CO.CO.MAT

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An optical lattice based quantum simulator for relativistic fermions and topological insulators

We present a proposal for a versatile cold-atom-based quantum simulator of relativistic fermionic theories and topological insulators in arbitrary dimensions [1]. The setup consists of a spin-independent optical lattice that traps a collection of hyperfine states of the same alkaline atom, to which the different degrees of freedom of the field theory to be simulated are then mapped. We show that the combination of bi-chromatic optical lattices with Raman transitions can allow the engineering of a spin-dependent tunneling of the atoms between neighboring lattice sites. These assisted-hopping processes can be employed for the quantum simulation of various interesting models, including the realization of different types of relativistic lattice fermions, which can then be exploited to synthesize a majority of phases in the periodic table of topological insulators. An example concerns how to implement Wilson fermions with inverted masses: the atomic gas corresponds to a phase of matter where Maxwell electrodynamics is replaced by axion electrodynamics, i.e. a 3D topological insulator [2].

[1] L. Mazza, A. Bermudez, N. Goldman, M. Rizzi, M.A. Martin-Delgado and M. Lewenstein, New J. Phys. bf 14 015007 (2012)

[2] A. Bermudez, L. Mazza, M. Rizzi, N. Goldman, M. Lewenstein and M.A. Martin-Delgado, Phys. Rev. Lett. 105 190404 (2010)

4. April 2012, 14:00 Uhr

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