Summary

When considering tiny constituents of matter, such as single atoms or molecules, the laws of physics seem to contradict common sense. Atoms or small elementary particles can properly be understood only by quantum physics, which tells that matter and energy consist of small packets, quanta. On the other hand, according to quantum physics, they both can also behave as waves.

Since everything is built with atoms, in principle also macroscopic sized objects follow the counterintuitive quantum laws. We never directly see quanta, because the quantum waves in sizable objects usually immediately cancel each other, leaving behind the everyday world. However, if well protected from noise from the surroundings, tangible objects can retain some quantum features. It is important that the surroundings are cooled down to a very low temperature near the absolute zero at -273 centigrade. Then, the energies of single vibrational quanta are not excessively disturbed by random motion of atoms due to temperature. Under these conditions, sizable objects, such as micromechanical oscillators studied by Sillanpää, measuring only a tenth of a diameter of hair, but which are huge at atomic scale, become quantum-mechanical.

In Sillanpää's work, the micromechanical resonators devised inside a superconducting cavity resonator. When the two quantum resonators, micromechanical and cavity, are put together, they begin exchange quanta, and the mechanical vibrations can be manipulated through interaction with the cavity.

According to quantum physics, two particles or objects can end up in a so-called entangled quantum state, where they share each others' properties. In particular, looks like measuring one of them will instantaneously affect the other. In 1935 Einstein strongly criticized this kind of phenomenon as contradicting physical reality. However, entanglement has been experimentally verified for atomic particles. One of the goals of Sillanpää is to observe entanglement between micromechanical resonators.

Although Sillanpää's work is basic research aiming on understanding the laws of nature, there is also an important technological motivation: future quantum information processing. Micromechanical resonators can serve as an intermediator of quantum information from the quantum bits via optical fibers even to the other side of the Earth, thus creating a quantum internet.

Translated by the author