Just what is it?

Phys. Rev. Lett. (in the press); preprint available at http://arxiv.org/abs/0708.0584v1 (2007)

A large number of quantum phenomena have been explored over the past couple of decades, but still we lack an intuitive understanding of basic concepts — such as the fact that measurements of entangled particles are correlated, no matter how widely the particles are separated. This is the starting point for a new study by Cyril Branciard and co-workers, which, through classic popperian falsification, reveals something more about quantum mechanics.

To try to understand why quantum behaviour is as it is, physicists have devised generic theories that share characteristic features with quantum mechanics, and whose compatibility with 'real' quantum mechanics has been tested experimentally. The most famous examples are tests of Bell's theorem that rule out the possibility that non-classical correlations arise because the measurement outcome is determined by a 'local hidden variable' imprinted in the particles when they leave the common source.

A different class of theories assumes non-local hidden variables. Branciard *et al.* have investigated one such model — proposed in 2003 by Tony Leggett — and demonstrate that it too is at odds with experimental observations, further restricting the set of possibilities for how quantum mechanics really works.

Missing crystals report

Nature Mater. **6,** 941–945 (2007)

Quantum chemistry is essentially focused on developing sophisticated algorithms to describe the quantum mechanical response of electrons and ions within a molecular structure, without *ad hoc* assumptions about its behaviour. Combined with increasing computer power, this has led to an unprecedented ability to predict the dynamics of ever more complex molecules. But because most algorithms must begin with an assumption about the initial arrangement of atoms in an ensemble, they have been unable to confidently predict the ground-state structure of a material given only its composition.

Gus Hart prefers to assume that the more geometrically simple a structure is, the more likely it is to represent a possible ground state. To demonstrate the potential of this approach, he has compiled a list of possible structures for a variety of chemical compositions and searched the published literature for their occurrence. As well as correctly identifying many structures that have been observed, his search suggests the possibility of several that have not.

Qubit quality quantified

New J. Phys. **9,** 384 (2007)

A number of physical systems have been proposed as platforms for a quantum information processor, from trapped ions to superconducting circuits. Information is typically encoded in pairs of quantum states, which can be brought into superposition — something that is not possible with a classical bit. However, many quantum systems possess more states than the ones used for defining the qubit, and leakage to these states results in the deterioration of the quality and usefulness of the qubit.

The details of the leakage processes are specific to the platform considered. But is there, nonetheless, a way to compare qubits implemented using different physical systems? Yes, say Simon Devitt and colleagues, who propose a protocol based on a generic experiment involving oscillation between the two qubit states. They argue that the Fourier spectrum of the data obtained in such a basic experiment can reveal general characteristics that are widely independent of the qubit's structure and of the means by which it is controlled — and hence can be used for 'quality control' in a wide range of systems.

Pump up the volume

Appl. Phys. Lett. **91,** 193901 (2007)

Ultrasonic waves are most commonly known for their use in the minimally invasive imaging of unborn babies — less well known is that they can also be used for surgery. When focused to sufficient intensities, ultrasonic waves can induce rapid localized heating of living tissue, causing its cells to coagulate. This means that cancer cells targeted at the focus of an ultrasonic beam array can be destroyed, while leaving healthy tissues away from the focus unharmed. But with current technology, small focal volumes and long exposure times limit this approach to tumours below 4 cm in diameter.

David Melodelima and colleagues have developed a device that could broaden the use of ultrasonic surgery. The device consists of 32 independently controlled transducers arranged in eight concentric rings. By driving one ring after another, they maintain constant intensity at the focus while minimizing exposure to the surrounding tissues. An average volume of 8.6 cm^3 can be treated in a total exposure time of 40 s.

A river runs through it

Astrophys. J. **670,** L109–L112 (2007)

A turbulent stream of gas — the Magellanic Stream — runs through our nearest galactic neighbours, the Large (pictured) and Small Magellanic Clouds, and into the Milky Way. That the Stream contains ionized hydrogen in addition to neutral hydrogen has challenged researchers for more than two decades. There are no nearby stars, for instance, to ionize the gas. Moreover, the stream is inhomogeneous: there are clumps and compression fronts, and the brightest ionization emissions occur at the leading edges of the neutral clouds.

Joss Bland-Hawthorn and co-workers present a hydrodynamic model that can explain these observations consistently. At the boundary of the Milky Way lies a spherical Galactic halo of cool stars and hot gas. Alone, a tenuous halo gas cannot account for shockwaves in the clouds. However, the authors propose that the halo gas also disrupts the flow of gas. The decelerated gas causes a 'log jam' upstream. Subsequent clouds plough into this gas, which leads to gas ablation and shock ionization in a 'shock cascade' downstream, and gas accretion onto our Galaxy.