Simulating spin-lattice models with cold Rydberg atoms

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Spin lattice models play central role in the studies of quantum magnetism and non-equilibrium dynamics of spin excitations – magnons. But realizing tunable spin lattices in the quantum regime is challenging [1, 2, 3, 4]. We show that a spin lattice with strong nearest-neighbor interactions and tunable long-range hopping of excitations can be realized by a regular array of laser driven atoms, with an excited Rydberg state representing the spin-up state and a Rydberg-dressed ground state corresponding to the spin-down state [5]. We find exotic interaction-bound states of magnons that propagate in the lattice via the combination of resonant two-site hopping and non-resonant second-order hopping processes.

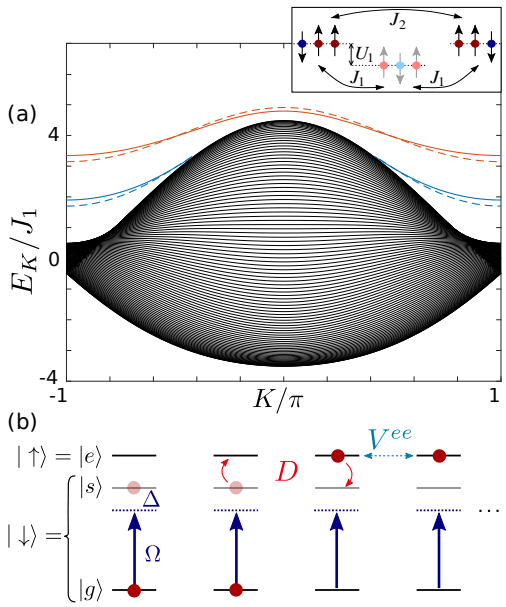

FIG. 1: (a) Spectrum of the scattering and bound states of two spin (Rydberg) excitations in a lattice versus the center of mass quasi-momentum K. Inset illustrates the motion of the bound pair via resonant two-site hopping and second order hopping. (b) Level scheme of Rydberg-dressed atoms to realize a tunable spin-lattice model.

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