Many-body Anderson localization of strongly interacting Bose-Einstein condensates in disordered lattices

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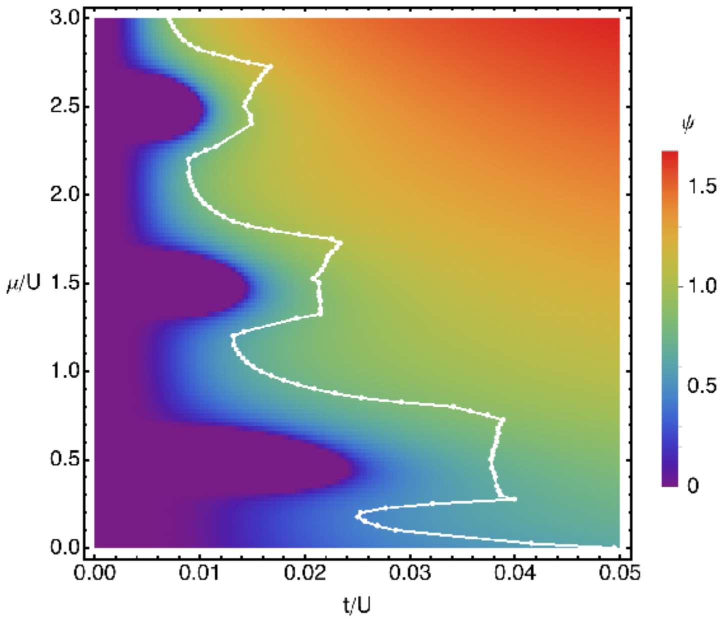
We have developed the transport theory for a Bose gas in the disordered Bose-Hubbard model in the regime of strong, repulsive interactions, i.e. in the vicinity of the Mott lobes of vanishing Bose-Einstein condensate (BEC) amplitude. In contrast to previous approaches, the Bose glass phase in a disordered system should be defined not via a vanishing averaged BEC amplitude with finite compressibility, but via vanishing superfluid transport. That is, we define the Bose glass phase as the state where the averaged BEC amplitude is finite, but the superfluid current vanishes due to Anderson localization of the interacting BEC wave functions and its many-body excitations (Anderson localized, BEC puddles). The theory is based on a calculation of the on-site many-body eigenstates within a stochastic mean-field theory which treats the on-site Hubbard interaction exactly by diagonalizing the local part of the Bose-Hubbard Hamitonian exactly in Fock space. Non-local effects of the interaction are neglected in analogy to dynamical mean-field theory (DMFT). The transport theory for these hopping many-body states, including quantum interference processes (Cooperons) is formulated as a generalization of the self-consistent theory of Anderson localization. The theory describes semiquantitatively the Mott localized phase (Mott lobes), the superfluid phase and the Bose glass phase as well as the respective phase transitions. In particular, the theory obeys the theorem of inclusions which states that in a disordered system there is no direct transition from the Mott phase to the superfluid phase.



Phase diagram of the disordered Bose-Hubbard model in d=3 for disorder parameter $W/U = 0.6$. U: Hubbard repulsion, t: hopping, μ: chem.potential. The color code represents the modulus of the averaged BEC order parameter. White line with dots: phase transition line between the superfluid (right) and the Bose glass (left of the line).