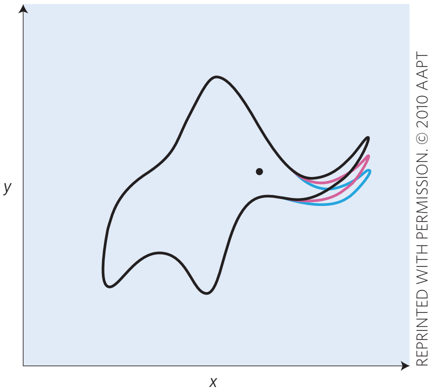
research highlights

Fitted at last

Am. J. Phys. **78,** 648–649 (2010)



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In the spring of 1953, Freeman Dyson travelled to Chicago to meet Enrico Fermi. In his luggage, the young professor had the results of his group's long effort to calculate meson–proton scattering. But Fermi was not impressed, even if the agreement of Dyson's calculations with experimental data obtained at the Chicago cyclotron was good. Fermi didn't trust the arbitrary parameters used in the calculations: "I remember my friend Johnny von Neumann used to say, with four parameters I can fit an elephant, and with five I can make him wiggle his trunk."

Dyson took Fermi's point seriously, and changed his career direction. ("I am eternally grateful to him", Dyson said half a century later, "for destroying our illusions and telling us the bitter truth.") But still — can the outline of an elephant be really defined with only four parameters? An early attempt at implementing that task with least-square fits failed. But Jürgen Mayer and colleagues have now succeeded, using appropriate truncated Fourier expansions. With four complex parameters, they describe a curve that can be interpreted as 'elephantine' (pictured). And with a fifth parameter, they can control both the position of the trunk and the position of the eye.

On-demand entanglement

Nature **465,** 594–597 (2010)

An entangled-photon-emitting diode has been created by Cameron Salter and colleagues. An applied bias injects two electrons and two holes into a single indium arsenide quantum dot. The electron–hole pairs recombine in a cascade fashion that can follow one of two paths: the emission of a left-hand-polarized photon followed by a right-hand-polarized photon, or vice versa. As long as these two paths are indistinguishable, the two photons are polarization-entangled. The team had to take special care to ensure that which-path information wasn't available by another means — measuring the energy of the photons, for example — and that the cascade wasn't interrupted by any rogue third electron.

The device has the advantage over the competing parametric down-conversion approach in that the process is deterministic, potentially enabling the creation of an entangled pair at the press of a button.

The work by Salter *et al.* is a beautiful combination of the two most important motivations for quantum-dot research: an electronic structure more complicated than 'natural' atoms leads to a richer array of physics, in this case entanglement; and solid-state approaches promise compact devices that don't require a room full of expensive lasers.

Hyperbolic spontaneity

Opt. Lett. **35,** 1863–1865 (2010)

Spontaneity usually isn't easily controlled. One way to control an otherwise spontaneous process is through stimulation, as occurs in a nuclear chain reaction or a laser. Another is to change the environment in which the process occurs. This was one of the motivating concepts in the development of photonic crystals: if an excited fluorescent atom is placed in the centre of a material engineered to have no states for the atom to decay into, the atom should remain in its excited state indefinitely. The challenge has been to engineer a material with an effective and complete bandgap.

Mikhail Noginov and colleagues have taken the opposite approach. Rather than reduce the rate at which fluorescent atoms emit by limiting the density of states into which they can decay, they enhance the emission rate by increasing the density of these states. They have demonstrated this by depositing a layer of laser-dye atoms onto a forest of silver nanowires embedded in a porous alumina template — a structure that has been predicted to behave as a so-called hyperbolic metamaterial with an anomalously high density of photonic states. The decay rate of the dye atoms increased by more than a factor of six. Such control is expected to be useful in the development of single-photon emitters.

Go retro

Mon. Not. R. Astron. Soc.
doi:10.1111/j.1365-2966.2010.16797.x (2010)

At the centre of every galaxy is a supermassive black hole, surrounded by an accretion disk of gas and dust and possibly with jets streaming out of the plane of the disk. It had been thought that the faster the spin of the black hole, the more powerful the jets — but then some fast-spinning supermassive black holes were found to have no jets at all.

David Garofalo and colleagues think it's not only about how fast the black hole spins, but in which direction. Black holes spinning in the same direction as their accretion disks — 'prograde' — may indeed have no jets, whereas the strongest jets are more likely to arise from a galaxy that has a 'retrograde' black hole, spinning in the opposite direction to its accretion disk.

Garofalo *et al.* show that the key is the gap between the black hole and its disk, which can be large for retrograde black holes, but decreases as the black hole, accreting material from the disk over time, evolves towards increasing prograde spin. Jet production is most effective for a large gap, which is associated with strong black-hole-threading magnetic fields.

If a spin fluctuates in a forest

Science **328,** 1246–1248 (2010)

A quantum spin liquid is a low-temperature state of an antiferromagnet in which quantum fluctuations prevent the spins ordering magnetically. The trouble is, how do you measure nothing? Several promising Heisenberg antiferromagnets show no magnetic order down to the lowest attainable temperatures — but it's not possible to reach absolute zero to be sure. Minoru Yamashita and co-workers have addressed this limitation by probing the low-energy excitations of the organic insulator, $\mathrm{EtMe_3Sb[Pd(dmit)_2]_2}$, also known as dmit-131.

Heat conduction is an excellent probe of low-lying excitations. Indeed, the extrapolated zero-temperature thermal conductivity of dmit-131 has a term that is linear in temperature, which is the signature of gapless excitations such as those found in a standard metal. Given the insulating nature of the material, it is surprising to find gapless excitations. Moreover, the mean free path exceeds 1,000 times the distance between the spins, consistent with ballistic propagation. This and other properties of dmit-131 suggest a quantum state that is distinct from the ordered states that we know.