The ever changing Moon

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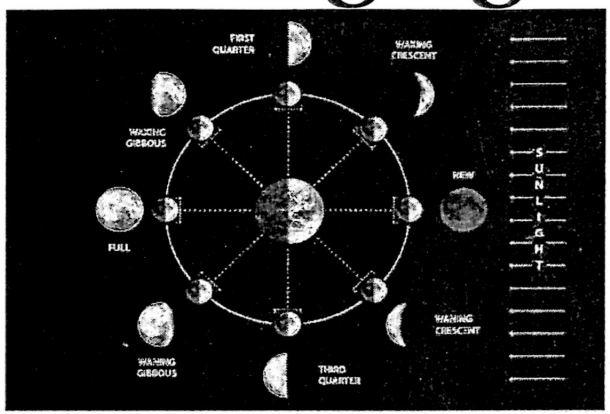
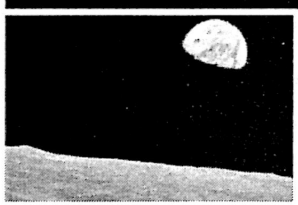
The claim that astronomy is probably the oldest of all sciences arises from the fact that the ancient man must have been intrigued and even bewildered by the variety of phenomena which the sky displays. No one, for example, could have escaped noticing the regularity with which the apparent 'shape' of the moon changes over a timescale of about a month. While we take it completely for granted, its explanation has important implications for our understanding of celestial phenomena.



Today, even a child knows that the Moon's changing phases are created by the changes in the relative positions of the Earth, the Moon and the Sun as the Moon orbits the Earth (see figure). The New Moon occurs when the Moon is positioned approximately between the Earth and the Sun so that the illuminated portion of the Moon is on the lunar hemisphere facing the Sun — which we cannot see from the Earth. During the days after the New Moon, the portion illuminated by the Sun increases and this period is called the waxing crescent. When Moon is at a 90 degree angle with respect to the Earth and the Sun, we see it half illuminated. After this first quarter, more than half the Moon is brightened up and this phase is called waxing gibbous. Soon, we reach a configuration in which the Sun, the Earth and the Moon are again in a straight line but with the Earth located between the other two.





(Top) Phases of the moon (left) Earth-phase seen from the Moon.

We can now see the full illuminated face of the Moon leading to the full moon that has fascinated the poets and artists of all times. After the full moon, we enter the waning gibbous phase when the illuminated part of the Moon keeps decreasing but it is still more than half lit. After the third quarter, when the Moon is again seen half illuminated, we get to the waning crescent phase with the Moon finally disappearing on the New Moon day.

All these rely on two facts which should have been far from apparent to the ancient man. First, Moon is not a self-luminous body unlike the sun though it lights up our night sky. Second, the Moon has to orbit the Earth which in turn is orbiting the Sun for the simple explanation given above to hold. (Try explaining the waxing and waning of the Moon in a geocentric model of Solar system in which everything revolves around Earth. It is a good test of your ingenuity, though we know that this model is not correct.)

Against the background of distant stars, the Moon completes one orbit around Earth in about 27.3 days which is called the sidereal period of the Moon. However, the Moon goes through a complete cycle of its phases not in this period but in about 29.5 days. (This can be ascertained by direct, careful, observations.) The reason has to do with the fact that the Earth itself is moving around the Sun against the stellar background all the time. During one lunar cycle, the Earth would have moved around a little bit in its orbit around the Sun. It turns out that the Moon has to go around a bit further to reach the same initial angle vis-a-vis the Earth-Sun line. Once again, we see that the Earth moving around the Sun is an important ingredient in providing a simple explanation to the above observation.

Interestingly, the moon also completes one rotation about its own axis in almost the same period of time. As a consequence, we always end up seeing the same hemisphere of the moon. This kind of 'locking' between the period of rotation and orbital period of a satellite arises because of gravitational dynamics and is well-understood theoretically.

Next week: Total solar eclipse

Astrophysicist Jayant Narlikar and theoretical physicist Thanu Padmanabhan will contribute to DNA's special series through 2009, designated the International Year of Astronomy.