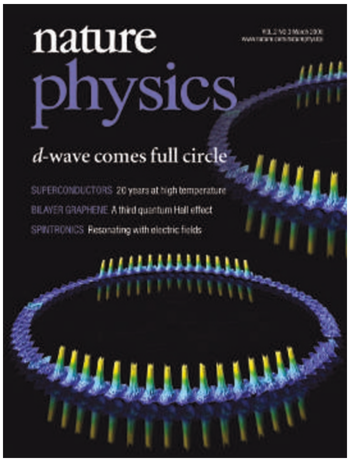


COVER STORY

Vol.2 No.3 March 2006

Superconductivity arises when electrons form pairs that condense into a coherent ground-state. The symmetry of the pairing determines the overall superconducting behaviour, including the transition temperature, T_c. In high-T_c superconductors, the pairing has *d*-wave symmetry, which changes sign four times on rotation through 360°. Using their celebrated phase-sensitive technique, John Kirtley and co-authors revisit optimally doped $YBa_2Cu_3O_{7-\delta}$ to map out the in-plane angular dependence of the pairing symmetry. A square pick-up loop scans over the arrangement of 72 rings to detect any spontaneous supercurrents (shown as peaks in the image). Owing to the presence of Cu–O chains along one crystalline axis, the superconducting energy gap is larger in that direction. The authors also find no evidence for time-reversal symmetry breaking and set an upper bound to any imaginary components of the main *d*-wave gap. **[Article p190]**

THE IMPACT OF HIGH T_c

Although high-temperature superconductivity remains a theoretical problem, the experimental response to the challenge has been tremendous. Techniques developed (or at least dramatically improved) for high-T_c studies now find applications beyond superconductivity and fundamental research. At the same time, huge effort has gone into understanding and controlling the crystal chemistry of the complicated copper-oxide-based materials. Douglas Bonn reviews the latest measurement probes designed for these compounds that defy conventional theories of metals and insulators. In addition to exotic superconductivity, copper-oxide systems also host other forms of collective behaviour, such as charge stripes, and the relationship between the different states is unclear. What is clear is that high-T_c superconductors have yielded many surprising phenomena, and that we can expect the unexpected. **[Review p159]**

A THIRD INTEGER QUANTUM HALL EFFECT

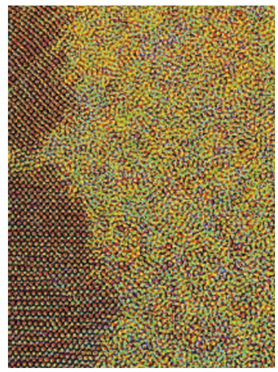
The conventional integer quantum Hall effect (IQHE) occurs when the transverse conductivity of a semiconducting two-dimensional electron system at low temperature and high magnetic field is exactly quantized into integral steps of elementary conductance. A second type of IQHE observed in graphene (a single atomic layer of graphite) exhibits similar quantized conductivity steps, but shifted by exactly half a unit of elementary conductance. This is caused by the electrons in graphene acquiring an additional phase — known as Berry's phase — of π radians. Kostya Novoselov *et al.* now report that in bilayer graphene, the conductance steps of the IQHE are shifted yet again — as reported in earlier work, although its significance was not noted — demonstrating that here electrons acquire an unanticipated Berry's phase of 2π radians, and representing yet another type of IQHE. **[Letter p177]**

SPINTRONICS AT HIGH FREQUENCY

In traditional electronics, the charge and spin of the electron are considered separate degrees of freedom. Spintronics, on the other hand, is concerned with regimes in which the two entities combine. In semiconductors, for example, the spin–orbit interaction provides a means of electrically manipulating the magnetic moment associated with the spin. The theoretical, and practical, ramifications of this connection have so far mostly been studied in the limit of static or slowly oscillating electrical fields. Now, Mathias Duckheim and Daniel Loss go further, and develop a theory of spin control with electric fields that are in resonance with spin-flip transitions (in the radio-frequency range, which should mean that spins can be addressed very efficiently, even when impurities are present in the samples.
[Article p195; News and Views p149]

PEERING THROUGH THE DUST

Colloid particles suspended in a dusty plasma mimic the behaviour of atoms over greater length scales and longer time periods than in conventional materials, and hence provide a convenient way to study a range of condensed-matter phenomena, including the dynamics of melting and the nucleation of crystals. Milenko Rubin-Zuzic and colleagues identify the motion of individual particles from a sequence of snap-shots taken of a dusty plasma over time, and obtain detailed information about the structure and evolution of the growth front of a three-dimensional colloidal crystal as it forms from a supercooled fluid-like region of the plasma. They report that the propagation of this front is accompanied by short-lived crystallites in the liquid phase and similarly short-lived liquid droplets in the crystal phase. **[Letter p181]**



Time-sequence images of a dusty plasma reveal colloidal crystal dynamics.

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FROM A GLASS TO A CRYSTAL AND BACK

Some liquids become disordered glasses on cooling, instead of forming ordered crystals. To investigate this, Hiroshi Shintani and Hajime Tanaka propose possibly the first two-dimensional model of a single-component system that can be tuned continuously from one state to the other. The system behaves as a crystal, a plastic crystal, a melt or a glass containing crystalline clusters. The authors take a liquid model whose ground state has 6-fold crystalline order, and add an anisotropic potential that favours local 5-fold symmetry. The symmetry mismatch introduces a frustration to the system, which serves as a control parameter. For instance, as the frustration is increased, local long-lived crystalline domains form, which are a natural source of the slow dynamics in a glassy system. **[Article p200; News and Views p157]**