research highlights

Something fishy

Proc. Natl Acad. Sci. USA http://doi.org/t53 (2014)

Close your eyes and try to guess the shapes of bodies moving around you. Having trouble? It might help to generate an electric field, like certain fish species. Weakly electric fish (pictured) locate both predators and prey by sensing changes in their transdermal potential in response to objects whose electromagnetic properties differ from those of water. Habib Ammari and colleagues have now devised a scheme that these fish may employ to determine the shape of the objects they sense.

The way that a target perturbs the electric field produced by a weakly electric fish is a nonlinear function of its shape and proximity. And it differs depending on whether the target is living or dead: the electromagnetic properties of biological matter are frequency dependent, whereas those of their inanimate counterparts are not.

Ammari *et al.* simplified the problem of shape determination by proposing a method based on a multipole expansion of the field perturbations. Within their scheme, sensing a non-biological target involves drawing on a dictionary of shapes — a kind of model memory for the fish. But living targets can be classified using the spectral content of field-modulation data they amass. *AK*

Cheap trick

Phys. Rev. Lett. **113,** 055301 (2014)

One of the first things that springs to mind when thinking about superfluids — apart from a liquid creeping up the sides of its container — is a laboratory stuffed with equipment. Indeed, keeping a superfluid at temperatures close to absolute zero is a task that demands formidable experimental effort. And that's not even the whole story. In addition to maintaining low temperatures, one also has to keep thermally driven phase fluctuations to a minimum, as they are primarily responsible for the breakdown of the long-range order that supports the superfluid state. Or are they?

Johan Carlström and Egor Babaev have now shown that it is possible to find cases in which these thermal fluctuations actually drive the system into a superfluid state. And for this, it seems, we have entropy to thank. The pair predicted that in certain systems, an energy landscape featuring a local minimum surrounded by a flat slope can make phase fluctuations around the minimum energetically cheap, allowing the existence of entropically stabilized states. Instead of restoring symmetry, the fluctuations permit a superfluid that wouldn't otherwise exist. *FL*

Stacks of potential

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Two-dimensional materials have been heralded as core components of future electronic devices. Graphene, hexagonal boron nitride and transition-metal dichalcogenides: each material has a different electronic band structure, and can be layered into an endless variety of stacks. It is anticipated that 'designer heterostructures' with specific physical properties can be engineered.

Marco Furchi and colleagues have now made and studied a device consisting of two transition metal dichalcogenides — molybdenum disulphide and tungsten diselenide — held together by van der Waals forces, on a substrate of silicon oxide. The authors found that their stacked sample acts not only as a diode, but also as a photovoltaic cell.

The observed behaviour is a consequence of the interplay between the band structures of the two layers. The diode function involves, for forward biasing, electrons or holes hopping from one layer into the other. As for the photovoltaic effect, when the device is irradiated with photons, electron–hole pairs form in both the MoS_2 and the WSe_2 layer. The ensuing carrier relaxation results in a charge transfer across the two layers — and a photocurrent. *BV*

The outsider

Nature Commun. **5,** 4566 (2014)

Topological protection ensures that the conductive surface states of topological insulators are robust against defects and impurities — making them prime candidates for spintronic and quantum-computing applications. But three-dimensional topological insulators typically also have conducting states in the bulk, which makes it difficult to study or use the topological properties of the surface states. Nan Xu and colleagues now provide evidence for topological surface states atop a truly insulating bulk crystal.

Kondo insulators are materials with strongly correlated electrons that give rise to a bulk bandgap at low temperatures due to a hybridization of localized and conduction electrons. Using photoemission spectroscopy, Xu *et al.* show that the surface states of the Kondo insulator samarium hexaboride are spin polarized, with the spin locked to the crystal momentum, fulfilling time-reversal and crystal symmetries.

The reported spin texture is precisely what one would expect of surface states with topological origins, supporting recent theoretical proposals. As topological Kondo insulators are insulating in the bulk they provide an ideal platform for probing the topological behaviour of the surface states. *LF*

Scatter plot

Phys. Rev. Lett. (in the press); preprint at http://arxiv.org/abs/1405.6241 (2014)

Using data from CERN's Large Hadron Collider, the ATLAS Collaboration has collected evidence of a process known as vector boson scattering (VBS). The vector boson in question is the *W* boson, discovered at CERN in the early 1980s. Now, ATLAS has identified an excess of events — in a 20.3 fb^{-1} sample of proton–proton collisions at a centre-of-mass energy of 8 TeV — that is consistent with the scattering of two *W* bosons, each having been radiated from the quarks inside the colliding protons.

By seeking a particular signature of VBS — of two same-electric-charge *W* bosons decaying to a neutrino plus either an electron or a muon, and accompanied by two jets of particles — the physicists were able to home in on the 'electroweak' class of VBS processes, and compare their cross-sections with the standard-model predictions. The now-discovered Higgs boson is a vital part of the theory, keeping the VBS amplitude under control (lest unitarity break down at the TeV scale). However, VBS is still usefully sensitive to 'new physics' — but, almost inevitably, ATLAS conclude that all is in line with the standard model. *AW*

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