Quantum flip-flops

Superconducting π-rings — small loops designed to spontaneously generate circulating currents — famously revealed the pairing symmetry in high-temperature superconductors as indisputably *d*-wave. The current must circulate in a clockwise or counter-clockwise direction, so the ground state is degenerate. It seems that this property can be exploited for practical purposes, according to Thomas Ortlepp *et al.* (*Science* doi:10.1126/science.1126041; 2006).

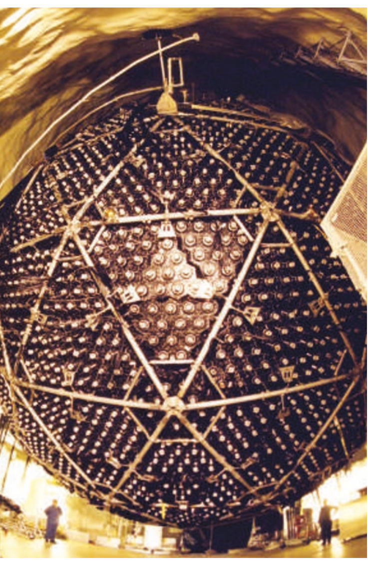
The circulating current naturally produces a magnetic flux of a half flux-quantum. Pointing either 'up' or 'down' out of the plane of the π-ring, the trapped magnetic flux represents one bit of information that can be toggled by the application of a single flux-quantum pulse. The resulting bistable device is the quantum version of a flip-flop, a common logic-circuit element for digital data transfer and storage, which switches its output state depending on the input signal. Without the π phase shift (accomplished by combining a conventional *s*-wave superconductor with a *d*-wave superconductor), a half flux-quantum would somehow have to be introduced into the device. Their way, the authors say, is simple, more stable and compact.

ELECTRON BEAMS DO THE TWIST

Magnetic circular dichroism (MCD) is the tendency of certain materials, in the presence of a magnetic field, to absorb light that is circularly polarized in one direction more than in the opposite direction. X-rays provide a useful means to study MCD — and hence the material's properties — at microscopic scales, but they can only probe a material's surface. An electron microscope could, in principle, provide similar information from deeper within a sample, but it has been assumed that to do so, its beam would need to be spin-polarized, which is unfeasible in practice.

Peter Schattschneider and colleagues show that this needn't be the case (*Nature* 441, 486–488; 2006). They use electron energy loss and X-ray absorption spectroscopy to demonstrate that electrons and X-ray are absorbed in a similarly orientation-dependent way when they interact with a magnetized iron film.

Beta version

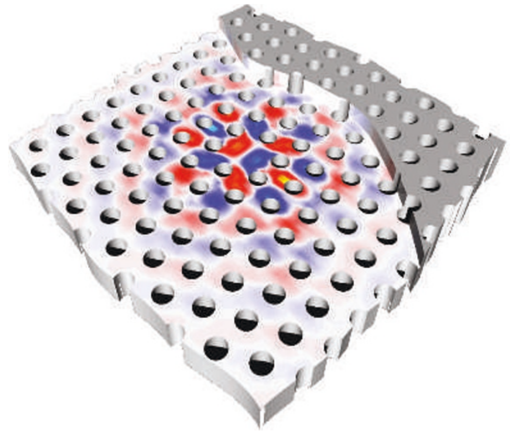


SNO

On 23 February 1987, the burst of light from a supernova was picked up by telescopes around the world. Three hours earlier, a total of 24 neutrinos from the supernova had hit three detectors in Japan, Russia and the USA. Although a tiny sample, it was a rare opportunity for direct observation of the physics of a core-collapse supernova. With the increasing number of capable neutrino detectors worldwide (including SNO, pictured), there is potential to learn more from future supernovae, through the energy spectra of the neutrinos they produce.

But, as N. Jachowicz and G. C. McLaughlin point out (*Phys. Rev. Lett.* 96, 172301; 2006), there are some difficulties in untangling such information from detected signals. One problem is the limited knowledge, at the relevant energies, of the scattering cross-sections for neutrinos with the nuclei present in the large volume of a typical detector. Jachowicz and McLaughlin show that these cross-sections could be better pinned down through low-energy scattering experiments using 'beta beams' — intense, collimated beams of neutrinos generated in the beta-decay of radioactive nuclei. The building of a beta-beam facility is currently being explored in the EU-funded study, EURISOL.

Diamond photonic crystals



CUDOS@USYD

Of the many candidate systems that have been proposed for constructing the circuits of a practical quantum computer, the scheme that uses the long-lived electron spins of nitrogen vacancies in diamond (see page 408 of this issue) has become a favourite.

Initialization and read-out of the spin-states of such a scheme is carried out using light. To increase the efficiency of this process, it would be useful to integrate a series of photonic-crystal cavities into the diamond itself to concentrate the optical field around each input/output spin-state. But at first glance, diamond's low refractive index suggests that it will be difficult to obtain the high quality factors needed for strong coupling.

Not so, say Snjezana Tomljenovic-Hanic and colleagues (*Opt. Express* 14, 3556–3562; 2006), who numerically optimize the structure of a nanoscopic diamond photonic crystal cavity (pictured) to achieve a quality factor of 3 × 10^4 — just enough for a proof-of-principle demonstration of optical addressing.

Noisy Images

Tomographic imaging techniques are versatile and non-invasive. Magnetic resonance imaging (MRI) is particularly convenient, as it uses harmless radio waves to look through a subject or object. But exposure to radiofrequency radiation can lead to sample heating. Typically this is a small effect, but still potentially hazardous. Norbert Müller and Alexej Jerschow, however, have done away with the radio waves, and obtain images somewhat differently — by detecting noise (*Proc. Natl Acad. Sci.* USA **103,** 6790–6792; 2006).

Their experiment does not look much different from traditional MRI, with strong magnetic fields present as well as a sensitive radiofrequency circuit. The latter, however, is not used to address the nuclear spins in the sample, but to register their statistical fluctuations, known as spin noise. In images taken of a 4.2-mm-wide test object, its inner structure could be clearly resolved, but the signal strength is inferior to conventional techniques. However, Müller and Jerschow expect that nuclear spin noise imaging will be competitive for very small samples, or imaging in very low magnetic fields.