

A law that isn't



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By the time the heliocentric model of the solar system gained acceptance, it became clear that the planets orbit the Sun along elliptical paths and are at different distances from the Sun. Since the eccentricity of the elliptical orbits are rather small, one can attribute to each orbit an approximate radius. In the early days of solar system studies, people were intrigued by the question: What determines the orbital radii of the planets in the solar system?

Several models were proposed based on different notions of symmetry and elegance to explain orbital radii of the planets. For example, Kepler and others had models based on Platonic solids which have very symmetric 3-dimensional shapes. But closer scrutiny showed that none of them were quite satisfactory.

One of the most intriguing attempts in this direction was an empirical rule proposed by two German astronomers Daniel Titius (1729-1796) and Johann Elert Bode (1747-1826) who proposed a formula for the distances of the six planets which were known at that time. The Titius-Bode 'law' said that the distances X from the Sun are given by $X = (k+4)/10$ where k is taken to be 0, 3, 6, 12, 24, 48 and the distances are measured in astronomical units (AU), making $X=1$ for Earth. Later on, this law was modified to a more accurate, modernised version given by $X = 0.4 + 0.3 \times 2^n$ where the symbol 2^n stands for 2 multiplied n times. If we take for n the values 0, 1, 2, 4 and 5 we get the distances to Venus, Earth, Mars, Jupiter and Saturn.

(To get Mercury, one has to take

a large negative value for n which will give $X=0.4$.) Thus, one could predict quite well the distances of Mercury, Venus, Earth, Mars, Jupiter and Saturn. What happens if one applies the formula with the missing value of $n=3$? Astonishingly enough, it predicts the location of the asteroid belt at 2.8 AU while the first asteroid discovered, Ceres, was at 2.77 AU. Thus, not only could the formula reproduce the location of known planets but could also suggest the existence of another which could have broken up into the asteroids. Going beyond Saturn, the Titius-Bode law indicated the existence of a planet at distance of 19.6 AU and lo and behold, Uranus was discovered at 19.8 AU.

Unfortunately, it does not 'work' any further. The predicted distance to Neptune is 38.8 AU while, it was discovered at 30.1 AU; for Pluto the prediction is 77.3 AU while its actual distance is 39.4 AU. What is worse, one could never come up with a physical theory which could give a theoretical basis for this law.

Today, it remains an interesting curiosity and a mnemonic device but certainly, a remarkable one. Modern theories of planet formation suggest

that they condensed out of local instabilities which exist in a proto-planetary disk of gas around a star. Hence, the actual distances at which different planets move around a given star is not considered to be an issue of fundamental significance.

(Next week: Occultations)

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



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