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The earth's heartbeat

Variation in the length of the day reveals movement at the earth's core, says S.Ananthanarayanan.

The length of a day is regarded as the rock steady and unvarying standard, to measure nearly everything else against. This is because we know the earth is a ball that is spinning, once every day, in empty space and there is nothing, but nothing to make it change its speed at all. And yet, there is evidence that the earth once went round much faster than it does today, and it is not any force of friction that has made is slow down.

The slowing, or changing speed has to do with changes in the dimensions of and movements within the earth. It is not really the speed of a spinning ball that stays constant, it is a quantity called the angular momentum, or net result of both how fast parts of an object are spinning around an axis as well as how far from the axis these parts are. And again, if parts of the object move with respect to each other, the whole object would need to spin faster, or slower, to keep the net effect unchanged.

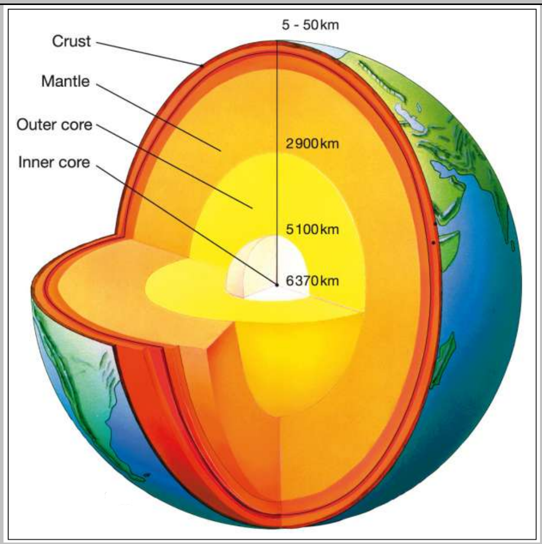
Richard Holme of the School of Environmental Sciences, Liverpool and Olivier de Viron of the Institute of the Physics of the Earth, Sorbonne, inParis, report in the journal, ***Nature*** that they have worked out the effect that movement deep within the earth has on her rate of spin. Measuring the length of the day could then help understand the dynamics of the earth's core!

Size and motion

Spinning objects with the same mass go round faster if their parts are closer together than farther apart. We may have seen this with a spinning ballerina or figure skater, who throws her arms out to slow down or draws them in to speed up. In the same way, if geological or other changes in a planet bring more of the mass of the planet to the surface, then the rotation of the planet would slow down. Such effects are not likely to be of major importance very soon after the planet has formed into a reasonably stable sphere But they may be effective at a smaller scale because of seasonal warming of different parts of the planet or changes in the content or extent of the atmosphere.

A more powerful factor is the movement of materials within the spinning object. We can imagine a stationary log of wood starting to turn if the lumberjack standing on it begins to walk. In the same way, a planet would turn one way if the water on the surface of the planet begins to flow the other way. Ocean currents and winds, driven by differences in temperature or salinity, set huge masses into motion. This motion has to be balanced by movement of other masses or the mass of the earth, which amounts to variations in the speed of rotation.

Just as there is movement of surface water or in the atmosphere, there are also flows within the earth. The structure of the earth is a solid core, under great pressure, surrounded by a molten, liquid region, the mantle, with a solidified crust in the course of stabilizing, effectively afloat on the mantle. While we can see evidence of the mantle in



the form of volcanic activity through imperfections in the crust, the material of the mantle, being liquid, although very heavy and viscous, is also in motion. There are gradients of temperature and pressure, motion overshooting a point of equilibrium and periodic reverse motion, etc., rather like ocean currents or tides. These movements deep within the earth also affect the speed of rotation of the earth, although their effects last for longer durations than movements at the surface. In fine, for all these reasons, the length of the day is not constant but shows differences from day to day.

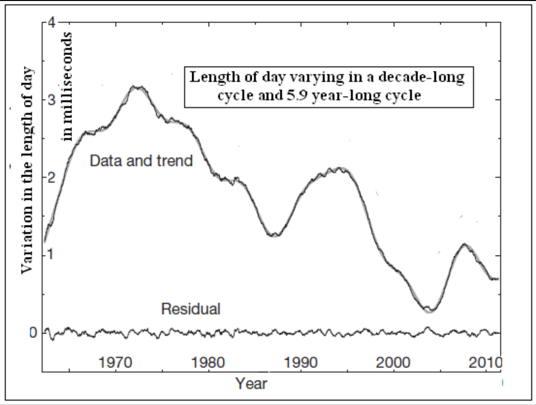
Tidal motion

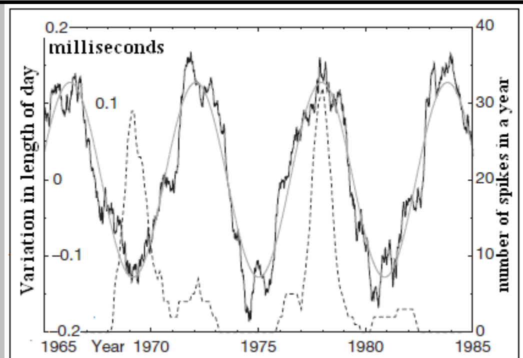
But the most powerful drivers of movement of the masses in the earth are the tidal forces caused by the gravity of the moon and the sun. We are familiar with the tides in the oceans, where a bulge in the water lines up with the moon, returning to a place on the earth nearly twice every day. This is a very powerful force which moves billions of tones of water and is responsible for re-circulating cold water, which sinks to the bottom of the ocean, thereby maintaining the pattern of ocean currents. The same forces also act on the mass of the earth and cause movement of the material in the mantle. It is these forces, along with the forming of liquid water on the surface of the earth, that have slowed the rotation of the earth from a day of just 6 hours when the earth was formed, to 21 hours 400 million years ago and to the 24 hours at present.

While the work of tidal forces creates movement and heat, the effect of tides is really a slowing down of the opposite rotations of both the bodies involved. The effect of the earth on the moon, for instance, has slowed the rotation to just once a lunar month, which keeps the moon always showing the same face to us. On the earth, the slowing action may be imperceptible, but the mix of forces cause small, periodic variation in the length of day, which can related to the motion of winds, oceans and material in the mantle and the outer core.

The work of ***Holme*** and ***Viron*** has been to review the collected data of the length of day, as measured by the time for the centre of the sun to reappear at the horizon or along a fixed line of sight, over a 50 year period, from 1962 to 2012. The variations caused by movements in the atmosphere and in the oceans are a rise and fall that has short periods, that is, annual or shorter. Models of circulation were used to assess and factor out these effects, so that the data represented only the longer period, typically the variations over periods of decades, which were attributed to movement in the mantle and outer core.

The data showed variations which repeat over a period of a decade and other variations which repeat over 5.9 years, interspersed with spikes that, at times, correspond to geomagnetic events. Analysis of the timing of the spikes, with reference to the stage of the decade long variation, limits the kind of geomagnetic event which could lead to spikes – and this has led to conclusions about the electrical properties of the lower mantle, which in turn, narrows the possible range of its structure or composition.





The dark line shows the 5.9 yr oscillation and the dotted line the occurrence of events reflected in the number of spikes