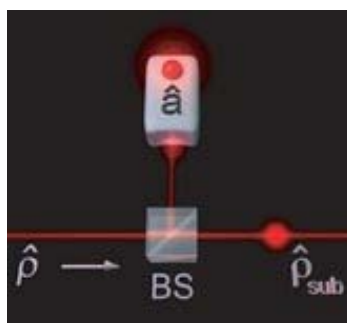


Dec 17, 2008

Experiment verifies Nobel-winning theory

Physicists take important step towards “quantum state engineering”

A property of laser light first predicted in 1963 by the future Nobel laureate Roy Glauber has been verified by physicists in Italy.



One photon out

Marco Bellini and colleagues from the University of Florence have shown that if one photon is removed from a beam of coherent laser light, the light remains in the same coherent state. According to Bellini, the ability to remove photons from light in this way could be used to develop quantum information and quantum metrology systems.

Despite being comprised of many photons, the output of a laser can often be described as a single quantum (or coherent) state. What Glauber did in 1963 — five years after the first laser was built — was to use quantum electrodynamics to show that the addition and subtraction of single photons from coherent light does not affect its coherence. Changing the number of photons only changes the amplitude of the beam.

Laboratory tour-de-force

Verifying this prediction in the lab has proved far from easy because it is very difficult to remove just one photon at a time from a beam. Another big problem has been actually measuring the coherence of the beam before and after the photon has been removed.

About five years ago, however, Bellini and colleagues started developing a way of removing single photons from a laser beam. In their experiments, which they report in *New Journal of Physics* (<http://www.iop.org/EJ/abstract/1367-2630/10/12/123006>), a relatively intense laser beam is first passed through a highly-reflective beam splitter, which deflects most of the light into a coherent reference beam.

The rest of the light travels straight through the beam splitter and emerges as relatively weak but still coherent beam. This beam is then sent through a second beam splitter, which is extremely inefficient and only occasionally diverts a photon away from the beam and into a very sensitive detector (see “One photon out”). When the detector “clicks”, the team can be fairly certain that just one photon has been removed from the beam.

Hearing a click

In their most recent study, the team then looked for any changes in the coherence of the beam by recombining it with the reference beam in an interferometer. With each successive “click”, the interferometer is used to measure a different aspect of the phase and amplitude of beam. These data are then analysed using a technique called quantum state tomography, which gives the complete quantum state of the light.

The team found that removing a photon from the light did not change its coherent state — verifying Glauber's 1963 prediction.

In similar experiments Bellini and colleagues have worked out a way to add a single photon to a coherent state and have confirmed another pillar of quantum optics called “noncommutivity” — that removing a photon from a coherent state and then adding a photon is not the same as adding a photon and then removing a photon.

physicsworld.com

WEBINAR SERIES

Multiphysics simulation – the new pacemaker of EM design.

Widen your scope to create new product concepts by applying multiphysics modeling techniques to EM analysis.

**10 June 2009
10.00 a.m. BST**

[Click here](#) to join us for this free webinar

advertisement

As a result, the team has assembled a “toolbox” for quantum optics that includes the “creation” and “annihilation” operators that add and remove photons, as well as establishing the noncommutivity of these operators. They have also shown that a coherent state is an “eigenstate” of the annihilation operator by showing that the state is not altered by the removal of a photon.

Bellini told *physicsworld.com* that these tools should allow physicists to engineer quantum-optical states that are optimized for a range of applications such as measuring very small changes in distance or the secure transmission of quantum information.

About the author

Hamish Johnston is editor of *physicsworld.com*

