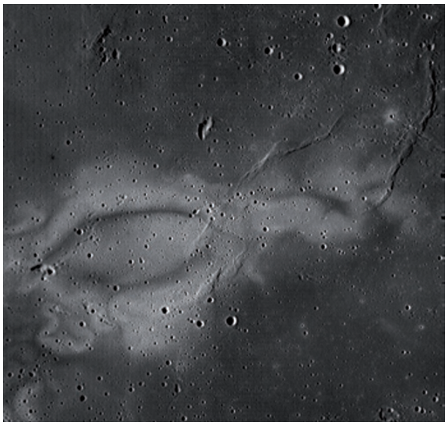
Force shield

Phys. Rev. Lett. (in the press); preprint at http://arxiv.org/abs/1207.2076 (2012)



NASA/GSFC/ARIZONA STATE UNIV.

Lunar swirls are delicate light-coloured markings on the Moon's surface. The lighter soil is unweathered, having been somehow shielded from the solar wind. Although lunar swirls are known to be associated with anomalous magnetic fields, their exact origin has remained mysterious — however, Ruth Bamford and colleagues have now tied together satellite data, laboratory experiments and a theoretical model to better understand the formation of these swirling patterns.

Bamford *et al.* suggest that the magnetic-field component of the solar wind and the magnetic anomalies on the lunar surface create a 'bubble' bounded by a strong magnetic field. Solar-wind electrons are deflected by this barrier, but heavier ions pass through: this charge separation gives rise, in turn, to an electric field that further deflects charged particles. The result is an effective shield that protects large areas of the lunar surface from the impact of the solar wind.

Interestingly, the deflection strength of the electric field depends on the magnetic field gradient of the bubble and not its actual size. Magnetic anomalies associated with lunar swirls cover areas of hundreds of kilometres, but the topology of the magnetic bubbles is irregular, creating alternating shielded and unshielded regions and forming complex light and dark patterns. *IG*

Mean machine

Proc. Natl Acad. Sci. USA (in the press); preprint at http://arxiv.org/abs/1206.5553 (2012)

When Lord Kelvin weighed in on James Clerk Maxwell's formulation of a demon capable of defying the second law of thermodynamics, he did so by conjuring up "an intelligent being endowed with free will". Although somewhat whimsical, this interpretation remains popular today: Maxwell's demon is often cast as an imaginary creature dreamed up to facilitate a thought experiment. A more modern take on the idea involves a purely mechanical demon that can generate work by manipulating fluctuations without any external influence. Dibyendu Mandal and Christopher Jarzynski have devised such a machine — the first of its kind, designed to operate as a Maxwell demon by amassing information that can later be erased to settle the system's thermodynamic account.

The proposed device makes thermally activated transitions between three states, interacting with a memory register that enables directed rotation through these states and allows the system to convert heat into the work required to raise a mass. Mandal and Jarzynski have solved the steady-state behaviour of a minimal model for their device, constructing a phase diagram that suggests the system can behave as either engine or eraser. The study offers a clever blueprint for a Maxwell demon — and a tangible system on which to base future discussion. *AK*

Higgs out in the cold

Nature **487,** 454–458 (2012)

Physicists at the Large Hadron Collider aren't the only ones seeking the Higgs — Manuel Endres and colleagues are also hot on the trail, albeit using a rather different (cold) approach. Endres *et al.* are seeking evidence of Higgs modes in a system of ultracold rubidium atoms, held in an optical lattice. Although strides have been made in the past in identifying Higgs-like behaviour in various condensed-matter scenarios, these authors have the advantage of recent progress in the high-resolution imaging of single atoms in optical lattices — and hence have been able to find and study Higgs modes in a two-dimensional superfluid close to the quantum phase transition to a Mott insulating state.

Spontaneous symmetry breaking (of U(1) symmetry) in the ordered superfluid, leads to the emergence of a Higgs mode, which is related to amplitude-variation of the complex order parameter for the dynamics close to the order–disorder transition. By carefully tracking the spectral response of the ultracold atoms, through the transition from superfluid to Mott insulator, the authors' long-wavelength, low-energy study turns up just the kind of spectral softening that is expected of Higgs modes. *AW*

Cavity-enhanced graphene

Nature Commun. **3,** 906 (2012)

Graphene possesses extraordinary electrical properties that could potentially be used in the development of high-speed optoelectronic devices, such as photodetectors, optical modulators and solid-state lasers. Unfortunately, its single-atom thickness restricts its ability to absorb or emit light, limiting the performance of such devices. Hence, to enhance the interaction between graphene and light, Michael Engel and colleagues have tried embedding a graphene transistor into a planar optical cavity.

When an emitter — such as an atom, molecule or quantum dot — is placed inside a cavity whose resonance is matched to one of its radiative transitions, the emission and absorption rate of the transition is enhanced. By the same token, Engel *et al.* find that the optical absorption and generated photocurrent of their transistor is greatest when illuminated with light at the resonant frequency of the cavity. Moreover, when the transistor–cavity devices are heated by passing a current through them, their infrared emission shows a sharply peaked (as opposed to black-body) distribution. *EG*

A Hall effect for superfluids

Proc. Natl Acad. Sci. USA **109,** 10811–10814 (2012)

A charge-carrying particle moving through a magnetic field feels a force perpendicular to its direction of motion. The resulting build-up of charge on one side of a material creates an electric potential that was first identified by Edwin Hall in 1879. Now, Lindsay LeBlanc and colleagues have seen a similar type of 'Hall effect' in an ultracold gas of neutral atoms.

LeBlanc *et al.* used lasers to trap and cool a rubidium cloud until it condensed to a superfluid. Despite the fact that the atoms are charge neutral, the team has previously shown that the effects of magnetic fields can be mimicked by firing in two more laser beams at a wavelength corresponding to a particular atomic transition. Now, they have observed the mass transport indicative of a Hall-like response by showing that the superfluid wobbles when the trapping strength is varied.

The conventional Hall effect has proved to be a useful and sensitive tool for investigating semiconductors. The superfluid Hall effect could soon play a similar role in better understanding Bose–Einstein condensation. *DG*

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