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Mean Field Theory of Resonant Matter Wave Amplification[1]
YUPING HUANG, MICHAEL MOORE, Michigan State University — Previous studies of matter wave amplification (MWA) in Bose- Einstein condensates have focused on the off-resonance regime, where the excited electronic state is only virtually occupied, resulting in a relatively slow amplification rate. In order to determine the maximum obtainable MWA rate, we investigate Raman MWA in the resonant regime, using intense nanosecond pulses to complete the amplification process on a time scale where spontaneous emission can be neglected. We find that phase-coherent MWA is still possible even when the transition is fully saturated. The MWA rate initially increases linearly with the laser intensity and then saturates when the Rabi frequency of the driving pulse becomes comparable to the superradiance-broadened linewidth of the excited state. We compare two theoretical approaches: 1) a master-equation treatment of a coupled-mode model with no spatial dynamics, and 2) a full multi-mode solution of the Maxwell-Schrödinger dynamics. We find that spatial effects become significant only when the sample size of seed wave surpasses that of gain medium, after which the MWA process is slowed by at least an order of magnitude.

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