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Free-space, multimode spatial self-organization of cold, thermal atoms[1] BONNIE L. SCHMITTBERGER, JOEL A. GREENBERG, DANIEL J. GAUTHIER, Duke University — The collective behavior of atoms upon interaction with light has been a topic of increasing interest since it was shown to lead to novel phase transitions. In order to induce a spontaneously-emergent lattice structure, cold atoms are typically placed in a cavity, which provides a sufficiently strong light-matter interaction. While many experiments have employed single-mode cavities, the use of multimode cavities would explore a new regime with the potential to study phenomena such as dislocations and topological defects. However, multimode cavities present certain technical challenges, and a strongly-interacting multimode system existing in free space is desirable. We create such a system by trapping cold, thermal atoms in a highly anisotropic MOT. When we shine counterpropagating beams along the long axis of our trap, we observe a superradiant phase transition from a homogeneous array of atoms to one that is spatially organized. We are able to infer information about this spatial self-organization by observing the superradiant light that is emitted in the form of transverse optical patterns. We find that the patterns spontaneously hop between spatial modes during single realizations of the experiment, and we study the effects of quantum fluctuations on the atomic organization.

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