Classroom

In this section of *Resonance*, we invite readers to pose questions likely to be raised in a classroom situation. We may suggest strategies for dealing with them, or invite responses, or both. "Classroom" is equally a forum for raising broader issues and sharing personal experiences and viewpoints on matters related to teaching and learning science.

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Surya Majjana

Ancient Indian temples are famous for their architectural grandeur. At the same time, they also symbolize certain interesting facts, which are of scientific interest. One such example is the well-known Gavi Gangadeshwara temple in Bangalore. Every year the temple attracts a big crowd for an event called *Surya Majjana*. The Sun's rays just before sunset fall on the idol of Shivalinga, which is located inside the cave. The rays pass through an arch and through two windows perpendicular to each other before entering the cave. Futher, the idol of the bull "Nandi" is so aligned that the rays pass through the horns of the bull before touching the main idol of Shivalinga. It is claimed that this is a unique event that happens only on 14th January, although it may extend a couple of days on either side. Here, we attempt to explain the specific configuration of the event and deduce that this special event also occurs on November 28th of every year. This was observationally verified in 2006 and 2007.

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Planetary motion, archeo-astronomy.

Stars in a night sky appear to be located on a sphere with Earth as its centre. This imaginary sphere on whose surface stars are projected is called the celestial sphere. We describe the position

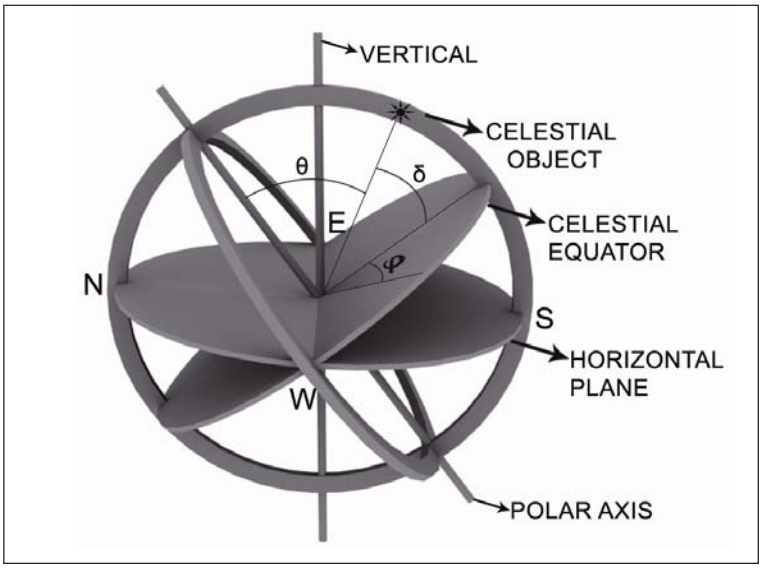

Figure 1. A diagram of the celestial sphere depicting the angles used in the description of the position of a celestial object.

of a given object on this sphere using a spherical polar coordinate system (r, θ, φ system).

Since we are projecting stars at various distances to a common sphere (celestial sphere) we can neglect the r coordinate as long as we are interested only in their direction. An observer not rotating with Earth can almost ignore the motion of stars (due to their huge distances) and specify the position using θ and φ. The rotation axis of the Earth serves as the polar axis of the coordinate system. Instead of θ coordinate, conventionally $\delta = 90^0 - \theta$ is used. δ is called 'declination' and is analogous to latitude on Earth. Any direction on the equator ($\delta = 0$) can be chosen as the direction of the initial line ($\varphi = 0$). Conventionally the direction of 'first point of Aries' (the point where Sun crosses the equator on 21st March) is chosen for this purpose. The φ coordinate defined in this manner is called 'right ascension' (RA).

However, since Earth is rotating, an observer on Earth sees the celestial sphere to be rotating in the opposite sense about the polar axis. Thus stars appear to move on circles of constant δ, completing a full circle in a day. Similarly as the Earth moves around the Sun once in a year, it appears as though the Sun moves around the

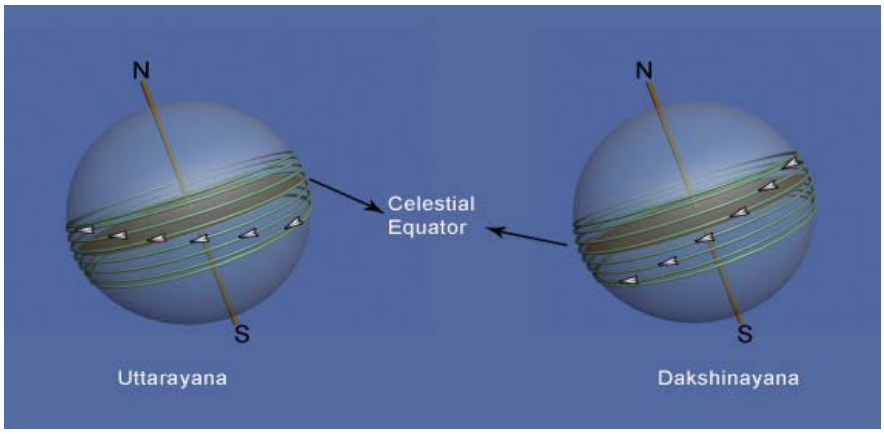

Figure 2. The yearly motion of Sun as seen by an observer fixed to Earth. The duration from December 21st to June 21st in which the declination increases is called Uttarayana and the duration from June 21st to December 21st in which the declination decreases is called Dakshinayana.

Earth once in a year on the celestial sphere (apart from its daily motion). The angle between the Earth's rotation axis and the normal to its plane of revolution is 23½ degrees. Hence the Sun's declination varies over the range of +23 ½ and –23 ½ degrees in a year. Thus the Sun changes the declination, day by day throughout the year. Consequently, the annual motion of Sun will appear to us as shown in *Figure* 2.

The variation of declination with date in a year is represented by the graph in *Figure* 3.

Accordingly, we have two days in a year (except the solstices, which are the extrema in the graph) symmetrical to the solstices

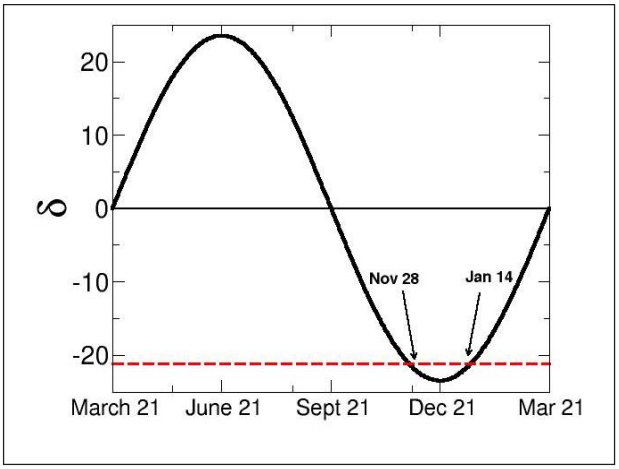

Figure 3.

on which the declination of the Sun is the same. Since, in any given day the azimuth angle of the Sun takes all values, with nearly the same declination δ, the Sun reaches the same position twice a year. From the graph it is clear that the declination of the Sun on January 14th and November 28th is the same (nearly – 21°). In other words, the path of the Sun as it appears to us on January 14th and November 28th is nearly the same.

Thus, in Gavi Gangadeshwara temple, if the arch, windows and the Shivalinga are aligned with the Sun on January 14th at a certain time of the day, it is necessary that they also be aligned once on November 28th. Thus, this special event 'Surya majjana' can be observed twice in a year.

It is also noticed that the event is spread over a few days and not confined to only one day. This is because (1) the slow change in the declination of the Sun accompanied by its significant angular size (about ½ °) and (2) large size of the windows such that a range of declinations permit the light to reach the deity.

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