Liquids in no man's land

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When it comes to its physical properties, water is weird. The most obvious demonstration of this is the fact that ice floats. Less widely known but even more unusual is the fact that it exhibits at least two distinct phases in its amorphous ice state — a low-density phase and a high-density phase. How it undergoes the transition between states has been a subject of debate.

It has been suggested that it could be mirrored by an equivalent transition between different liquid states. But simulations of this liquid–liquid transition predict its critical point to be in the middle of water's so-called no man's land — an experimentally inaccessible region of water's phase diagram where it spontaneously crystallizes. And so, its very occurrence has remained speculative.

To try to gain some insight into the structural dynamics of liquid water in this region, Ken-ichiro Murata and Hajime Tanaka have explored the phase diagram of mixtures of water and glycerol. It is well known that glycerol hinders crystallization of water. This allowed the mixtures to reach supercooled liquid states, enabling the authors to identify a distinct transition between low- and high-density liquid states, providing the strongest suggestion so far that such a transition should indeed be possible in pure water. *EG*

Frozen light switch

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Enhancing the efficiency of optical switching or other nonlinear optical processes usually requires high-intensity light. However, it is also possible to maximize efficiency with very-low-intensity light if the interaction time is long. Stopping light pulses and making them interact in a medium is a way to get more for less.

Yi-Hsin Chen and co-workers made two light pulses motionless by slowing them down and trapping them in an atomic vapour. The frozen light pulses could then interact for almost seven microseconds. This long interaction allowed the very-low-intensity light pulse to trigger another light pulse — thus realizing an all-optical switch. The mechanism behind this scheme is a quantum interference effect known as electromagnetically induced transparency, which makes the atomic medium transparent to resonant light.

The results predict that switching could be activated for even-lower-intensity light if the optical density of the atomic medium is increased by cooling the atoms — a promising perspective for low-light-level nonlinear optics and quantum information processing. *IG*

Optics for a better memory

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Temporary data storage, known as random access memory (RAM), is a crucial concept in computing and information processing. Optical approaches promise faster operating speeds and lower power consumption than the prevalent electronic equivalent. Kengo Nozaki and colleagues have now demonstrated writing, storing and erasing of data in a photonic-crystal-nanocavity memory that uses 300 times less power than previous devices.

A key characteristic of a RAM element is the ability to stably exist in one of two states: '0' and '1'. Such optical switches have been demonstrated before using bistable lasers, but the devices were bulky and didn't take full advantage of the potential power savings offered by optics.

Nozaki *et al.* use a photonic-crystal cavity in which, above a threshold input power, the light transmittance can take one of two stable values. Decreasing the volume and increasing the quality factor of the cavity reduces this threshold, enabling more efficient operation.

Their structure, etched into a semiconductor membrane, had a memory time of over one microsecond with a power consumption of just 30 nanowatts. *DG*

Strange goings-on

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A proton is made of three quarks — except that it isn't. Those three 'valence' quarks are in fact adrift in a sea of virtual quarks and gluons, according to the rules of quantum chromodynamics. To understand the proton — for example, its mass, its spin — the contribution of the sea, and particularly of strange quarks in the sea, must be taken into account. It isn't easy to study the sea in isolation, but Zafar Ahmed and colleagues, of the HAPPEX collaboration at Jefferson Laboratory, in Virginia, USA, have a valuable data point to contribute.

Using a polarized electron beam and a liquid-hydrogen target, Ahmed *et al.* have measured the asymmetry of the scattered electrons to access 'form factors' in the equations that describe the scattering and are sensitive to the strange-quark sea. Previous data from other experiments have suggested that the combined electric and magnetic form factors could have a value that is non-zero. However, this measurement (although only for a single value of four-momentum transfer, Q^2) has sufficiently small statistical and systematic uncertainty to signal that the strange contribution to the form factors is consistent with zero after all. *AW*

Bacteria get around

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Throwing non-adsorbing polymers into a system of colloidal particles induces an osmotic pressure that drives the particles together. When the colloids are passive, this depletion mechanism can lead to phase separation — a process tuned by the polymer concentration. But what happens when the colloids are capable of moving themselves around? Jana Schwarz-Linek and colleagues have shown that bacteria can act as motile colloids that exhibit intriguing self-assembly behaviours.

A quick calculation reveals that the bacterial propulsion forces should be of the same order as those associated with the depletion mechanism. Schwarz-Linek *et al.* found that the ensuing competition between activity and interparticle attraction suppressed phase separation, meaning that higher polymer concentrations were needed to push the system towards coexistence.

When the interparticle attraction was too weak to overcome the motile force — but strong enough to cause phase separation in passive systems — the group noticed that the bacteria formed tiny unidirectionally rotating clusters. The chiral symmetry was broken by the torque associated with the bacterial flagella, but simulation results suggested that formation of these microrotors may be a generic property of attractive active colloids. *AK*

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