research highlights

Fine etchings

Small doi:10.1002/smll.201000291 (2010)

The apparent effortlessness with which massless Dirac fermions — the principal carriers of charge in single-layer graphene — move offers the potential to build electronic devices that operate at speeds faster than even the fastest GaAs-based devices. But that same effortless movement also makes it difficult to control their flow.

The most effective way to control how and where charges flow in graphene is to physically etch it into nanometre-sized channels. Although a quasi-infinite sheet of graphene has no bandgap, when it is etched into nanoribbons a width-dependent gap opens up. This makes it easier to switch the flow of an electrical current on and off. But the properties of graphene nanoribbons are extremely sensitive to the structure and the presence of chemical impurities at their edges.

Soeren Neubeck and colleagues demonstrate a simple technique for etching graphene into nanoscale features comparable to those produced by electron lithography but with edges that are potentially much cleaner. It works by drawing the desired structure onto a graphene sheet using a biased atomic force microscope tip in a humid atmosphere. The high field at the tip causes water molecules in the vicinity to dissociate, etching material directly beneath the tip by oxidation.

Relative success

Phys. Rev. Lett. **105,** 012001 (2010)

'New' physics at accelerators such as the Tevatron at Fermilab, near Chicago, and CERN's Large Hadron Collider in Geneva may be revealed in the form of a brand new, clear signal — of a Higgs boson, say. But there are more subtle signs to be sought in the comparison of various measureable quantities to the predictions of the standard model of particle physics.

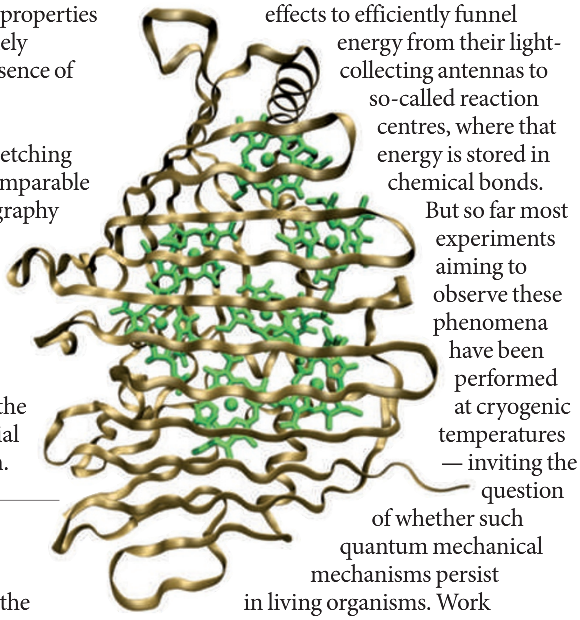
The CDF collaboration, analysing data on proton–antiproton collisions at the Tevatron, has now made the most accurate measurement yet of the cross-section for the production of pairs of top quarks. As the heaviest of the known fundamental particles, the interactions of the top quark are expected to be an especially sensitive probe, but still the result is consistent with the standard model and the new physics remains elusive.

The top-quark pairs are picked up through their decay to pairs of *W* bosons, either by directly identifying the decay products of the *W*s or by recognizing their topology. This analysis uses a larger data sample than ever before, and systematic uncertainties have become the limiting factor — in particular, the precision with which the 'luminosity' (or, basically, the rate of proton–antiproton collisions) is known. But by measuring the cross-section in each case relative to another process (the decay of a *Z* boson or photon to a pair of leptons), the overall systematic uncertainty of the CDF result has been considerably reduced.

Warm and fuzzy

Proc. Natl Acad. Sci. USA doi:10.1073/pnas.1005484107 (2010)

There is now a growing body of evidence that certain photosynthetic complexes can harness non-trivial quantum mechanical effects to efficiently funnel energy from their light-collecting antennas to so-called reaction centres, where that energy is stored in chemical bonds. But so far most experiments aiming to observe these phenomena have been performed at cryogenic temperatures — inviting the question of whether such quantum mechanical mechanisms persist in living organisms. Work by Gitt Panitchayangkoon and colleagues suggests that they might well do.



Panitchayangkoon *et al.* studied the Fenna–Matthews–Olson complex (pictured, courtesy of Graham Fleming and Yuan-Chung Cheng), which helps green sulphur bacteria to carry out photosynthesis. Their electronic spectroscopy data indicate that quantum coherence can survive at 277 K for at least 300 fs. This is long enough, in principle, to improve the efficiency of energy transport through the complex by a previously proposed mechanism, in which quantum coherence and dephasing engage in a favourable interplay.

These experiments, together with a study that found evidence for similarly long-lived quantum coherence at ambient temperature in light-harvesting proteins isolated from marine cryptophyte algae (*Nature* **463,** 644–648; 2010), could mean that the warm, wet environment of living cells might not be as hostile to quantum effects as one might think.

Neutral states with veto

Nature **466,** 585–590 (2010)

In fractional quantum Hall systems, currents are carried by fractionally charged quasiparticles. Instead of integer multiples of e^2/h, the Hall conductance contains a non-integer filling factor ν. For certain filling factors, neutral modes — which flow 'upstream' against convention — have been predicted. Aveek Bid *et al.* have succeeded in detecting these uncharged modes.

They use a quantum point contact to perturb the neutral mode, which fragments into charge-carrying quasiparticles. These charged modes in turn contribute to measureable shot noise for states with $\nu = 2/3$, 3/5 and 5/2. The existence of a neutral current in the 5/2 state shows that this state cannot be Abelian. However, which kind of non-Abelian state, where the exchange of two particles leads to a different state of matter, remains to be established.

Entangled photons from both barrels

Nature **466,** 217–220 (2010)

The confinement of a small space forces an electron into one of a series of discrete energy levels. Atoms are the most obvious example of this, but engineered structures, called quantum dots, can achieve the same thing. A single electron decaying from one of these states to the next emits one photon. Scientists have used this effect to develop triggered sources of single photons, and even pairs of entangled photons. But, in the case of the latter, the efficiency has been very low: an entangled pair is produced only 1% of the time when the device is activated. Now Adrien Dousse and co-workers have developed a double-barrelled microcavity to increase this efficiency to 12%.

Cavities are often used to enhance waves. In fact, micropillars — cylinders just a few micrometres across with a high-reflectivity mirror at each end — have already improved the performance of single-photon emitters. But it's more difficult for entangled-photon sources as the cavity must then enhance at two different wavelengths. However, Dousse *et al.* have found that adjusting the separation of two nominally identical pillars can engineer the required spectral structure.