Physicists create nanoscale mirror with only 2000 atoms

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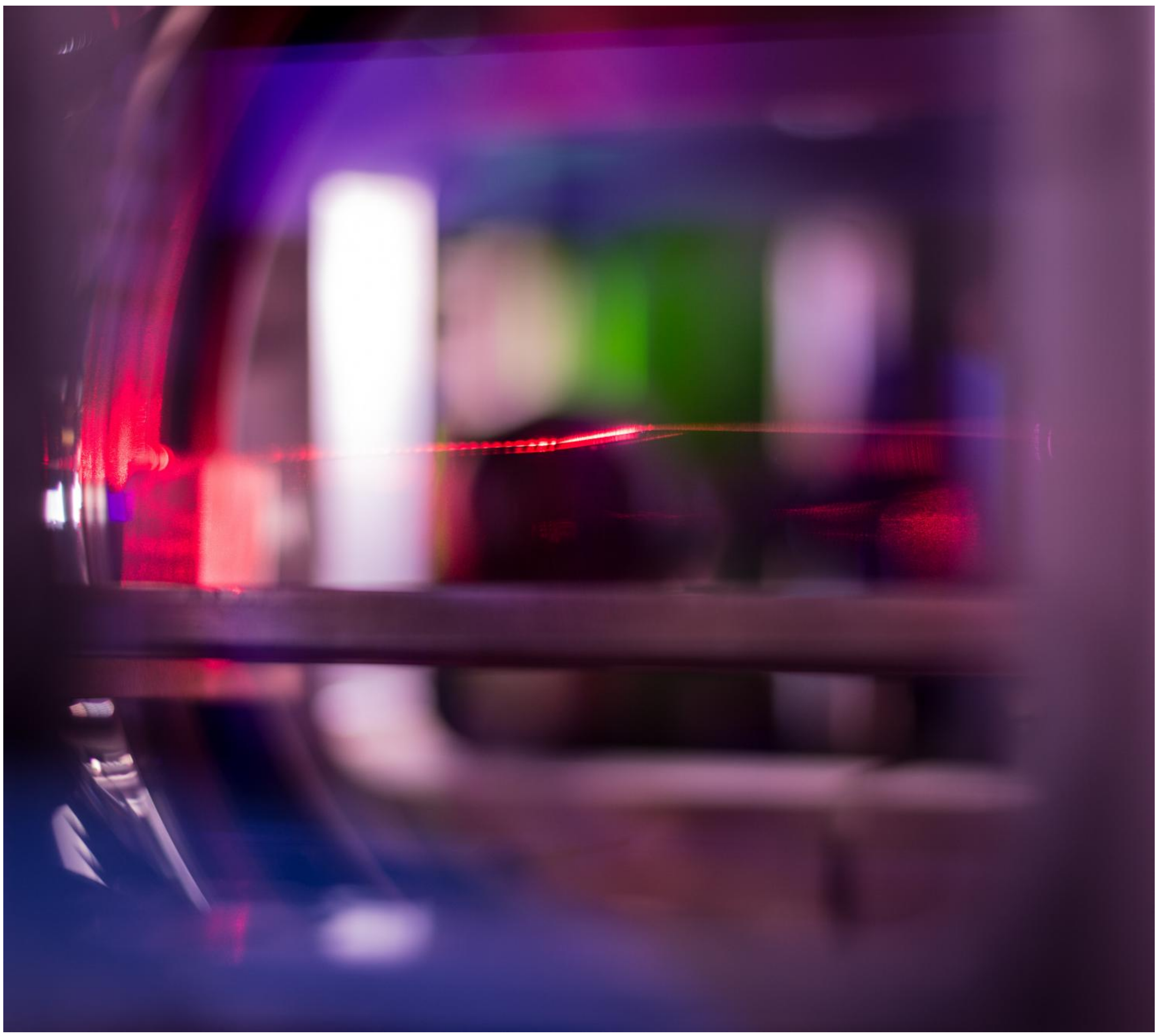

An array of about 2000 cold atoms trapped in the vicinity of a nanoscale fiber enables to realize an efficient mirror for the guided light. Credit: Laboratoire

Kastler Brossel – N.V. Corzo

Mirrors are the simplest means to manipulate light propagation. Usually, a mirror is a macroscopic object composed of a very large number of atoms. In the September 23th issue of the *Physical Review Letters*, Prof. Julien Laurat and his team at Pierre and Marie Curie University in Paris (Laboratoire Kastler Brossel-LKB) report that they have realized an efficient mirror consisting of only 2000 atoms. This paper is accompanied by a "Focus" item in *APS-Physics*.

By engineering the position of cold atoms trapped around a nanoscale fiber, the researchers fulfill the necessary conditions for Bragg reflection, a well-known physical effect first proposed by William Lawrence Bragg and his father William Henry Bragg in crystalline solids. They earned the Nobel Prize for this work in 1915. In the current experiment, each trapped atom contributes with a small reflectance, and the engineered position allows the constructive interference of multiple reflections.

"Only 2000 atoms trapped in the vicinity of the fiber were necessary, while previous demonstrations in free space required tens of millions of atoms to get the same reflectance," says Neil Corzo, a Marie-Curie postdoctoral fellow and the lead author of this work. He adds, "This is due to the strong atom-photon coupling and the atom position control that we can now achieve in our system."

The key ingredient is a nanoscale fiber, whose diameter has been reduced to 400 nm. In this case, a large fraction of the light travels outside the fiber in an evanescent field where it is heavily focused over the 1-cm nanofiber length. Using this strong transversal confinement, it is possible to trap cold cesium atoms near the fiber in well-defined chains. The trapping is made with the implementation of an all-fibered dipole trap. With the use of well-chosen pairs of beams, the researchers generate two chains of trapping potentials around the fiber, in which only one atom occupies each site. By selecting the correct colors of the trap beams, they engineered the distance between atoms in the chains to be close to half the resonant wavelength of the cesium atoms, fulfilling the necessary conditions for Bragg reflection.

This setting represents an important step in the emerging field of waveguide quantum electrodynamics, with applications in quantum networks, quantum nonlinear optics, and quantum simulation. The technique would allow for novel quantum network capabilities and many-body effects emerging from long-range interactions between multiple spins, a daunting prospect in free space.

This demonstration follows other works that Laurat's group has done in recent years, including the realization of an all-fibered optical memory.

More information: "Large Bragg reflection from one-dimensional chains of trapped atoms near a nanoscale waveguide," *Physical Review Letters* 117, 133603 (2016). doi.org/10.1103/PhysRevLett.117.133603

Focus by *APS-PHYSICS*: "Strong light reflection from few atoms." physics.aps.org/articles/v9/109

B. Gouraud et al. Demonstration of a Memory for Tightly Guided Light in an Optical Nanofiber, *Physical Review Letters* (2015). DOI: 10.1103/PhysRevLett.114.180503

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