MAR17-2016-020114

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Dynamic gauge fields and topological state of fermionic quantum gases in optical cavities

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The realization and control of topologically non-trivial quantum phases is currently of great interest after discovery of the topological insulators. The extended edge state existing in such materials are non-local and linked to the topological characteristics of the bulk. Therefore they are well protected against environmental influences and ideal candidates for quantum computation. It is not easy to manipulate the topologically protected quantities, which are typically of non-local character, via local and unitary operations. This difficulty can be overcome by coupling atoms to the cavity field which leads to an effective long-range interaction betweem atoms. We discuss how a fermionic quantum gas confined to a two-dimensional optical lattice and coupled to an optical cavity together with a running pump laser beam, can organize into a topologically non-trivial state. The cavity field emerges spontaneously and induces a dynamical gauge field. This feedback leads to the self-organization of the topological quantum state which carries an extended edge state as the attractor state of a dissipative dynamics in a finite system.