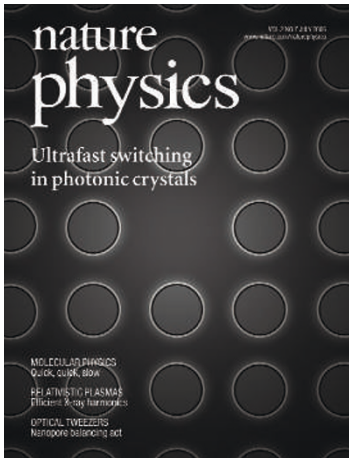


COVER STORY

Vol.2 No.7 July 2006

The speed at which a semiconductor laser can be switched is related not only to the time it takes to populate its excited states to inversion, but also to how quickly these relax to their ground state. One way of shortening this process is to pump the laser harder, but in many instances doing so can be undesirable or simply impractical. Another way is to increase the rate at which excited electrons spontaneously decay to the ground state to give off photons and stimulate further emission. This rate is determined not by the material properties of the lasing medium but by its electromagnetic environment. In this issue, Hatice Altug and colleagues show that by exploiting the enhanced spontaneous emission rate of a laser cavity formed within a photonic crystal, they can achieve switching speeds in excess of 100 GHz. **[Article p473]**

FAST SLOW-DOWN

To produce ultracold gases, the constituent particles have to be slowed down. Although laser cooling proved the way to go in atomic systems, the same principle cannot be applied to molecules. An alternative is to harness the interaction of polar molecules with inhomogeneous electric fields. This has been done successfully in experiments using several electric-field stages, but typically the braking zone extends over roughly a metre, and it takes a few milliseconds to slow the molecules down. Ray Fulton and colleagues use standing optical waves instead, and achieve comparable results. They have to step on the brakes for only a few nanoseconds to reduce the translational energy of a molecular beam by up to 50%, over a distance of less than a micrometre.
[Letter p465; News and Views p437]

X-RAY HARMONICS IN RELATIVISTIC PLASMAS

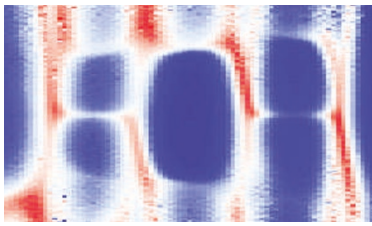
The intense flux of X-rays from a synchrotron enables the imaging of objects at a resolution approaching the scale of molecules. Moreover, unlike electron microscopy, X-ray microscopy does not require that a sample be stable in a vacuum, and causes much less damage, making it more compatible with soft materials and biological tissues. But the continuous nature of synchrotron radiation makes it ill-suited to tracking rapid changes in an object's makeup or structure. Brendan Dromey and colleagues show that the solution could be the high X-ray harmonics generated as electrons are accelerated to relativistic speed by a petawatt laser focused onto a solid target. Created as a train of attosecond pulses, the wavelengths of these harmonics extend well into the so-called water window, enabling them to penetrate deep into a sample and to discern organic molecules within an aqueous environment.
[Letter p456; News and Views p439]

DNA TUG OF WAR

Like a piece of spaghetti trapped in a plughole, it is possible to pull a single DNA molecule in ionic solution through a voltage-biased nanopore. The onset of a decrease in the ionic current through the pore signals the entrance of the DNA. To realize the potential of nanopores for detailed biomolecular structure studies, however, requires a means to position and manipulate the molecule as it passes through the pore. With this in mind, Ulrich Keyser and colleagues have successfully combined the position control of optical tweezers with nanopore detection of a single DNA molecule. Not only do the tweezers manoeuvre the molecule, but by balancing the calibrated restoring force of the tweezers against the electrostatic force on the molecule at the pore entrance they can directly measure the DNA's effective charge in solution. **[Letter p473]**

CORRELATIONS BEYOND EQUILIBRIUM

It is perhaps unsurprising that, under conditions of low temperature and zero applied bias, the electrons in a mesoscopic system such as a quantum dot may exhibit correlated behaviour. But whether such correlations persist in a system perturbed far from equilibrium has been unclear. One reason is the inherent difficulty in distinguishing the signatures of potential correlations from more-mundane non-equilibrium effects. Using a theoretical approach developed explicitly to tackle the physics of non-equilibrium systems, and state-of-the-art measurements of the low-temperature electrical characteristics of a carbon-nanotube quantum dot, Jens Paaske and colleagues provide clear evidence that such correlations can indeed persist. Their analysis suggests that a sharp conductance anomaly, evident at finite bias in these characteristics, arises from Kondo-like correlations that are commonly observed at zero bias in similar systems. **[Letter p460]**



Kondo-like correlations observed far from equilibrium in a carbon nanotube.

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TWO-DIMENSIONAL ELECTRON MELT

Two-dimensional electron gases within semiconductor structures exhibit all kinds of intriguing behaviour, such as the integer and fractional varieties of the quantum Hall effect. A strong perpendicular magnetic field induces the electrons within a high-density electron gas to localize, and eventually crystallize into a solid. This solid, report Yong Chen and co-workers, does not melt as a classical solid — which, for instance, melts when classical thermal motion disturbs the balance between Coulomb and kinetic energies. In other words, classical melting depends on the density. Instead, the melting temperature for the electron crystal is determined by the correlation effects between electrons — a quantum mechanical effect, controlled by the size of the single-particle wavefunction.
[Letter p452]