Krittika

Astronomy Demystified!

It all started a long time ago! Even the primitive men would look at the tiny , sweet lamps glowing in the Heavens and ponder about their origins! Since then , many great men have devoted their lives to know about the numerous unanswered questions, about the mother earth , its companion moon, the stars , planets … Sitting on the heads of giants like Kepler , Newton , man today knows a lot more truths about the Universe! Even a 7 year kid would say that the earth revolves round the sun. We know a lot of facts today about Our planet Earth, The solar system and the Universe in general, but do we have any simple methods by which we can validate these facts?...

Lets' begin our Journey with our **mother Earth!**

THE BLUE MARBLE

Today, we do know a lot of things about our Planet. Let's consider the most basic facts we know :

FACTS:

- Earth is Round
- Rotation
- Revolution around the sun
- Heliocentric Solar System

How do we verify these facts?

- **Spherical Earth**
  We all have seen that on a seafront that we can see the top-portion of the ships earlier than the rest. This does tell us that Earth has some curvature. The circumnavigation of the Planet also seconds the fact. But, what about the spherical nature of the Earth? Of course man knows that the moon is spherical and so is the sun, that does give a intuitive feeling of the earth being a sphere? Do we have convincing reasons to believe it?... The pictures taken of the earth from ISS do confirm it beyond doubt that the earth is spherical. But, can we verify the fact without going into the outer space? Well, yes!
  Have a look at the picture below:

Lunar Eclipse!

We know that the Lunar eclipses occur due to the Earth's shadow falling over the moon. Now, do you see the Earth's shadow is circular? Here a better picture to illustrate the point:

Now what figure has a circular shadow along any direction? It's a sphere! So yaa we found a wonderful and a convincing reason to believe that the Earth is spherical! Just a small deviation ,why does the moon look reddish during a total Lunar Eclipse ? and not completely vanish? Got the point? Well, here's one more beautiful image!

Once in a ~~Blue~~ **Red** moon!

The answer is that, we know that higher the wavelength the lesser the light gets scattered. Hence , the blue light from the sun scatters in all directions while the red component passes almost undeviated into the Earth-shadow region!

Now Let's return to our original topic of discussion:

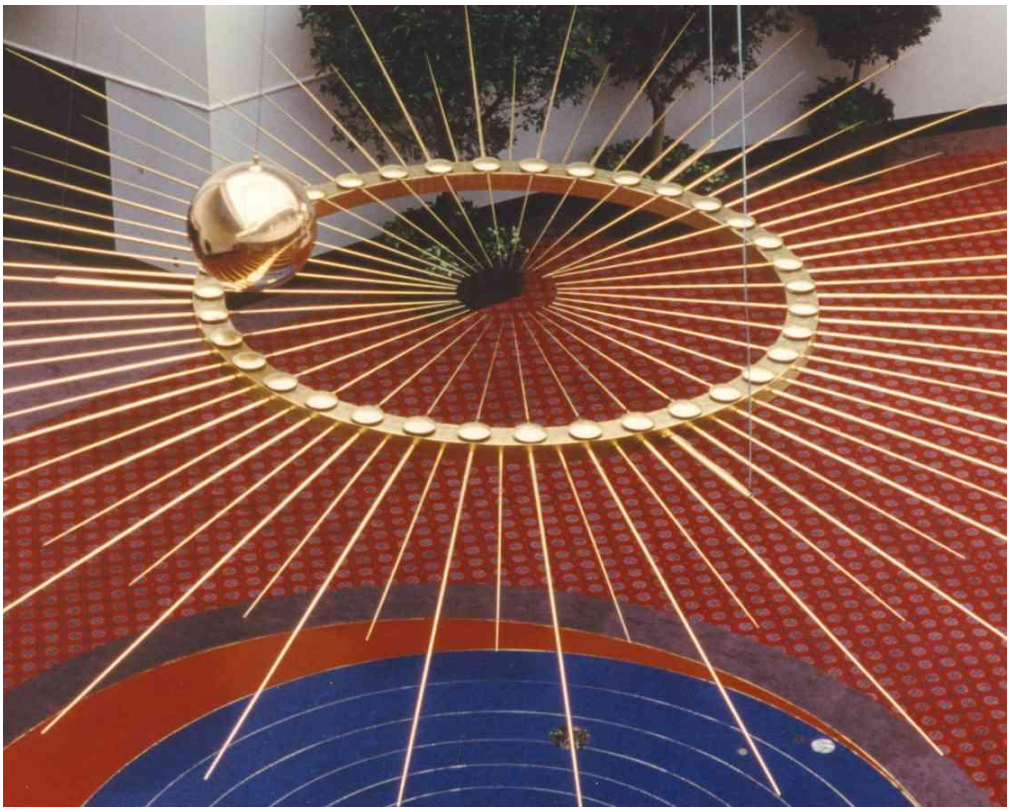
- **Rotation of Earth!**
  Every night the tiny shining lights rise up at the east and set down at the west! Isnt that a convincing enough reason to believe that the earth rotates? Well, not actually! It's possible that the stars are attached to a fixed huge globe which is rotating-isnt it?

A small deviation:
What does this picture tell us?, It's a time-exposure picture of an extremely dark sky.(the exposure time is more than 8 hrs!).Its seen that all the stars revolve round in circles about the pole star. As the pole star is fixed , the axis of rotation passes through it. But, the original problem still remains unanswered , how do we know that it's the earth that is rotating and not the stars which are moving round the earth! The answer came through the means of focault pendulum:
Here's what Wikipedia has to say about it!:

The **Foucault pendulum** (pronounced /fuːˈkoʊ/ "foo-KOH"), or **Foucault's pendulum**, named after the French physicist Léon Foucault, is a simple device conceived as an experiment to demonstrate the rotation of the Earth. While it had long been known that the Earth rotated, the

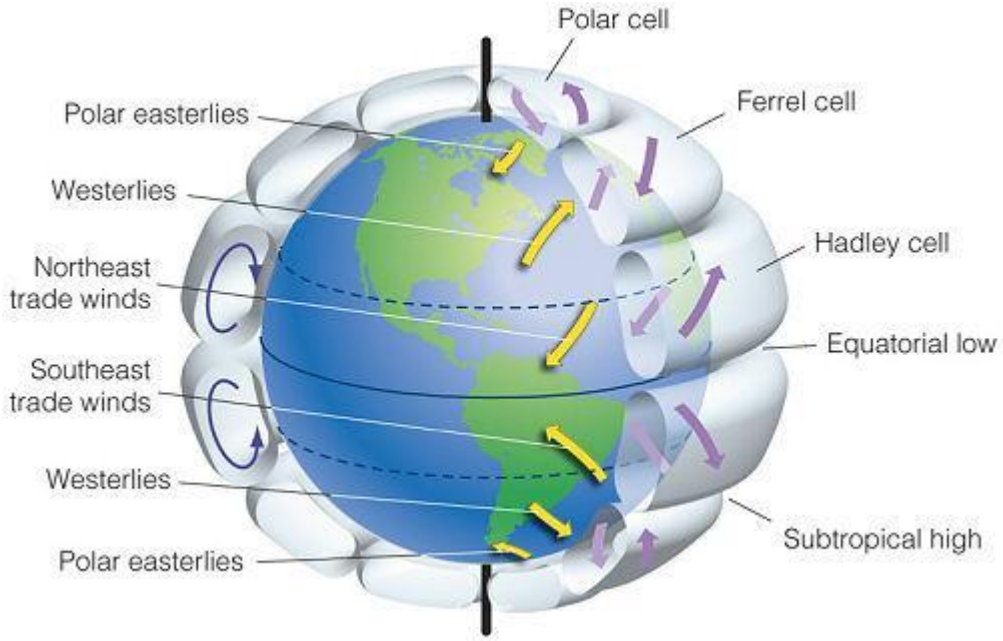
introduction of the Foucault pendulum was the first simple proof of the rotation in an easy-to-see experiment. Today, they are popular displays in science museums and universities. Focault's Pendulum is a tall pendulum free to oscillate in any vertical plane. The direction along which the pendulum swings appears to rotate with time because of Earth's daily rotation. This is because the plane of the pendulum's swing, like a gyroscope, tends to keep a fixed direction in space, while the Earth rotates under it. The first public exhibition of a Foucault pendulum took place in February 1851 in the Meridian Room of the Paris Observatory. A few weeks later, Foucault made his most famous pendulum when he suspended a 28 kg bob with a 67 meter long wire from the dome of the Panthéon, Paris. The plane of the pendulum's swing rotated clockwise 11° per hour, making a full circle in 32.7 hoursin 1851 .

Look out for the wiki article to get more insight into the working of the Focault's Pendulum!



The Focault's Pendulum is dependent upon the Coriolis' force (in the reference frame of the Earth). Hence it does tell us that the earth is a non-inertial frame of reference and hence it is the earth which is rotating!

What more things can we explain using the Coriolis force?...Here's an example: It can help explain the wind patterns on the Earth's surface. In fact the name Coriolis force was coined first by Meteorologists studying the globe.



- **Earth's Revolution**

  This question was one of the most debatable topic in the history of Astronomy. Today the Heliocentric theory is the unanimously accepted one, but it was the Geocentric Theory.

  Here is what wiki says:

To anyone who stands and looks at the sky, it seems clear that the Earth stays in one place while everything in the sky rises in the east and sets in the west once a day. Observing over a longer time, one sees more complicated movements. The Sun makes a slower circle eastward over the course of a year; the planets have similar motions, but they sometimes move in the reverse direction for a while (retrograde motion).

As these motions became better understood, more elaborate descriptions were required, the most famous of which was the **geocentric Ptolemaic system**, which achieved its full expression in the 2nd century. The Ptolemaic system was a sophisticated astronomical system that managed to calculate the positions for the planets to a fair degree of accuracy.[2]Ptolemy himself, in his *Almagest*, points out that any model for describing the motions of the planets is merely a mathematical device, and since there is no actual way to know which is true, the simplest model that gets the right numbers should be used.[3] However, he rejected the idea of a spinning earth as absurd since it would create huge winds. His planetary hypotheses were sufficiently real that the distances of moon, sun, planets and stars could be determined by treating orbits' celestial spheres as contiguous realities. This made the stars' distance less than 20 Astronomical Units,[4] a regression, since Aristarchus of Samos's heliocentric scheme had centuries earlier necessarily placed the stars at least two orders of magnitude more distant.

What were the factors that led to the decline of the geocentric theory and the birth of the Heliocentric Theory? Heliocentrinism was first proposed by Aristarchus of Samos in 3rd century BC. But it wasn't until the 16th century AD that a fully predictive mathematical model was proposed by Nicholas Copernicus giving bud to the 'Copernician Revolution'. In the coming century the model was substantially developed by Johannes Kepler and were seconded by practical telescopic observations by Galileo Galilei.

Galileo, said to be the first Astronomical telescopic Observer, penned down a lot of remarkable observations which resulted in a stronger and stronger belief in the Copernician Theory.Galileo observed the sun-spots and said that they changed with time, he also observed the four famous moons of Jupiter and noted that they revolved round the planet and not earth.Some of the other observations included the periodic appearance-disappearance of Saturn's rings!

The 4 'Galilean Satellites'!

So, can we verify whether what Copernicus said was right?..

Here are some known facts:-

- Movement of sun against the stellar Background
- Stellar Parallax
- Starlight Aberration
- Spectral periodic shift in the stellar spectra…

Its known that the sun changes its position with every passing day!.Not convinced ?..look at the following picture below. Notice any difference in the solar rising positions?

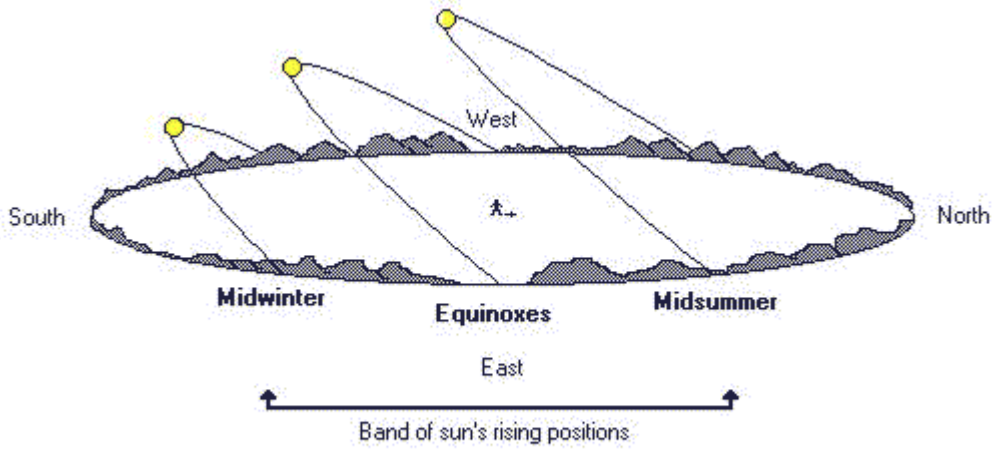


Figure 1 The six month range of the sun

The picture shows the sun's position thoughout the day just on 3 days. In fact if such observation os the sun's position is done everyday at the exact same time in the clock, it takes very weird shapes, called analemma (or analaema..etc).

Here's an analemma on the Astronomy Picture of the Day website(APOD).

ASTRONOMY PICTURE OF THE DAY

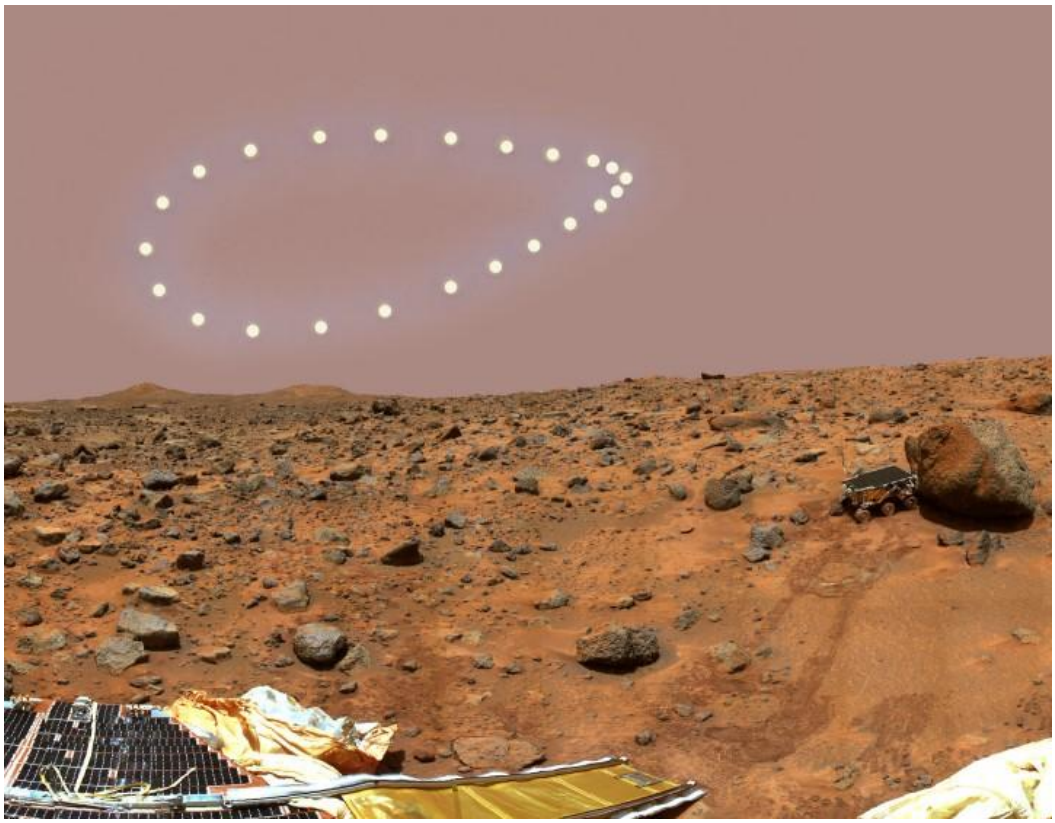
Analemma over Ukraine
Credit & Copyright: Vasilij Rumyantsev (Crimean Astrophysical Obsevatory)

Explanation: If you took a picture of the Sun at the same time each day, would it remain in the same position? The answer is no, and the shape traced out by the Sun over the course of a year is called ananalemma. The Sun's apparent shift is caused by the Earth's motion around the Sun when combined with the tilt of the Earth's rotation axis. The Sun will appear at its highest point of the analemma during summerand at its lowest during winter. Analemmas created from different Earth latitudes would appear at least slightly different, as well as analemmas created at a different time each day.
The analemma pictured to the left was built up by Sun photographs taken from 1998 August through 1999 August from Ukraine. The foreground picture from the same location was taken during the early evening in 1999 July.

Just for fun also do have a look at the analemma of sun as observed from Mars!

Explanation: On planet Earth, an analemma is the figure-8 loop you get when you mark the position of the Sun at the same time each day throughout the year. But similarly marking the position of the Sun in the Martian sky would produce the simpler, stretched pear shape in this digital illustration, based on the Mars Pathfinder project's famous Presidential Panorama view from the surface. The simulation shows the late afternoon Sun that would have been seen from the Sagan Memorial Station once every 30 Martian days (sols) beginning on Pathfinder's Sol 24

(July 29, 1997). Slightly less bright, the simulated Sun is only about two thirds the size as seen from Earth, while the Martian dust, responsible for the reddish sky of Mars, also scatters some blue light around the solar disk.



Ok, so after a long deviation from our original topic of Discussion , lets return back , the Heliocentric theory!

STELLAR PARALLAX

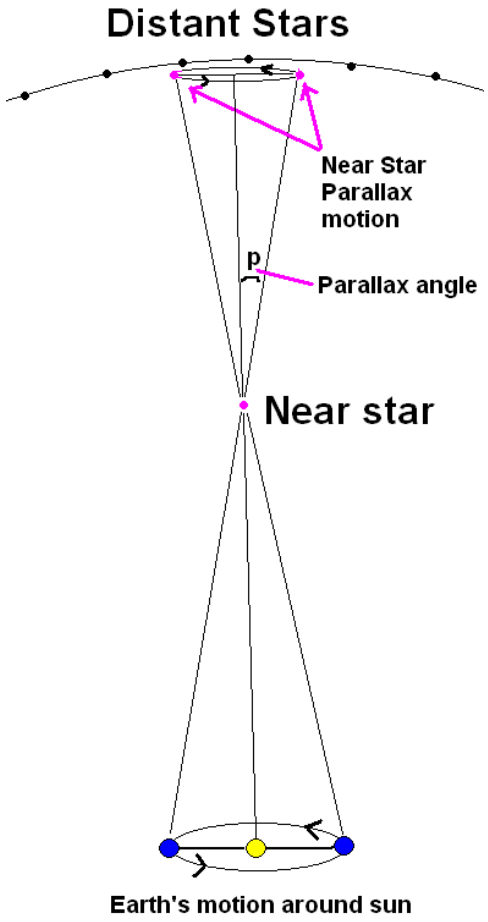
Well, first of all what is parallax ? Here is what wiki says!

http://en.wikipedia.org/wiki/Stellar_parallax

Stellar parallax is the effect of parallax on distant stars in astronomy. It is parallax on an interstellar scale, and it can be used to determine the distance of Earth to another star directly with accurate astrometry. It was the subject of much debate in astronomy for hundreds of years, but was so difficult it was only achieved for a few of the nearest stars in the early 19th century. Even in the 21st Century, stars with parallax measurements are relatively close on a galactic scale, as most distance measurements are calculated by red-shift or other methods.

The parallax is usually created by the different orbital positions of the Earth, which causes nearby stars to appear to move relative to more distant stars. By observing parallax, measuring angles and using geometry, one can determine the distance to various objects in space, typically stars, although other objects in space could be used.

Because other stars are far away, the angle for measurement is small, the distance to an object (measured in parsecs) is the reciprocal of the parallax (measured in arcseconds): d(pc) = 1 / p(arcsec). For example, the distance to Proxima Centauri is 1/0.7687=1.3009 parsecs (4.243 ly).[1] The first successful measurement of stellar parallax was made by Friedrich Bessel in 1838 for the star 61 Cygni using a Fraunhofer heliometer at Königsberg Observatory.



It can be said that the precession of stars gave a convincing reason to believe that it is the Earth that's moving round the sun!

So, here we end the first tour of our long journey through the mystic world of astronomy as it gets demystified! Stay tuned, and do read up the upcoming articles in the same series: **Astronomy Demystified!**

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