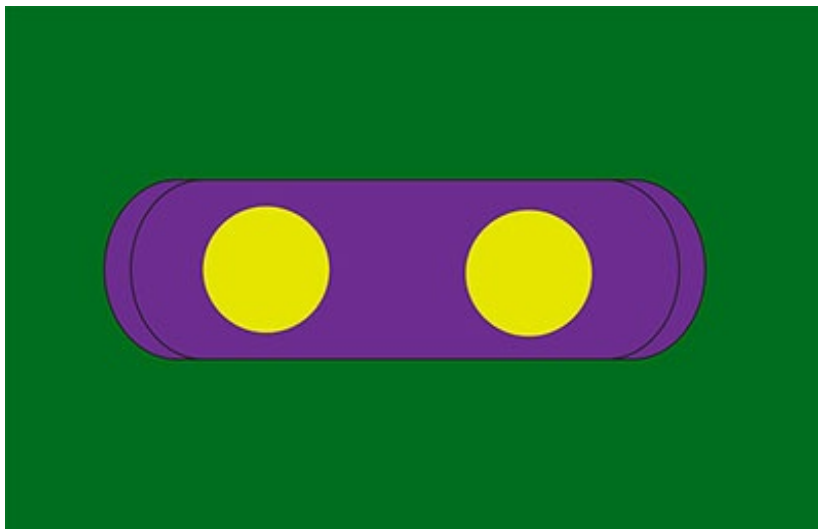


# Single photon simultaneously excites two atoms

 [physicsworld.com/cws/article/news/2016/aug/01/single-photon-simultaneously-excites-two-atoms](https://physicsworld.com/cws/article/news/2016/aug/01/single-photon-simultaneously-excites-two-atoms)

When two atoms are placed in a small chamber enclosed by mirrors, they can simultaneously absorb a single photon. So says an international team of researchers, which has found that the reverse process – two excited atoms emitting a single photon – is also possible. According to the team, this process could be used to transmit information in a quantum circuit or computer.

Physicists have long known that a single atom can absorb or emit two photons simultaneously. These two-photon, one-atom processes are widely used for spectroscopy and for the production of entangled photons used in quantum devices. However, [Salvatore Savasta](#) of the University of Messina in Italy, together with colleagues at the RIKEN Institute in Japan, wondered if two atoms could absorb one photon. Savasta asked his PhD student at the time, Luigi Garziano, to simulate the process. When Garziano's simulation showed that the phenomenon was possible, Savasta was so excited that he "punched the wall," he told *physicsworld.com*.



## One for two?

Their simulation found that the phenomenon occurs when the resonant frequency of the optical cavity containing the atoms is twice the transition frequency of an individual atom. For example, in a cavity whose resonant frequency is three times that of the atomic transition, three atoms can simultaneously absorb or emit a single photon. The optical-cavity's dimensions are determined by this resonant frequency, which must be a standing wave. According to the researchers' calculations, the two atoms would oscillate back and forth between their ground and excited states. Indeed, the atoms would first jointly absorb the photon, ending up in their excited states, before jointly emitting a single photon to return to their ground states. The cycle would then repeat. In addition, they found that the joint absorption and emission can occur with more than just two atoms.

## Quantum switch

A two-atom, one-photon system could be used as a switch to transmit information in a quantum circuit, Savasta says. One atom would act as a qubit, encoding information as a superposition of the ground and excited states. To transmit the information outside of the cavity, the qubit would need to transfer the information to a photon in the cavity. The second atom would be used to control whether the qubit transmits the information. If the second atom's transition frequency is tuned to half the resonance frequency of the cavity, the two atoms could jointly absorb and emit a single photon, which would contain the encoded information to be transmitted. To ensure that the atoms do not re-adsorb the photon, the atom's resonant frequency can be changed by applying an external magnetic field.

Savasta's group has begun to look for experimental collaborators to produce its theoretical prediction in the lab. While the experiment could be performed using actual atoms, Savasta plans to use artificial atoms: superconducting particles that have quantized energy levels and behave analogously as atoms, but whose transition energies can be more easily tuned by the experimentalist. In addition, controlling real atoms involves expensive technology, while artificial atoms can be created cheaply on solid-state chips. "Real atoms are only good for proof-of-principle experiments," he says.

Savasta anticipates that their collaborators will be able to successfully perform the experiment in about a year. "We think that, especially if using superconducting qubits, that this experiment is well within the reach of present technology," he says.

According to [Tatjana Wilk](#) at the Max Planck Institute for Quantum Optics in Garching, who was not involved in the current research, [speaking to the American Physical Society's \*Physics Focus\*](#), she cautions that the excited states of the atoms may not last long enough to be useful in an actual quantum device.

The research is published in [Physical Review Letters](#).