# Simulations show a single photon can simultaneously excite two atoms

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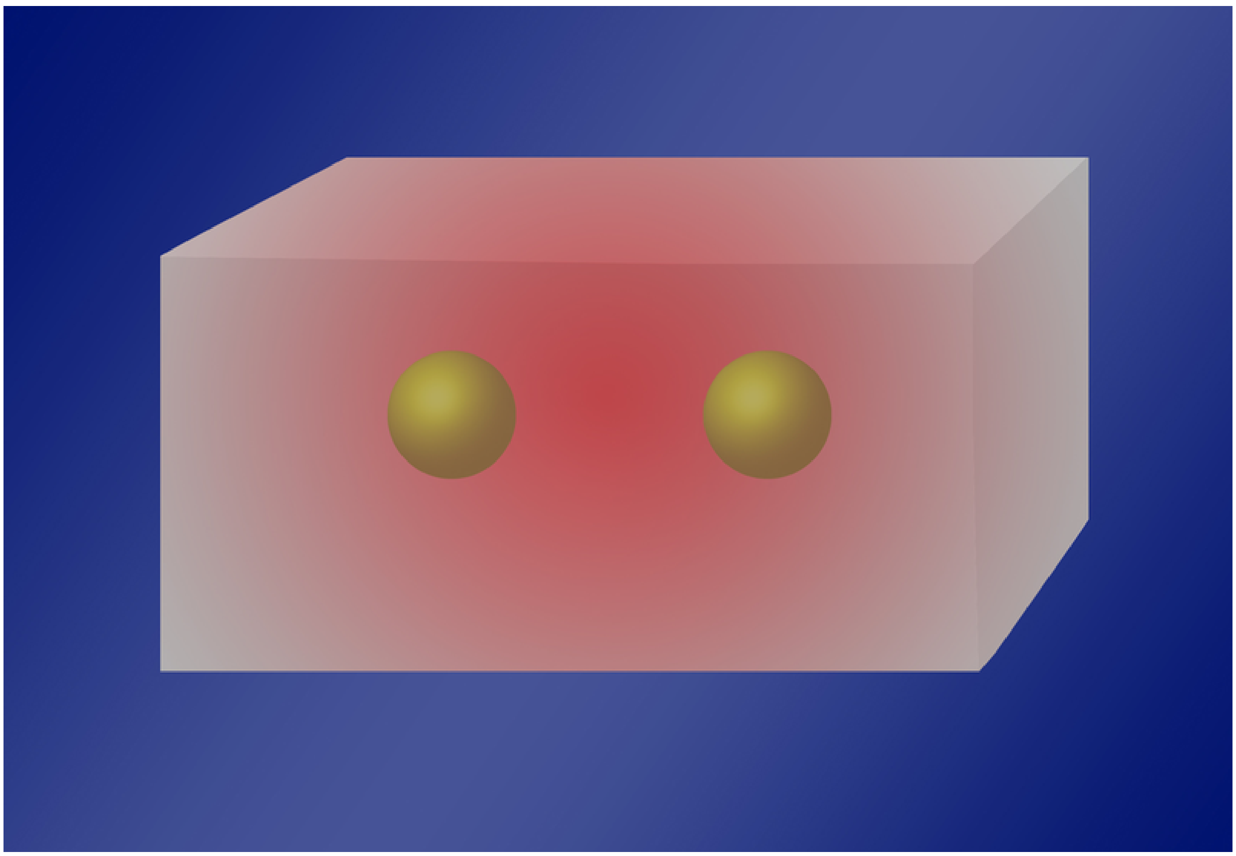

Sharing the limelight. Two or more atoms in an optical cavity can absorb a single photon, according to theory. The cavity allows standing light waves of a single frequency (red glow), which can be limited to one photon. Credit: APS/Joan Tycko/via *Physics*, 9, 83.

(Phys.org)—A small team of researchers with affiliations to institutions in Italy, Japan and the U.S. has created a simulation that suggests that it should be possible for a single photon to simultaneously excite two atoms. In their paper published in the open access journal *Physical Review Letters*, the team describes the process leading to their simulation, what it showed and why they believe their findings have applications in quantum computers.

Scientists have known for several years that it is possible to have a single atom absorb two photons, causing it to move to a higher energy state. The process has actually been observed many times and is now used in microscopy and spectroscopy—its reverse, extracting the two photons from a single atom, has also been used as a means for producing entangled photons. In this new effort, the researchers wanted to know if the same would hold true for causing a single photon to be absorbed by two different atoms—theory has already suggested it should be possible.

To find out, the team created a simulation in which two atoms were held in place by mirrors inside of a chamber—creating a virtual optical cavity. They reasoned that the size of the cavity should be based on the frequency and wavelength of the photon that would be introduced (i.e. it should be double that of the photon). They then introduced the photon and found that in such a circumstance, both atoms were able to absorb the photon—each grabbing half of its energy—and moving into a higher energy state. And because the process could be reversed—the two atoms together producing a single photon, the team believes it might be possible to use the phenomenon in a quantum system—one of the atoms would theoretically serve as a qubit, carrying information. To give up its information, the qubit would move the information to the cavity where the second atom could be used to control transmission.

The researchers found that the simulation worked for three atoms and one photon, as well—the energy from the photon was equally divided between the atoms.

**More information:** Luigi Garziano et al. One Photon Can Simultaneously Excite Two or More Atoms, *Physical Review Letters* (2016). DOI: 10.1103/PhysRevLett.117.043601 , On *Arxiv*: arxiv.org/abs/1601.00886

**ABSTRACT**
We consider two separate atoms interacting with a single-mode optical or microwave resonator. When the frequency of the resonator field is twice the atomic transition frequency, we show that there exists a resonant coupling between one photon and two atoms, via intermediate virtual states connected by counterrotating processes. If the resonator is prepared in its one-photon state, the photon can be jointly absorbed by the two atoms in their ground state which will both reach their excited state with a probability close to one. Like ordinary quantum Rabi oscillations, this process is coherent and reversible, so that two atoms in their excited state will undergo a downward transition jointly emitting a single cavity photon. This joint absorption and emission process can also occur with three atoms. The parameters used to investigate this process correspond to experimentally demonstrated values in circuit quantum electrodynamics systems.