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Controlling interaction of ultracold atoms in an optical superlattice[1]

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First, I will briefly review the methods to control spin- exchange interaction for ultracold atoms in an optical lattice [1], and the recent experimental techniques to demonstrate the second-order tunneling responsible for the spin exchange interaction with a superlattice [2]. Then, I will discuss the interaction for strongly interacting atoms in a lattice near a wide Feshbach resonance. The strong interaction brings in a number of new features such as multi-band populations and direct neighboring interaction. Under certain circumstances, this complicated system can be described by an effective single- band model (the general Hubbard model) which has particle assisted tunneling for the atoms [3]. The particle assisted tunneling means that the effective atomic tunneling rate from the site i to j depends on whether there is another atom on these two sites. The particle assisted tunneling brings in new feature for quantum many-body physics. I will describe an experimental scheme to test the prediction of the particle assisted tunneling for strongly interacting atoms based on the use of the optical superlattice technique [4].

[1] L.-M. Duan, E. Demler, M. D. Lukin, Controlling Spin Exchange Interactions of Ultracold Atoms in Optical Lattices, Phys. Rev. Lett. 91, 090402 (2003).

[2] S. Fölling, S. Trotzky, P. Cheinet, M. Feld, R. Saers, A. Widera, T. Müller, I. Bloch, Direct Observation of Second Order Atom Tunnelling, Nature 448, 1029 (2007).

[3] L.-M. Duan, Effective Hamiltonian for fermions in an optical lattice across a Feshbach resonance, cond-mat/0508745, Phys. Rev. Lett. 95, 243202 (2005); L.-M. Duan General Hubbard model for strongly interacting fermions in an optical lattice and its phase detection, arXiv:0706.2161, Europhys. Lett. 81, 20001 (2008).

[4] T. Goodman, L.-M. Duan, Test of particle assisted tunneling with strongly interacting atoms in an opticla superlattice, in preparation.

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