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Light-induced Abelian and non-Abelian gauge potentials for cold atoms

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In the initial part of the talk we shall review schemes enabling to produce an artificial magnetic field for cold atoms using several light beams. We discuss possibilities to create both Abelian and also non-Abelian gauge potentials. Subsequently we present a novel scheme simulating a spin-orbit coupling of the Rashba-Dresselhaus (RD) type for cold atoms [1]. The RD coupling is known to be described by a non-Abelian vector potential proportional to the spin-1/2 operator. It applies not only to electrons in semiconductors and also to cold atoms. For cold atoms, the RD coupling can be generated by means of a tripod scheme in which the laser beams couple three atomic ground states with an extra state [2-6]. The RD coupling is then formed for atoms populating two internal dark states. However the dark states are not the ground states of the tripod atom. This is a drawback in studying the Bose-Einstein condensation in the presence of the RD coupling [7,8]. Here we propose and analyze an alternative setup where the light beams couple three or four atomic levels in a close loop topology [1]. By properly setting amplitudes and phases of the laser beams, one can arrive at a twice degenerate atomic ground state manifold affected by the RD coupling. We discuss implementations of this scheme using the Raman transitions between the hyperfine levels of the ground state manifold.

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