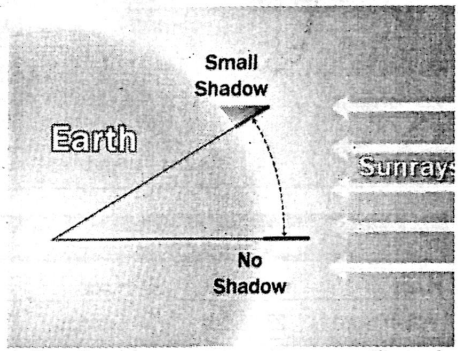
Eratosthenes and the Radius of the Earth





Eratosthenes (R) with a student; How a vertical direction changes as we move northwards along a longitude line

JAYANT NARLIKAR & THANU PADMANABHAN

Is the Earth flat or shaped like a ball? This question had figured frequently in different civilisations and there were long arguments for and against. In ancient Greece, this issue was settled by Eratosthenes, a mathematician, librarian, astronomer, athlete and poet — in short — a man with a multifaceted personality. He operated from Alexandria around 240 BC.

Eratosthenes found an ingenious way of measuring the radius of the Earth, assuming that it is shaped like a ball. His basic idea can be explained in this way. He noted that in a place called Syene, south of Alexandria, the walls of a structure cast no shadow at noon on or around June 21 (the longest day of the year: also known as the summer solstice). This was because the Sun was overhead at that time at Syene. However, on the same day, at the same time, a vertical pillar in Alexandria cast a small shadow. This meant that the Sun was not overhead at Alexandria. If the Earth were flat, then the vertical directions at all points on it would be parallel and the Sun would be overhead at the same time everywhere. Hence, the above finding implied that the Earth cannot be flat.

Thus, the observations seemed to suggest that if we select two places on the same longitude separated by an appreciable distance, then vertical sticks planted there would have directions passing through the centre of the sphere that is the Earth. If the Sun is vertically above Syene at noon, then its rays would make a small angle with the vertical at Alexandria. Thus, the stick planted in Alexandria would cast a small shadow there. The measurement of the length of the stick and the shadow will allow us to determine that small angle, which happens to be around 7 degrees.



Eratosthenes then measured the distance between Alexandria and Syene by making an army walk the stretch. The distance was about 800 kilometres. He then argued that if a distance of 800 km changes the angle at the centre to 7 degrees, then in proportion, a walk round 360 degrees (complete round of the Earth) would involve a distance of 40,000 kilometres. Therefore, this must be the circumference of the Earth and the corresponding radius would therefore be around 6,363 km. Eratosthenes had obtained a value with an error of 5-10 % at most.

It is worth noting that in India, Aryabhata also records the circumference of the Earth as around 4,967 *yojanas*, which in modern units is 39,968 km, which is only 62 km less than the current value of 40,030 km. He, however, does not give a clue to how he got this value.

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