A single-atom light switch

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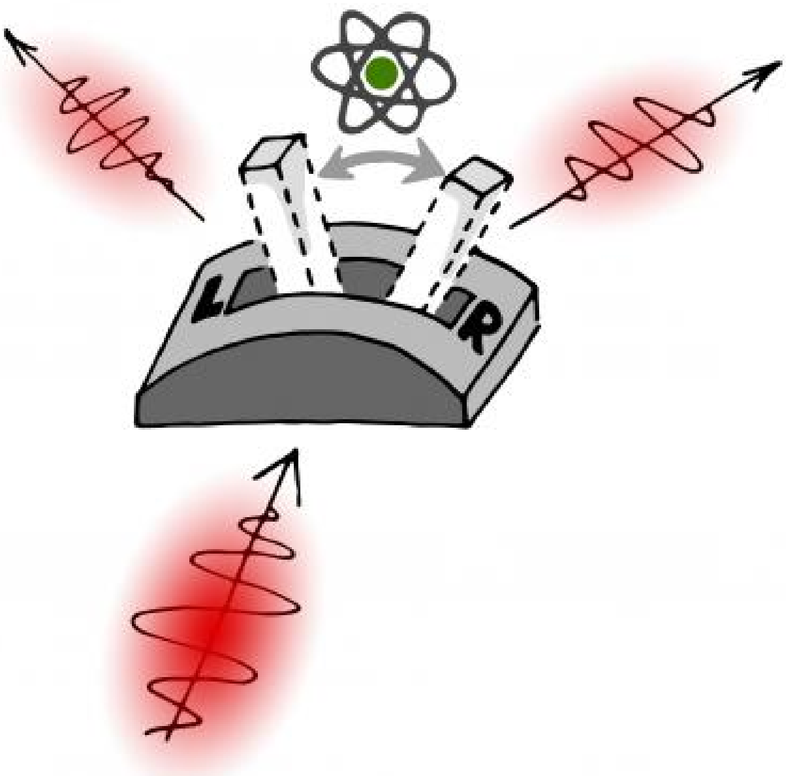


Credit: Vienna University of Technology

With just a single atom, light can be switched between two fibre optic cables at the Vienna University of Technology. Such a switch enables quantum phenomena to be used for information and communication technology.

Fibre optic cables are turned in to a quantum lab: scientists are trying to build optical switches at the smallest possible scale in order to manipulate light. At the Vienna University of Technology, this can now be done using a single atom. Conventional glass fibre cables, which are used for internet data transfer, can be interconnected by tiny quantum systems.

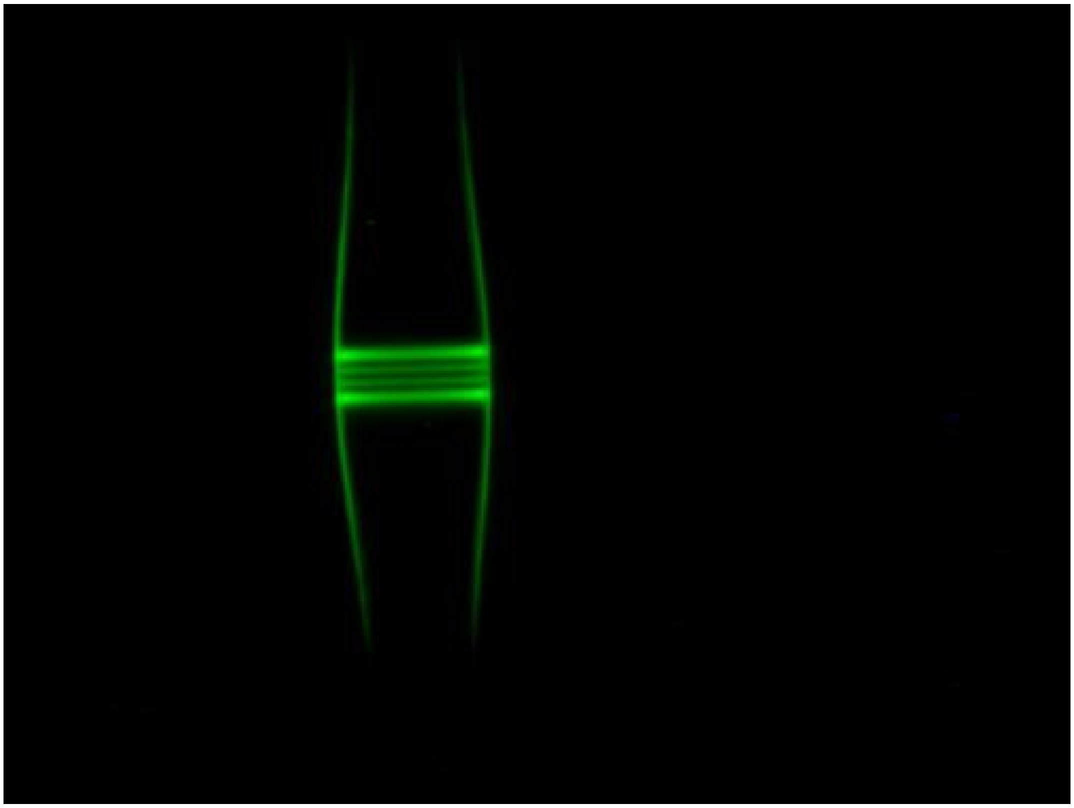
Light in a Bottle

Professor Arno Rauschenbeutel and his team at the Vienna University of Technology capture light in so-called "bottle resonators". At the surface of these bulgy glass objects, light runs in circles. If such a resonator is brought into the vicinity of a glass fibre which is carrying light, the two systems couple and light can cross over from the glass fibre into the bottle resonator.

"When the circumference of the resonator matches the wavelength of the light, we can make one hundred percent of the light from the glass fibre go into the bottle resonator – and from there it can move on into a second glass fibre", explains Arno Rauschenbeutel.

A Rubidium Atom as a Light Switch

This system, consisting of the incoming fibre, the resonator and the outgoing fibre, is extremely sensitive: "When we take a single Rubidium atom and bring it into contact with the resonator, the behaviour of the system can change dramatically", says Rauschenbeutel. If the light is in resonance with the atom, it is even possible to keep all the light in the original glass fibre, and none of it transfers to the bottle resonator and the outgoing glass fibre. The atom thus acts as a switch which redirects light one or the other fibre.



Credit: Vienna University of Technology

Both Settings at Once: The Quantum Switch

In the next step, the scientists plan to make use of the fact that the Rubidium atom can occupy different quantum states, only one of which interacts with the resonator. If the atom occupies the non-interacting quantum state, the light behaves as if the atom was not there. Thus, depending on the quantum state of the atom, light is sent into either of the two glass fibres. This opens up the possibility to exploit some of the most remarkable properties of quantum mechanics: "In quantum physics, objects can occupy different states at the same time", says Arno Rauschenbeutel. The atom can be prepared in such a way that it occupies both switch states at once. As a consequence, the states "light" and "no light" are simultaneously present in each of the two glass fibre cables.

For the classical light switch at home, this would be plain impossible, but for a "quantum light switch", occupying both states at once is not a problem. "It will be exciting to test, whether such superpositions are also possible with stronger light pulses. Somewhere we are bound to encounter a crossover between quantum physics and classical physics", says Rauschenbeutel.

This light switch is a very powerful new tool for quantum information and quantum communication. "We are planning to deterministically create quantum entanglement between light and matter", says Arno Rauschenbeutel. "For that, we will no longer need any exotic machinery which is only found in laboratories. Instead, we can now do it with conventional glass fibre cables which are available everywhere."

More information: prl.aps.org/abstract/PRL/v111/i19/e193601

Provided by Vienna University of Technology