Einstein scores again

Nature **461,** 373–376 (2009)

That Einstein was able to explain the 'missing' precession in Mercury's orbit — owing to gravitational effects in curved spacetime — helped his general theory of relativity gain some acceptance, before Eddington's demonstration of curved light during the solar eclipse of 1919 brought general relativity to the masses. However, the anomalously slow precession of the two binary stars in DI Herculis does not agree with general relativity (or Newtonian mechanics). Could Einstein's theory fail in the limit of strong warping of spacetime? Is there a third as-yet-undetected body involved? According to Simon Albrecht and co-workers, the mystery has been solved.

From spectra taken at the Observatoire de Haute-Provence, Albrecht *et al.* used a model to derive the relative orientation between the stellar rotational and orbital axes. Surprisingly, the usual assumption that the spin axes are perpendicular to the plane of orbit fails. In fact, the best fit results when the spin rotation axes are tilted 72° and –84° with respect to the orbital plane. The resulting oblateness introduces a negative precession term, which exactly accounts for the erstwhile discrepancy.

Standard-model copyists

Phys. Rev. D **80,** 055001 (2009)

Particle physics has a hierarchy problem. The weak scale, at teraelectronvolt energies, is much lower than the Planck scale, which is of the order of 10^{28} eV — that's 16 orders of magnitude between them. Although the presence of the Higgs field could justify the gap, the problem comes with divergences in calculations of the Higgs mass, which particle physicists dislike for being 'unnatural'.

Gia Dvali and Michele Redi are exploring an alternative solution, one that involves the existence of not just one standard-model's-worth of particles, but 10^{32} copies. The number of copies is determined by the square of the ratio between the Planck and weak scales — hence 10^{32} — but we're only aware of our own standard model, the other copies are 'dark'.

The model fits existing cosmological and particle-physics data, and also includes a means of generating the observed small masses for the neutrinos (something the standard model alone can't do). Moreover, Dvali and Redi present the possibility that oscillations of the neutron into a large number of its dark counterparts are detectable, as well as the production of microscopic black holes at particle colliders.

Obeying the golden rule

Science **325,** 981–985 (2009)

Fermi's golden rule is a simple equation that determines the rate at which an electron makes a radiative transition between two states. Chi Chen and co-workers have now been able to 'see' this fundamental law in action.

A scanning tunnelling microscope (STM) can be used to visualize the electron states in a chain of silver atoms by measuring the differential conductance at a specific bias voltage (equivalent to the electron state) between the STM tip and the silver atoms. A two-dimensional map is created by scanning the tip over the whole chain.

The spatial dependence of emission at a certain wavelength can be mapped in a similar way. An electron is injected into the atomic chain from the STM tip at a certain bias voltage (the initial electron state), which can then scatter into a lower state and emit a photon.

Chen *et al.* compared the wavefunctions of the initial and final electron states with the map of photons emitted with the commensurate energy. Fermi's golden rule was manifest as a correlation between the number and the position of the peaks in the images.

Opposites (don't always) attract

Nature **461,** 377-380 (2009)

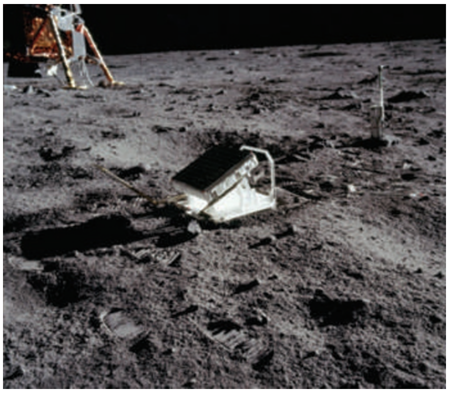
The laws of electromagnetism dictate that oppositely charged objects should attract; the stronger the charge difference, the greater the attraction. In which case, all other things being equal, one would expect oppositely charged and freely suspended droplets of liquid to draw together, collide and merge. In most cases, this is indeed what happens. But as the opposing charge increases, William Ristenpart and colleagues have found that something unusual happens: above a critical charge difference, two oppositely charged droplets will bounce apart.

The explanation rests on the way in which capillary bridges form between droplets when they come into contact with each other. As two oppositely charged droplets approach each other, high-resolution photographs show the emergence of tiny cone-like protrusions from each opposing surface. When the protrusions touch, the local charge difference neutralizes.

Weakly charged droplets produce blunt protrusions that form broad stable bridges, which rapidly widen under surface tension causing the droplets to merge. In contrast, strongly charged droplets produce sharp protrusions that form thin, unstable bridges when they touch. Consequently, when the local charge neutralizes, the bridges snap back and the droplets bounce apart.

To the Moon and back

Am. J. Phys. **77,** 854–857 (2009)



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One of the scientific milestones of the Apollo 11 mission to the Moon was the installation of an optical retroreflector array (pictured) on the lunar surface. Its 100 fused-silica cubes reflect laser pulses sent from Earth; from the delay of the return signal, the Moon–Earth distance can be determined with a precision of a couple of centimetres.

Luca Girlanda now describes a high-school experiment for measuring the lunar distance based on the same principle, but using audio tapes recorded during the Apollo flights. Using open-source software, youngsters can measure, for example, time delays in the communication between NASA mission control in Houston and Neil Armstrong on the Moon. On the tapes (available at http://www.hq.nasa.gov/alsj/), echoes of words spoken at the Earth end of the line can be discerned, owing to re-transmission through Armstrong's microphone.

The approach is good enough to measure the Moon–Earth distance with an accuracy of 0.1% — sufficient, in principle, to observe the effect of the eccentricity of the lunar orbit.