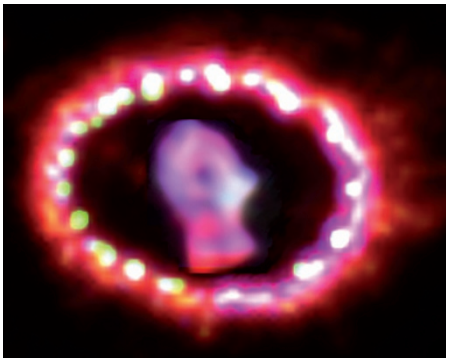
Fade to bright

Nature doi:10.1038/nature10090 (2011)



NASA / ESA / P. CHALLIS

Not only was supernova 1987A (pictured) the first supernova spotted in 1987, it was even visible to the naked eye. And, crucially, it was the closest supernova to Earth since the invention of the telescope. The Hubble Space Telescope, in particular, has recorded its evolution in detail. From 1994, we've watched the ejecta (the debris ejected during the original explosion) slowly fade — but then it started to brighten. Josefin Larsson and co-workers now have an explanation for the increased flux.

Well before the progenitor star collapsed, its stellar wind created a circumstellar ring of gas. As the expanding ejecta interacts with the ring, shock waves produce X-rays. Larsson's team suggests that the X-rays are heating up the inner ejecta and causing it to glow more brightly. Moreover, as the density of the ejecta core will decrease over time, the X-rays will be able to pierce the ejecta and offer insights into the structure and composition of the progenitor star. Whether the star collapsed to a neutron star, pulsar or black hole will hopefully become clearer as the supernova makes the transition to supernova remnant.

The strength of the weak

Nature **474,** 188–191 (2011)
Science **332,** 1170–1173 (2011)

We alter the state of a system simply by looking at it — this is a central tenet of quantum measurement. So-called weak measurements, however, can provide some small insight into a system without disturbing it too much. Two research groups have now used this concept to observe quantum effects directly.

Jeff Lundeen and co-authors measured the wavefunction of a photon. A wavefunction — the square of which gives the probability that the photon will be found at a specific place — collapses after a conventional measurement. Instead, Lundeen *et al.* first weakly measured whether the photon was at a particular position, then followed that with a strong measurement of its momentum. If the momentum measurement was zero, the photon was kept; all others were rejected. This procedure was repeated, testing for different photon positions and enabling the team to build up a picture of the wavefunction.

The same combination of weak measurement and post-selection was also used by Sacha Kocsis and colleagues to observe the trajectories of single photons passing through two closely spaced slits.

Challenge to a dual

Phys. Rev. Lett. **106,** 221601 (2011)

String theory isn't universally popular — not least for its seeming lack of connection to anything testable in the real world. But an interesting avenue of exploration has emerged, using string theory, through the recognition of the duality of (or equivalence between) gravitational and non-gravitational theories, the latter in a lower dimensional space. It may sound like mathematical abstraction, but has in fact been applied successfully in condensed-matter systems, such as superconductors.

Gary Horowitz and colleagues have now constructed a gravitational dual of a Josephson junction. Specifically, they've analysed a junction formed by a normal conductor linking two superconductors: the phase difference that emerges in the link between the superconductors causes current to flow, without any applied voltage; this is the dc Josephson effect. For their gravitational dual, Horowitz *et al.* prove that the maximum current through the junction behaves as expected, and also explore its temperature dependence.

Further effects such as applied voltage and magnetic field are still to be incorporated. And, although this work is primarily concerned with duality, there could, say the authors, also be further insight to be gained into Josephson junctions and superconductors.

In the neighbourhood

Phys. Rev. Lett. (in the press)

Asteroids, aliens and even solar collapse are among the threats regularly depicted in Hollywood blockbusters that have the potential to bring about global apocalypse. Less common, but no less potentially catastrophic, is the possibility of a supernova occurring nearby in our Galaxy. It's been suggested that the immense burst of radiation from such an event — as well as being a danger to life itself — could strip the Earth's protective ozone layer. And analysis of lunar soil cores supports suspicions that a nearby supernova did occur relatively recently in Earth's history.

David L. Cook and colleagues have analysed the isotopic content of samples, collected by the Apollo 12 and 16 missions, from regions of the Moon that were relatively undisturbed by recent meteor impacts. They found that the concentration of the short-lived isotope iron-60 — produced by exposure of soil to cosmic rays — was higher at the Moon's surface than deeper down. The results support similar evidence collected from deep-sea Earth cores for a nearby supernova sometime in the last 2–3 million years.

And thus the quantum

New J. Phys. **13,** 063001 (2011)

To go beyond quantum theory — to incorporate gravity in a consistent manner, for instance — it can only help to better understand it in the first place. In a step towards establishing a clear axiomatic foundation of quantum mechanics, Lluís Masanes and Markus Müller present a derivation of quantum theory based on imposing five physically well-defined requirements on the framework of generalized probabilistic theories.

Usually, the formulation of quantum theory is based on postulates about its mathematical structure. This is in contrast to, for example, special relativity, where the principle of relativity and the invariance of the speed of light are constraints with a clear physical meaning and from which the mathematical structure of Minkowski space–time can be derived.

There have been several attempts at alternative axiomatizations of quantum theory, from geometric to information-theoretic approaches. Masanes and Müller, extending previous work, show that in their approach the only theories that satisfy the five requirements they impose on generalized probabilistic theories are quantum theory and classical probability theory. If one of the requirements is tightened, quantum theory remains the only possibility. Hence, it seems that modifying any of the five requirements offers a systematic way of exploring theories beyond quantum mechanics.

© 2011 Macmillan Publishers Limited. All rights reserved