QUANTUM MANY-BODY PHASES IN SUBWAVELENGTH BRICK WALL LATTICE

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The study of quantum many-body systems has led to the discovery of numerous exotic quantum phases of matter, driven by the interplay between particle interactions, quantum fluctuations, and symmetry breaking. Among these, pair superfluids [1] and supersolids are particularly fascinating, as they represent different manifestations of quantum coherence and collective behavior in strongly correlated systems. In this paper, we propose a state-dependent lattice [2] for ultracold bosons based on a particular tripod atom-light coupling scheme [3]. We show that it manifests an extended Bose-Hubbard model and we explore the emergence of novel quantum phases, chief among them (pair) superfluids, supersolids, and Mott insulators.
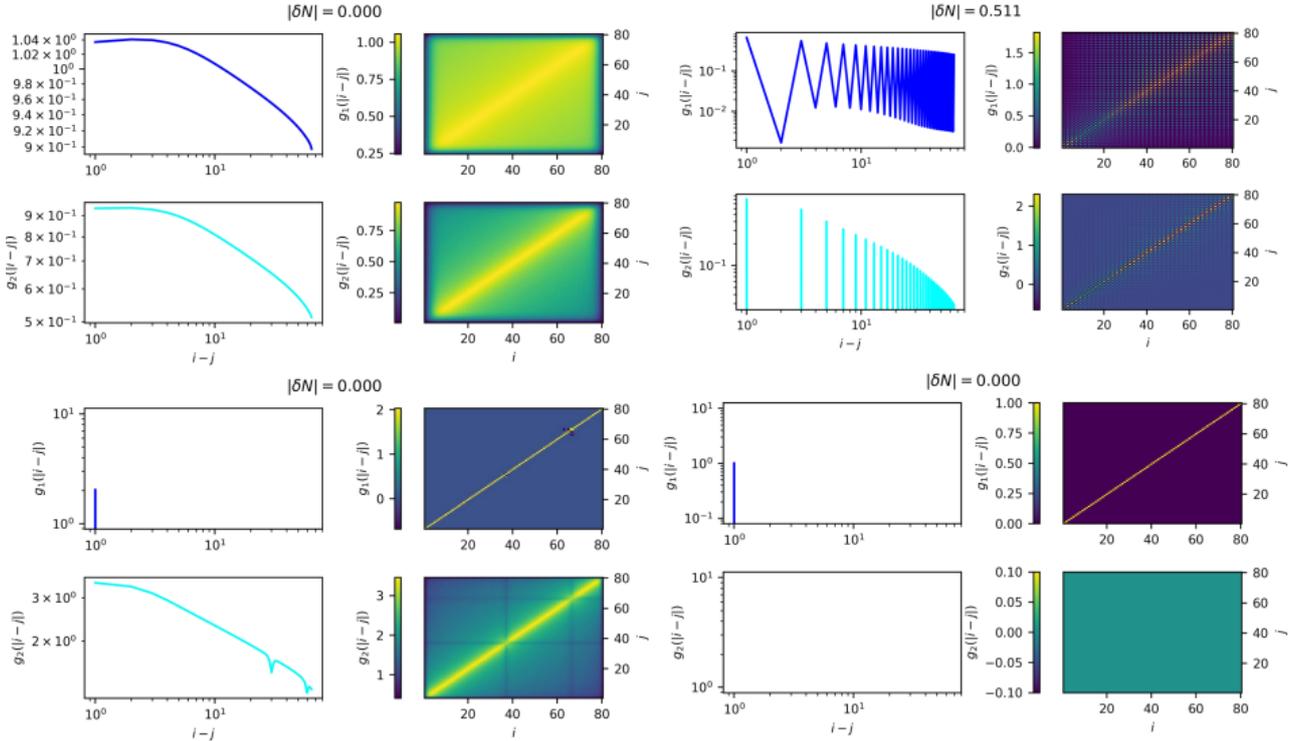
Fig. 1. Bottom-right (MI): Quantities for following p-band parameters in canonical ensemble: J1 = J2 = 0, g0 = 1.0, gx = 0, gz = 0, G000 = 1.0, G011 = −G001 = 0.5, Npart = Nlat , Nlat = 80, boson-dim= 6 Top-right (SS): Quantities for following p-band parameters in canonical ensemble: J1 = −0.1/ √10, J2 = 0.1, g0= 0.5, gx = −0.5, gz = 0.05, G000 = 1, G011 = −G001 = 0.5, Npart = Nlat , Nlat = 80, boson-dim= 6. Top-left (SF): Quantities for following p-band parameters in canonical ensemble: J1 = J2 = 0, g0 = 1.0, gx = 0, gz = 1.0, G000 = 1, G011 = −G001 = 0.5, Npart = Nlat , Nlat = 80, boson-dim= 6. Bottom-left (PSF): Quantities for following p-band parameters in canonical ensemble: J1 = J2 = 0, g0 = 0.1, gx = 1.0, gz = 0, G000 = 1, G011 = −G001 = 0.5, Npart = 2Nlat , Nlat = 80, boson-dim= 6.

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