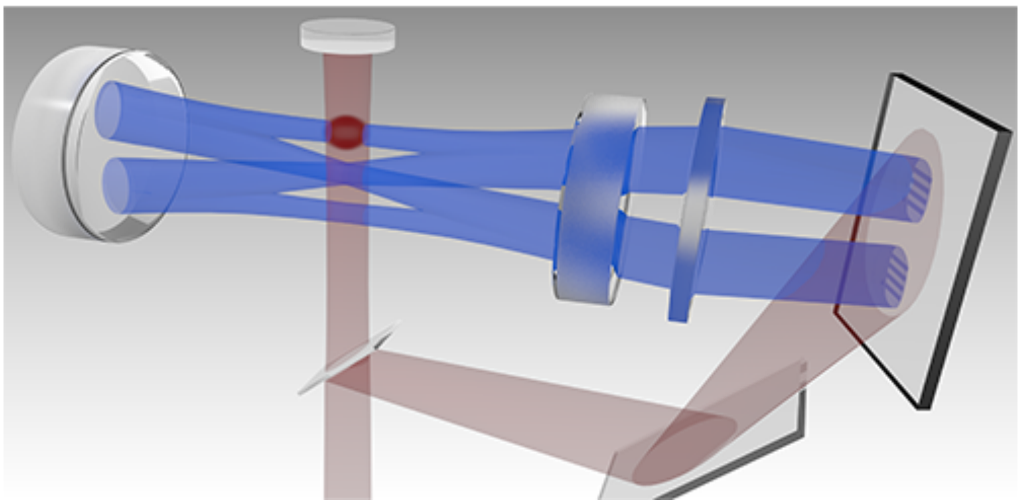
Synopsis: A Step Toward Simulating Spin Glasses

May 14, 2019

Cavity-mediated interactions can force two Bose-Einstein condensates into one of two mutually exclusive states, potentially allowing for quantum simulation of spin frustration.



Y. Guo *et al.*, Phys. Rev. Lett. (2019)

Atomic condensates in an optical cavity can potentially be used to simulate various quantum systems. One of these—an exotic magnet known as a spin glass—comprises a network of interacting particles, each of which can take one of two spin states. Now, researchers are a step closer to simulating these interactions. Yudan Guo at Stanford University, California, and colleagues have shown that two Bose-Einstein condensates (BECs) in a cavity can organize themselves into either of two possible states, which could stand in for the two spin states in a spin glass.

The team confined two BECs in a cavity and pumped them with a laser, causing the atoms in each BEC to scatter pump photons into the cavity. By exchanging momentum via these cavity photons, each BEC changed from having a simple density maximum at the atomic cloud's center to having a density that oscillated in space in two perpendicular directions. These multiple density peaks formed a sort of "checkerboard" pattern. The relative positions of the BECs, which the researchers controlled with optical traps, determined whether the density-wave patterns in the two clouds had the same or opposite phase.

With control over the BEC-BEC interaction, Guo and colleagues say that researchers could simulate a frustrated system such as a spin glass by confining three or more BECs in the cavity. In this case, the phase of the density-wave pattern would emulate particle spin, with the system arranged so that no configuration could satisfy every condensate's phase preference simultaneously.

This research is published in ***Physical Review Letters*** and ***Physical Review A***.

–Marric Stephens

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Subject Areas

Atomic and Molecular Physics

Condensed Matter Physics

Sign-Changing Photon-Mediated Atom Interactions in Multimode Cavity Quantum Electrodynamics

Yudan Guo, Ronen M. Kroeze, Varun D. Vaidya, Jonathan Keeling, and Benjamin L. Lev

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Emergent and broken symmetries of atomic self-organization arising from Gouy phase shifts in multimode cavity QED

Yudan Guo, Varun D. Vaidya, Ronen M. Kroeze, Rhiannon A. Lunney, Benjamin L. Lev, and Jonathan Keeling

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