Astronomy in Ancient, Medieval and Early Telescopic Era of India
Prof. Amitabha Ghosh
Department of Physics
Indian Institute of Technology Kanpur
Session 05
Introduction of Telescopic Astronomy and Concluding remarks

Professor 1: The last lecture of the series and I am sure it is very nice to see same people who are around and quite a large number than we had initially anticipated. And I have request, after 8 O' clock when the talk gets over, each playback all of you for couple of minutes from then. Okay, Just 40 minutes, then (())(0:33).

Professor 2: So I think the last one is introduction of telescopic astronomy and some important remarks. Now I will not discuss telescope here because that is not the objective and I hope that most of you are aware of the basic principles behind optical telescope, both reflecting type and refracting type. Now how it was developed by Galileo under what circumstances, that is the wonderful story.

And I give a lecture on that and drama has been written which will be staged in Calcutta and Bhopal. That story of Galileo is generally not known, it is only the fight with the church et cetera, inquisition, that is the main theme of drama popularly. But this one I prepared during the summer and now rehearsals are going on. Maybe sometimes I will request IIT Kanpur Gymkhana to stage it in. You identify a person for Galileo's role.

So what I will do today is that introduction of telescopic astronomy in India briefly and some interesting stories behind it. And another thing I will tell that it came primarily for observing the transit of Venus. You might have heard about it, recently in 2012 we had the transit of Venus, is not it? Did, was there any observation in the campus? You have an astronomy club.

Because these transits are very important because that helps you to determine the distance of the earth, sun et cetera very accurately. So it has always been an important task and it is not a very frequently. When now I think the next one will be about some hundred years back later. So in one lifetime one can see at the most two such transits.

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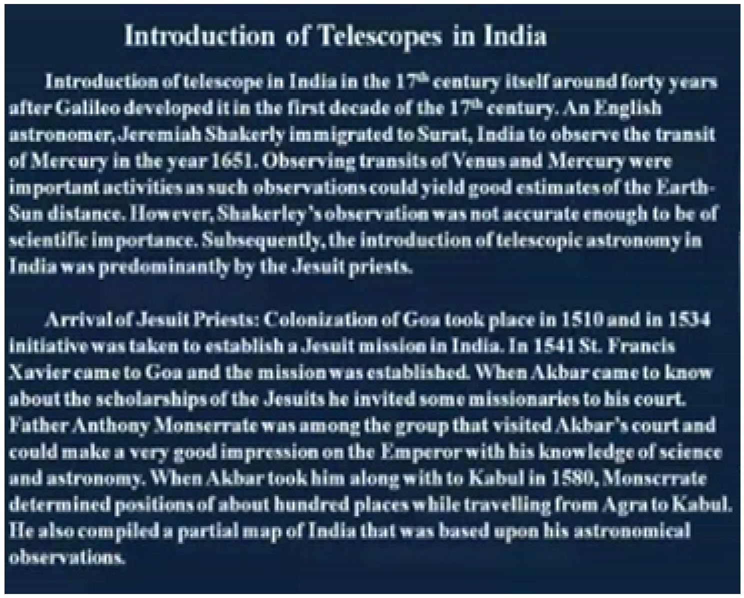

So I think in India the first telescope came along with the Jesuit priests. And if you remember in the very first lecture I mentioned that in Thailand French government, King of France sent a team at the request of the king of Thailand and they came with it 12 telescope and some astronomers in the 16th century or 17th century. Then there was cue and they had to leave and they fled to India and settled in Pondicherry with their telescope.

But even before that the first Jesuit priests came and they colonized Goa in the 16th century, beginning of 16th century. And then I think in 1541 St. Francis Xavier came to Goa and the mission was established if you have read that. Even Akbar came to know about the scholarship of the Jesuit priest and he invited some missionaries to his court. And Father Anthony, I do not know how to pronounce it in French, it must be something different as it looks like.

The French pronunciation is very different from what you write, I do not know why. Had it been German, I would have read it. And he was in the group that visited Akbar's court and could make a very good impression on the emperor with his knowledge of science and astronomy. When Akbar took him along with to Kabul in 1580, he actually determined the positions of about 100 places while traveling from Agra to Kabul. And he also compiled a partial map of India that was based upon his astronomical observations.

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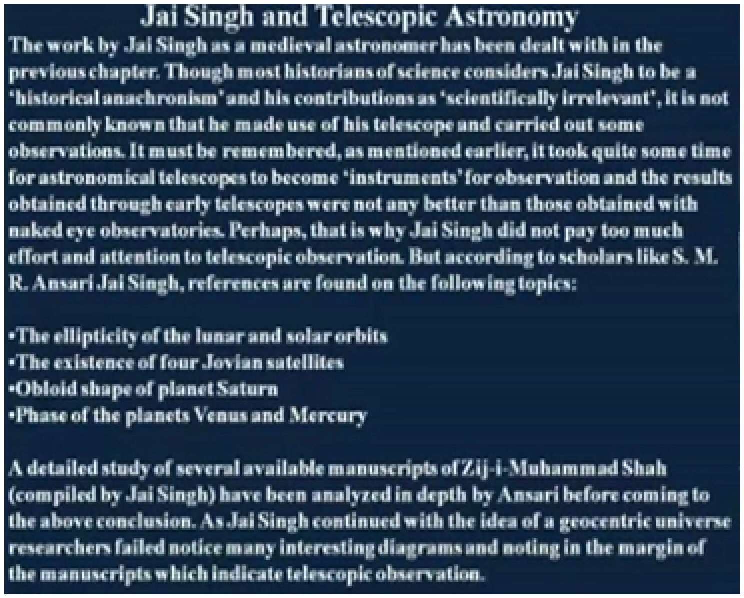

Now Jai Singh we have discussed in the last lecture. The, it was of course he was Medieval astronomer and dealt with only the siddhantic or Zij astronomy considering a geocentric model. And most historians of science consider Jai Singh to be historical anachronism and his contributions as scientifically irrelevant. It is not commonly known that he made use of his telescope which he had and carried out some observations.

It must be remembered as mentioned earlier, it took quite some time for astronomical telescope to become instruments for observation when this cross-wire technology was found out. It is not a technology but the device kind of thing. So it took quite some time for astronomical telescope to become instruments and earlier it was only for viewing kind of thing. Qualitative results you could get.

And the results which we could get from the heliocentric model and those early telescopes were no way better. Actually you could see that even 1 minute of arc you could do, 2 minutes of arc with the help of naked eye instruments. So there was no motivation on the part of Jai Singh to pay too much effort and attention to telescopic observations or the heliocentric. According to scholars like S. M. Ansari, Jai Singh actually did something and references are found on the following topics in his writings.

That means the ellipticity of the lunar and solar orbits, he worked on that. The existence of four Jovian satellites, oblate shape of planet Saturn as I mentioned in last class and phases of planet Venus and Mercury. Now the detailed study of several available manuscripts of Zij-i-Muhammad Shah which was compiled by Jai Singh have been analyzed in depth by Ansari before coming to the above conclusion.

Now as Jai Singh continued with the idea of geocentric universe, researchers failed to notice many interesting diagrams and noting in the margin of the manuscript which indicate telescopic observation. Not in the main text but in the margins they were also noticed. Another thing I mentioned that why Jai Singh really could not go into the heliocentric model. Because he depended too much on Jesuit priests and he sent them to Portugal and Jesuit priests they themselves were very much against the heliocentric model and they did everything possible to isolate Jai Singh from the new developments in Italy and Europe.

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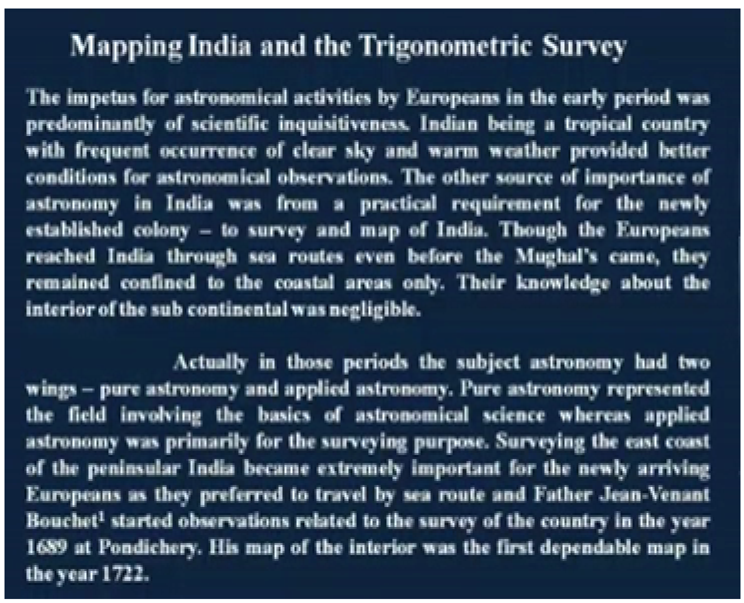

Anyhow, but the main impetus for astronomy, astronomical activities by Europeans in the early period was predominantly of scientific inquisitiveness and another thing that is the India being a tropical country with frequent occurrence of clear sky and warm weather provided better conditions for astronomical observations for the people from France and England.

The other source of importance of astronomy in India was from a practical requirement for the newly established colony to survey and map India. Though the Europeans reached India through sea routes even before the Mughals came actually, they remained confined to the coastal areas only. So their knowledge about the interior of the subcontinent, it was negligible. Peninsular India was not known to them.

And in those period the subject astronomy had two wings, pure astronomy and applied astronomy. Pure astronomy represented the feel involving the basics of astronomical science whereas applied astronomy was primarily for surveying purpose. Astronomy was the very important tool for surveying the land and the initial major application of astronomy in India, telescope astronomy in India was for surveying purpose.

One was for determination of the latitude, other was determination of longitude. And determination of longitude was with the help of transit telescope, they are very special telescopes you will find I have given in the book. And these telescopes had very limited maneuverability but gave much accurate results. They were used for the longitude determination. Latitude determination was somewhat easier.

And Father Jean-Venant Bouchet started observation related to the survey of the country in the year 1689 at Pondicherry. The great triangular survey of India, it is very famous, I think I do not know whether our library had that book. Many things happened finding the height of the peaks like Everest et cetera. All it was a very great activity in the history of civil engineering and surveying, great trigonometrical survey of India. And it started from south. The first one what you say the backbone was created and then it spread on both sides by triangulation. Now his map of the interior was the first dependable map in the year 1722.

“Professor-student conversation starts.”

Student: Just one curious question. From that positional astronomy, from that different timings like Banaras or Ujjain, from the difference in sun shadow when we get the longitude as, longitude by this…..

Professor: Oh, then actually for longitude you need a clock. Earlier the problem of longitude, there is a book, book’s name itself is Longitude. When Galileo gave the first hint that you can use the four moons of Jupiter which are visible from any place and their occultation can be used which is a periodic event which could be used as clock.

"Professor-student conversation ends."

And it was being done and when it was being done, Roemer was one of the person who was trying to do that and he had a byproduct, the speed of light. Because you have all read in history of science that he found first the history of, velocity of light. And that was, on that occasion he was trying to use the moons of Jupiter as a clock. So he got the speed of light.

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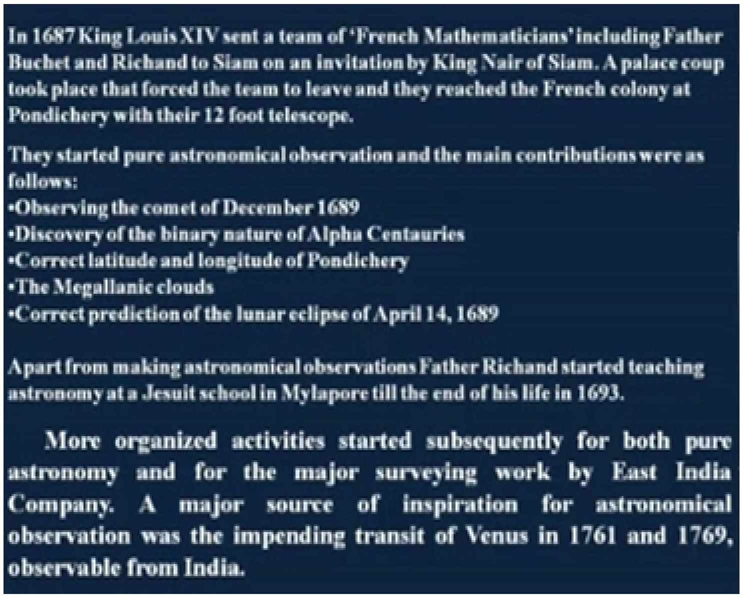

And 1687, as I, this is that story I will not repeat. And those people they brought their 12 foot telescope, 12 foot, it is not 12 inch, 12 foot telescope and they started pure astronomical observation from Pondicherry. The main contributions were observing the comet of December 1689, discovery of the binary nature of Alpha Centauries, then correct latitude and longitude of Pondicherry, the Magellanic clouds and correct prediction of the lunar eclipse of April 14, 1689.

Apart from making astronomical observations, the Father started teaching astronomy at a Jesuit school in Mylapore till the end of his life in 1693. More organized activity started subsequently for both pure astronomy and for the major surveying work by East India company. And major source of inspiration for astronomical observation was impending transit of Venus in 1761 and 1769.

This transit of Venus occurs at interval of 8 years, then it will take another 100 years, you have to wait for the next one. That was the main thing and at that time during this period England and France they were at war, a 7-year war was going on when this was to happen. So both governments sent the teams to India and there is a very nice story and about this.

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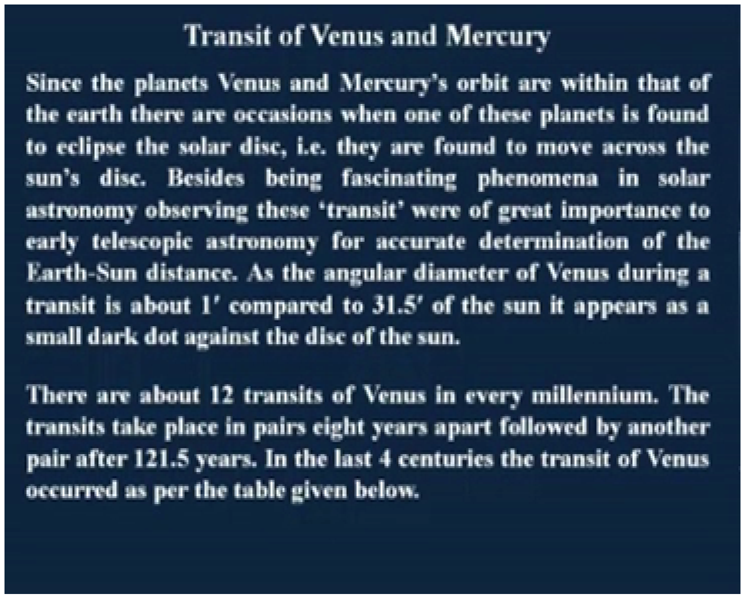

So the story I will tell, then I will explain about the how it is used. This story is very interesting story in the history of science and it is also a tragic thing. I will read, it is a story, it is just like a story you see how sometimes fate can be so cruel to scientists. It should be remembered that when the first of these transits took place in1761, Europe's 7-year war was raging from 1756 to 1763. Both the British and Kent scientists are planning the observation at different places from where the transit was expected to be visible.

The British team which headed to Sumatra had to make their observation at Cape of Good Hope. Because of bad weather the ship had lot of difficulties and so they were forced to do it from Cape of Good Hope and the results were not at all acceptable because it was moving ship. The French team went to Siberia on an island, in the Indian and an island in the, because you read to have the observation from two different latitudes, almost along same meridian approximately.

I will explain the whole thing, then you will realize why. It is essential to observe and take the data from two different latitudes of the transit phenomenon. The astronomer in charge of the team to India was Le Gentil whom I mentioned. And Le Gentil after arriving near the Malabar Coast came to know that the French colony at Pondicherry that was his destination was taken over by the British.

So he had to turn back towards Mauritius and which was under French control and observed the transit on 6th June from a moving ship with great difficulty. So Le Gentil decided to observe the next transit on 4th June 1769, so this was 1761, so the next one was after 8 years. So he decided not to go back to Europe, to wait and observe the next one. So he stayed at, waited at Mauritius for the next 7 years and arrived at Pondicherry on 27th March, 1768 to observe that 4th June transit almost a year in advance.

And a suitable observatory was erected at Pondicherry with the help of the local French government and interestingly the British at Madras also helped Le Gentil by providing him a very good telescope for the observation. By that time the war was over in Europe. So during the year Le Gentil spent at Pondicherry, he came across some siddhantic astronomers as I mentioned, that (())(15:32) and other, that story who could do the calculation using a table.

But the ultimate climax of the story that Le Gentil's long wait and 11-year long voyage to India was that on the day of the event in June 1769, the sky was over Pondicherry covered with clouds and the mission to observe two transits of Venus remained unaccomplished. So 11 years effort nothing happened, it is really painful thing. Now I think the observation, now I will say this was interesting story how scientists devote their life, ultimately sometimes they may not be rewarded with good results.

Now the planet Venus and Mercury's orbit are within that of the earth and obviously therefore you will see at times they are crossing through the disk of the sun and that is called the transit. And they are found to move across the sun's disk because they are very small. Besides being fascinating phenomena in solar astronomy these transits were of great importance to early telescopic astronomy for accurate determination of the earth-sun distance.

As the angular diameter of Venus during a transit is about 1 minute of arc compared to 31.5 minutes of arc of the sun's disk. It appears as a small dark dot against the disk of the sun. Lot of people in Calcutta they arrange observation of the transit of Venus. I wonder why it was not done here. Many groups, student groups and researchers they did it, they went to different places and did it. But of course I must tell you that observing it from just one place may not give you that good result.

So generally sometimes they view it from two places with two different latitudes. Now there are above 12 transits of Venus in every millennium, that means in 1,000 years you will get only 12 opportunities to observe Venus transit. That is why they are so important. And the transits take place in pairs, 8 years apart followed by another pair after 121.5 years. So 2012 we had one, so the next one will be (2000), how much? 2133 year. So in the last your grand grandsons can observe that of course. In the last four centuries the transit of Venus occurred as per the table given below.

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Year	Month	Day
1631	December	07
1639	December	04
1761	June	06
1769	June	03
1874	December	09
1882	December	06
2004	June	08
2012	June	06

You can see (16), which were observed actually, 1631, 1639 in December; 1761, 1769 in June. That is why it is difficult because in June in India generally you will have cloud cover whereas December is good one time.

“Professor-student conversation starts.”

Student: Pondicherry is rest, never rains there.

Professor: But in winter it rains, the return monsoon. Then 1874, 1882 and the last one was 2004 and 2012. So now I think we lost the opportunity, none of us will be able to see the next one.

"Professor-student conversation ends."

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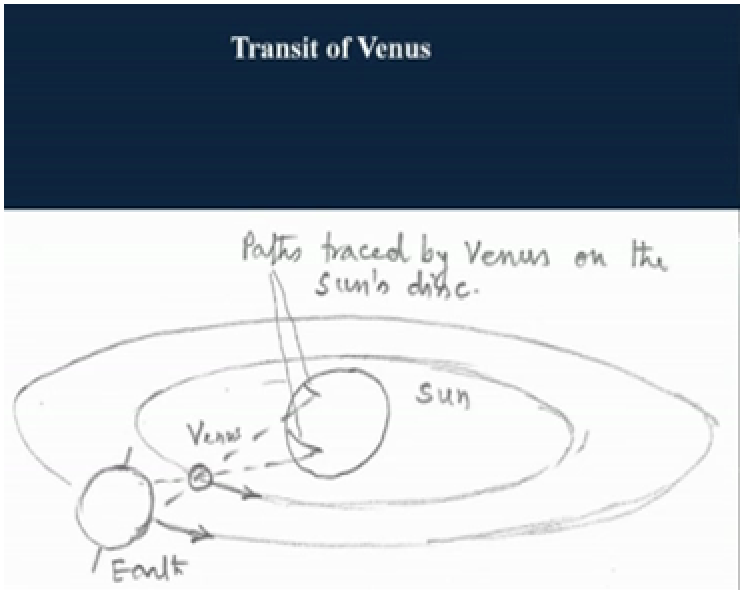

You see transit of Venus is like this: So this is the sun, this is the orbit of Venus and this is the orbit of the earth. So from earth, from two places you observe the transit. So what did happen? Venus describes an arc or a line in this disk of the sun as seen from the earth. But the two lines are different because one draws a line here and this draws a line there. And these two lines, their gap is nothing but the parallax of Venus at sun, is not it?

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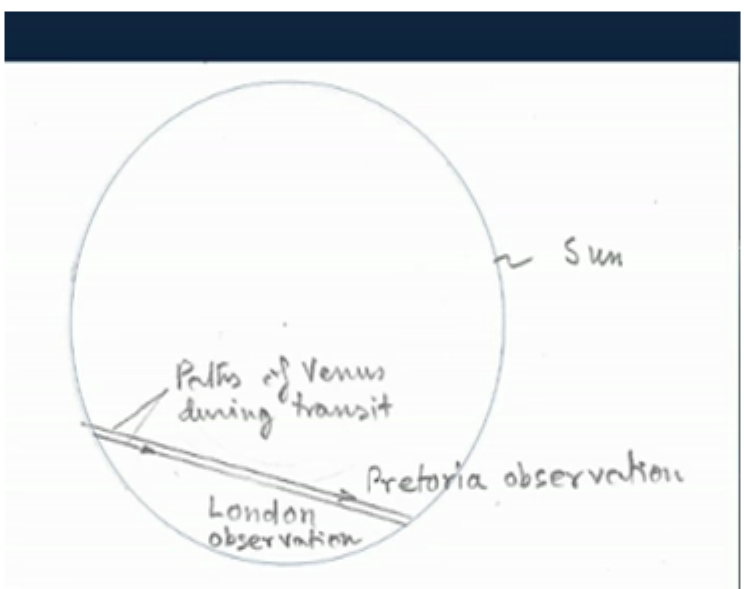

So the one which I think was observed from Pretoria and London simultaneously, the two lines which were seen, path of Venus during the transit. This is seen from Pretoria, that is South Africa and this is observed from London. These are the two lines which were described and found.

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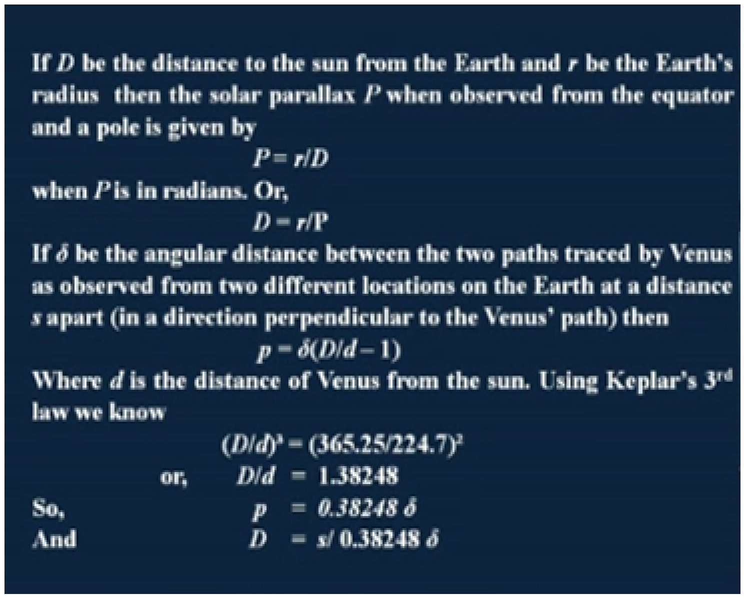

So you see D be the distance to the sun from the earth and r be the earth's radius, then the solar parallax P when observed from equator and from the pole, that means the distance is r. So parallax will be r by D, simple. And P is nothing but angle in radians. Or the distance you can find out. If you can find out the parallax, then distance you can find out as r by P. Now delta be the angular distance between the two paths just now I have shown you.

Case by Venus as observed from two different locations on the earth at a distance of s apart in a direction perpendicular to the Venus's path of course, then the parallax which you will get in this case is nothing but delta and D by d minus 1, simple geometry. And where d is the distance of Venus from the sun and using Kepler's third law we know that the radius of the earth orbit and radius of the Venus orbit, their ratios q is square of the periods ratio.

You all know that is Kepler's third law. So what they do, they apply that. So now you get another relation D by the, distance of the earth from sun by distance of Venus from sun, that q is the period is known accurately. So in all such measurements distance is the most difficult thing to measure, period you can measure, angle you can measure. I mean to say angular distance. So you can find out the two ratios, the distance of the earth and distance of the Venus from sun, that is 1.38248.

So when p is 0.38248 delta and D is s by 0.38, that this, D by d is this much, minus 1 means what? It will be 0.38248 and into delta. So this is nothing but this, you subtract 1. And D will be then also s divided by this, that is the parallax. So this is the typically the procedure, very simple procedure. And the observation of 1761, Venus turns it from India, it resulted in inaccurate and varying values of the solar parallax.

However a reanalysis of all the observational data led to a mean value of 8.56 seconds of arc. So the distance which I showed you it is not, it was about 5.5 seconds of arc. So this was one of the primary motivation to bring telescope in India observing the Venus transit. And both group of scientist they did it. And another important motivation was the survey of India as I was mentioning.

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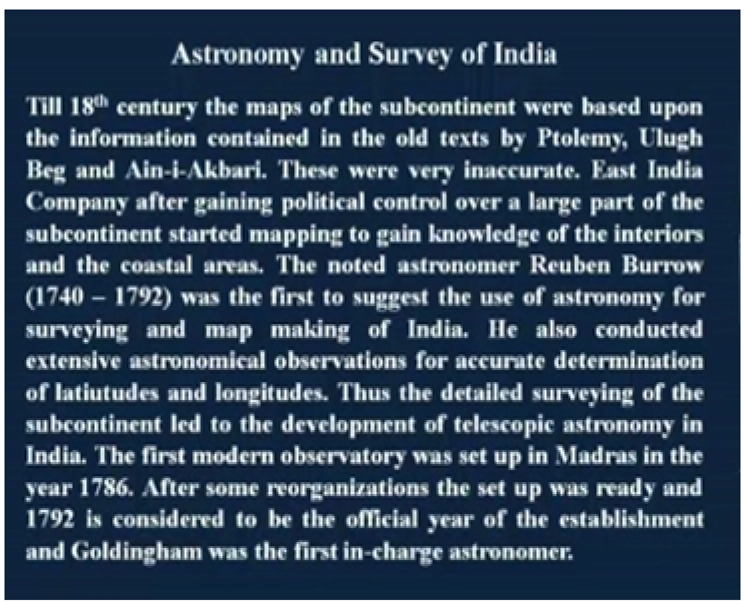

Now till the 18^{th} century the maps of the subcontinent were based upon the information contained. Ptolemy gives a detailed description, of course inaccurate about the Indian peninsula, that is something very surprising. So old texts by Ptolemy, Ulugh Beg and Ain-i-Akbari, these were the source from which maps of India is to be drawn. And obviously they were very inaccurate. And East India company after gaining political control over a large part of the subcontinent started mapping to gain knowledge of the interiors and coastal areas for their further plans to expand their kingdom.

So the noted astronomer Reuben Burrow was the first to suggest the use of astronomy for surveying and mapping India. And he also conducted extensive astronomical observations for accurate determination of latitudes and longitudes. These are the two primary requirements. And thus the detailed surveying of the subcontinent led to the development of telescopic astronomy in the year of 1786.

Some reorganizations and et cetera, the setup was ready and 1792 considered to be the official year. And this was done in Madras. In India the first observatory, it was a very ramshackle affair of course, a small building, the photograph, the pictures of those I have given in the book. So it was a small building, some small outfield. That was the first observatory 1786. Initially it was semi-government, some private enterprise kind of thing. But formally accepted government observatory it became 1792. And this is also considered to be the official year of the establishment and Goldingham was the first in-charge astronomer of that first observatory in India in 1792.

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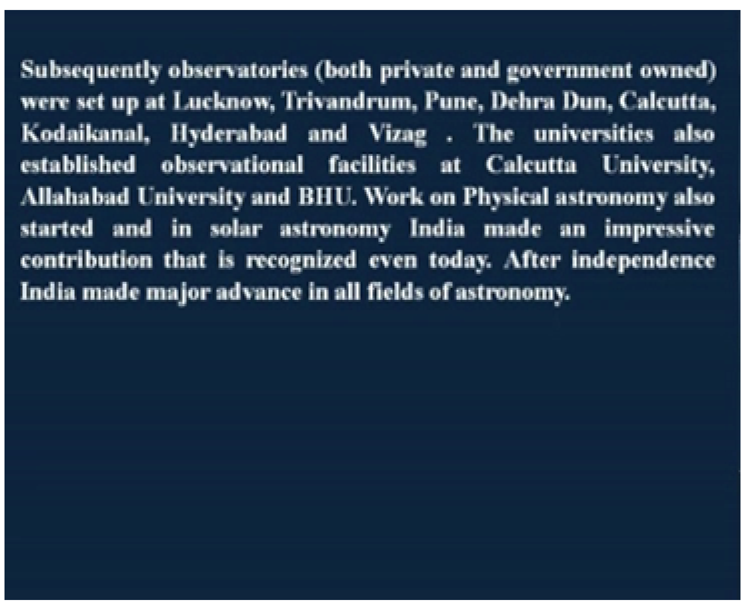

Now subsequently observatories both private and government owned were set up at Lucknow, Trivandrum, Pune, Dehradun, Calcutta, Kodaikanal, Hyderabad and Vizag. The universities also established observational facilities at Calcutta, Allahabad University and BHU. Work on physical astronomy also started, that was of course bit later. And in solar astronomy India made an impressive contribution. Because Evershed was the astronomer in-charge of, for Kodaikanal observatory for a long time and he is considered to be one of the most noted astronomer for solar astronomy and his data are still used and kept in Kodaikanal.

Now some important things should be known to you at this time. So I told about Madras observatory, this Madras observatory from the beginning of 19th century, its major usage was related to great trigonometric survey of India. And Madras became the Greenwich of India. Till 1830 this observatory was engaged in surveying organized astronomical finding oriented astronomy because of the ongoing survey of India.

And subsequently this observatory made many important contributions including the publication of the famous Madras catalogue of 11,000 stars in the southern sky in the year 1843. From this observatory Captain Jacob showed that the recently discovered ring of Saturn was not solid. And after 1864 this observatory did not receive any new instrument. And the most productive period for this observatory was 1830 to 1864.

The first Indian astronomer who was associated with Madras observatory in the 19^{th} century was Chinthamani Ragoonatha Chary, he was the head assistant and skilled observer. His first paper was submitted to the royal astronomical society in 1859 and he was the first Indian to have discovered two new variable stars. In 1872 he was elected as fellow of the royal astronomical society, the first one in India.

Now the government of India decided to set up an observatory at Kodaikanal which still one of the major observatory of India and which had the objective of making solar observations as I mentioned. Solar activities, why they were interested in solar observatory? Because India being tropical country, it was expected that solar activity will be controlling our monsoon which is so important for the agriculture in India.

That is why they decided to establish Kodaikanal observatory primarily for solar observation. Also something like that was done in Dehradun. And Lucknow and Trivandrum observatories, that is two for the funny story. The progress of Madras observatory and great trigonometric survey prompted to native kings, one in the north and the other in the south to promote astronomical observations.

Now truly speaking they did so to assist the British because in those days many things they used to do to assist and help them to get all kinds of other thing like kitab like Rai Bahadur this. So somebody will make a racecourse, somebody will make a hall for (())(28:58) dams all kinds of things. So they did this to primarily assist with this. The Nawab of Oudh declared independence from the yelling Mughal empire in 1819 and his successor Nasir-ud-din Haider founded an observatory at Lucknow in the year 1831.

It is interesting if somebody does research to trace where it was and what kind of remanence are still available, nobody has done it so far. However he requested the British to appoint a director for the observatory and the Major of James Dowling, Harvard was appointed as the incumbent. Receiving generous funding from the king, Harvard ordered for the best possible instruments. Unfortunately he died in 1833 just after two years.

And the next astronomer in-charge was Lieutenant Colonel Richard Willcocks who was also an astronomical assistant at the great trigonometric survey. He built the observatory and the instruments were put up and he planned the observational activity quite meticulously. Finally the observatory was ready for regular observation in 1841. Since it contained the best possible instruments including a mural quadrant, this mural quadrant you will find if you see typographic pictures et cetera. This quadrant was very favorite instrument for angular measurement.

Bigger the quadrant, more accurate the markings and better will be the result. A mural quadrant, a transit telescope, as I mentioned transit telescopic to rotate only like that and their objective was primarily to see when a particular star just crosses the zenith that time. Since it contain an equatorial telescope and clocks, because clock was very important, so you will find that every old astronomical observatory, so clock will be mentioned. That is so important.

And also there was hope for producing excellent results. But unfortunately the results from the observations were never published. And after Willcocks died in 1848, the king closed down the observatory on the ground of its not being useful to the people of Oudh. The British wanted to rebuild it after the mutiny of 1857 but it was found to have been destroyed by the rebel soldiers.

And the records containing all the results were also eaten by insects. And thus one of the best equipped astronomical observatories in India was closed down without producing any result.

The initiative for setting up the Trivandrum observatory was taken up by the British scientists and King Raja Varma appellate who approved the request and John Caldecott was the main person when the observatory was established in 1837. They are more or less same kind, the Oudh and this one. The observatory was also furnished with transit telescope, mural circle, equatorial telescope and clocks.

Unfortunately this observatory also met with the same fate as that of the counterpart in London. By 1852 the instruments were so dilapidated that the astronomical observation came to an end and luckily Trivandrum being located near the magnetic equator, the observatory sustained some scientific work on magnetism and metallurgy. More or less during the same period then I think I went on, Pune there was an observatory and some observatories were erected on private enterprise in those days.

So Pune observatory has an interesting story. Dehradun observatory, then observatories in Calcutta, then this is a private observatory very well known, Takhta Singhji observatory Pune. So after this solar observatory at Dehradun, another solar observatory came up in Pune in 1888. The single person behind the setting up of this first modern astrophysical observatory was Kavasji Dadabhai Naegamvala. He was born in the year 1857 and was brilliant student of physics at Elphinstone College, Bombay.

He received Chancellor's Gold Medal in his MA examination in 1878. Subsequently he joined the college as a lecturer in physics, 1882. In the same year when Maharaja Takhta Singhji of Bhavnagar visited the college, he appealed to the Maharaja for a donation to start a spectroscopic laboratory. You can see now spectroscopic activity started. The grant of Rs. 5,000 was matched by a similar amount and after the discovery of solar spectral lines were formed up around 1812 and subsequent work by Kashyap and Musan in the 1859 the spectroscopy started being used to the celestial bodies.

In India Father Lafont, I think many, Amitabha you may have heard about Father Lafont. He was a professor at St. Xavier College. And at the same time Swami Vivekananda, Lafont, they are very close collaborators. And Lafont was one of the major persons to promote science education in India. And Mahendra Lal Sarkar, Lafont, they used to organize scientific lectures as IIT Kanpur does evening like this.

The ticket used to be Rs. 2 at the beginning of the 20^{th} century. And most often the hall used to be full without any seat many vacant. Now if you organize a lecture in Calcutta, if you give people Rs. 200, you may get a few but you see the how the society deteriorates. Anyhow so the St. Xavier's College also had an observatory, Calcutta. When we were students, it was there. So Father Gore used to be the primary person.

Now the St. Xavier's College observatory, Naegamvala visited and he was so impressed and gained experience in his spectroscopy. And at Lafont's recommendation Naegamvala proceeded to Europe in 1884 to finalize the equipment he wanted to have. Then of course he changed his area, he became an astronomer and he came back and started the astronomical observatory in Pune.

Of course later it had to be because all such single person endeavors they make with unfortunate situation that after their death nobody was there to take up. So what happened, all the equipment of these were transferred to Kodaikanal. Kodaikanal observatory is still one of our primary observatories. And I think it is under the control of Indian Institute of Astrophysics at Koramangala, Bengaluru. They operate it, they control it.

Then there was another private entrepreneurship in Hyderabad, Nizamia observatory. It did not produce much good result but it made some very good stark catalogues. It was the special effort they had. And this work which they started I think 7,63,542 stars observed and located. And result was published in 12 volumes. Then there was another very private observatory in Vizag, Jagga Rao and Narasinga Rao. The father-in-law and son-in-law, they set up something which of course vanished after some time.

And in West Bengal or not West Bengal, Bengal this Kalinath Mukherjee and Radhagobinda Chandra were some early astronomers and what happened, Kalinath Mukherjee was born at Zajia in Jessore district which is now in Bangladesh and received his college education at Krishna Nagar and graduated with honors in mathematics, philosophy and Sanskrit. After graduating 1872 he studied law and 1873 he started practicing law at his native district.

During his college education at Krishna Nagar he came in contact with Sir MJ Herschel, the grandson of the great astronomer Sir William Herschel. Herschel's, he discovered which one? Uranus or (())(37:50).

"Professor-student conversation starts."

Professor: I think Uranus or Neptune, which one I forget, which is called Herschel's planet?

Student: Maybe Neptune.

Professor: Yeah.

"Professor-student conversation ends."

So I think he also made lot of observations and he wrote a Sanskrit text also, Bhagola Chitram. Raja Ravindra Chandra was also a private astronomer in Bengal. And ultimately the main impetus to astronomy in India came from Professor Vainu Bappu. Must have heard his name. He is the primary person in promoting astronomy. He first came to Allahabad observatory which was shifted to Nainital which is still there. Now they have changed the name to Aryabhatta Research Institute for observational science at Manora peak but later he shifted to Kodaikanal and spent his life.

And the main big telescope was his design, the largest telescope we had till recently. Now of course we have bigger one. But he unfortunately died at a young age but his that telescope and that observatory has been named after him as Vainu Bappu observatory. Then of course…..

"Professor-student conversation starts."

Student: None, was any of these people when Raghunathacharyaji or Kalinath Mukharji, they also did astrology because lot of astronomers did astrology?

Professor: No, I think they, it does not so. They did astronomy only. Primarily star catalogues, observation, finding out dummy stars or variable stars, these are the kind of thing. They were not astrologers.

Student: Typographic was astrology.

Professor: Yeah, they, even Kepler was an astronomer.

Student: Kepler.

Professor: Kepler earned his livelihood just because he was the king's astronomer. They told the king that you should do this, then will we work, and that kind of thing. Most of the people they are, nobody was interested in what is happening, whether earth going around the sun or sun going around the earth. It hardly matters to me. Even today also I believe you do not really bother but I think their main thing was astrology.

Student: Okay.

Professor: But the only good thing is that he provided the motivation to do astronomy and the science progressed.

"Professor-student conversation ends."

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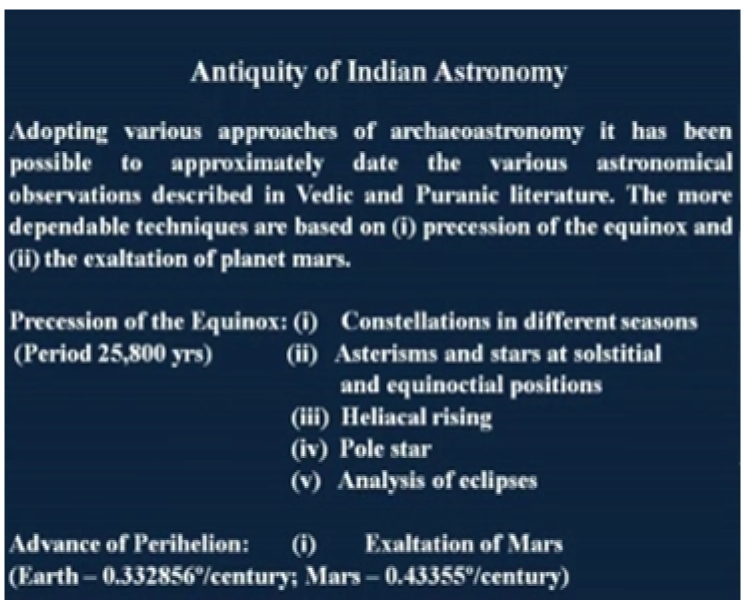

Now I think I will take up the last two topics I wanted to take. The two, one will be antiquity of Indian astronomy and the other will be originality of the Indian astronomy. Both are actually little bit controversial issues because there are two camps. And one camp will say they are all, it is Indian astronomy is very recent, they are all copied from the Hellenistic astronomy in Greek and 11th century AD et cetera.

Another group will say no, no, they are very original and long back they had the originality and they are very old. So I think it is better to have some discussion and primarily keeping the scientific aspect of the whole thing rather than depending being emotional that our everything you push back to very antiquity and millions of years ago. I think that is not a good thing and that is why we have always lost credibility in the western science. Because there will be always a group of people will show these are all tens of thousands of years, lakhs of years.

But as I mentioned, personally I think though it I have not found it anywhere, that this kind of idea came mainly because of the calculation procedure, Mahayuga, these, people really started thinking they are real physical things like Mahayuga, Kali. Now I think archeoastronomy is very interesting topic. Nowadays planetarium softwares are there and as I, you have done, anybody can download and can do little bit of study.

Though you cannot do research with the simple softwares, for that you need some more elaborate softwares. But I think many things you can study. So this archeoastronomy is a new kind of subject. Now it has two branches. In one branch of archeoastronomy, you look into the orientation of very ancient structures like say pyramid or Harappa Mohenjodaro settlements. Because it has been found, even in ancient times the major structures, they, people used to orient with some important principal directions like north-south, east-west like that.

They will not put it at (())(42:19). So like pyramids et cetera they are very accurately oriented towards north-east of that time. So then saying the present day orientation, the deviation from the two directions you can find out approximately how many years or thousand years back the directions which was used could be the true directions of north or east. That is one, for that you need a big structure.

Another branch of archeoastronomy, there you do not need any structure or anything. You only need a description. And by now I am quite sure you have an idea what that description is. It is the precision of the equinox. But there are two, quite a few things which can be done. One is the precision of the equinox and another is the advance of the perihelion. Both are useful in archeoastronomy.

So in the precision of the equinox where our axis précises with a period of 25,800 years, long enough period to span the whole human history, civilization history. And what are actually seen, the (observ) the constellations in different seasons. So like as I have mentioned that now in winter if you stand in the evening, you will find Orion is rising in the eastern sky. But if you find a description that Orion is rising in the spring time, then obviously it was much much earlier sometime.

Another is the asterisms that is nakshatras and stars at solstitial and equinoctial positions. That means which nakshatra was at the equinox. This was very important as you will see later when I come to the application of that. And that was, that mentions are there. And that changes because of the precision of the equinox. What is on vernal equinox today, after few thousand years will not be there because the vernal equinoctial point will shift along the ecliptic to a different position.

So different nakshatra will be the equinox. Third is description of helical risings. Helical rising I have explained that what stars you find last to rise before the sunlight appears. And that was very common in India because our moon is, this is they used to get up early not like our students and our children, at 10 O'clock you have to push them up. So they used to go, take bath and they used to pray, all those thing facing east always.

Of course in India early morning it is always we pray facing the east and obviously you will observe things. If you do it again and again, day after day, year after year, you will observe if you are observant. And also analysis of the pole star as I mentioned. The pole star changes with time. Today we have a pole star which is called Polaris and 15 or 2000 years back there was no pole star and maybe again 3,500 years back there was another pole star. So that also give some idea of giving approximate, it cannot make any accurate calculation but it can give you some idea about the antiquity of things.

And another one which one tries is the analysis of the ancient eclipses. There will be always some description, particularly total solar eclipse is a very what I say, very noticeable event. And in all texts you will find that suddenly daylight it becomes dark. There always there will be impetus for describing it. And now you know that if you analyze those eclipses, you can try to find out where it happened. Because the location when it happened, which particular season, the date it happened, which particular time of the day.

As I think who was telling it, many people tries to interpret Jayadrath Vadh where the sun disappeared, then came out again as total or near total solar eclipse before sunset you know. So people have used that and tried to use software and find out that whether or when such a solar eclipse took place. But difficulty as I was mentioning that eclipse particularly total eclipse is only visible from a small area on the surface of the earth.

And the, so location of the earth surface in a particular orientation is very important. When you go back thousands of years back, it is very difficult because rotational history of the earth it is slowing down, it is approximately I think 6 into 10 days to minus 22 radian per second square is our retardation but that is an average value. There are fluctuations. So this the secular mean value may not give you correct location of the earth surface. So sometimes it does not match.

So therefore different softwares, the different results about this eclipse. Another thing which is used, rarity of event, the two consecutive eclipses. So in Mahabharata you will find that there were two eclipses within fortnight as 13 days gap. That was considered to be very bad woman. It is very clearly mentioned in the Udyoga Parva I believe. So that also people have used software and they tried to see that when two consecutive eclipses took place within 13 days which is very rare event, they found something.

But it is not very easy, particularly this eclipse during Mahabharata war, results do not match. Different softwares give different results. So therefore this can give sometime some idea but not very dependable in my opinion. My opinion is that precision of the equinox is the best and most stable and dependable way. Now advance of perihelion is used in two ways. One is important, exaltation of Mars. This is a purely astrological terminology but the phenomena is not astrological.

What happens that Mars's orbit is elliptic, earth's orbit is also elliptic but ellipticity or eccentricity is very small. So when Mars is in opposition, opposition means what? That sun, earth, Mars, they are in one line. So Mars will be nearest to earth. Now that becomes still more pronounced when Mars is at the perihelion position nearest to sun. So therefore there are rare occasions when the Mars is at perihelion and also in opposition.

That means, so that is the time when Mars is nearest to earth. And at that time the brightness of Mars is three times that of star Sirius which is the brightest star. And that is very visible, red star so bright that is what they call as exaltation of Mars. And there are reference to such exaltation of Mars in the past. And that also gives you because I will show you the calculation because earth's rotation of the or advance of perihelion is 0.332856 degrees per century. And for Mars the advance of perihelion is 0.43355 degree per century.

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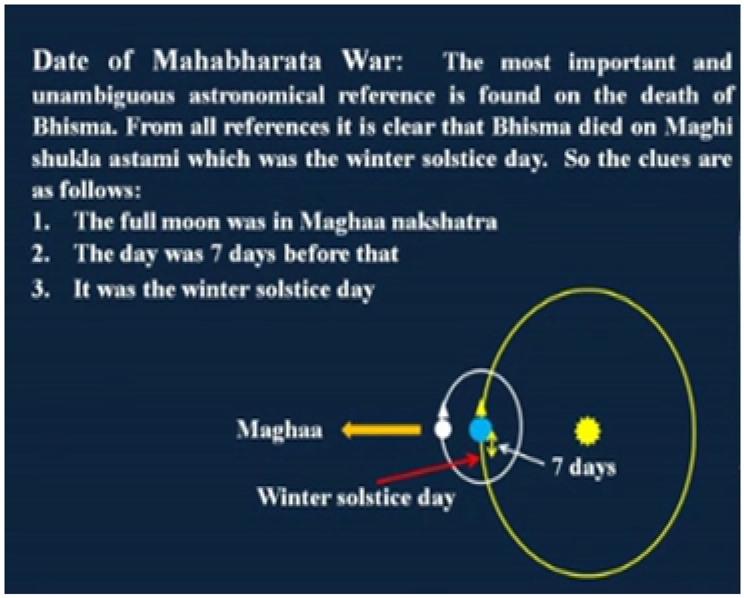

Now you see first let us see that Mahabharata war if you try to apply archeoastronomy, what results you get. Now I will not go into all kinds of Jayadrath Vadh, the two eclipses within period of 13, I will not go into that. There was another total solar eclipse at the time of death of Krishna which was 28 years after Mahabharata war. That also sometimes people see and it was visible in Dwarka.

You see that one which is most I will say non-ambiguitous was the death of Bhisma. It is very clearly mentioned that he died on the winter solstice day when the whole thing changed from Dakshinayan to Uttarayan. He wanted to die on Uttarayan, so he died on the winter solstice day. And it was also mentioned that it was the eighth day on the brighter half of the month Magha. So Shukla Ashtami in month of Magha.

Now you see in, if you use this terminology, month of Magha means that full moon should be on Magha nakshatra. So the configuration of the situation will be earth here, Magha nakshatra, this is the moon, and Magha nakshatra in this direction and this is sun. So therefore in this situation you will see the full moon in Magha nakshatra. And it happened not on the full moon day, winter solstice was 7 days before.

So earth was somewhere actually, not here. So this gap is 7 days. By calculation you can see that on 2400 BC full moon took place at Magha nakshatra also on the winter solstice day. Just I think I will try to show you using that same, actually you can do all these things study yourself. Now let us see 2400 BC how was the situation. And now you are familiar how to get it. So 2400 BC will be, 2400 and winter solstice day let us see it will be……

“Professor-student conversation starts.”

Student: Equal to 02, put 02 at this.

Professor: Same thing, it will not matter much. Month of I think I will put it say…..

Student: March.

Professor: January, or February. Let us see with….So you apply, so I think let us see.

“Professor-student conversation ends.”

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Winter solstice day will be when sun is at the extreme end of the ecliptic, is not it? So it is the ecliptic, this is the ecliptic. And extreme I think……

“Professor-student conversation starts.”

Student: The location……

Professor: This is sun, you can see now you have got the sun and this is the moon. Now it is not the full moon because on full moon sun and moon will be 180 degree apart, is not it? And now it is not the full moon day. So you have to fix the date and date if you change to January 18th to say let us say if you let me go to February 18th where we are.

Student: 18.

Professor: You can do little bit trial and error, you can find out. So you can see now sun is here but it is not winter solstice day. Sweet but I think now it is actually new moon time. So I think with this I did it somewhere but I think I do not remember the dates exactly. You can bring sun and the winter solstice, that means extreme end of this, it will be somewhere here. And moon’s longitude will be or right ascension should be 12 hours different. And also you will find that full moon, the moon will be against the nakshatra Magha. So that has been done and it is……

Student: Magha is which?

Professor: Regulus I think.

Student: Regulus.

Professor: So this is easy to find out by using little bit of trial error, that 2400 BC on such and such date full moon took place in Magha, it was the winter solstice day. But Mahabharata war took place or the even Bhisma dies, it was not the full moon day. It was winter solstice but 7 days before the full moon.

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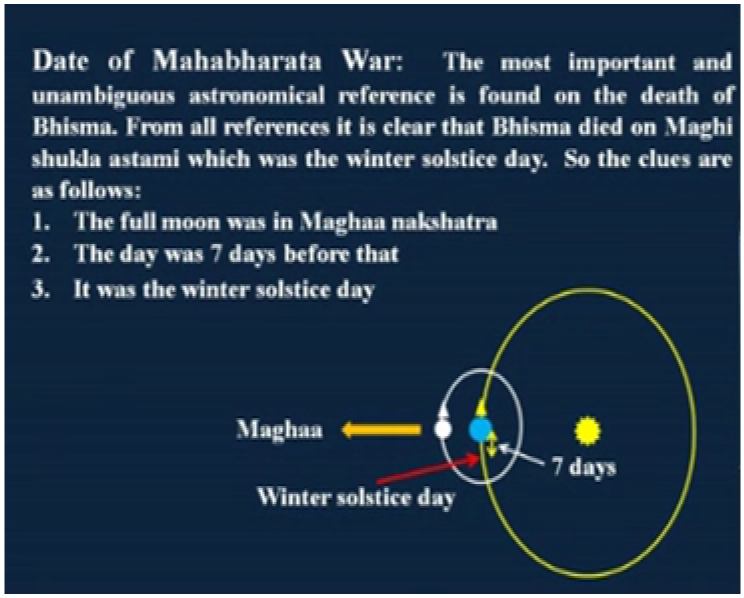

So what happens, so now what will be this day therefore? Now to this whole thing represents 365 days but it takes how much time for it to come? 25,800 years. So 7 days used in how many years? 7 into, 7 by 365 into 26,000 say. So this is about 300-400 years. So 24 BC and you reduce 5,000 or 6,000 years, whatever comes, you can calculate. So that is the approximate time when this could have happened that on the shukla ashtami of the month when the full moon took place on the Magha nakshatra and it was winter solstice day.

So there are all these conditions you have meet. Of course it is very clear with this it is difficult to do because Magha nakshatra is not one point. Each nakshatra spans how much? 13 degrees. So therefore there will always be chance plus minus this way that way. I personally believe so. Many people try to show that such and such date such and such time, that gives far more analysis. But one thing is to you can say that Mahabharata war was approximately 15 to, I think around 1800-1900 or 1500 kind of BC kind of thing.

I think it will be around 1900 BC. The reason is another. Everything must match. I think Balram is described to have taken a path along the bank of Sarasvati and went up to the place where it vanished in the desert, vinasha. So there and in the geological research shows Sarasvati completely dried around 1900 BC. So after few hundred years of that perhaps it will not be there. Most probably therefore around that time it happened.

But there is another clue. That clue is as I mentioned that there is only one character who is found both in Puran and also in history. That is Mahapadma Nanda. So Vishnu Puran says that after Parikshit there were 1,050 or 1,500 years when Nanda became the king. “Javat parikshito janmo javat Nanda visheshnam, yetat varsha sahasantu pancha dashotaram gan.” Somebody say it is pancha shatotaram, somebody says pancha dashotaram.

So whatever it is, you will find, you can easily calculate 1500 years was the time from Parikshit to Mahapadma Nanda. Mahapadma Nanda, 10 generations from Chandragupta’s time. So if you take 20 years or 25 years per generation, so another 200 years. So 1,500 to 200 years or 1,050 to 200 years, so 1,250 years.

“Professor-student conversation starts.”

Professor: And Chandragupta was about 258 BC or…..?

Student: 300 BC.

Professor: So you get about 1600-1700 BC. It is only other calculation which has nothing to do with astronomy. So therefore it is opined by the experts like Bankimchandra Chattopadhyay who did lot of research in 19th century on this that Mahabharata war took place around 1600-1700-1800-1900 around that time. You can tell approximate. But not 3000 BC definitely.

“Professor-student conversation ends.”

What many people say that because Kaliyuga is described as 3102, that was considered to be the end of Mahabharata when the Kali started. So many people do it that way. And I think that is the source of mistake because Kali era was taken that day, who told? You did and we found that yes, approximately the planets were more or less the same meridian. And people describe this as Kali era and Kali is the beginning of after Mahabharata war. So people associate Mahabharata war with 3100 BC but calculation show other.

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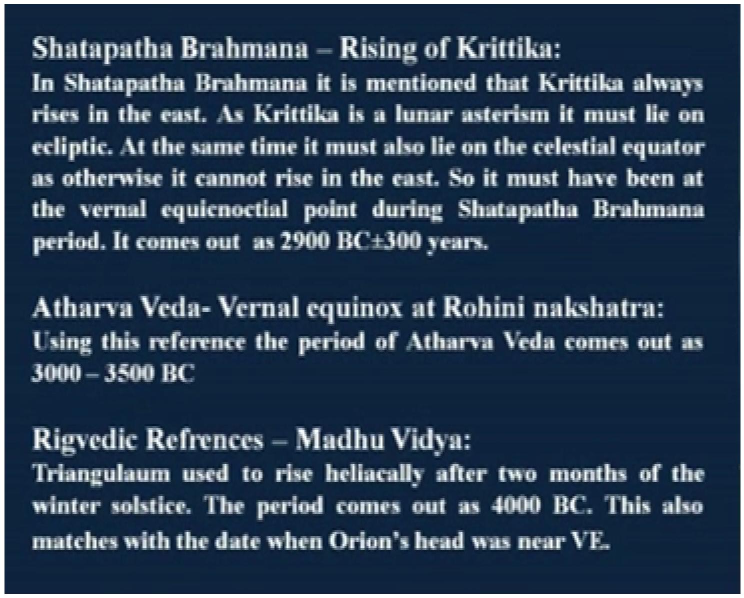

Now again another thing used in Puranic text, Shatapatha Brahmana says clearly very interesting thing, rising of Krittika. Now Krittika was very important nakshatra, it was the deity of the thing fire as I mentioned. And it is mentioned that Krittika always rises in the east. What does it mean? Something can rise in the east, means it must be on the celestial equator. But the nakshatras are not on the celestial equator, they are on the ecliptic.

So only when it can be also in celestial equator that where it is in one of the equinoctial point, either vernal equinoctial point or the autumn. Now if you assume that it was at autumn equinoctial point, then you will find that it is very difficult. It will be some few tens of thousands of years back which is not acceptable. If it is on vernal equinoctial point, you can easily see just now that Krittika is at the vernal equinoctial point around 2900 BC. And you can see when it rises now and when it used to rise then. Say if I give the date as 2400 most probably I did, I think I would change it to 2900. Let us see. Okay.

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Now let us see whether it rises Krittika in the east. Vernal equinox means that when the ecliptic is coming from the south and intersects the, yeah you can this is Krittika. This is Krittika. This is very much near the intersection of, this is the vernal equinoctial point. But now if you say if you want to do, where it will be…..

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Now you see it is rising far north, it is here. It is rising here. So again and again it is described that Krittika is rising exact in the east. It means it will be a description at least 2700-2800 years BC. That is another reference we get.

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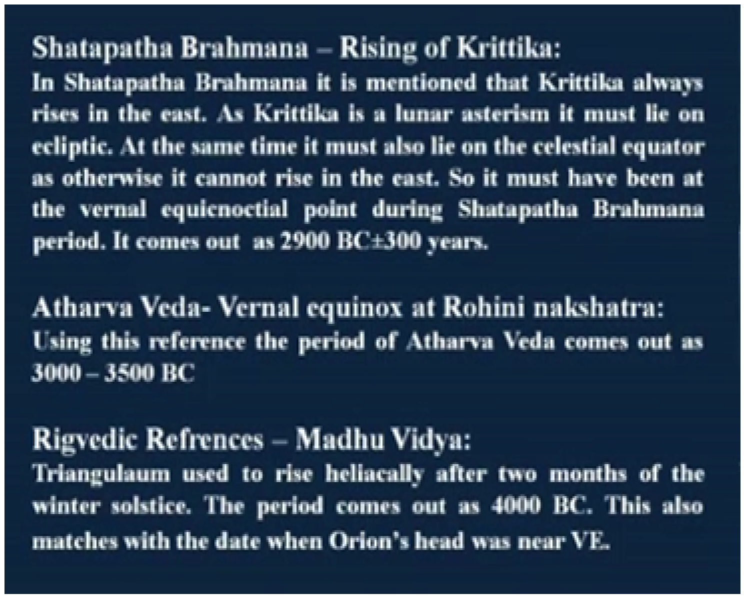

Another thing we will get, so all the Puranic texts, this is the way the chronology has been derived by the pundits or scholars. Say Atharva Veda says that vernal equinox at Rohini nakshatra, so again the same way you will find that when Rohini nakshatra is near the vernal equinox when it could be there. This is more or less reasonable. It is easy to identify the vernal equinoctial point and which nakshatra is there.

So they find it is 3000 to 3500 BC, it was in the vernal equinoctial basis. And Rig Vedic reference, it gives quite a few references. One is very interesting which is called Madhu Vidya. Now Madhu was the name of season Vasanta. Vasanta is comparatively more recent term. And the in the east the sages used to tell that when people should be prepared for harvesting in this northern Punjab region, west Punjab region. And that is why it is called Madhu Vidya. And normally the harvesting et cetera, all those things are that season Vasanta starts after two months of winter solstice. So very commonly now everybody cannot find out when is the winter solstice et cetera. So the easy way to was to see that helical rising of sun constellations.

So Triangulum which is they call Aswini and the helical rising of Aswini was found to be happening after two months of winter solstice, that means on the onset of….Now you see here it says many shlokas are there in Rig Veda. When it says that maybe 3-wheel cart, the Aswins which is the harbinger of spring drawn by swift horses. So it cannot be filled with pleasure and every way auspicious come to our presents and bring prosperity to our people and all these thing.

Another, many shlokas are there. In most cases now people have, they have found that it is the rise, helical rising of Triangulum. And you find that, you find Triangulum to rise helically around 4000 BC after two months of winter solstice. Another reference which I showed you before, that finding the true south direction by joining Alpha Canis Minoris with Alpha Canis Majoris. That also previously I showed in the I think first lecture as well, that it is 4000 BC approximately or 4100 BC.

These two were in the same meridian. That means if you join them, it will point towards south pole. So all these things, another thing which Madhu and says that with the Orion's head was near the vernal equinoctial point. Now it is quite far off but if you see at 4000 BC, so date and time let me give 4000 BC.

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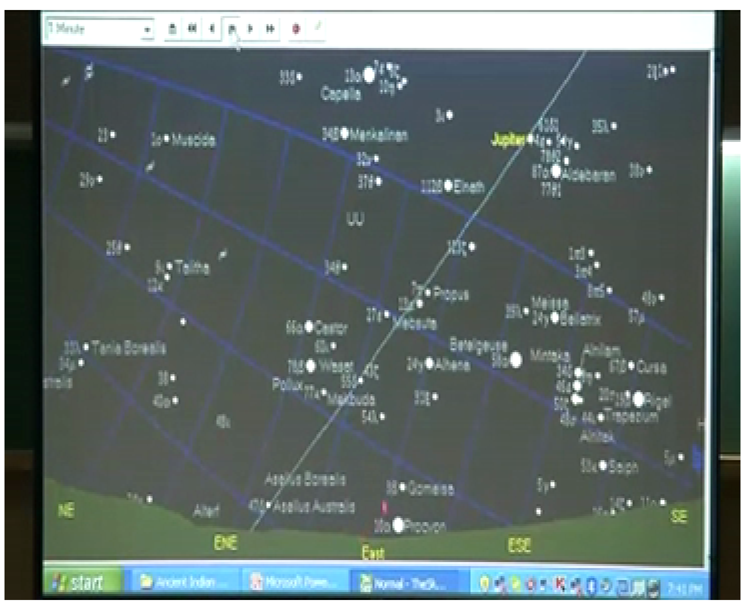

So I think you will find vernal equinox is somewhere here. So we have to go back. Computer will help us to rotate, change the rotation of earth. So you see this is the east, that means this is the east and this is the vernal equinox, I should stop. This is the vernal equinox, this is the celestial equator and so this is vernal equinoctial point and this is the Orion. And head of Orion is here, okay. And it cannot be on vernal equinox obviously because it is not on the ecliptic, now on celestial equator.

So it will never be on, but its head will be nearest to vernal equinoctial point. And that is what you find that the head of the Orion is near the vernal, nearest to vernal entity. The vernal equinox is here and this is the head of the Orion. So you see currently if you see that…..

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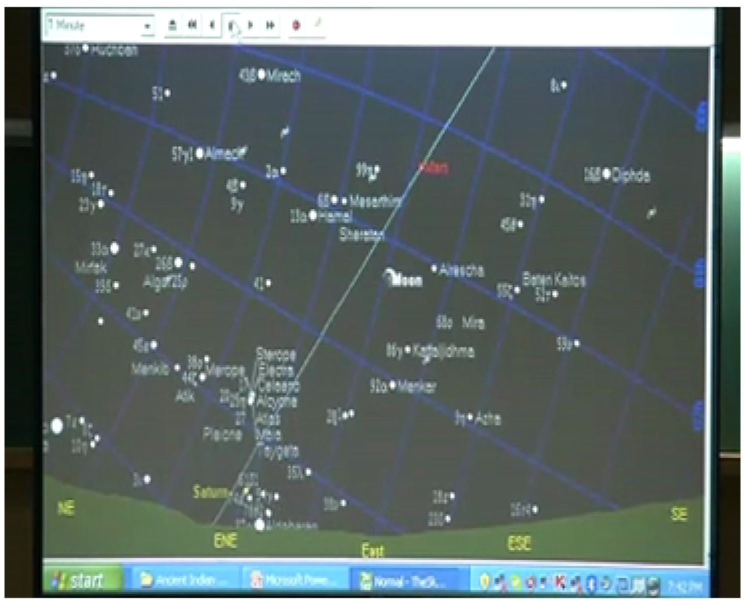

And at present vernal equinox is where, I should go. This is the vernal equinox point. This is the vernal, this is the east and this is the vernal equinox point and Orion is here. You can see. Yeah, so it is far away. This is the Orion. This is Orion, this is Orion shade. And vernal equinox is somewhere here. So many indications you have to match. Just one description you cannot take and predict or take a decision.

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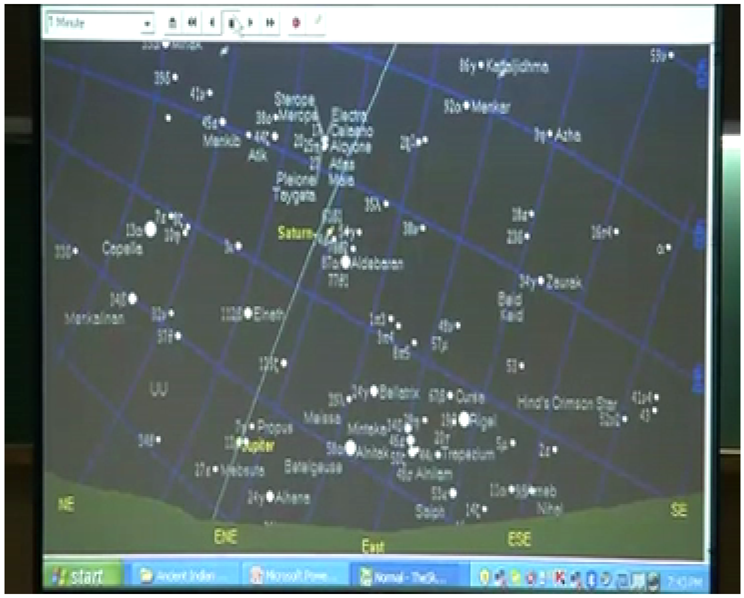

There are many ways you have to do and you will find most of the things that way will ultimately lead to this kind of thing. I have already given to you that vernal equinox was at Orion shed or Mrigashira. Summer solstice what Rig Vedic text gave rise to was in Uttara Falguni, Beta-Leonis. Autumn equinox was in Moola, that is Lambda Scorpion mix. And winter solstice location in Purva Bhadrapada and all these descriptions match 4000 BC. Then Atri's description of that annular eclipse on the summer solstice day what has been analyzed by professor PC Sengupta was 4100 or some BC and….

"Professor-student conversation starts."

Student: That depended on the calculation of the partial units of angular units.

Professor: Angular.

Student: And as you are saying these calculations may not be very reliable.

Professor: May not be very reliable.

Student: And especially he did the wrong (())(70:17), now we have computers.

Professor: Yeah. So but I think you may not, what, why I am saying this? In that region it could have happened. Exact spot you not notice, that is the point. For (())(70:31) or Kurukshetra is very spot but if you increase your size of the region, then of course you can vary it because it, you will find it there. That is how people think that you could do it. That such a thing happened exactly. Where you saw that, that you will not be able to see. But anywhere eclipse happened, that you can always measure it.

“Professor-student conversation ends.”

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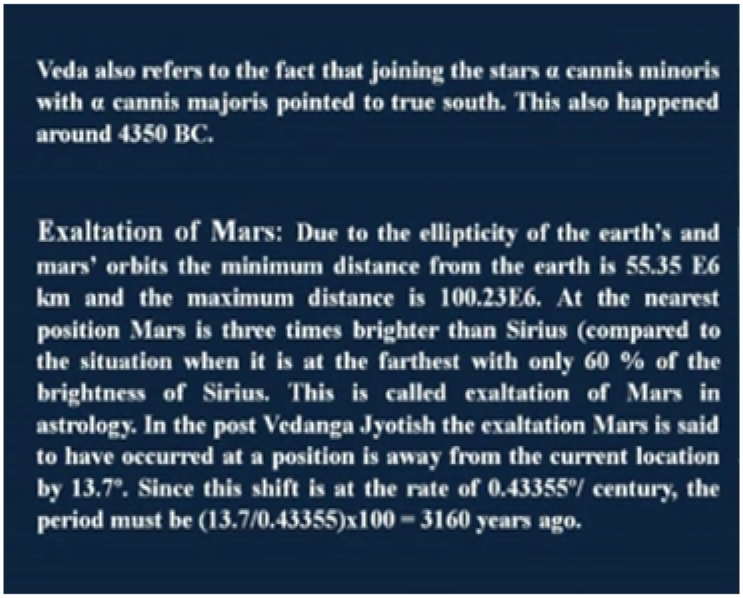

Then the time period et cetera, I have given my first slide already, so I need not go into that. And also as no need for, to show the helical rising because we are short of time. And so this way Veda also refers to the fact that joining the stars Alpha Canis Minoris, Alpha Canis Majoris. I told you the 4350 BC. Now another very interesting astrology can be of help, exaltation of Mars. Now due to the ellipticity of the earth’s and Mar’s orbit the minimum distance from the earth is 55.35 into 10 raised to 6 kilometer between Mars and earth.

And the maximum distance is 100.23, 10 raised to 6. At the nearest position Mars is three times brighter than the Sirius compared to the situation when it is at the faintest with only 60 percent of the brightness of the Sirius. So with 6 times the brightness varies of Mars, and this is called exaltation of Mars in astrology. In the post-Vedanga Jyotisha, the exaltation of Mars is said to have occurred at a position which is now away from the that of the current location by 13.7 degrees.

Now where the exaltation takes places nowadays? And that time when, where it took place the difference is 13.7 degrees. Now since this shift is at the rate of, now every century the location of the exaltation point of Mars shifts by 0.43355 degree. And the period because that is the rate of advance of perihelion of Mars, just now I told. The Mars orbit's perihelion shifts and exaltation will be always at the perihelion position.

So the rate at which perihelion position shifts, that is the way the location of the exaltation position of Mars in the ecliptic will also shift the same way. So for century this position of exaltation shifts by 0.43355 degrees. So when it occurred at a location which is now at a distance of 13.7 degrees and that must have taken place almost 1160 BC. So that is the post-Vedanga period.

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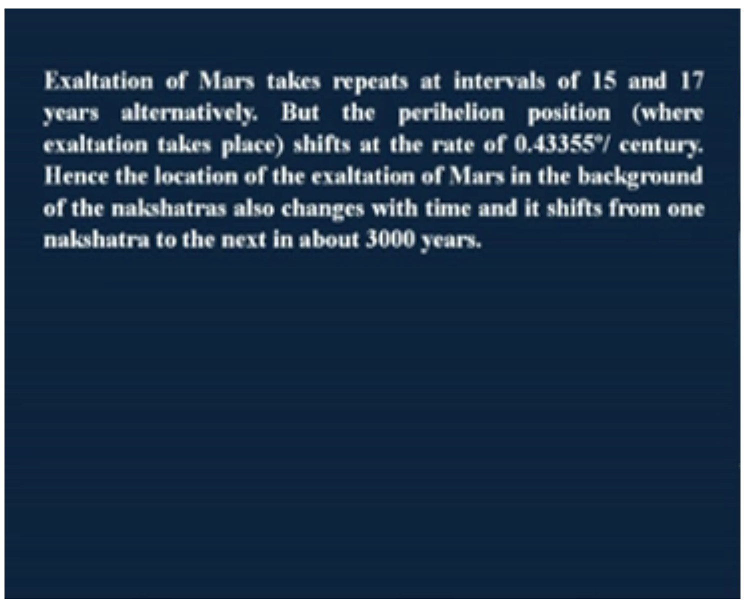

So and exaltation of Mars takes, Mars repeats at intervals of 15 and 17 years alternatively. But the perihelion position shifts, that is what I mentioned.

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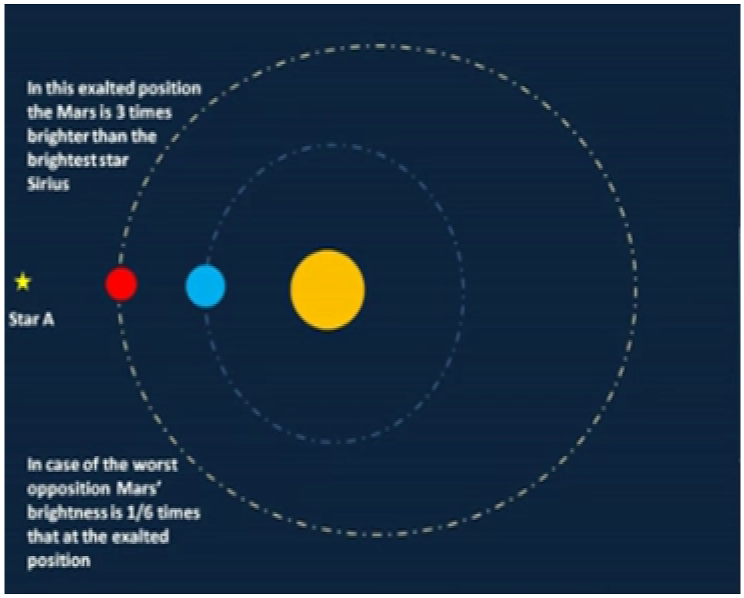

So this is the picture that this is the star against which the perihelion of the Mars is there and there is an exaltation. So what happened, this slowly shifts. So exaltation position also will shift continuously.

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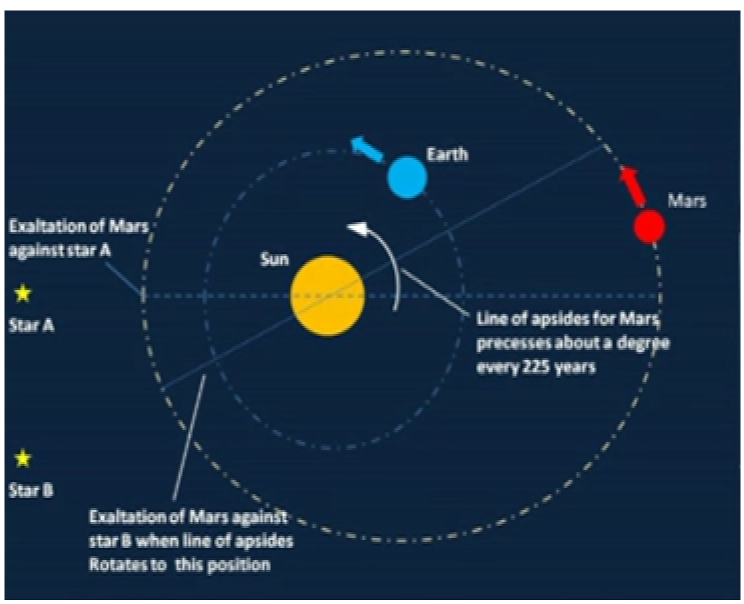

Maybe after some time you will find that exaltation of Mars against star B when the line of upside rotates to this position. And you can easily find out the duration, this angle divided by 0.4355. So that will give you so many centuries and obviously you can easily calculate. So this calculation was again done very meticulously by Professor Rana of IUCAA. Of course he is not alive, I think he is dead. He was very outstanding astronomer. In 225 years it moves to 1 degree or which is the same thing, 0.4 something like that.

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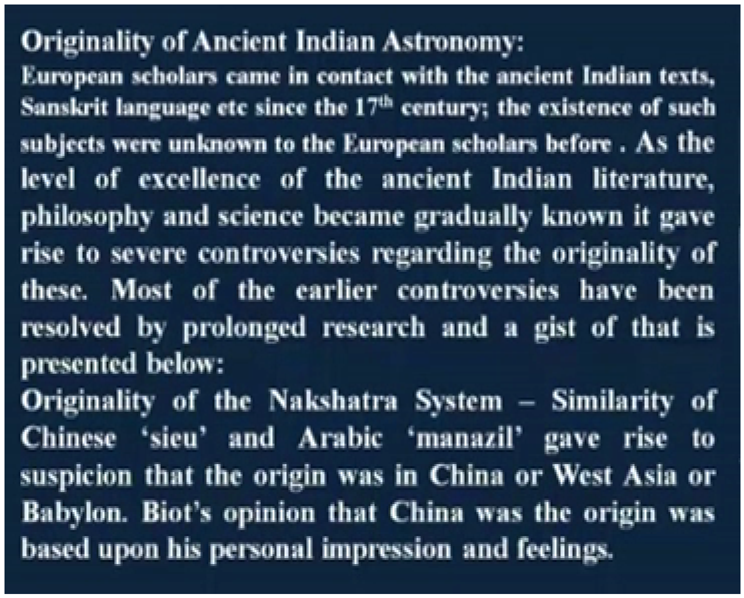

Now another last topic I will talk about, originality of ancient Indian astronomy. Now this was a matter of bitter controversy. And they used to fight, this is far worse than the emails our faculty members in IIT Kanpur exchanges. So I think European scholars they came in contact with the ancient Indian text. They never knew about language like Sanskrit and they are so amazed to see its richness. That is why they are jealous to say that they are, those things were done by them.

As the level of experience of the ancient Indian literature philosophy and science became gradually known, it gave rise to severe controversies. And I mentioned that they thought that this people could not have done that, they are all bogus, third race, niggers. And really society was extremely degenerated in 18th, 17th century. And some of course were somewhat more scholarly, they did not have this kind of bias. They said no, no, antiquity et cetera I think there.

So two things are, one most important thing is the originality of the nakshatra system. That was one of the major debating point. Because in Chinese they 'sieu' with 24 stars, there is a system and they thought that, that is the first nakshatra system. In Arabic there is something like manazil, that also used to describe the locations of the moon and gave rise to the suspicion that the origin was in China or West Asia or Babylon.

Because the any source of wisdom they generally had the tendency to stick to Babylon. That was the usual habit. Even many of their scholars said that what is this, anything would you find, nigger, they said it must have happened in Babylon and it has come here. Now Biot for example, his opinion was that the China was the origin based upon his personal impression and feeling. The China, that these, that and not based on any scientific reading. Rather in the book you will find I have given the detailed analysis from various sources.

Now Sanskrit, I will not go into those details but Max Muller did some linguistic analysis and he proved that nakshatras find mention in Indian text dating back to 3^{rd} millennia of BC. Of course this date was not by him, this date was by the text we refer. Now the dating of those texts are, that is 3^{rd} millennia BC.

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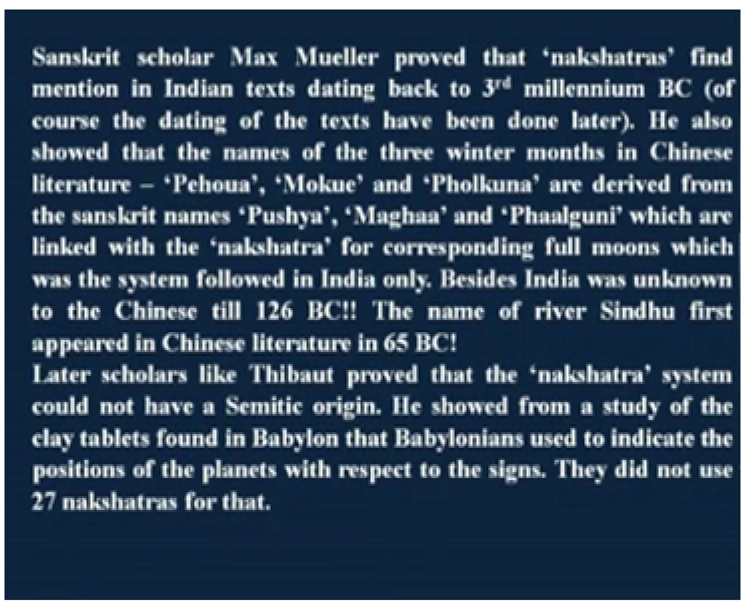

He also showed that the names of the three winter months in Chinese literature, Pehoua, Mokue, and Pholkuna are derived from the Sanskrit name Pushya, Maghaa and Phaalguna. And these names are linked with the typical Indian system of naming months where full moon takes place against nakshatra. This system is not there in any other literature or any other astronomy. So he said that since in China the names of the three winter months are according to the names of the

Indian nakshatras which is followed there, he said that it must have originated in India first and then went to China. It could not have happened the other way.

And there are some other reasons of course there, I do not have time to discuss everything. Another thing of course is very surprising that India was unknown to Chinese till 1126 BC. The name of river Sindhu first appeared in Chinese literature in 65 BC only. Later scholars like Thibaut proved that the nakshatra system could not have a Semitic origin either. That means not in West Asia. He showed from his study of the clay tablets found in Babylon that Babylonians were using to indicate the positions of the planets and moon with respect to the 12 divisions of the ecliptic which you call signs.

Those days they did not have the names but that was their system, they never had 27. So they did not use the 27 nakshatras for that. Some scholars feel that since moon's 27 positions is not very difficult to observe, many civilizations could have had perhaps arrived at the same conclusion. So there is nothing strange about it. It was a very obvious thing to do. So there is no need to fight like that.

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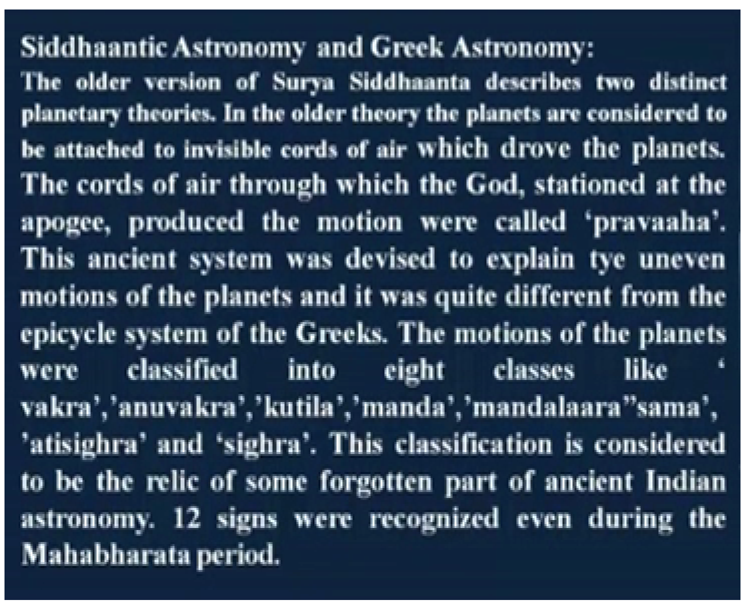

Another important point is the similarity with siddhantic astronomy and Greek astronomy. The old, it has been found, I will not go into the detailed description. That is in the book you will find. But the older version of Surya Siddhanta which was later changed by Varahamihira, it describes two distinct planetary theories. In the older theory the planets are considered to be attached to invisible cords of air which drove the planets.

The cords of air through which the God stationed at the apogee, produce the motion were called pravaaha. This is a very unique thing in Indian astronomy, it is not there in Greek astronomy. And this ancient system was also devised to explain the uneven motions of the planets, why it is sometimes fast, sometime it is slow. And the motions of the planets were classified into 8 classes, far more sophisticated than Greek astronomy.

And it was before the Greeks came, it was in the older version of Surya Siddhanta. And the 8 classes of motions of the planets were vakra, anuvakra, kutila, manda, mandalaara, sama, atisighra, and sighra. So qualitatively since they did not have numbers to measure, what they did, they described it qualitatively with 8 different classes of motion which is obviously quite sophisticated considering the period. And this classification is considered to be the relic of some still forgotten parts of ancient Indian astronomy. 12 signs were also recognized as I mentioned even during the Mahabharata period but the names were not given.

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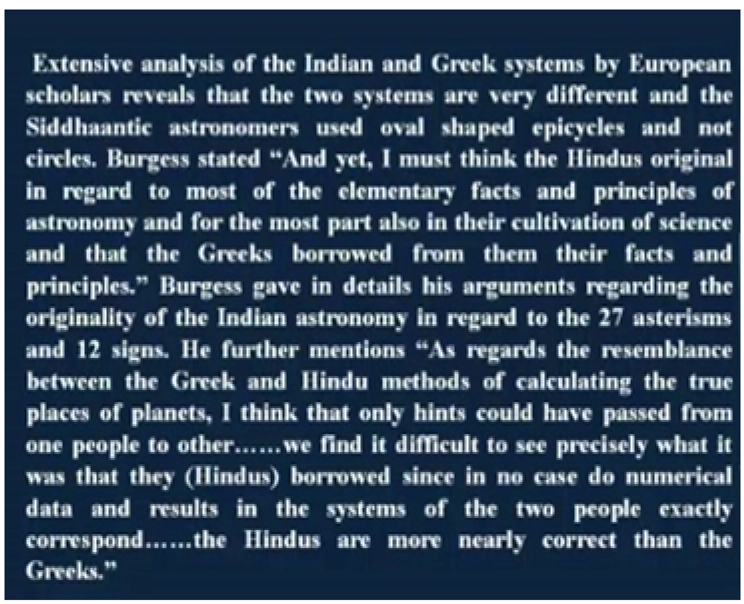

Now extensive analysis of the Indian and Greek system of European scholars reveal that the two systems are very different and the siddhantic astronomers use oval shaped epicycles and not circles. The reason you know, in Ptolemic system you could not match it well with one epicycle with circular shape. Then they added another epi-epicycle, then another epi-epi-epicycle. Whereas Indian system they did not use the circle at all. They used an oval shaped body. And what Burgess stated in the middle of 19th century……

“Professor-student conversation starts.”

Student: Just, so if it is typographic kind of system, then oval is elliptical orbit. Elliptic, oval is the ellipse.

Professor: Actually they did not know the ellipse. They called all such things as oval shaped. Even Kepler initially tried when that 8 minutes of arc he was unable to match in Mars’s orbit, he first tried it oval. Much later he came to ellipse to see the perfection. He did lot of experiment with oval shaped like eggs. The reason is this that it is very psychologically you see, if sun is helping or influencing and sun is one side, then the body cannot be symmetric like this. Tendency will be to consider in sun-centric or one focus, so it tends to become oval psychologically.

“Professor-student conversation ends.”

So Burgess stated and yet I must think the Hindus original in regard to most of the elementary facts and principles of astronomy. And for the most part also in their cultivation of science and that the Greeks borrowed from them rather they are facts and principles. Burgess gave a detail in his arguments regarding the originality of the Indian astronomy in regard to the 27 asterisms and 12 signs also.

He further mentions, “As regards the resemblance between the Greek and Hindu methods of calculating the true places of planets, I think that only hints could have passed from one people to another. We find it difficult to see precisely what it was that Hindus borrowed since in no case do the numerical data and results in the two systems exactly correspond….values are very difficult.” So it was definitely not a kind of copying, maybe some ideas are exchanged. “And the Hindus are more really correct than the Greeks in their numerical values.”

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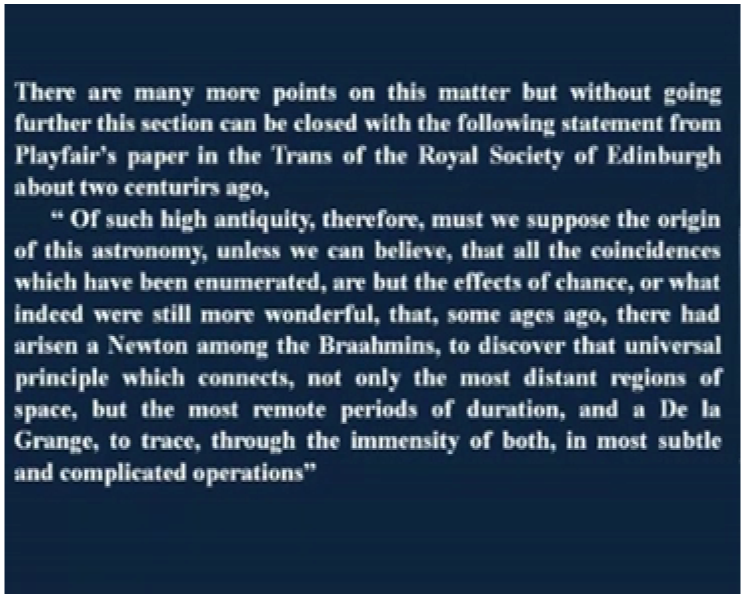

And of course there are many more points on this matter but without going further I will end this session by the following statement from Playfair, his paper in the Transactions of Royal Society of Edinburgh about two centuries ago. I quote, "Of such high antiquity, therefore, must we suppose the origin of this astronomy unless we can believe that all the coincidences which have been enumerated are but the effects of chance, or what indeed were still more wonderful that some ages ago, there had arisen a Newton among the Brahmins to discover that universal principle which connects not only the most distant regions of space but the most remote periods of duration, and a De la Grange to trace through the immensity of both in most subtle and complicated operations."

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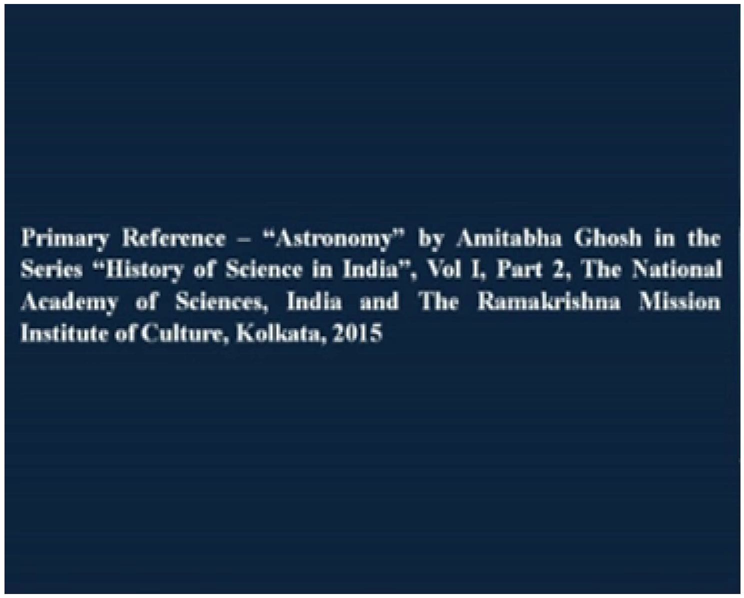

So I think friends, I think I will stop here. And I think that you will enjoy going through more elaborate text. But the simpler version for a common man's language we have done at the request of Ramakrishna Mission Institute of Culture which students can read. Of course what I have given far more details are there. More importantly this gives all the necessary bibliography and references entertaining.

So if you want to read further, all the references you will find here. And that I have given this the book here as the primary reference but you can see the bibliography. And of course this is the end of the lecture series and many thanks. I never expected that there will be so many till the last lecture because normally I am told that it is the camerawala or cameraman or the dari isko le jana he naa.

Somebody was telling that he was happy that lecturer that you are still here. No sir, I cannot read that the dari, the carpet is mine, I have to take it. So many interesting stories. One person came to give a lecture and he is a very famous on the topic and audience is there. He was invited. Then he was asking that how long can you talk. Then the organizer, the persons like Amit said sir, I think you are such outstanding speaker coming from distant, you are so fortunate that you are here. So you can speak as long as you want but we leave in 55 minutes. Okay, thank you friends, thank you very much.

Professor 1: He has only told he was born as a teacher, still attract people here from the five lectures. So I just request everyone to stay back for a couple of minute before he takes the questions and answer. I will again request Professor Mahendra Varma to (())(86:18) small memento on behalf of physics society.

Professor 2: You are creating….

Professor 1: From that line, so photo lenge.

Professor 3: Okay, photo session. Thank you very much, excellent!

Professor 2: Thank you.

Professor 1: Okay, now we just open for questions. You should have any questions. And from Monday you can send request, PDF file, ppt files, I will send the PDF version whoever is. Okay? So if you have any question?

Student: In Somnath Temple which I visited recently there supposed to be a pole.

Professor 2: Supposed to be…?

Student: I think there is a pole and supposingly some temples however you see them aligned, go to the south pole. That is now, I am not sure which year does it correspond to but….?

Professor 2: I do not know. I have never visited.

Student: That is there in Ahmedabad also. (())(87:22) landfills also.

Professor 2: Acchha suniye, aap woh pendrive lei aayena, ismise lelijiye usko. They want to take because they need this ppt.

Professor 1: Okay. There are no more questions. You have a question? Please, Amit udhar. He has it.

Professor 2: Hah.

Student: Like there are various panjika definitions.

Professor 2: Various what for the….?

Student: Punjika, that definitions miscued.

Student: And they often denote by word. Something group of panjika says today is (())(87:56) or some panjika tells (())(87:59). So these kind differences there will be in panjikas.

Professor 2: No, panjika in India it is the total confusion. That is why Bal Gangadhar Tilak, they all tried to bring a reform and uniformity. There was lot of work on that. And the reason you can see somebody is using this era, somebody is using this data. All kinds of variations were there. But I think Government of India later I think with Meghnad Saha, they tried to, they did something.

Professor 1: Calendar committee.

Professor 2: Yeah, calendar committee was there. Yeh konsa hai aapka? Yeh wala? Just a minute.

Professor 1: Just a minute. I think this should be yes, physics society for IIT lectures.

Professor 2: Yeah. Should I write to…..

Professor 1: (())(88:55)? Or I will write to Piyush.

Student: Sir, I want to check for that, check again.

Professor 2: Yeah.

Professor 1: But these machines does not have the converter I think.

Student: Now this is responding......

Professor 2: I have to give my 15 minutes interview to Tushar. Are you here? Yeah, he asked me everything, where I graduated from, whether my PhD in mechanical engineering. And he said that he want do become a scientist, so that is very good, excellent. But only unfortunate thing that he want to MDA. Yeah.

Professor 1: Yes.

Student: Winter solstice day is at 3 or 22nd of (())(89:56).

Professor 2: Nowadays.

Student: Nowadays.

Professor 2: Actually about 2000 years back some of our rituals we started and that time it was the 14^{th} of January was the date of winter solstice. That is why you are still doing that Makar Sankranti kind of thing.

Professor 1: On 14^{th}.

Professor 2: But which it is, it has nothing to do with that now. It has shifted to 21st December but earlier about 2000 years back you can easily calculate considering the precision of the equinox how many thousand years back it was the winter solstice day. And then we started our rituals and such things.

Student: You should, pointed out that it was Vikram Samvat, basically Vikramaditya time.

Professor 2: So that is…..

Student: So 70 years it shifts by Monday.

Professor 2: Yeah.

Student: So basically it was not corrected, correction means…..

Professor 2: So it remains as 14^{th} of January but it has come. I think it is…..

Student: (())(90:52) 15 because of the 76 years, we will keep.

Professor 2: So it is very easy to calculate that.

Student: All the corrections administered. All the given corrections that….

Student: Yeah, the correction I think in Panchang after, initial days that they have not corrected after Vikramaditya. Vikramaditya, that there was 22^{nd} December at Ujjain, that is when we started but the correction was not made. So it is shifting maybe 76 years.

Professor 2: Actually about approximately Vikram Shaka was around 2000 years old. So you will find that it was started then. And so it has shifted but that has not been taken note of. We are taking the same data in winter solstice, otherwise there is no significance of 14^{th} of January.

Professor 1: Okay. So no more questions. We thank Professor Ghosh again and also the team of physics society outward, (())(91:53) and members from lecture hall and student team all of you attended, so big hand for them.