Frontiers

In brief

Seeking the Earth next door

Wet, rocky planets – the most likely to harbour life – are hard to come by. Although a handful of such planets have been spotted outside our solar system, only one has displayed even the possibility of having liquid water. But now US astronomers believe that an Earth-like planet could potentially be hiding away in Alpha Centauri, our nearest star system. The team has performed simulations of the evolution of the system and found that if any rocky planets do exist, then about 40% of them would lie in the so-called habitable zone around the star Alpha Centauri B. A five-year stint of observations should be enough to glimpse the planets (arXiv:0802.3482).

The mirror of superconductivity

An international team of physicists has discovered the first "superinsulator". Unlike a superconductor, in which current flows without resistance, a superinsulator has infinite resistance and can indefinitely retain electrical charge. The team found the state in thin films of titanium nitride cooled below 70 mK in a magnetic field of 0.9 T. Superinsulation is believed to arise because the films partition into superconducting "pools", in which the roles of charge and magnetic vortices become reversed. They suggest that the vortices circulate pairs of opposite charges, thereby preventing charge from flowing at all (*Nature* **452** 613).

Graphene shows promise for displays

Physicists from the UK and Russia have found that graphene has the ideal properties to make the electrodes in liquid-crystal displays (LCDs). The nature of LCDs means that the electrodes have to be both transparent and conductive, and for these properties engineers would normally turn to indium tin-oxide (ITO). However, the researchers found that graphene lets about 10% more light through than standard ITO – and at a tiny sheet resistance of just 50 Ω (arXiv:0803.3031).

Tiny cargo gets from A to B

Commuting in the nanoworld is no longer a problem, thanks to researchers in Europe who have built the first nanotube "monorail". The rail itself is a thin nanotube, while the car is a wider nanotube that fits over the rail like a sleeve. When the researchers pass an electric current through the rail, it heats up in the middle, which forces lattice vibrations – known as phonons – to move towards each end. These vibrations could push the sleeve along the rail at speeds up of to 1 μm s^{-1}, even when it was carrying cargo in the form of a fleck of gold (*Science* 10.1126/science.1155559).

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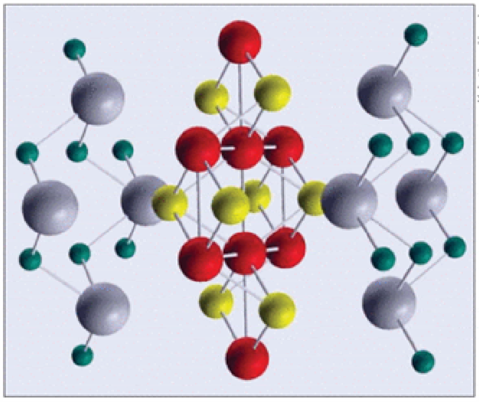
Iron rocks the high-T_c world



Kristjan Haule

A class apart New high-temperature superconductors contain layers of oxygen (green) and a rare-earth metal (grey), between layers of iron (red) and arsenic (yellow).

Physicists are beginning to understand the mechanism behind a new class of high-temperature superconductor. Unlike most such materials, which contain complex copper-oxide or "cuprate" structures, the new class is based on iron in a simple layered structure, and might lead to a material that is superconducting at room temperature.

Superconductors are materials that, when cooled below a transition temperature T_c, lose all electrical resistance. Low-temperature superconductors with a T_c close to absolute zero can be described well by the BCS theory, which reveals how electrons behave collectively as a result of interactions with lattice vibrations known as phonons. High-temperature superconductors, however, have no consistent theoretical basis. These materials, which can have a T_c as high as 138 K, usually consist of cuprate structures but sometimes compounds including uranium, cerium or plutonium.

Earlier this year, a team led by Hideo Hosono at the Tokyo Institute of Technology discovered another class of high-temperature superconductor to add to this list. LaOFeAs consists of layers of lanthanum and oxygen (doped with fluoride ions) sandwiched between layers of iron and arsenic, and it has a T_c = 26 K (*J. Am. Chem. Soc.* **130** 3296). More recently, a team led by Zhi-An Ren at the Chinese Academy of Sciences in Beijing found that by replacing the lanthanum with samarium – another rare-earth metal – the T_c can be increased to 55 K, the highest among non-cuprates (arXiv:0804.2053). Many physicists have suspected that the first room-temperature superconductor would be a non-cuprate, so it is plausible that this new class might hold the key.

Kristjan Haule and colleagues at Rutgers University in New Jersey, US, think that, like other high-temperature superconductors, the iron-based class cannot be described by phonons as in BCS theory (arXiv:0803.1279). They have used density functional theory, which can be used to compute the states of many-body systems, to create simulations of electron behaviour in LaOFeAs. "The T_c would be around 1 K at most if phonons were indeed responsible," says Haule. The researchers also found that the compound should be almost insulating at low temperatures – another indication that its superconductivity is not mediated by phonons, which would require a good metallic state.

Single photons in space

A team of scientists from Italy and Austria has managed to bounce single photons off a satellite back to a receiving station on Earth, thus demonstrating that global quantum cryptography is, in principle, possible.

Quantum cryptography is a system for encoding messages that is immune to eavesdroppers. It works by generating "keys" – strings of 1s and 0s, which can be represented by the quantum states of particles such as the polarization of single photons. Because in general it is impossible to make measurements of a quantum system without altering it, sneaking a look at a key on its way from sender to receiver would render it useless.

Although quantum cryptography is already available commercially to send messages over short distances, it is limited on large scales by high losses. For example, single photons sent through optical fibres can scatter, while those sent through the atmosphere can get deflected because of turbulence.

One way to overcome this problem, as a team including Anton Zeilinger of the University of Vienna has shown, is to divert the photon through space. The team used the Matera Laser Ranging Observatory (MLRO) in Italy to bounce photons off the Japanese "Ajisai" satellite, which orbits at an altitude of about 1500 km. Although the MLRO is more suited to sending laser beams into space, Zeilinger and colleagues found that they could make the beam weak enough to send single photons. Moreover, the researchers can prove that the photons detected are not straying from background sources, because they can take into account the changing position of Ajisai to calculate when the photon should return (*New J. Phys.* **10** 033038).