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Ultracold atoms in a cavity: synthetic gauge fields and cavity-mediated long-range interactions FAROKH MIVEHVAR, DAVID FEDER, University of Calgary — The collective coupling of ultracold neutral atoms to electromagnetic fields in cavity QED results in cavity-mediated long-range atom-atom interactions, paving the way for the realization of strongly correlated states and collective phenomena. That said, quantum Hall and topological insulator states are not directly accessible in these environments because they require the coupling of the particles' center-of-mass motion to external magnetic fields and to internal spin degrees of freedom, respectively. In this work, we show that coupling three-level atoms to two counter-propagating ring-cavity modes in the Λ scheme can give rise to synthetic spin-orbit interactions and large synthetic magnetic fields. In the presence of an additional optical lattice, the Hamiltonian in the weak-coupling regime corresponds to an effective spin-orbit coupled Hubbard model for the atoms in the first Bloch band, including a variety of long-range atom-atom interactions. The eigenstates of this model are explored for various choices of the parameters.

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