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Tunable Spin-orbit Coupling and Quantum Phase Transition in a Trapped Bose-Einstein Condensate YONGPING ZHANG, GANG CHEN, CHUANWEI ZHANG, Department of Physics and Astronomy, Washington State University, Pullman, WA, 99164 USA — Spin-orbit coupling (SOC), the intrinsic interaction between a particle spin and its motion, is responsible for various important phenomena, ranging from atomic fine structure to topological condensed matter phenomena. While the SOC strength in typical solid state materials is much smaller than the Fermi velocity of electrons, it can reach the same order or even beyond the Fermi velocity of atoms in a recent breakthrough experiment that realizes SOC for ultra-cold atoms. However, the SOC strength in the experiment, determined by the applied laser wavelengths, is not tunable. Here we propose a scheme for tuning the SOC strength through a fast modulation of the laser intensities. We find that tuning SOC strength can drive a quantum phase transition (QPT) from a spin-balanced to a spin-polarized state in a harmonic trapped Bose-Einstein condensate (BEC). The QPT is similar as that in the long-sought Dicke model in quantum optics, which has important applications in quantum information. We characterize the QPT using the periods of collective oscillations (center of mass motion and scissors mode) of the BEC, which show pronounced peaks and damping around the quantum critical point.

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