# Long-distance quantum communication gets closer as physicists increase light storage efficiency by an order of magnitude

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(PhysOrg.com) -- In a new demonstration of reversible light storage, physicists have achieved storage efficiencies of more than a magnitude greater than those offered by previous techniques. The new method could be useful for designing quantum repeaters, which are necessary for achieving long-distance quantum communication.

Physicists Thierry Chaneli?re of the Laboratoire Aimé Cotton - CNRS in Orsay, France, and his coauthors have published their results of the new light storage method in a recent issue of the New Journal of Physics.

The new technique involves mapping a light field onto a thulium-doped crystal. Compared with other kinds of rare-earth ions, thulium has an interaction wavelength that makes it more easily accessible with laser diodes, allowing for a better preparation of the tool used to store the light - an atomic frequency comb.

“I would say that the most important factor [in achieving high-efficiency light storage] is the ability to properly prepare the atomic comb from a very absorbing medium,” Chaneli?re told *PhysOrg.com*. He explained that there is a tradeoff involved: “the absorption allows the storage, but is also a source of loss during the retrieval process.”

To prepare the atomic frequency comb, the physicists filtered preparation pulses into evenly spaced absorption peaks, which resulted in an absorption comb with a specific periodicity. The scientists then sent a weak signal pulse into the comb to be stored. The signal’s spectrum was covered by many of the comb peaks, which temporarily held the signal and delayed its retrieval.

Using this technique, the physicists estimated that the total light storage efficiency was about 9%, which is a significant improvement over previous demonstrations’ efficiencies of less than 1%.

“The efficiency is the probability of retrieval,” Chaneli?re explained. “In our case, for 100 storage trials, we only retrieve our photon nine times. So we need to repeat the operation to be sure that something is transmitted. This is the way a quantum repeater will work. A strong advantage of the atomic frequency comb protocol is its large intrinsic repetition rate that has already been demonstrated experimentally. The ‘quantum data rate’ of a quantum repeater will be at the end directly proportional to the efficiency and the intrinsic repetition rate. That's why it is so important.”

The scientists also found that the total light storage efficiency strongly depends on the shape of the frequency comb, which can be controlled by varying the relative intensity of the preparation pulses. Using this information, the physicists hope that by controlling the spectral properties of the atomic frequency comb, they will be able to improve the design of quantum repeaters.

“The main application of the protocol is quantum repeaters,” Chaneli?re said. “This is the future of quantum cryptography, which is an active field of research but suffers from the limitation of current optical networks. The range of this fully-secured communication is currently limited to 100km typically because of residual absorption in the optical fibre. The goal of a quantum repeater is to extend this range toward longer distances (thousands of km). This is what we mean by ‘long-distance quantum communication.’”

**More information:** T. Chaneli?re, J. Ruggiero, M. Bonarota, M. Afzelius, and J-L Le Gouet. “Efficient light storage in a crystal using an atomic frequency comb." *New Journal of Physics*, 12 (2010) 023025. www.iop.org/EJ/abstract/1367-2630/12/2/023025/

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