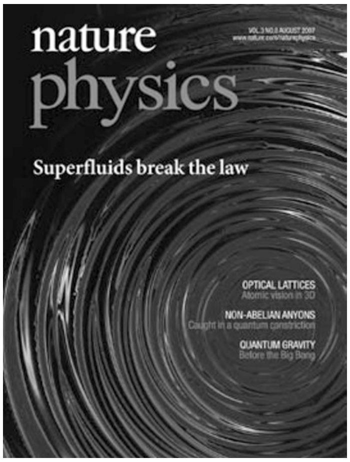


Cover story

Vol.3 No.8 August 2007

Superconductors, superfluids and supersolids can be defined in terms of how they respond to rotation. According to the London law, a rotating superconductor will generate a magnetic field that depends on fundamental constants alone. And for superfluids composed of neutral particles, such as helium-4, rotation velocities above a certain threshold will result in the formation of vortices; the quantization of the superfluid velocity within a vortex is known as Onsager–Feynman quantization. Both of these laws would be broken by a two-component superconductor, propose Egor Babaev and Neil Ashcroft. They show that for liquid metallic hydrogen, in which Cooper pairs can be formed through electron pairing and proton pairing, the superfluid velocity quantization becomes fractional and the generated magnetic field no longer depends only on fundamental constants but on density as well.
[Letter p530]

HERDING CATS

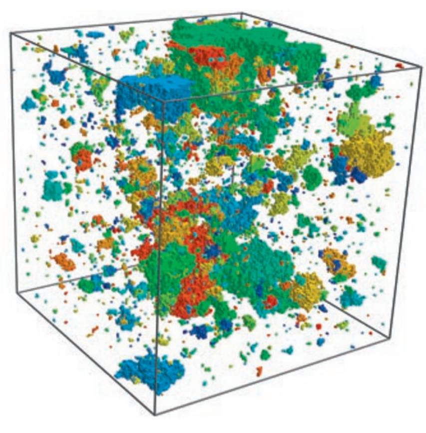
The operation of a quantum computer will ultimately require control and observation of a large number of objects that display quantum properties. Karl Nelson and colleagues take important steps towards the development of such a system that would be based on cold neutral atoms. They have trapped and imaged 250 individual caesium atoms in a three-dimensional optical lattice. The imaging procedure reveals the hopping of atoms from site to site, driven by thermal activation. In principle, the atoms are far enough apart to be addressed individually, but sufficiently close to be entangled — necessary properties for their exploitation as carriers of quantum information.
[Letter p556]

FRACTIONAL CONSTRAINT

The anyon quasiparticles that populate the 5/2 fractional-quantum-Hall state in certain 2D electron systems are believed to be governed by so-called non-abelian statistics, which arise when the exchange of particles in a system is not commutative and thus is order dependent. Such behaviour has been proposed as a means of constructing topological quantum gates, but the 5/2 state is fragile and difficult to reproduce. Nonetheless, Jeffrey Miller and colleagues show that it is possible to maintain this state when the electron system is constricted by a quantum point contact — work that could be extended to make devices capable of probing experimentally the non-abelian statistics of anyons.
[Article p561; News & Views p517]

ACROSS A CLASS DIVIDE

If a ferromagnetic film is placed in an increasing magnetic field, the magnetization will grow in a sawtooth-like manner. The magnetic domains grow when a cluster of spins all flip their spins in an avalanche. These avalanches look the same on all length scales. Such scale-invariance usually means that the phase transition belongs to a certain universality class with a given set of scaling exponents. But Kwang-Su Ryu and co-workers have observed different scaling laws at different temperatures, which suggests that there are two universality classes, and that, depending on the temperature, they can tune the system from one to the other.
[Letter p547; News & Views p518]



Avalanches of magnetic spins look the same whether you zoom in or out.

p518

BEFORE THE BIG BANG?

Could we ever know what happened before the Big Bang? That's the question posed by Martin Bojowald in this issue. If the Big Bang is a singularity that marks a transition between states — a cataclysmic bounce — then, using equations inspired by loop quantum gravity, it is possible to track back from our exisiting Universe, through the singularity, to whatever state preceded it. But Bojowald's calculations show that aspects of the previous universe are irretrievably lost through the Big-Bang transition: we will never be able to make precise enough measurements on 'our side' to be sure about what went before.
[Letter p523; News & Views p520]

TALK ABOUT THE WEATHER

The Earth and the gas-giant planets are not the only ones to experience weather; a seven-year study of α Andromedae has revealed that stars too can form dynamic clouds. Of course these are not clouds of water vapour but of mercury, which somehow manage to float in an atmosphere of hydrogen. Oleg Kochukhov and colleagues mapped the changes in the abundance of mercury over time. On stars such as the Sun, magnetic field lines are responsible for evolving surface structure, but α Andromedae has no measurable magnetic field. So what causes such stellar weather? The authors suggest the same diffusion-driven processes as those found on Earth.
[Letter p526; News & Views p515]

ONE ON ONE

Studies of decoherence typically involve a small system interacting with a large environment. But Izhar Neder and co-workers have considered the extreme case in which single electrons in an artificial environment scramble the phase of another electron. In an experiment that monitors electrons passing through a two-path interferometer, they let one of the interferometer arms interact with a few — one to three — electrons. They found that the interference signal behaves in a way that suggests that noise does not act in the familiar gaussian fashion, but that higher moments of the noise come into play.
[Letter p534]