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Spin Squeezing for Ultracold Fermions in Optical Lattices

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Generation, storage and utilization of correlated many-body quantum states are crucial objectives of future quantum technologies and metrology. Such states can be generated by the spin-squeezing protocols. In this work [1-2], we consider the dynamical generation of spin squeezing in a lattice system composed of ultracold fermionic atoms in the Mott phase at half-filling. To induce the generation of squeezing, there is a position-dependent laser coupling between the internal degrees of freedom of atoms. We study the Ramsey-type spectroscopy scheme in which the atom-light coupling is turned on during the interrogation time. By choosing an appropriate propagation direction of the laser beam inducing the spin-orbit coupling and acting on a fermionic lattice with a sequence of such laser pulses we expect to realize efficient spin-squeezing. We show analytically, using the perturbation theory, how the Fermi-Hubbard model with the atom-light coupling effectively simulates the one-axis twisting model with the tunable axis of squeezing. This paves the way for the simulation of the famous two-axis counter-twisting model when two laser couplings are used during interrogation time. The presented method can be applied in optical clocks.

References

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