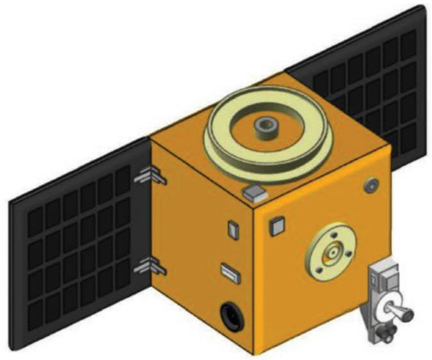
research highlights

QUANTUM COMMUNICATION

Satellite to ground control

Nat. Photon. **11,** 502–508 (2017)



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Twenty years after the first experiment demonstrating quantum teleportation with photons, quantum communication is a well-established field. But very recently it made the headlines again, with the first successful distribution of entangled photon pairs between a satellite and ground, covering distances of over 1,200 km. To achieve this, the Chinese team behind the experiment used Micius, the 600-kg dedicated quantum communication satellite launched last year. Now, Hideki Takenaka and colleagues demonstrate some of the essential features of quantum communication in the transmission from a microsatellite in low-Earth orbit to ground.

Takenaka and colleagues used the 48-kg SOCRATES (Space Optical Communications Research Advanced Technology Satellite) microsatellite: a low-cost 50-cm cube (pictured). They successfully transmitted non-orthogonal polarization states and tested the feasibility of implementing quantum communication protocols. The results are encouraging for future satellite-to-ground laser communication systems and quantum key distribution for microsatellite communication. The latter is particularly relevant in the context of satellite constellations for which secure communication is increasingly important. *IG*

ULTRACOLD GASES

A test of scaling

Phys. Rev. Lett. (in the press); preprint at http://arxiv.org/abs/1702.04433

The Bose–Hubbard model provides a basic description of the behaviour of interacting spinless bosons on a lattice. At low temperatures, it predicts an interaction-driven phase transition between a superfluid and a Mott insulating state. Under a mean-field approximation, the phase diagram of the Bose–Hubbard model is determined by the lattice coordination number, not the lattice geometry. Can this effect be tested in experiment?

Claire K. Thomas and colleagues address this question using ultracold atomic gases loaded into optical lattices with two different coordination numbers — four for a kagome lattice or six for a triangular lattice. The coherent fraction in two different lattices was monitored and plotted as a function of the rescaled interaction energy. The data points superimposed on each other confirmed the scaling prediction. A phase transition from the Mott insulating to the superfluid state barely driven by the change of the coordination number was also observed. *YL*

QUANTUM THERMODYNAMICS

In the demon's mind

Proc. Natl Acad. Sci. USA **114,** 7561–7564 (2017)

Can quantum technology help peek into somebody's mind? This may sound like the stuff of science fiction, but something of the sort is possible when the subject of the exercise is Maxwell's demon, as Nathanaël Cotteta and colleagues demonstrate.

Since James Clerk Maxwell formulated his famed thought experiment challenging the second law of thermodynamics 150 years ago — in a letter to Peter Tait dated 11 December 1867 — several experimental implementations have been realized. That of Cotteta *et al.*, however, stands out in that they can control and measure at the quantum level all relevant thermodynamic quantities involved and directly track the work extracted by the 'demon'.

In the experiment, a microwave cavity takes the role of the demon. That cavity controls the quantum state of a superconducting qubit coupled to it, from which it can extract work. The precise amount depends on the information stored in the cavity, or on the state of the demon's memory. Cotteta and co-workers determined the full density matrix of that memory, providing direct insight into its role in the demonic process. *AHT*

MAJORANA MODES

The new black

Phys. Rev. X **7,** 031006 (2017)

The Sachdev–Ye–Kitaev model is a quantum mechanical model describing a collection of randomly interacting Majorana fermions. Using holographic duality arguments, this model has been shown to have connections and similarities to black holes and quantum chaos, and so may provide a way of exploring the quantum nature of black holes. The quest is therefore on to create such a model experimentally. Dmitry Pikulin and Marcel Franz propose a physical realization of the Sachdev–Ye–Kitaev model in a solid-state system.

The surfaces of three-dimensional topological insulators host quasiparticle excitations that behave like Dirac fermions. If the topological insulator has a thin layer of a conventional superconductor on top of it that contains an irregularly shaped hole with magnetic flux flowing through, proximity effects lead to the formation of bound states that are not Dirac, but Majorana-like. What Pikulin and Franz show is that, with the right ingredients, which all look within experimental reach, these Majorana zero modes can be described by the Sachdev–Ye–Kitaev Hamiltonian, meaning that they would obey the same equations as those describing the horizon of a black hole. *LF*

PLASMA PHYSICS

Turbulent tabletops

Nat. Commun. **8,** 15970 (2017)

Wouldn't it be handy to have your very own miniaturized Solar System in the lab, offering the chance to experiment with astronomical events with relative ease? In reality, this is less impossible than it sounds: phenomena that are scale invariant could, in principle, be reproduced in much smaller systems. Now, Gourab Chatterjee and colleagues show that magnetic turbulence is one of them.

Following interaction with ion free-energy sources, the solar wind exhibits different regimes of turbulent behaviour, which are reflected in its magnetic-field spectra. The experiment by Chatterjee and co-workers takes place on a tabletop, and yet presents exactly the same features. The researchers focused a 20-terawatt laser on a millimetre-thick target, generating a plasma with turbulent megagauss magnetic fields. At first these fields are generated by the hot electron currents created by the laser–matter interaction. After 12 picoseconds, a kink appears in the magnetic-energy spectra, which signals the transition to a turbulent regime dominated by the magnetization of the ions — precisely the regime that was found by spacecraft measurements of the solar wind. *FL*

Written by Luke Fleet, Iulia Georgescu, Federico Levi, Yun Li and Andreas Trabesinger.