Rotational superradiance in a polariton fluid of ligth

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The amplification of field excitations in rotating systems is a universal phenomenon known as rotational superradiance. Initially predicted in shear layers of water flows, rotational superradiance was later recognized as a fundamental aspect of black hole physics [1]. It has also been recently proposed to govern the instability of multiply quantized vortices in quantum fluids [3] [4], though direct experimental evidence remains elusive. In this work, we leverage the high optical tunability of our system to generate a multiply charged vortex fluid profile. By probing the excitation spectrum across the vortex with an optical beam, we reveal the presence of negative energy modes at the vortex core, indicative of an ergoregion—a necessary feature for rotational superradiance. Furthermore, we show that the excitation of these negative energy modes drives vortex instability, with their depletion being compensated by the generation of positive energy modes at larger radii. Finally, we demonstrate that this mechanism leads to the amplification of the probe field. These findings open new perspectives on quantum rotational superradiance, particularly the entanglement between negative- and positive-energy waves, a phenomenon recently predicted in our system [2]. Such effects could be explored using quantum optics techniques.

References

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