

Manipulating photons non destructively and taming Schrödinger cats of light

We know since Einstein's seminal paper of 1905 on the photoelectric effect that light, known since Maxwell to be an electromagnetic wave, is also made of discrete quanta, the photons. This strange wave-particle dualism has opened the way to the quantum theory and revolutionized physics.

When they discussed the counter-intuitive quantum concepts, the fathers of the theory – Einstein, Bohr and Schrödinger among them – used to describe “thought experiments” in which they imagined that they freely manipulated photons, electrons or atoms and observed their weird behaviour. At the same time, they believed that these ideal experiments would be forever impossible to turn into actual ones in the laboratory.

A major difficulty to realize these experiments with photons is that they are very fragile particles, usually destroyed upon detection. Technological advances have recently changed this state of affairs and made it possible to manipulate photons in ways, which were previously thought impossible.

I will describe this adventure and show how we have built a “photon box” in which we can count light quanta without destroying them, as we can do with marbles in a bag. We have also “tailored” the light trapped in the box and generated laboratory versions of the famous Schrödinger cat, which the Austrian physicist imagined to be suspended between life and death. In our case, the “cat” is made of photons instead of atoms and it is maintained “half-way” between two states, which classical physicists would consider to be incompatible.

By studying this strange behaviour, we get a deeper knowledge about the quantum laws and learn tricks that we hope to use one day for developing new technologies, which could improve the precision of measurements, the secrecy of communications or the power of computer simulations.

Vita

Serge Haroche was born in 1944 in Casablanca. He graduated from Ecole Normale Supérieure (ENS), receiving his doctorate from Paris VI University in 1971 (thesis advisor: Claude Cohen-Tannoudji). After a post-doctoral visit to Stanford University in the laboratory of Arthur Schawlow (1972-73), he became full professor at Paris VI University in 1975, a position he held until 2001, when he was appointed Professor at Collège de France (Holder of the chair in quantum physics).

He has been Maître de Conference at Ecole Polytechnique (1974-1984), visiting professor at Harvard (1981), part time professor at Yale University (1984-1993), member of Institut Universitaire de France (1991-2000) and chairman of the ENS Department of Physics (1994-2000). His research has mostly taken place in Laboratoire Kastler Brossel at ENS, where he now works with a team of senior coworkers, postdocs and graduate students.



Serge Haroche has received many prizes and awards. The most outstanding one is the Nobel Prize in Physics, which he received 2012 together with David J. Wineland for their “ground-breaking experimental methods that enable measuring and manipulation of individual quantum systems”.

Panel Discussion on Research & Innovation

Central question of the discussion is, how innovation is related to basic research, and if research needs to be application oriented to benefit the society. This question arises in view of the new European Framework Programme Horizon 2020, which will promote research and innovation in an integrated manner. The discussion aims at examining the link between research and innovation in the eyes of representatives from basic research, politics, and industry.

Participants

Wolfgang Bartscher is Deputy Director of the European Commission's Directorate-General for Research and Innovation in Brussels, where he is in charge of Policy and Management of the EU Research Framework Programmes.

Tommaso Calarco is Professor at the Institute of Quantum Information Processing of the University of Ulm. He is coordinator and stakeholder of several European research projects.

Carlos Härtel is Managing Director of General Electric's Global Research Center Europe, which is situated in Garching. His main areas of activity are the continued expansion of the research center, as well as the growing collaboration and interaction with European research partners.

Serge Haroche is Professor at Ecole Normale Supérieure and Collège de France in Paris, where he holds the chair of quantum physics.

Jeanne Rubner is head of the editorial office on „Research & Education“ of the Bayerischer Rundfunk in Munich.

Programme

- 19:00 **Welcome Note**
by **Wolfgang M. Heckl**, Director General of the Deutsches Museum and **Gerhard Rempe**, Director of the Max-Planck-Institute of Quantum Optics
- 19:10 **Public Lecture by Serge Haroche:**
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- 20:00 **Questions from the audience**
moderated by **Gerhard Rempe**
- 20:20 **Presentation of an exhibit**
handing over by **Serge Haroche**
- 20:30 **Panel Discussion on Research and Innovation**
with representatives from basic research, politics, and industry, moderated by **Jeanne Rubner**, Bayerischer Rundfunk.
- 21:15 **Questions from the audience**
- 21:30 **End**



CIRCUIT AND CAVITY
QUANTUM ELECTRODYNAMICS

The public lecture and the panel discussion are held as a satellite event of the "Conference on Resonator Quantum Electrodynamics" which is organized by CCQED (<http://www.ccqed.eu>), an EU funded Initial Training Network.

The network is dedicated to the education of young researchers and provides them with scientific and supplementary training. Serge Haroche's research group at Collège de France is part of the CCQED network.



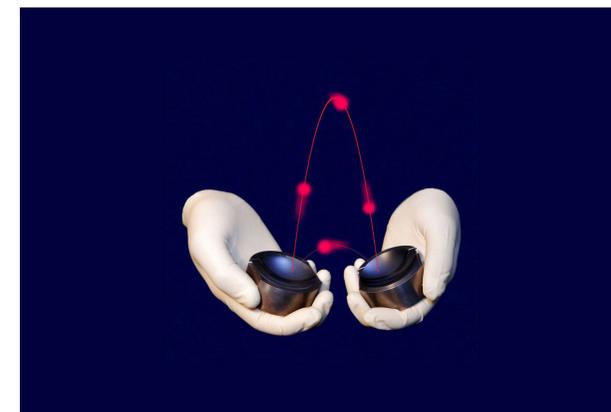
This event is co-organized by the Max-Planck-Institute of Quantum Optics, CCQED and the EU Office of Max-Planck-Institutes – Regional Cluster Bavaria in collaboration with the Deutsches Museum in Munich.

Deutsches Museum



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Nobel Laureate **Serge Haroche** about thought experiments, quantum physics and the nature of light.



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Panel Discussion on Research & Innovation

With representatives from basic research, politics, and industry, moderated by **Jeanne Rubner**.

11 September 2013

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