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TOPOLOGICAL CHARGE PUMPING IN SUBWAVELENGTH OPTICAL LATTICES

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Ultracold atoms in optical lattices represent a unique platform for simulating various condensed matter phenomena as well as realizing paradigmatic models. However, conventional optical lattices for ultra-cold atoms rely on the AC Stark shift to produce a potential proportional to the local optical intensity. As a direct result, the lattice period cannot be smaller than half the optical wavelength λ. Recently, two techniques have emerged to create deeply sub-wavelength lattices [1, 2, 3]; both can be understood in terms of "dressed states" created by coupling internal atomic states with one- or two- photon optical fields.

Here we focus on a scheme, relying on sequentially coupling N internal atomic states using two photon Raman transitions. This results in an adiabatic potential for each of the N dressed states, displaced by $\lambda/2N$ from each other. We show that adding temporal modulation to the detuning from Raman resonance can couple the s and p bands of adjacent lattice sites belonging to different dressed states. In the tight-binding limit, this gives rise to a pair of coupled Rice-Mele (RM) chains with new regimes of topological charge pumping. The present study opens new possibilities in studying the topological properties of subwavelength optical lattices induced by periodic driving.

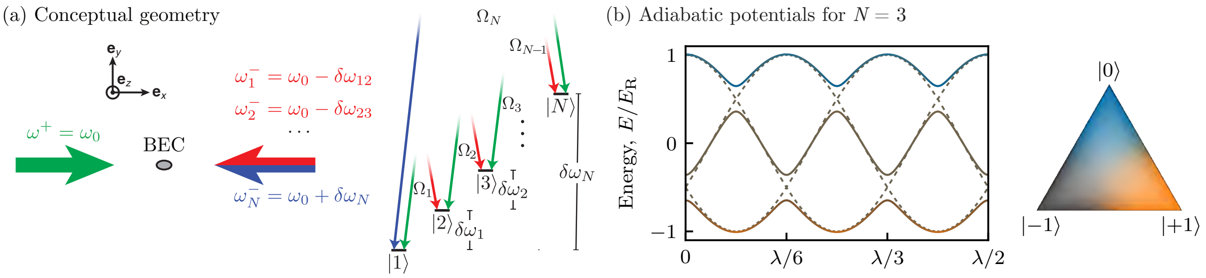

Fig. 1. Lattice concept. (a) Representative experimental geometry with a single frequency Raman beam traveling along $\boldsymbol{e}_x$ and N beams sharing the same spatial mode traveling along $-\boldsymbol{e}_x$. The level diagram for cyclic coupling is depicted on the right. (b) Dressed state energies for $N = 3$. The dashed curves are computed for $\Omega_j = E_R$ and the colored curves are computed with a non-zero detuning.

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