From one, many

Nature Nanotech. **4,** 167–172 (2009)

The ultimate density limit of conventional approaches to digital-information storage is likely to be determined by the density at which individual atoms can be placed and still distinguished from one another on a surface. This assumes that you can't store any more than a single bit per atom. But Christopher Moon and colleagues show that this is not a rigid limit, by encoding many tens of bits in a single quantum state.

Conventional digital storage encodes bits of information individually in the discrete states of a system (such as the presence or absence of charge on a capacitor). In contrast, the authors' approach encodes a 'page' of many bits at a time in the wavefunction of a two-dimensional electron gas, by placing carbon monoxide molecules on the surface of a clean copper film using a scanning tunnelling microscope (STM).

The molecules cause electrons below the surface to scatter, generating well-defined interference patterns that can be imaged using the STM. By positioning the molecules in just the right way, the researchers encoded images of the letters S and U, achieving an effective storage density of 20 bits nm^{-2} — 50% higher than possible with the molecules alone.

Light work

Phys. Rev. Lett. **102,** 050403 (2009)

For light within a medium, there are many ways to express the density of optical momentum. In different situations, different forms suit; but two favourites are the so-called Abraham and Minkowski forms. Ed Hinds and Stephen Barnett, in their theoretical study of a single two-level atom encountering a plane-wave light pulse, have found that both expressions are relevant — the Abraham term as an expression of kinetic momentum transfer, the Minkowski one as canonical momentum. They have also uncovered some unexpected behaviour.

The key is a term in the Lorentz force — the partial time-derivative of the impulse $\mathbf{d} \times \mathbf{B}$, for electric-dipole moment $\mathbf{d}$ and magnetic flux density $\mathbf{B}$ — that is usually overlooked. In most practical situations, that doesn't matter, as this impulse is outweighed by other factors. But here, if the light pulse encountered by the two-level atom is red-detuned, taking proper account of the term means that the atom is repelled from the light rather than, as usually expected, being attracted to it. Experiments using slow light could, suggest the authors, provide the means to probe such subtle effects.

The next generation

Phys. Rev. B **79,** 041304 (2009)

Topological states of matter could form the basis of a fault-tolerant quantum computer. Such states are neither bosons nor fermions, but obey so-called non-Abelian braiding statistics, which makes them robust against local perturbations. The $\nu = 5/2$ fractional quantum Hall (FQH) state has for a long time been the leading candidate for topological quantum computing, but Arkadiusz Wójs postulates that other FQH states could be of non-Abelian nature too.

The FQH effect has been described in terms of 'composite fermions' — electrons attached to an even number of magnetic flux quanta — which move as independent quasi-particles in an effective magnetic field. In this language, the FQH effect of the 'original' strongly interacting electrons in a magnetic field can be viewed as an integer quantum Hall version for composite fermions.

But composite fermions are not necessarily independent, and experiments have shown that residual interactions between them can give rise to additional FHQ states. This 'second generation' of FQH states is in essence a FQH effect for composite fermions, and Wójs presents numerical evidence for their non-Abelian nature.

Who's the bad guy?

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Anyone travelling regularly by plane is all too familiar with security screening. Such procedures for finding the rare villain in a large population are typically not based on evidence against specific individuals, but on assigning prior probabilities to everyone. Those who are most likely, according to the measure used, to be potential wrongdoers are then checked. But in terms of efficiency such 'strong profiling' is not optimal, argues William Press. In fact, it is no more efficient than uniform random sampling.

Under the simplest of assumptions, the fastest way to catch a malefactor would be to screen person after person, starting with the individual with the highest prior probability. This strategy, however, is difficult to implement, for political as well as practical reasons. Instead, in practice sampling proceeds in a less systematic order, and a given person might be checked several times.

But this leads to inefficiency: innocent individuals who happen to have high prior probabilities are oversampled. The optimal feasible strategy, Press's analysis shows, is weighting the search according to the square root of an individual's prior probability, leading to more broadly distributed screening that avoids the oversampling problem.

Molecular memory

Nature Mater. **8,** 194–197 (2009)

Single-molecule magnets (SMMs) need to be wired to a metallic surface without losing their all-important memory effects. Matteo Mannini and colleagues have now shown how this can be done.

SMMs differ from conventional magnetic materials in that it is the intrinsic properties of the molecule that give rise to the magnetism, not the interaction between molecules. SMMs can maintain their magnetization for a long time, making them a promising alternative for high-density data storage, but, to be individually addressed, it is likely that SMMs will need to be connected to a conducting surface. Until now, however, hysteresis has only been seen in SMMs placed on magnetic substrates.

Mannini *et al.* have studied a different class of SMM, one that is based around four atoms of iron. The rest of the molecule is made up of oxygen, carbon and sulphur atoms — it's the sulphur that enables a single layer of SMMs to attach to a gold substrate by self-assembly. The authors saw the signature hysteresis loop at a temperature of 0.5 K, and the magnetization was maintained for about 220 seconds.