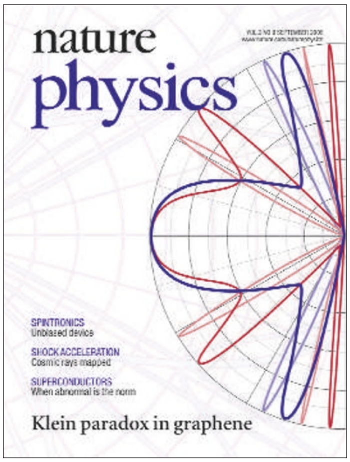


COVER STORY

Vol. 2 No. 9 September 2006

The Klein Paradox enables a relativistic electron to pass straight through a potential barrier of at least twice its rest mass, as if the barrier were not even there. Such behaviour, which is just one of the many counterintuitive consequences of the Dirac equation, is usually expected to occur under only the most extreme of circumstances, such as in the vicinity of a black hole. But Mikhail Katsnelson and colleagues suggest that analogous conditions to those that support this paradox exist in a single sheet of graphene. They predict that when the massless Dirac fermions that carry charge in graphene encounter a square barrier at normal incidence, they too will pass through it with perfect efficiency. Moreover, analysis of related effects at oblique incidence and in bilayer graphene suggests this behaviour could be used for device applications. **[Article p620; News & Views p579]**

STRANGE BY ANY NAME

Landau's Fermi liquid model forms the basis of our understanding of metals. But a growing list of metallic materials do not behave as expected. Many are 'heavy fermion' compounds, in which the electronic correlations are very strong and the effective masses huge. They are generally called non-Fermi liquids. In high-temperature superconductors, both the normal and superconducting states are unusual. In fact, the normal state above the superconducting transition temperature is often considered the stranger of the two, and is sometimes referred to as a 'marginal Fermi liquid'. According to P. W. Anderson, this 'strange' metal shares the same underlying physics as the superconducting state, in which double occupation of an electron state is completely suppressed. And it is only subtly different from a Fermi liquid: the excitation spectrum is Fermi-liquid-like, but not symmetric for electrons and holes. This asymmetry could account for tunnelling spectra. **[Article p626; News & Views p585]**

RID OF ANY BIAS

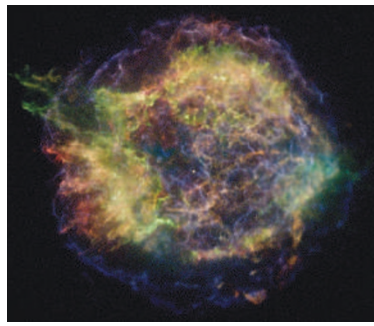
In low-dimensional electron systems such as two-dimensional electron gases in semiconductors, the electron spin offers an extra degree of freedom, and 'spintronics' exploits just that. The field could now have a new tool for spin manipulation. Sergey Ganichev and colleagues explore ways to separate spin-up and spin-down states without applying electrical currents. Ganichev *et al.* make use of the spin-dependent scattering of electrons and show that Drude absorption of terahertz radiation yields spin currents, even up to room temperature. But Drude absorption could be just one way to achieve such zero-bias spin separation; heating the electron gas by other means might have the same effect. **[Letter p609]**

COMPLEX MOLECULES SIMPLIFIED

Conjugated organic molecules have myriad potential uses, especially in the field of optoelectronics and solar energy generation. But the almost infinite combination of the building blocks from which organic molecules can be synthesized makes the development of new organic materials a formidable task. This is made all the more difficult because calculating the properties of a given organic molecule is computationally intractable for all but the simplest systems. Chao Wu and co-workers suggest that this can be overcome by breaking the problem down into many simpler parts. Treating a conjugated dendrimer molecule as a network of linear segments connected by appropriately described junctions leads to surprisingly accurate predictions about the distribution of excited states within the larger system. **[Article p631; News & Views p591]**

THE REMAINS OF THE BLAZE

Just before a supernova, the core of the dying star undergoes gravitational collapse until repulsive forces — from cramming nuclei so close together — finally overcome gravity. The resulting explosion produces shock waves that create new isotopes and heavy elements in the star's outer layers. This hot-matter soup, the supernova remnant, surrounds the newly formed neutron star, or black hole, in certain cases. Many believe that supernova remnants are the source of high-energy cosmic rays reaching Earth, but the origin of the particles and their acceleration mechanism are not clear. The Chandra X-ray space telescope is an ideal probe for these relativistic electrons. Michael Stage and co-workers use its high-resolution images of the supernova remnant Cassiopeia A to investigate the diffusion and acceleration dynamics of cosmic rays, and confirm that shock diffusion is an efficient way to accelerate charged particles to the maximum theoretical limit. **[Article p614; News & Views p589]**



Cassiopeia A, a supernova remnant in our Galaxy, is a natural particle accelerator.
p614

MOLECULE IN A SOLID WORLD

A quantum-information processor will have to provide a handle for the coherent control of qubits and simultaneously protect them from decoherence. The first goal is achieved more easily in mesoscopic solid-state systems, but for the second, quantum optical systems such as trapped ions, atoms or molecules normally do better. Mikhail Lukin and colleagues analyse ways to combine these qualities. Their proposal for integrating single molecules and superconducting circuits describes trapping, cooling, detection, coherent manipulation and quantum coupling of isolated polar molecules near cryogenic stripline microwave resonators, and could amount to a scalable quantum computer architecture that resembles cavity quantum electrodynamics. **[Article p636; News & Views p583]**