

The magnetic mystery

The origin of galactic magnetic fields is a long-standing puzzle. The fields are very weak – on the order of a microtesla – and could have been generated from much weaker “seed” fields, although there have been few viable candidates. Now Kiyotomo Ichiki and colleagues at the National Astronomical Observatory of Japan have demonstrated that these weak fields could be a signature of the early history of the universe before protons and electrons combined to form atoms.

The idea is that density fluctuations in plasma could produce “winds” of photons from high-density regions to low-density ones. This wind would push electrons more than the

heavier protons, and give rise to charge separations and rotating electric currents that could have seeded the magnetic fields we see today. The theory is even testable, as it would lead to magnetic fields in regions of space that are very empty of matter (free of stars and galaxies) – something that experiments could conceivably try to detect.

Further reading

Kiyotomo Ichiki *et al* *Science* DOI:10.1126/science.1120690, to appear in *Science*; online at Science Express: www.sciencemag.org/cgi/content/abstract/1120690.

Photon pairs get hyperentangled

Most of the time entangled states are thought of in terms of a nonfactorizable wavefunction of two objects – photons, say – with the spins, or another attribute correlated so that what you do to one affects the state of the other no matter where it may be. Now Paul Kwiat and colleagues at the University of Illinois at Urbana-Champaign, US, and the University of Brisbane, Australia, have demonstrated for the first time that more than one characteristic – indeed, every degree of freedom – can be entangled, leading to what is known as “hyperentanglement”.

For example, with photons, not only polarizations but also orbital angular momentum and energy can be entangled, as the team has demonstrated experimentally. Possible applications to quantum computing and other quantum technologies are interesting because the discovery means that more than one “qubit” of information can be associated with a single physical particle.

Further reading

Julio Barreiro *et al.* 2005 *Phys. Rev. Lett.* **95** 260501.

Photonic crystals make male beetle shine

Photonic crystals have been found to play a significant role in many biological systems, but perhaps none as beautiful as in the male beetle *Hoplia coerulea*, which is found in southern Europe. Jean Pol Vigneron and colleagues of the University of Namur in Belgium have shown that this little fellow owes his striking blue coloration to a 3D photonic crystal structure made of multiple layers of dielectric biological material.

In detail, the structure discovered involves layers of thin plates alternating with rows of parallel rods. This results in a change in the reflected light from blue to violet as the angle of incidence becomes larger. The structure could lend itself to commercial fabrication,



Photonic crystals underlie the iridescent blue-violet colour of this male beetle.

albeit not without some effort.

Further reading

Jean Pol Vigneron *et al.* 2005 *Phys. Rev. E* **72** 061904.

Skunk cabbage generates plenty of heat

Symplocarpus foetidus, the plant known in English as skunk cabbage and whose Japanese name, Zazen-sou, means Zen meditation plant, has a property of which a Zen master would be proud: it can maintain its temperature as high as 20°C, even on a freezing cold day. Unlike animals, which generate heat throughout their bodies, the skunk cabbage makes most of its heat through metabolic processes in the spadix, the plant's central spike-like flowering stalk.

Takanori Ito and Kikukatsu Ito at Iwate

University in Japan have monitored the temperatures of the spadix in wild skunk cabbages to understand the dynamics of this temperature control. They found that a phase space plot of temperature at separated times is a strange attractor, which they refer to as a Zazen attractor. This is the first demonstration of deterministic chaos in a higher plant.

Further reading

Takanori Ito and Kikukatsu Ito 2005 *Phys. Rev. E* **72** 051909.

Bacteria slow light

The group velocity of light can be made amazingly slow in the right material, but often the apparatus required is rather exotic and requires significant cooling. Pengfei Wu and D V G L N Rao at the University of Massachusetts have made the remarkable discovery that light can go as slowly as 0.091 mm/s in a thin film of bacteriorhodopsin (a bacterial pigment) at room temperature.

More than that, it turns out that this speed can be optically controlled to be anything in a broad range from “snail's pace” to normal light speed, *c*. The process takes place at high efficiency, being effective for light levels down to microwatts. Bacteriorhodopsin is stable and inexpensive so this could lead to many interesting technologies.

Further reading

Pengfei Wu and D V G L N Rao 2005 *Phys. Rev. Lett.* **95** 253601.