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Optical Pattern Formation in Cold Atoms: Explaining the Red-Blue Asymmetry[1] BONNIE L. SCHMITTBERGER, DANIEL J. GAUTHIER, Duke University — The study of pattern formation in atomic systems has provided new insight into fundamental many-body physics and low-light-level nonlinear optics. Pattern formation in cold atoms in particular is of great interest in condensed matter physics and quantum information science because atoms undergo self-organization at ultralow input powers. We recently reported the first observation of pattern formation in cold atoms but found that our results were not accurately described by any existing theoretical model of pattern formation. Previous models describing pattern formation in cold atoms predict that pattern formation should occur using both red and blue-detuned pump beams, favoring a lower threshold for blue detunings. This disagrees with our recent work, in which we only observed pattern formation with red-detuned pump beams. Previous models also assume a two-level atom, which cannot account for the cooling processes that arise when beams counterpropagate through a cold atomic vapor. We describe a new model for pattern formation that accounts for Sisyphus cooling in multi-level atoms, which gives rise to a new nonlinearity via spatial organization of the atoms. This spatial organization causes a sharp red-blue detuning asymmetry, which agrees well with our experimental observations.

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