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Schrodinger's cat comes into view

[5 Jul 2000] In 1935 Erwin Schrodinger proposed a famous thought experiment in which a cat was somehow both alive and dead at the same time. Schrodinger was attempting to demonstrate the limitations of quantum mechanics: quantum particles such as atoms can be in two or more different quantum states at the same time but surely, he argued, a classical object made of a large number of atoms, such as a cat, could not be in two different states. Now Jonathan Friedman and co-workers at the State University of New York (SUNY) in Stony Brook have demonstrated a macroscopic Schrodinger cat state for the first time (*Nature* 406 43). In their experiment a superconducting device is placed in a quantum superposition of two states: one that corresponds to a current flowing through the device in a clockwise direction, and another that corresponds to an anti-clockwise current.

In his original thought experiment, Schrodinger imagined that a cat is locked in a box, along with a radioactive atom that is connected to a vial containing a deadly poison. If the atom decays, it causes the vial to smash and the cat to be killed. When the box is closed we do not know if the atom has decayed or not, which means that it can be in both the decayed state and the non-decayed state at the same time. Therefore, the cat is both dead and alive at the same time - which clearly does not happen in classical physics.

The SUNY-Stony Brook experiment uses superconducting quantum interference devices (SQUIDs). These are ring-shaped devices in which persistent currents, made of billions of pairs of electrons, can circulate in either a clockwise or an anti-clockwise direction without decaying. Their device is made from niobium, which is superconducting at the temperatures of 40 millikelvin used in the experiment, and aluminium oxide, which acts as a barrier. A palladium-gold shield protects the device from interactions with the environment that would otherwise wipe out the quantum superpositions being studied.

The system can be represented as a potential well with two minima, both of which contain several bound states, separated by a barrier. Friedman and co-workers start with a current of about 1 microamp flowing in, say, the clockwise direction. Next they illuminate the SQUID with microwaves which excite the system to a clockwise state with higher energy. The system can now tunnel from the clockwise state into the anti-clockwise state, and back.

The question is essentially whether the system remembers or forgets its quantum state as it tunnels. To answer this the Stony Brook team measures the probability of finding the current flowing in the anti-clockwise direction as the shape of the double-well potential is changed. The results are exactly as predicted by assuming that the system is in a macroscopic superposition of states. The difference between the two states corresponds to a current of 2 to 3 microamps or a magnetic moment of 10 billion Bohr magnetons, which is "truly macroscopic" according to Friedman and co-workers.

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