Einstein's dream surpassed

September 2 2011

(PhysOrg.com) -- A constant stabilization experiment of a quantum state has been successfully carried out for the first time by a team from the Laboratoire Kastler Brossel headed by Serge Haroche. The researchers succeeded in maintaining a constant number of photons in a high-quality microwave cavity. The results of their study are published in the online journal *Nature* on September 1, 2011.

The photon, the basic unit of light, can normally only be observed when it disappears. The eye absorbs photons, destroying them and translating the information they carry as it is recorded. However, this destruction is not indispensable. Four years ago, a team from the Laboratoire Kastler Brossel made a major breakthrough: observing, hundreds of times, a single and same microwave photon trapped in a box.

In their new work, the researchers have gone even further: they have succeeded in stabilizing a given number of photons in a “photon box”, a cavity formed of two superconducting mirrors. It is the first complete experiment of quantum stabilization. Generally speaking, stabilizations ensure the operation of the systems that surround us. In the case of an oven, its heating temperature is dependent on a set value: as long as the ideal temperature has not been reached, the oven continues to heat up then maintains its state according to the thermostat readings.

The transfer of these concepts to the microscopic quantum world comes up against an obstacle: the measurement – the thermometer – changes the state of the system. Quantum stabilization consists in a measurement performed through the injection of atoms, ultrasensitive probes, into the

cavity. This measurement does not fix the number of photons, but provides a vague estimation. Like any quantum measurement, it however modifies the state of the cavity. A monitor – the thermostat – takes into account this information as well as the perturbation of the measurement and controls a conventional microwave source – the oven's heating elements. In this way, the cavity is taken or returned to a state where the number of photons has exactly the prescribed value.

Einstein had a dream: to trap a photon in a box for a period of around one second. This quantum stabilization has now enabled the LKB group to go even further in fulfilling this dream by maintaining, in a permanent manner, a given number of photons in the box. This experiment represents an important step in the control of complex quantum states.

More information: Real-time quantum feedback prepares and stabilizes photon number states, C. Sayrin, et al., *Nature*, 1st September 2011.

Provided by CNRS