Juggling with photons in a box to explore the quantum world

Serge Haroche

École Normale Supérieure, Laboratoire Kastler-Brossel, 24 rue Lhomond, 75005 Paris, France

Collège de France, 11, place Marcelin Berthelot, 75231 Paris Cedex 05, France

Atoms interacting with microwave photons trapped between highly reflecting mirrors realize an ideal system to perform some of the thought experiments imagined by the founding fathers of quantum physics and to illustrate fundamental aspects of the quantum meassurement theory. While photons are generally annihilated when detected, we are able to count light quanta without destroying them. This has allowed us to manipulate and control light fields in novel ways. We have for instance prepared and detected so called "Schrödinger cats" of radiation, in reference to the famous feline that the Austrian physicist imagined to be suspended between life and death. In our experiments, we generate a field made of a few photons which is suspended between two states with opposite phases and we observe how this counterintuitive superposition vanishes under the effect of decoherence. The study of this kind of strange states, impossible to comprehend by classical logic, is now developing in many laboratories around the world in a very active and fast expanding domain of research called quantum information science. By controlling and manipulating simple atomic or photonic systems in state superpositions, scientists hope to develop new devices which will use the principles of quantum physics to improve the precision of measurements, the secrecy of communications or the power of computer simulations.