions 348 × 1296000 = 451008000·00

452158267·79

Divided by 1127700 days = 400·95616546067216″

The difference of the two rates divided by 121778 is equal to 0·00000004954370764466.″ This is the daily decrease in the rate of the Moon's perigee.

Node.

1—Kali Ahargan 1564737 = 2ˢ – 15° – 6′ – 48·58″

,, 1808293 = 4 – 8 – 28 – 41·26

Difference 243556 10 – 6 – 38 – 7·32 = 1103887·32″

Complete revolutions 35 × 1296000″ = 45360000·00

46463887·32

Divided by 243556 days = 190·7729118560 A

2—Kali Ahargan	1317122	= 7ˢ-26°-57'-16'44"	
do.	1564737	= 2 -15 - 6 -48'58	
Difference	247615	5 -11 -50 -27'86 =	582627'86"
Complete revolutions	36×1296000" =		46656000'00
			47238627'86

Divided by 247615 days = 190'7745001716" B.

These rates A and B were on Kali Ahargans 1686515 and 1440929'5 respectively. The difference of rates is divided by the difference of days and the result is 0'0000000064674649". This is the daily decrease in the rate of the Moon's Node. These variations in the rates of the Moon and of its Node and Perigee appear to have some connection with the changes in the tropical motions of the Sun and of its Perihelion, as the following figures will show:—

Daily variation in the Moon's motion divided by the daily variation in the Node's motion is equal to 1'937283 A. Daily variation in the motion of the Perigee divided by the daily variation in the Moon's motion is equal to 3'954224 B

A×B = 7'660450934 C

A+B = 5'891507 D.

The daily variation in the Moon's motion divided by C = '000000001635584" E.

The daily variation in the Moon's Node divided by D = '000000001097761" F.

E+F = '000000002733345". This exactly agrees with M. Leverrier's determination of the daily increase in the tropical motion of the Sun's Perihelion.

The figure marked F is the daily increment in the sidereal motion of the Sun's Perihelion. The figure marked E is the daily rate of variation in the tropical motion of the Sun and it nearly corresponds to the latest determination by Mr.

Harkness, according to whom the variation is '000000001652385' The Sun's tropical positions for the epoch of Lata Deva (505 A. D.) and of Yudhishtara (2448 B.C.) if calculated according to E, show only a difference of two seconds. It is noticeable, that this difference is the same at both the epochs, which suggests that it is not due to any error in the rate but to some other cause. The period of lunation on 1st. January 1850 A. D., according to my rate of the increase in the Moon's motion comes to 29'530588785703 days as against 29'5305887865069 as determined by the European astronomers, vide Herschel's astronomy. The rate of decrease in the period of lunation, according to my calculations, comes to 0'00000000000843073 per day. I may mention, that 4131 lunations closely correspond to 334 tropical years and the difference between the two periods is the least, as compared with all other such periods hitherto determined. Moreover, this difference is annually decreasing owing to the variations in the Sun's and the Moon's motions.

3—Indian Astronomical Works and Erás.

As the Indian observations were not made by means of a telescope, there must have been some difference between the Indian and the modern astronomer's measurements, vide Sir Robert Ball's Elements of Astronomy of 1910, page 22, para 12, Instruments for measurements. It is also probable, that the vernal equinoctial point which is not a visible object in the heaven, was not so accurately determined by the ancient Indians, with the means at their disposal, as is done by a modern astronomer, with the highly perfect instruments. With a view to find out accurately these variations, I take up first of all the Romak and Paulis Sidhantas, as revised by Lat Deva in 505 A. D., in which the exact difference of meridian in time from Benares is stated. These revised works have been treated by Varah Mihar in his Panch Siduantika.

Paulis Sidhanta

Epoch 505 A. D. Kali Ahargan 1317122, time evening. Difference of meridian in time from Benares 100 Palas West. Sun's daily (sidereal) motion is 3548'19251520906".

Sun's tropical position according to M. Leverrier on 1st. January 1850 A.D. time noon, Paris, Kali Ahargan 1808293	9^s-10°-46'-43'51"
Deduct longitude of the star Zeta Piscium	0 -17 -46 -41'17
Sun's mean position (sidereal)	8 -23 - 0 - 2'34
Converted to Lata Deva's sphere which started from the point 5o' beyond the star. —	0 - 0 -50 - 0
	8 -22 -10 - 2'34
Deduct difference due to meridian 11'-36'5;" and the Sun's sidereal motion for 3/4th of a day 44'-21'1J"	0 - 0 -55 -57'72
Sun's mean position (sidereal) Kali Ahargan 1808292 at Lat Deva's meridian, time evening.	8 -21 -14 - 4'62
Deduct sidereal motion for 491170 days.	8 -21 -35 -17'69
Sun's position at the beginning of the epoch.	11 -29 -38 -46'93
Sun's position according to Lat Deva's Paulis Sidhanta.	11 -29 -43 -44'25
Difference due to the method of making observations.	0 - 0 - 4 -57'32

Romak Sidhanta.

	TROPICAL.
Sun's daily rate on 1st January 1850 AD at my rate of increase.	= 3548'33039691631"
Sun's daily rate on 1st January 1850 at Professor Harkness' rate of increase	3548'33039679358
Sun's daily motion on Kali Ahargan 1317122 at my rate	3548'32959356488"
Sun's daily motion on Kali Ahargan 1317122 at Professor Harkness' rate	3548'32958519015
Sun's tropical position (mean) according to M. Leverrier on 1st January 1850 A.D. Paris noon, Kali Ahargan 1808293	= 9-10-46-43'51
Deduct difference due to Meridian 11'-36'60" and the sun's tropical motion for 3/4 of a day 44'-21'25" ...	0- 0-55-57'85
Sun's tropical position at Lat Devas' meridian—Time evening, Kali Ahargan 1808292	9- 9-50-45'66
Add difference due to measurement (see Paulis Sidhanta) ...	0- 0- 4-57'32
	9- 9-55-42'98
Deduct Aberration 20'54" and Nutation 14'30"	0- 0- 0-34'84
	9- 9-55- 8'14
Deduct Sun's tropical motion for 491170 days at my rate of increase	9-10-20-43'76
At Professor Harkness' rate of increase	9-10-20-41'67
Sun's position at the begining of the epoch at my rate ... ... A	11-29-34-24'38
At Professor Harkness' rate ... B	11-29-34-26'47

Sun's position according to Lat Devas' Romak Sidhanta	...	C	11-29-34-22·41
Differente A and C	...	D	0- 0- 0- 1·97
do. B and C	...		0- 0- 0- 4·06

Further calculations made about Yudhishtra's epoch will show that my rate of the increase in the Sun's tropical motion exactly suits that epoch. No corrections due to Refraction have been applied, as the ancients used to make observations when the heavenly bodies were on their zenith. They were aware of the effects of Refraction, vide Brahm Sphut Sidhanta but not of its cause.

Yudhishtra's Era.

Epoch 2448 B. C Kali Ahargan 238562.

Sun's daily rate (tropical) on Kali Ahargan 238562 at my rate of increase 3548·32782948941".

Sun's daily rate at Professor Harkness' rate 3548·32780299414"

The rates for Kali Ahargan 1317122 see Romak Sidhanta.

For sidereal rate see Paulis Sidhanta.

	Sidereal as per Paulis Sidhanta	Tropical as per Romak Sidhanta
Sun's position on Kali Ahargan 1317122, time evening, meridian 100 Palas West of Benares.	11ˢ-29°-43′-44·25″	11ˢ-29°-34′-22·41″
Deduct Sun's motion for 1078560 days	10-18-28-39·21	11-29-16-55·11
Add Nutation at the time of Romak. ...	Nil	0-0-0-14·30
Mean position on Kali Ahargan 238562, time evening ...	1-11-15-5·04	0-0-17-41·60
Add Nutation on Kali Ahargan 238562	Nil	0-0-0-15·94
	1-11-15-5·04	0-0-17-57·54

Sidereal position of Paulis converted to the sphere starting from the star Zeta Piscium, vide Paulis Sidhanta. ...	0 - 0 -50 - 0	
	1 -12 - 5 - 5.04	0 - 0 -17 -57·54
Less motion for $\frac{1}{8}$th of a day. ...	0 - 0 - 7 -23·52	0 - 0 - 7 -23·54
Position in the afternoon. ...	1 -11 -57 -41·52	0 - 0-10 -34· 0 A. A.
Difference between the sidereal and tropical positions	1 -11 -47 - 7·52	B. B.

This differenoe is equal to $3\frac{1}{4}$ of Nakshatras, *i.e.* $12\ 6/7^{\circ} \times 3\frac{1}{4}$. Therefore, the sphere started from a point, which was, at a distance of $3\frac{1}{4}$ of a Nakshatra from the star Zeta Piscium. It will appear from the above calculations, that I have not applied the correction due to aberration, because the position at both the epochs viz 505 A. D. and 2441 B. C. were of the same kind. If calculations were made according to Professor Harkness' rate of increase, the difference between sidereal and tropical position would amount to 1-11-46-45 *i.e.* about 23 seconds less than $3\frac{1}{4}$ of a Nakshatra.

I give below the position (tropical) as calculated from the epoch of 1850 A. D.

Sun's tropical position according to M. Leverrier on 1st. January 1850, Paris noon, Kali Ahargan 1808293 days	$9^{s}\text{-}10^{\circ}\text{-}46\text{ -}43{\cdot}51''$

Deduct meridional difference and motion for 3/4 of a day. ...	0 - 0 -55 -57·85
Sun's position on Kali Ahargan 1808292	9 - 9 -50 - 45·66
Deduct Sun's motion for 1569730 days at my rate. ...	9 - 9 -37 -38·87
Sun's position on Kali Ahargan 238562 Lata's meridian, time evening.	0 - 0 -13 - 6·79
Deduct aberration 20·54″ and add nutation at the epoch of 2448 B.C. *i.e.* 15·94″	0 - 0 - 0 - 4·60
	0 - 0 -13 - 2·19
Add difference due to measurement ...	0 - 0 - 4 -57·32
	0 - 0 - 17 -59·51
Deduct motion for 1/8 of a day	0 - 0 - 7 -23·54
	0 - 0 - 10 -35·97
The result of previous calculations marked A. A.	0 - 0 - 10 -34· 0
Difference	0 - 0 - 0 - 1·97

Thus my rate of the Sun's motion gives the same difference as in the case of Romak Sidhanta, marked D.

It was the practice of the ancient Indian astronomers to start their epochs from the Sun's positions having no fraction of a minute, as will appear later on; hence the fraction of 34 Seconds in the figures marked A.A. represents the meridional difference. It is equal to 34·5 Palas. This deducted from 100 Palas, the difference in time between Benares and Lat Deva's meridian gives 65·5 Palas, which was the difference between Benares and Yudhishtara's meridian. The latter therefore, started from a place at 76°-27′ East of Greenwich. The longitude of Kurukshetra

is actually 76°-20′ E. The difference therefore is slight. Possibly the meridian was started from the battle field of the war, which must have been fought at some place near Kurukshetra. The reason for fixing the afternoon of Kali Ahargan 238562, as the commencement of the epoch, was the fact that the first lunar day of the Indian month of Jyeshta, which was then the beginning of the calendar, exactly commenced from the afternoon of that day. as will appear from the following calculations.

For the sake of convenience in calculations I give below the position of the Moon and its perigee from the epoch of Vashisht Sidhanta *i.e.* Kali Ahargan 437037 in 1905 B. C.

Moon's daily rate of motion (sidereal) for the epoch of B.C. 2448	° 47434·86977069926142″
Moon's daily rate of motion (sidereal) for the epoch of B.C. 1905	47434·87225745443758″
Perigee's daily rate of motion (sidereal) for the epoch of B.C. 2448	400·99393386760242″
Perigee's daily rate of motion (sidereal) for the epoch of B.C. 1905	400·98410068022764″

Vashisht Sidhanta's meridian 72 Palas (28 4/5 seconds) West of Benares, time noon, Kali Ahargan 437037.

According to Vashishta Sidhant, vide chapter V·2 ...	Moon	Perigee
	11ˢ-28°-51′-,8·67″	11ˢ-28°-34 -20·40′
Sidereal motion for 198475 days at the *mean* rate.	4 -16 -40 -24·52	4 -27 -18 -15·20
Sidereal position on 238562 time noon.	7 -12 -10 -44·15	7 - 1 -16 - 5·20

Add motion for $\frac{1}{8}$th of a day ...	0 - 1 -38 -49·36	0 - 0 - 0 -50·12
Positions in the after noon.	7 -13 -49 -33·51	7 - 1 -16 -55·32
Deduct the difference between the sidereal and the tropical, marked B.B. ...	1 -11 -47 - 7·52	1 -11 -47 -7·52
Tropical positions.	6 - 2 - 2 -25·99	5 -19 -29 -47·80
Converted to Yudhishtra's meridian of Kurukshetra. ...	0 - 0 - 1 -25·65	0 - 0 - 0 - 0·72
Mean positions.	6 - 2 - 1 - 0·34	5 -19 -29 -47·08
Corrections as per details below. +	0 - 0 -15 -16·69	− 0 - 0 -12 -32·76
Corrected mean positions. ...	6 - 2 -16 -17·03	5 -19 -17 -14·32
Equation, −	0 - 1 - 4 -24	
True position of Moon F	6 - 1 -11 -53	
Sun's tropical position marked A. A. (Lata's meridian)	0 - 0 -10 -34· 0	
Convert to Yudhishtra's meridian −	0 - 0 - 0 -34· 0	
	0 - 0 -10 - 0	
Equation +	0 - 1 - 1 -52	
True position of the Sun. G.	0 - 1 -11 -52	

Figures F. and G. show that there was a difference of 180 degrees and the first lunar day of an Indian month exactly commenced from the afternoon of Kali Ahargan 238562 in 2448 B. C.

Details of the Moon's corrections.

Plus.		Minus	
3rd. correction	1°2014′	1st. correction	4°9833′
4th. ,,	0°3006	2nd ,,	2.3310
5th. ,,	20°4571	6th. ,,	0°1764
8th. ,,	0°6664	7th. ,,	1°0540
9th. ,,	0°9533	...	...
10th. ,,	0°2441	...	...
	23°8229′		8°5447′

Net + 15°2782′ or 15′–16.69″

Sun's Perihelion tropical 0ˢ–27°–42′–55″

Moon's Node do. 3 –22 –29 –55°9

The positions of the Sun's Perihelion and of the Moon's Node have been calculated according to the rates determined in chapter V. 2.

For the purpose of finding out the Sun's and the Moon's equation, it was necessary to ascertain the greatest amounts of the equations for the epoch of Yudhishtara. It appears, that the Indian astronomical constants, were determined and fixed for the epoch of 2448 B. C. by the astronomers of Maharaja Yudhishtar. Many of these constants have not been changed by the subsequent Indian astronomers, probably because of the slight changes they undergo. But in the case of those constants, which showed much variations, the later astronomers were obliged to change them, but often with inperfect accuracy. The reason, I think, was the degeneracy of the Indo-Aryans, ever since the war of Mahabharat. So in the case of the Sun's equation of the centre, thy made little or no change.

According to Surya Sidhanta, it is 133′-47″. By calculating it according to M. Leverrier it comes to 129-36″ for the epoch of 2448 B. C. There is a difference of only about 4 minutes, but considering the disagreements between the rates of the astronomical constants, as determined from time to time by the various Western astronomers, no perfect reliance can be placed in M. Leverrier's rate, which was probably based on some older figures of doubtful accuracy. So I accepted the Surya Sidhanta's figures for the epoch of Yudhishtara. As regards the Moon's greatest equation, the Indian astronomers made some changes from time to time. The oldest available work is Vashishta of 1905 B. C. and there is no reason to believe, that he changed the old figure of 2448 B. C., as the Indians were very conservative people and never meddled with the old things, unless obliged to do so. This Sidhanta is, however, silent about the Moon's greatest equation, but I deduced the figure from his rules for converting the Moon's mean position into a true one. I thus found, that according to his rules, the figure was 286′-36″. Thus I got the figures for the Sun's and the Moon's greatest equations and they exactly suit the epoch of Yudhishtara and must therefore be correct.

Vashishta Sidhanta.

This Sidhanta's epoch was Kali Ahargan, 437037, midday, 1905 B.C. Meridian, 72 Palas from Benares *i.e.* Ujjain or some place close to it. The Moon was in its perigee.

The epoch commenced from the first day of the lunar month of Kartik, Yudhishtara's era 543.

The Sun's position is calculated below:—

As per Paulis Sidhanta on Kali Ahargan 1317122, evening ...	11ˢ-29°-43′-44·25″
Deduct motion for ¼th of a day	0 - 0 -14 -47·05
Mean position at noon.	11 -29 -28 -57·20

Deduct sidereal motion of the Sun for 880085 days. ...		5 -29 -43 -29·75
Mean position on 437037 at noon Lata's meridian *i.e.* 100 Palas west of Benares. ...		5 -29 -45 -27·45
Convert to Vashishta's sphere.	+	0 - 1 -50 - 0
		6 - 1 -35 -27·45
Less the meridional difference.		0 - 0 - 0 -27·45
		6 - 1 -35 - 0

Paras Ram.

Epoch 1176 B. C.

The era of Paras Ram is used in Malayalam (Manglore to Cape Comorin). Its 4th cycle of 1000 years began in 1824 A.D. This era commences at present from 1st of Singh (Leo) or when the sun enters Magha Nakshatra, the principal star of which is Alpha Leonis. Orginally it commenced from the North Solstice and middle of Ashlesha.

Rate of lunation on 1st January 1850 A.D. ...		29·5305887856 days.
Rate of lunation on Kali Ahargan 703241 in 1176 B.C.		29·5305981021 ,,
New Moon according to Mr. Hansen's position of the Moon (about 11th January 1850) Kali Ahargan 1808304 ...		1808304·855366 days.
Convert to Latas' meridian as the above figures are reckoned from the noon of Greenwich	+	0·202810 ,,
Latas' meridian which is 100 Palas from Benares (west) time reckoned from noon.		1808305·058176 ,,

Deduct period for 37421 lunations at mean rate *i.e.* 29·5305934439		1105064·337264 days.
New Moon at about the time when the era commenced		703240·720912 ,,

The Sun's position at the time is calculated below.

Position of the Sun according to M. Leverrier on 1st January 1850 A.D. corresponding to Kali Ahargan 1808293, Paris, time noon. (Tropical position) A 9s- 10°-46'- 43·51"

Deduct longitude of Zeta Piscium		0 – 17 – 46 – 41·17
Sidereal position		8 – 23 – 0 – 2·34
Convert to Lat Deva's meridian (—11' – 36·57") and deduct motion for ¾th of a day (44' – 21·14")		0 – 0 – 55 – 57·71
		8 – 22 – 4 – 4·63
Convert to Lat Deva's sphere	–	50 – 0
		8 – 21 – 14 – 4·63
Add difference due to measurement		0 – 0 – 4 – 57·32
Position on Kali Ahargan 1808292 at Lata's meridian, time evening		8 – 21 – 19 – 1·95
Deduct motion for 1105051 days.		4 – 28 – 14 – 47·13
Position on Kali Ahargan 703241, time evening.		3 – 23 – 4 – 14·82
Add motion for a quarter of a day		14 – 47·04
Kali Ahargan 703241, time midnight	B	3 – 23 – 19 – 1·86
Tropical position marked	A	9 – 10 – 46 – 43·51
Covert to Lat Deva's meridian (minus 11'-36"·60) and deduct motion for 3/4th of a day i.e. 44'–21·25"		0 – 0 – 55 – 57·85
		9 – 9 – 50 – 45·66

Add difference due to measurement		0 – 0 – 4 – 57·32
		9 – 9 – 55 – 42·98
Deduct motion for 1105051 days		6 – 10 – 17 – 24·41
		2 – 29 – 38 – 18·57
Add motion for a quarter of a day		0 – 0 – 14 – 47·08
		2 – 29 – 53 – 05·65
Deduct Aberration and Nutation		0 – 0 – 0 – 24·74
Kali Ahargan 703241, time midnight	C	2 – 29 – 52 – 40·91
Difference between B and C	D	0 – 23 – 26 – 20·95

The sidereal position (B) should be 3^s–23° 20′. The slight difference was apparently due to meridian. The sphere was the same as that of Lat Deva's. D should be 23°–20′ and the difference is most probably due to some defect in ascertaining tropical position at the time. The era now commences from the beginning of Magha instead of the middle of Ashlesha. The change is due to the Indian rate of the Sun's motion which is slow.

Jyotish Vedang.

According to this work, the southward and the northward courses of the Sun used to take place from the middle of Ashlesha and the beginning of Dhanishta Nakshatras, respectively. The number of Nakshatras was therefore 27. No year of the epoch is given, but it is stated that the first Yuga commenced when the northward course of the Sun began from the first of Dhanishta at the end of the dark half of the month of Paus and the beginning of the bright half of Magh at sunrise and when Jupiter had set or was close to the Sun. This shows that lunar months according to the work commenced from a new moon.

I have found by calculations that the only year which could suit the above circumstances was 1181 B. C. Kali Ahargan 701233 days.

The Sun's tropical position according to M. Leverrier on 1st January 1850 A. D. Paris, noon of Kali Ahargan 1808293		9ˢ-10°-46′-43·51″
Deduct mean longitude of Zeta Piscium		0 -17 -46 -41·17
The Sun's sidereal position		8 -23 – 0 - 2·34
Convert to Lata's meridian 100 Palas west of Benares	–	0 - 0 -11 –36·57
		8 -22 -48 -25·77
Deduct a quarter day's motion		0 - 0 –14 -47·05
		8 -22 -33 -38·72
Add difference due to measurement		0 - 0 - 4 –57·32
Sidereal position at Lata's meridian at sunrise		8 -22 -38 -36·04
Deduct motion for 1107060 days		10 -28 -20 - 5·89
Sidereal position on Kali Ahargan 701233		9 -24 -18 -30·15
Convert to the probable sphere of the book	–	0 - 1 - 0 - 0·0
	A	9 -23 -18 -30·15
The position should be 9-23-20, so the difference is due to the change in meridian	+	0 - 0 - 1 -29·85
		9 –23 -20 -00·00

The meridian therefore started from a place 63°54′ east of Greenwich and 35°-49′-5″ N. Latitude. The latter is according to the book's minimum duration of a day.

The Sun's tropical position according to M. Leverrier on 1st January 1850 A.D. Paris, noon of Kali Ahargan 1808293		9ˢ–10°-46′-43·51″
Convert to Lata's meridian	–	0 - 0 -11 -36·60
		9 -10 -35 - 6·91

Deduct motion for a quarter day	0 - 0 -14 -47·08
	9 -10 -20 -19·83
Add difference due to measurement	0 - 0 - 4 -57·32
	9 -10 -25 -17·15
Deduct motion for 1107060 days	0 -10 -27 -16·51
	8 -29 -58 - 0·64
Deduct Aberration	0 - 0 - 0 -21
Tropical position on 701233 Kali Ahargan	8 -29 -57 -39
Sidereal position marked A	9 -23 -18 -30
	0 -23 -20 -51

The above should be 0-23-20-0, only a slight difference, a part of which might be due to Nutation.

Synodical revolution of Jupiter according to Arya Bhatta, Kali Ahargan	1314340·89 days
Deduct 1537 revolutions at 398·8841 days	613084·86
	701256·03
The Ahargan of the epoch ...	701233
Difference only	23 days.

New Moon according to the Moon's position of Mr. Hansen in the beginning of 1850 A. D. Time reckoned from the morning of Greenwich Kali Ahargan 1808305·105366 days

Convert to Lata's meridian	+ 0·202810
	1808305·308176
Deduct 37489 lunations	1107072·417944
The new Moon (mean at epoch)	701232·890232

Original Paulis Sidhanta.

Epoch 51 B. C. Kali Ahargan 1114048, Ninth lunar day of the bright half of the month of Chaitra, Time noon. The meridian 39·65 Palas west of Benares.

The Sun's Sidereal position at the beginning of Lat Deva's epoch Kali Ahargan 1317122 time evening. Meridian 100 Palas west of Benares sphere, 50′ from Zeta Piscium ... ... 11s-29°-43′-44·25″

Deduct motion for ¼ of a day		0 - 0 -14 -47·05
Position at noon		11 -29 -28 -57·20
Convert to the sphere of Zeta Piscium	+	0 - 0 -50 - 0
		0 - 0 -18 -57·20
Deduct motion for 203074 days		11 -21 -34 - 6·83
Position on Kali Ahargan 1114048		0 - 8 -44 -50·37
Convert to the meridian of Paulis	−	0 - 0 - 0 -59·48
		0 - 8 -43 -50·89
The Sun's tropical position at the beginning of Lat Deva's epoch		11s-29°-34′-22·41″
Deduct motion for ¼ of a day		0 - 0 -14 -47·08
Position at noon		11 -29 -19 -35·33
Convert to the meridian of Paulis	−	0 - 0 - 0 -59·49
		11 -29 -18 -35·84
Deduct tropical motion for 203074 days		11 -29 -17 -30·16
Difference		0 - 0 - 1 - 5·68

The difference is partly due to nutation and partly to the defect in observation. Any how the tropical year commenced almost from the commencement of the epoch of Paulis.

New Moon in January-1850 A. D. according to European astronomers, Kali Ahargan, Lat Deva's meridian.	1808305·058176 days
Deduct period for 23510 lunations at the mean rate of the two epochs, viz 29·5305917126 days	694264·211163
New Moon (mean)	1114040·847013

Pita Maha Sidhanta.

Epoch 80 A. D. Kali Ahargan 1161822. According to the work the Sun and the Moon were in conjunction at the commencement of the epoch in Dhanishta Nakshatra *i.e.* their position was 9^s-23°-$20'$-$0''$.

Sun's position according to Lata's Paulis Sidhanta, Kali Ahargan 1317122, time evening, meridian 100 Pala's west of Benares 11^s-29°-$43'$-$44'25''$

Convert to the sphere of the star Zeta Piscium	+ 0 - 0 -50 - 0
	0 - 0 -33 -44'25
Deduct Sun's motion for ½ a day	0 - 0 -29 -34'10
Sun's position in the morning	0 - 0 - 4 -10'15
Deduct Sun's sidereal motion for 155300 days	2 - 5 - 4 -57'61
	9 -24 -59 -12'54
Add meridional difference	0 - 0 - 0 -47'46
	9 -25 - 0 - 0
As per Pita Maha Sidhanta	9 -23 -20
Difference due to the change in the starting point of sphere	0 - 1 -40 - 0

The starting point of Pita Maha Sidhanta was 1°-$40'$ from the star Zeta Piscium and the starting place of his meridian was 48·1 Palas west of Lata's meridian or 68°-$12'$ East of Greenwich and 65°-$52'$ East of Paris.

Surya Sidhanta.

Calculations are made according to the existing work and that treated by Varah Mihar. The starting point of the

sphere as stated in the existing work is 10 minutes from the star Zeta Piscium. It does not however suit the point of the Sun's perihelion, mentioned in Surya Sidhanta. Calculations are therefore made on the assumption that in the original work the starting point was made to commence from the star Zeta Piscium. It may however be noted that the former will give a later year as the time of the composition of the work *i.e.* about 72 years.

Existing Work.

Sun's motion 3548'16955652015" per day. Rate of Perihelion 0'1161" per year.

129 A.D. Saka 51 Kali Ahargan 1179776, time mid-night.

Sun's position at the beginning of Kali		0s- 0°- 0'- 0 "
Add motion for 1179776 days,		11 -20 -21 -26·71
Sun's position at mid-night	a	11 -20 -21 -26'71
Position of Perihelion at commencement of Kali		2 -17 - 7 -48
Motion in 3230 years	+	0 - 0 - 6 -15
Position of Perihelion on Kali Ahargan 1179776	b	2 -17 -14 - 3
Sun's Kendra *i.e.* b-a ...		9 - 3 - 7 -23'71

Sun's tropical position according to M. Leverrier on 1st January 1850 A.D. Kali Ahargan 1808293,

Paris noon	9s-10°-46'-43'51"
Deduct longitude of Zeta Piscium	0 -17 -46 -41'17
	8 -23 - 0 - 2'34
Difference due to meridian	0 - 0 -11 -36'57
Position at Lata Deva's meridian	8 -22 -48 -25'77

Deduct motion for half a day		0 - 0 -29 -34·09
Position at midnight		8 -22 -18 -51·68
Add difference due to measurement		0 - 0 - 4 -57·32
		8 -22 -23 -49·00
Motion for 628517 days .		9 - 2 - 1 -55·08
Position on Kali Ahargan 1179776		11 -20 -21 -53·92
As per Surya Sidhanta		11 -20 -21 -26·71
Difference due to meridian (Ujjain)		0 - 0 - 0 -27·21
Sun's Kendra according to Mr. Leverrier on 1st January 1850, Paris noon		6 - 0 -25 -22·01
Deduct difference due to meridian		0 - 0 -11 -36·54
		6 - 0 -13 -45·47
Deduct motion for half a day		0 - 0 -29 -34·08
		5 -29 -44 -11·39
Add difference due to measurement		0 - 0 - 4 -57·32
	A	5 -29 -49 - 8·71
Motion for 628517 days	—	8 -26 -40 -24·28
		9 - 3 - 8 -44·43
Convert to meridian of Ujjain	—	0 - 0 - 0 -27·21
		9 - 3 - 8 -17·22
As per Surya Sidhanta		9 - 3 - 7 -23·71
Difference		0 - 0 - 0 -53·51

Surya Sidhanta as treated by Varah Mihar in his book.

Sun's motion per day 3548·16961948208''

138 A.D. Saka 60 Kali Ahargan 1183055 midnight

Sun's position at the beginning of Kali 0s - 0° 0' -0 "

Add motion for 1183055 days		11 -12 -10 -9·17
Kali Ahargan 1183055, midnight		11 -12 -10 -9·17
Position of Perihelion at the commencement of Kali		2 -17 - 7 -48
Motion for 3239 years	+	0 - 0 - 6 -16·04
		2 -17 -14 - 4·04
Sun's Kendra on Kali Ahargan 1183055		8 -24 -56 - 5·13
Sun's Kendra according to M. Leverrier marked, A		5 -29 -49 - 8·71
* Deduct motion for 625238 days		9 - 4 -53 -17·56
		8 -24 -55 -51·15
Convert to meridian of Ujjain	−	0 - 0 - 0 -28
		8 -24 -55 -23·15
As per Surya Sidhanta		8 -24 -56 - 5
Difference		0 - 0 - 0 -42

Sun's position according to M. Leverrier at Lata Deva's meridian at midnight on Kali Ahargan 1808293 — 8s-22°-23'-49·00"

Motion for 625238 days	−	9 -10 -13 -11·83
Position on Kali Ahargan 1183055		11 -12 -10 -37·17
As per Surya Sidhanta		11 -12 -10 - 9.17
Difference due to meridian		0 - 0 - 0 -28.0

* NOTE—The motion has been calculated on the rate based on M. Leverrier's determination.

Arya Bhattiya.

The work was composed by Arya Bhatta in 498 A. D.

The Sun's position according to the work at the beginning of the Indian calendar in 498 A.D. Kali Ahargan 1314554 time morning $11^s\text{-}18^\circ\text{-}10'\text{-}52'76''$

Deduct motion for half a day	0 - 0 -29 -34·09
Evening of Kali Ahargan 1314553	11 -17 -41 -18·67
Add motion (sidereal) for 2569 days.	0 -12 - 1 -46·57
Sun's position at Lata's epoch	11 -29 -43 - 5·24
Sun's position as per Lata's Paulis Sidhanta	11 -29 -43 -44·25
Difference	0 - 0 - 0 -39

or 39·57 Palas

The starting point of the sphere was therefore the same as that of Lata but there was a change in the meridian which was 39·57 Palas East of Lata's meridian.

Rate of Lunation in 1850 A.D.	29·5305887856 days
Rate of Lunation in 498 A.D.	29·5305929483 ,,
Mean of both the epochs	29·5305908670 ,,
New Moon according to European astronomers, time reckoned from noon of Greenwich	1808305·058176 days
Convert to Arya Bhatta's meridian +	·010992 ,,
	1808305·069168
Add ¼th of a day, as Arya Bhatta's astronomical time began from morning	0·25
	1808305·319168

Deduct period of 16720 lunations at the mean rate		493751'479297
	A	1314553'839871
According to Arya Bhatta as per details below ...	B	1314553'839818

The difference between A and B is very slight, and considering the fact that calculations according to Arya Bhatta's work are made from the beginning of the creation or Kalp, a very lengthy period, it is strange that the difference is so little.

The details of the figures marked B.	Moon's position
according to Arya Bhatta's work	$11^s-20^\circ-1'-12''$
Add corrections	0 - 0 - 6 -50
Mean position	11 -20 - 8 - 2
Sun's position according to Arya Bhatta	11 -18 -10-53
Difference	0 - 1 -57 - 9

The time of conjunction was therefore 1314553'839818 days.

Maha Sidhanta.

According to my calculations this work was composed in 888 Shaka or 966 A.D. Kali Ahargan 1485507.

Sun's position according to M. Leverrier on Kali Ahargan 1808293, Paris, noon of 1st January 1850 A.D. ...	$9^s-10^\circ-46'-43'51''$
Deduct longitude of the star Zeta Piscium	0 -17 -46 -41'17
	8 -23 - 0 - 2'34
Convert to the sphere of Maha Sidhanta —	0 - 1 -45 - 0
Sidereal position, Paris noon	8 -21 -15 - 2'34

Deduct difference due to meridian	0 - 0 -11 -36·57
Position at Lat Deva's meridian	8 -21 - 3 -25·77
Deduct motion for quarter of a day	0 - 0 -14 -47·05
Position at day break	8 -20 -48 -38·72
Add difference due to measurement	0 - 0 - 4 -57·32
	8 -20 -53 -36·04
Deduct motion for 322786 days	8 -20 -47 -49·21
Position on Kali Ahargan 1485507.	0 - 0 - 5 -46·83
As per Maha Sidhanta, vide details below A	0 - 0 - 5 - 4·21
Its meridian therefore started from Cape Comorin	0 - 0 - 0 -42·62
Suns position at the beginning of Kali	0 - 0 - 0 -0
Motion for 1485507 days at Maha Sidhanta's rate (3548·17062741039″) +	0 - 0 - 5 - 4·21
Sun's position	0 - 0 - 5 - 4·21
Sun's Kendra's position according to Maha Sidhanta. Perihelion at the beginning of Kali ...	2 -17 -45 -0
Motion for 1485507 days at ·00075713	0 - 0 -18 -44·72
	2 -18 - 3 -44·72
Deduct from the Sun's position	9 -12 - 1 -19·49

Kendra's position calculated from the year 1850 A. D.

Sun's tropical position, according to M. Leverrier on 1st January 1850 A. D. Kali Ahargan 1808293, Paris noon 9°-10°-46'-43·51″

Deduct position of Perihelion 3 -10 -21 -21·50

6 - 0 -25 -22·01

Difference due to meridian	0 - 0 -11 -36·54
	6 - 0 -13 -45·47
Deduct motion for 1/4 th of a day	0 - 0 -14 -47·04
	5 -29 -58 -58·43
Add difference due to measurement	0 - 0 - 4 -57·32
	6 - 0 - 3 -55·75
Motion for 322786 days	— 8 -18 - 1 -46·38
	9 -12 - 2 - 9·37
Convert to the meridian of Maha Sidhanta	— 0 - 0 - 0 -42·62
	9 -12 - 1 -26·75
As per Maha Sidhanta	9 -12 - 1 -19·49
Difference	0 - 0 - 0 - 7·26

Bhashkaracharya.

Epoch 1183 A. D. He lived in the 12th century A.D. His standard work on astronomy called Sidhanta Shiromani is held in great esteem by the modern Hindu astronomers. He composed another work later called Karn Kutuhal. Its epoch was 1183 A.D. 1st day of the bright half of the lunar month of Chaitra. His day commenced from morning. It was Kali Ahargan 1564737.

Sun's position according to Lata Deva on Kali Ahargan 1317122 evening	11ˢ -29° -43′ -44·25″
Convert to the sphere of Zeta Piscium	+ 0 - 0 -50 - 0
	0 - 0 -33 -44·25
Add motion for half a day ...	0 - 0 -29 -34·09
Position on 1317123 morning	0 - 1 - 3 -18·34

Add motion for 247614 days	11 - 0 -35 ·41·50
Position on 1564737 morning	11 - 1 ·38 -59·84
As per Bhaskaracharya	10 -29 -13 - 0
Difference as detailed below	0 - 2 -25 -59·84

* Difference due to the change in the sphere 2°-25'

do. do. in the meridian 59·84"

Lata's meridian was 100 Palas west of Benares. Bhaskar's was therefore (100-61) 39 Palas west of Benares (59-84" being nearly equal to 61 Palas).

Please also see the chapter on the variation in the Moon's motion.

---

* NOTE—As the Sun's motion of Surya Sidhanta was slower by about 8·4' per year than the actual rate, all subsequent astronomers were obliged to change the starting point of their sphere, with a view to disturb as little as possible the calendar based on the above book, which was held in great esteem. There was a difference of about 2°-25 in 1183 A.D.

Conclusion.

Before concluding this book, I have to add, that I am much indebted to my old friend Rai Sahib Babu Hira Singh Rana, pensioner, Survey of India Department, for the help he has rendered me in passing the press proofs.

HCS