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A Superradiant Raman Laser with $<$ 1 Intracavity Photons JUSTIN BOHNET, ZILONG CHEN, JOSHUA WEINER, DOMINIC MEISER, MURRAY HOLLAND, JAMES THOMPSON, University of Colorado at Boulder, JILA — We have demonstrated a cold-atom Raman laser operating deep in the bad-cavity (or superradiant) regime, where the atomic linewidth is much narrower than the cavity linewidth. The collective light-atom excitation is stored predominately in the atoms, with intracavity photon number as low as 0.2 photons. The low intracavity photon number isolates the collective atomic dipole from the environment – a possible future method for overcoming thermal fluctuations of cavity mirrors that presently limit the stability of state-of-the-art lasers. This laser linewidth is measured to be $> 10^4$ below the Schawlow-Townes linewidth that normally applies to good-cavity optical lasers, as well as below single particle linewidths. Our system confirms key predictions that may enable the creation of superradiant lasers using highly forbidden atomic transitions that would have earth-sun coherence lengths, might improve optical atomic clocks by orders of magnitudes, and would contribute to searches for new physics beyond the standard model.

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