Corrected online: 15 February

In the loop

Nature **463,** 207–209 (2010)

The binary star system Algol in the constellation Perseus — appearing in the head of Medusa in celestial maps such as this seventeenth-century one by Johannes Hevelius — is visible to the naked eye. To image it, William Peterson and colleagues used the High Sensitivity Array (consisting of several radio telescopes, which act as one), and have discovered a large magnetic loop between the two stars. This is the first time that such a structure has been observed in a star other than the Sun.

Algol B, the less massive star of the system, is more evolved than the primary star, Algol A, around which it orbits with an eclipsing cycle of 2.86 days. The magnetic loop originates from the poles of Algol B and stretches towards Algol A, fixing the side that always faces its companion.

For the Sun, most of the flares and coronal loops are equatorial rather than polar, so the loop in Algol is more similar to the global magnetospheres of planets and certain low-mass stars. This behaviour is consistent with earlier observations of Algol and may also exist in other binary systems.

A quicker axion search

Phys. Rev. Lett. (in the press); preprint at <http://arxiv.org/abs/0910.5914> (2009)

Axions are hypothetical particles that were introduced as a solution to the so-called strong-CP problem of quantum chromodynamics (and named by Frank Wilczek after a laundry detergent, as they 'clean up' the problem). As a candidate for cold dark matter, axions play a part in astrophysics and cosmology too. However, their coupling to matter and radiation is expected to be weak, and axions have never yet been detected.

In a strong magnetic field, axions should be converted into observable photons in the microwave range. The Axion Dark Matter Experiment (ADMX) at the US Lawrence Livermore National Laboratory has been running since 1996 to look for such a signal. So far, the scan rate of the experiment has been limited by the noise of the field-effect transistor used in the first amplification stage.

But the ADMX collaboration has now introduced a new SQUID amplifier, designed to be suitable for operation near a strong magnetic field. The noise temperature achieved is a factor of 1.4 above the quantum-limited noise temperature — a 100-fold improvement over the amplifier previously used. The hunt for axions continues, but now at an accelerated pace.

Zitterbewegung baby!

Nature **463,** 68–71 (2010)

The Dirac equation marries the two most far-reaching scientific theories of the twentieth century: special relativity and quantum mechanics. Some of the more unusual predictions of the equation have proven difficult to observe using real particles. However, as is now shown, it should be possible to mimic these effects in trapped-ion systems.

One implication of the Dirac equation is *Zitterbewegung* — a trembling motion of relativistic quantum particles with an amplitude of the order of the Compton wavelength. Detection of such a small motion is a tough challenge, and so there is a drive to find other systems in which the same effects can be seen — so-called quantum simulations.

Rene Gerritsma and colleagues have now demonstrated a quantum simulation of the one-dimensional Dirac equation using a single trapped calcium ion. This approach provides a high degree of tunability: the effective mass of the simulated Dirac particle, for example, can be controlled using laser light. As the mass is increased, the particle enters the relativistic regime and its position can be seen to oscillate with an amplitude in agreement with numerical simulations of *Zitterbewegung*.

Above the gap

Nature Nanotech. **5,** 143-147 (2010)

The voltage generated by conventional photovoltaic solar cells is limited by the built-in electrostatic potential that exists within them to separate the electron–hole pairs generated by the absorption of light. This in turn is limited by the bandgap of the semiconductors from which the cells are made — well under 2 V for the most common cells made from silicon. But in devices based on the ferroelectric $BiFeO_3$ (BFO), Seung-Yeul Yang and colleagues have discovered a new type of photoelectric effect that produces voltages many times larger than the material's bandgap.

The effect is due to steps in the electrostatic potential across the walls separating the periodic stripe-like domains that form naturally in BFO thin films. When two parallel metal electrodes are grown on a BFO film so that they are oriented perpendicular to these domains, no photovoltage is generated when it is exposed to light. But when the electrodes are grown parallel to the domains, Yang *et al.* are able to measure open-circuit photovoltages of more than 17 V — well in excess of its intrinsic bandgap of roughly 2.7 eV. And by rotating the domains using a short high-voltage pulse applied between the electrodes, the researchers show that they can reverse the sign or even completely turn off the effect.

Maxwell or Podolsky?

Phys. Rev. D **81,** 025003 (2010)

Electromagnetism is the domain of James Clerk Maxwell, whose equations published in 1861 remain the bedrock of physics. However, using the more modern gauge-theory approach, it's not clear that Maxwellian electromagnetism is the final word.

The issue is how high an order of derivative should be included in the Lagrangian — a second-order derivative can be added (and still maintain Lorentz and gauge invariance) to arrive at Podolsky electromagnetism, named for Boris Podolsky who proposed it in 1942. Podolsky electromagnetism differs from its Maxwellian counterpart, not least in its dependence on a free parameter, and offers the possibility of new physics.

C. A. Bonin and colleagues, through their study of a gas of Podolsky photons at thermal equilibrium, show that Podolsky electromagnetism leads to a modified Stefan–Boltzmann law. Using data on the cosmic microwave background radiation, they have also set a limit on the Podolsky free parameter. But this alternative version of electromagnetism cannot yet be confirmed or ruled out — more work, on theory and experiment, is needed.

Correction

In the Research Highlights article 'Above the gap' (*Nature Physics* **6,** 78; 2010), the name of Seung-Yeul Yang was spelled incorrectly. This has been corrected after print in the HTML and PDF versions: 15 February 2010.