Quantum material goes classical

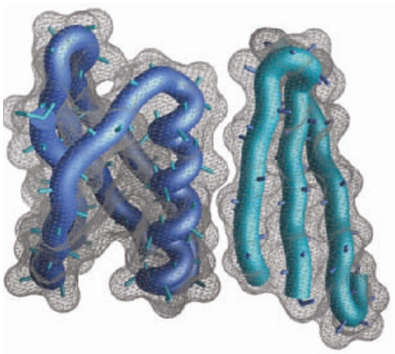
Solid–liquid interfaces are most familiar to us in terms of ice and water. Helium atoms (both ^{3}He and ^{4}He) at absolute zero temperature retain a residual energy, resulting in a zero-point motion that prevents solidification. Under pressure, however, the atoms can be stabilized into a lattice whose surface shows smooth facets determined by the underlying crystal symmetry. When the temperature is increased, thermal fluctuations cause surface roughening by creating steps. In ^{3}He, this roughening temperature of ~0.1 K is nearly three times lower than calculated. Recently, Todoshchenko and co-workers have resolved this discrepancy by considering the effect of quantum fluctuations of the interface (I. A. Todoshchenko *et al. Phys. Rev. Lett.* **93,** 175301; 2004). Quantum fluctuations reduce the energy required for step formation, or roughening, thus lowering the roughening temperature. Below this temperature, collective quantum effects in the liquid rapidly dampen the quantum motion of the interface, so that paradoxically, the effect of quantum fluctuations at higher temperature is stronger than at lower temperature, in contrast with ^{4}He. In this sense, the surface of solid ^{3}He behaves more classically than that of ^{4}He, despite a larger zero-point motion of ^{3}He atoms.

ESTIMATING NANOPARTICLE STRENGTH

Branched structures composed of nanoparticle chain aggregates (NCAs) are technologically important for manufacturing composite materials with enhanced mechanical properties such as reinforced rubber. However, the mechanism of NCA chain interaction with elastomers and the elastic nature of NCAs are not well understood and need to be studied quantitatively. Now, Sheldon Friedlander and colleagues describe force versus displacement (force spectroscopy) measurements of the interaction of an atomic force microscope tip with graphitic NCAs deposited on a silicon substrate (W. Rong, A. E. Pelling, A. Ryan, J. K. Gimzewski and S. K. Friedlander *Nano Letters* http://dx.doi.org/10.1021/nl0487368). The characteristic sawtooth patterns observed were interpreted as a series of aggregate stretching and breaking events. Using this approach, estimated values of Young's modulus of single aggregates were found to be significantly lower than expected, and provide a more general mechanistic insight into the influence of these nanoparticles on the bulk mechanical properties of elastomers.

Fibril prevention

Protein engineers are particularly interested in modelling and understanding the process of fibril formation because *in vivo* it leads to insoluble plaques that are associated with neurodegenerative diseases, such as Alzheimer's, Parkinson's and bovine spongiform encephalopathy. Using computational tools and molecular biology methods, researchers in California have redesigned the external surface of a model protein in order to obtain two mutant proteins that could bind to each other (U. J. Shukla, H. Marino, P.-S. Huang, S. L. Mayo and J. J. Love *Journal of the American Chemical Society* 126, 13914–13915; 2004). But the mutations introduced also affect the physico–chemical properties of these proteins — one mutant protein becomes ultra stable whereas the other is greatly destabilized and easily aggregates at low temperature. Fibril assemblies can be induced using just the destabilized mutant, or prevented when both mutants are present. The ultra-stable mutant is thought to bind the destabilized mutant to form a stable dimer complex that blocks the interface, thereby preventing further aggregation into fibrils. Applying these techniques to the actual proteins that form fibrils and cause diseases may lead to a new therapeutic approach for neuromedicine.



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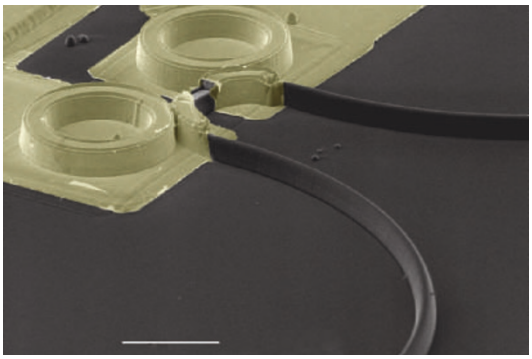
Light storage

The advent of nonlinear optical materials and devices for processing light signals at high speeds, and without the need to convert them continually to electrical signals for processing by conventional electronics, has led to significant improvements in the performance of optical-fibre telecommunications. To realize further improvements and to move towards truly all-optical networks, however, it will be important to develop a wider range of photonic devices to carry out functions that can currently only be achieved electronically. Writing in *Nature*, Martin Hill and colleagues demonstrate the operation of one of the more difficult of such devices, a high-speed, low-power optical memory (M. T. Hill *et al. Nature* 432, 206–209; 2004). The device is based on two micro-ring lasers connected by an optical waveguide that passes close to both (see image). By sending a pulse of light in one or other direction of the waveguide, light within the micro-rings can be made to resonate in either a clockwise or anticlockwise direction, each state representing either 0 or 1 of an optical bit. The device takes up just 18 × 40 μm, but simulations by the authors suggest this could be decreased still further.

Image: COBRA Research Institute, Technische Universiteit, Eindhoven



ASSIGNING CHIRALITIES WITH CONFIDENCE

Every bulk sample of carbon nanotubes contains tubes with a multitude of different diameters and chiral angles. For practical applications, a method of quickly assigning and separating bulk samples into their respective nanotube 'families' is needed. Semiconducting nanotubes exhibit bandgap fluorescence, and their optical spectra have been assigned to specific nanotube structures based on a combination of fluorescence and Raman data. Band-structure calculations have also been used to assign chiral indices and diameters to individual peaks in the absorption spectra from a bulk nanotube sample. Robin Nicholas and colleagues have now measured the strain-induced shifts of nanotube bandgaps caused by changing the temperature of the environment (L.-J. Li, R. J. Nicholas, R. S. Deacon and P. A. Shields *Physical Review Letters* **93,** 156104; 2004). Tubes with different quantum numbers (+1 or –1) undergo opposite shifts in their bandgaps with increasing temperature, giving researchers an independent check of the correctness of their nanotube structure assignment.