Saturation-Induced Bistability in the Resonant Regime

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We report on the observation of a novel manifestation of saturation-induced optical bistability in a resonantly pumped optical ring cavity interacting strongly with a cloud of atoms via a narrow atomic transition. The bistability emerges, above a critical pump rate, as an additional peak in the cavity's normal mode spectrum close to atomic resonance. This third transmission peak is usually suppressed due to strong resonant absorption, but in our experiment it is visible because of the linewidth of the atomic transition being much smaller than that of the cavity, which sets the experiment deep into the bad-cavity regime. Relying on complete saturation of the transition, this bistability has a quantum origin and cannot be mimicked by a classical material presenting a nonlinear refraction index. The appearance of the central peak in addition to the normal modes is predicted by a semi-classical model derived from the Tavis-Cummings Hamiltonian from which we derive a bistability phase diagram that connects our observations with former work on optical bistability in the good cavity regime. The phase diagram reveals several so far unexplored bistable phases.