Grain-boundary electronics

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In semiconductor electronics, lattice defects are unavoidable and cause the properties and behaviour of materials to depart from their theoretical ideal. In most cases, this degrades the performance of real devices. But a numerical study of the transport properties of graphene conducted by Oleg Yazyev and Steven Louie suggests that regular grain-boundary defects could provide useful means to control the flow of charge in graphene devices.

In conventional polycrystalline semiconductors, grain boundaries scatter charge carriers, increasing the material's resistance. But Yazyev and Louie's calculations suggest that, in graphene, the transport of charge across grain boundaries composed of periodic arrays of dislocations can vary dramatically, depending on their precise structure. This structure is determined by the relative orientation of the crystal grains on either side of the boundary. Certain types of boundary allow charges to pass across relatively unhindered, whereas other types reflect all charges within a wide range of energies. The latter could provide a means of overcoming the so-called Klein effect, which allows charges to pass through the electronic potential barriers used to control their flow in conventional semiconductor devices.

How big is big *G*?

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The set-up that first enabled an accurate determination of the gravitational constant *G* is one of the oldest in modern experimental physics. And yet it is an experiment that scientists continue to improve and repeat, finding ever more precise values. Harold Parks and James Faller now report on a modified version of the 200-year-old technique that indicates that *G* might be smaller than other recent studies suggest.

The original experiment, performed by Henry Cavendish building on a concept developed by John Michell, comprises two masses on either end of a rod supported by a wire. The motion of this torsion pendulum is influenced by the gravitational force between each mass and two nearby lead spheres. Cavendish monitored this motion using lamp light and a telescope. Parks and Faller instead used laser interferometers, among a whole host of other improvements, to determine a value of $G = 6.67234 \times 10^{-11}$ m^3 kg^{-1} s^{-2} to a precision of almost 1 part in 48,000.

This value is in good agreement with the standards agreed at present, but it is odd that it disagrees with other recent experiments. In the six years since Parks and Faller took their data, they have been unable to explain the discrepancy, so it remains a mystery to be solved.

Cracking the uncrackable

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Quantum key distribution (QKD) uses the quantum properties of photons to produce and share a code, or key, that can encrypt a message. Such techniques make communication theoretically secure — at least, if the optical components are ideal. But Lars Lydersen and colleagues have shown that they can hack into two commercially available QKD systems in a way that alerts neither sender nor receiver.

Lydersen *et al.* strike at the systems' weakest parts, the avalanche photodiodes (detectors capable of sensing even a single photon). They break into the optical fibre along which the key is being sent and then use bright light to blind the sensitive detectors. The hacker can then control the detector response using laser pulses, and steal the key without anyone noticing.

This is not the first time that a QKD system has been hacked; previously, however, only a fraction of the key was intercepted, leaving the hacker with an almost impossible task to decipher the message. Nor does it mean the end of quantum cryptography: the manufacturer of one of the systems has already implemented a countermeasure to close the loophole. But it does serve as a warning that security should never be taken for granted.

Charming!

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The Earth is bathed in cosmic rays, which create showers of secondary particles as they impinge on the atmosphere. For neutrino telescopes on Earth, the muons and neutrinos generated in these showers are of particular interest, both for calibration and as background to the signals they seek. The sheer size of modern neutrino telescopes, however — IceCube in Antartica will have an operational volume of 1 km^3 by 2011; others are planned in the Mediterranean Sea and in Lake Baikal, Russia — means they can also probe cosmic-ray physics as never before. Paolo Desiati and Thomas K. Gaisser propose that such apparatus should at last be able to tell us something about shower particles that contain charm quarks.

Large-volume detectors such as IceCube will be sensitive to incoming particles of energy 100 TeV and higher. At the lower energies studied so far, evidence of muons and neutrinos from the decay of charm-containing particles is obliterated by the dominant decays of pions and kaons, which do not contain charm quarks. But beyond 100 TeV the charm signal could be accessible, through the correlation of muon and neutrino production with the temperature of the stratosphere.

When lightning never strikes

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The chance of being struck by lightning is said to be higher than that of winning the lottery, but the more likely scenario is that neither will ever happen during your lifetime. Mark Tygert explored how the fact that unlikely events are rarely encountered can be exploited to make a class of statistical tests more effective.

Tygert considered tests that determine whether a sample of data contradicts an assumed distribution. When the data are acquired in draws that are all mutually independent and sample the same probability distribution, then so-called Kolmogorov–Smirnov tests, and a variant thereof known as Kuiper's test, are standard tools for comparing such data against predictions.

These tests do not use probability density functions directly, but integrals of them. The integration, however, brings the risk of smoothing over isolated events of low probability. Tygert demonstrates that the tests can be made more reliable when they are supplemented with a separate test to check whether the probability of any measured event is predicted to be small. If so, Tygert argues, it is safe to conclude that the draws did not arise from the assumed probability density function.