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Quantum liquids in low dimensional lattices

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The ground-state properties of two-component bosonic mixtures in a one-dimensional optical lattice are studied both from few- and many-body perspectives. We rely directly on a microscopic Hamiltonian with attractive inter-component and repulsive intra-component interactions to demonstrate the formation of a quantum liquid. We reveal that its formation and stability can be interpreted in terms of finite-range interactions between dimers. We derive an effective model of composite bosons (dimers) which correctly captures both the few- and many-body properties and validate it against exact results obtained by DMRG method for the full Hamiltonian. The threshold for the formation of the liquid coincides with the appearance of a bound state in the dimer-dimer problem and possesses a universality in terms of the two-body parameters of the dimer-dimer interaction, namely scattering length and effective range. For sufficiently strong effective dimer-dimer repulsion we observe fermionization of the dimers which form an effective Tonks-Girardeau state. Finally, we identify conditions for the formation of a solitonic solution.

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