Physicists move closer to the quantum limit

April 12 2004

A new experiment in the US has come close to detecting quantum effects in a macroscopic object. Keith Schwab and colleagues from the National Security Agency (NSA) working at the University of Maryland have measured the vibrations of a tiny nanoelectromechanical arm to probe the limits at which quantum behaviour breaks down and classical physics takes over. Although the experiment was not quite sensitive enough to test the uncertainty principle, it has come closer to doing so than previous attempts (M D LaHaye et al. 2004 Science 304 74).

The uncertainty principle states that we cannot simultaneously know both the position and velocity of a particle with complete certainty. The principle is used to describe the motion of particles at the atomic level, but has thus far not been observed in the behaviour of macroscopic objects. Such behaviour is described by classical physics.

To find out whether or not the uncertainty principle extends up to the macroscopic world, Schwab and colleagues studied the motion of a vibrating mechanical arm made from silicon nitride. At just 8 microns (8x10-6m) long, the arm is tiny by everyday standards but still macroscopic (having the mass equivalent to 1012 hydrogen atoms).

The researchers positioned the arm about 600 nanometres away from a single-electron transistor - which acts as a motion detector - and coupled the two together via a capacitor. They then applied a voltage to make the arm vibrate and cooled the system down to a few millikelvin. Cooling the system to such low temperatures reduced thermal vibrations close to the point where just "zero-point" quantum fluctuations remain. This zero-point motion results from the uncertainty principle, which prevents the arm from remaining completely at rest.

As the arm moved towards the detector, and then away from it, the amount of current flowing through the transistor changed. By measuring this current, the physicists were able to measure the displacement of the arm with a sensitivity that is only about a factor of 4.3 larger than the amplitude of zero-point fluctuations.

The NSA physicists now plan to increase the sensitivity of the detector and further reduce thermal vibrations in the arm. They also hope to extend their study to larger objects. "These experiments address a deep mystery in physics: where does the quantum world stop and the classical world begin?" Schwab told. "Success at manipulating the quantum state of a mechanical device would suggest that there is no boundary and encourage us to pursue even larger objects."

Schwab says his team would like to exploit the system for quantum computing applications.

Citation: Physicists move closer to the quantum limit (2004, April 12) retrieved 25 April 2024 from https://phys.org/news/2004-04-physicists-closer-quantum-limit.html