

## THE UNIVERSE AT LARGE

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# The Astro-Particle-Cosmo-Connection

*Observational astronomers and theoretical physicists  
have been getting in each other's hair since the time of  
Newton and show no signs of letting up.*

**F**OR ISAAC NEWTON (1642–1727), though there were laboratory data from the work of Galileo (1564–1642), the British Union of Growers of Poorly-Attached Apples (BUGPAA), and probably others, the real test of universal gravitation was its application to the lunar and planetary orbits that Johannes Kepler (1571–1630) had managed to extract from the observations of his mentor Tycho Brahe (1546–1601). Looking at the various dates, you might reasonably suppose that the planetary orbits would have been somewhat improved by the time *Principia* approached publication (1687), but as the names of other seventeenth-century astronomers will not be on the exam, you are not required to read or remember any of them.

Entering the twentieth century, we find the equally well-known example of Einstein's theory of general relativity facing reality in the form of the advance of the perihelion of Mercury\* and the gravitational deflection of light by the sun.\*\* From that day (1919) to this, GR has passed every test astronomy can throw at it, especially the correct description of the changing orbits of binary pulsars (meaning neutron stars in orbits with other neutron stars or massive white

\* Meaning that Mercury's elliptical orbit rotates once every 3 million years relative to the distant stars.

\*\* Meaning that the apparent positions of stars, and radio sources, have been seen to be shifted on the sky when your line of sight passes close to the limb of the sun.