Demonstrating 'vectorial' polaritons by levitating a nanosphere inside an optical cavity

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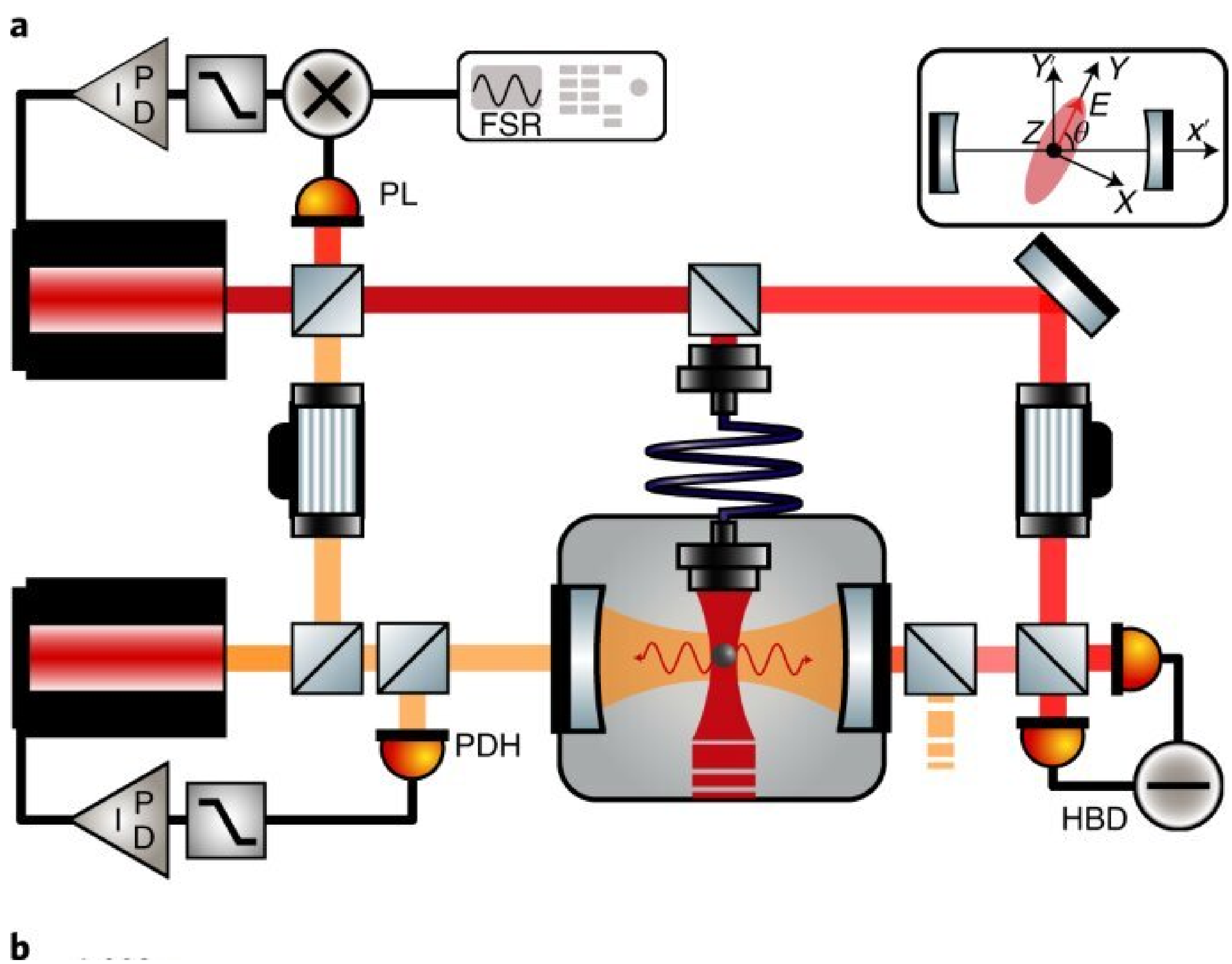

Figure 1. Credit: DOI: 10.1038/s41567-021-01307-y

A team of researchers from the European Laboratory for Non-Linear Spectroscopy, INFN, Sezione di Firenze and Università di Firenze has demonstrated a form of "vectorial" polariton by levitating a nanosphere inside of an optical cavity. In their paper published in the journal *Nature Physics*, the group describes their work and possible uses for their results. Tania Monteiro with University College London has published a News & Views piece in the same journal issue outlining prior work involved in gaining quantum control using polarizable nanoparticles and the work done by the team on this new effort.

As Monteiro notes, strong coupling is an unusual hybrid state of light interactions in which the state cannot be described using just the matter and light components involved. And as she also notes, polaritons are hybrid states created by interactions of light and matter that exist in a wide variety of venues. In this new effort, she explains, "vectorial" polaritons—condensed-matter quasiparticles—result from levitating a nanosphere inside of an optical cavity in a way that leads to light hybridizing with the motion that occurs on a plane instead of along an axis.

In their work, the team employed a coherent scattering approach whereby a nanosphere was first trapped using a tweezer trap inside of a vacuum. The team then created an X and Y axis using the tweezer potential, which resulted in the development of a plane perpendicular to the incoming laser light used to create the tweezers. Scattered tweezer photons were then used to populate the cavity. In the arrangement, the cavity field coupled strongly with the motion of both the X and Y axes, though more strongly with the X axis. Mirrors were used to promote higher quantum cooperation, which allowed the system to become a quantum coherent regime in which the rate of information exchange began to exceed the lifetime coherence. The result was the demonstration of vectorial polaritons.

The demonstration could pave the way toward new ways to transfer quantum information and also marks a step toward the creation of optomechanical entanglement at room temperature.

More information: A. Ranfagni et al, Vectorial polaritons in the quantum motion of a levitated nanosphere, *Nature Physics* (2021). DOI: 10.1038/s41567-021-01307-y