Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **36** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

2PI strong coupling approach to out of equilibrium dynamics of the clean and disordered Bose Hubbard model

Thursday 12 June 2025 14:00 (15 minutes)

Out of equilibrium phenomena in the Bose-Hubbard model (BHM), such as the spreading of correlations, thermalization and many-body localization have attracted considerable interest in recent years. We have developed a two particle irreducible (2PI) strong coupling (2PISC) approach that allows us to access out of equilibrium phenomena in dimensions higher than one. We have investigated the spreading of correlations in one, two and three dimensions and find quantitative agreement with measurements of the speed of spreading of single-particle correlations in both the one- and two-dimensional BHM realized with ultracold atoms. We demonstrate that there can be large differences between the phase and group velocities for the spreading of correlations and explore how the anisotropy in the velocity varies across the phase diagram of the BHM. We have also applied the 2PISC approach to the disordered Bose-Hubbard model and obtained equations of motion for spatio-temporal correlations and explored their equilibrium solutions, including phase diagrams. We note that the disorder strengths where the emergence of non-ergodic dynamics was observed experimentally in the two dimensional disordered BHM [Choi *et al.*, Science **352**, 1547 (2016)] appear to correspond to the Mott insulator - Bose glass phase boundary. Most recently we have used machine learning methods to obtain quantitative improvements to our calculations of single particle correlations. Our results establish the 2PISC approach as a powerful tool to study out-of-equilibrium dynamics in the BHM in dimensions greater than one.

Keyword-1

Bose Hubbard Model

Keyword-2

Out of equilibrium dynamics

Keyword-3

Disorder

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Session Classification: (DCMMP) R1-2 Quantum and Strongly Correlated Materials | Matériaux quantiques et fortement corrélés (DPMCM)

Track Classification: Technical Sessions / Sessions techniques: Condensed Matter and Materials Physics / Physique de la matière condensée et matériaux (DCMMP-DPMCM)