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Propagation of correlations in the Bose Hubbard model

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Lieb-Robinson and related bounds set an upper limit on the speed at which information propagates in non-relativistic quantum systems. Experimentally, light-cone-like spreading has been observed for correlations in the Bose-Hubbard model (BHM) after a quantum quench. Using a two-particle irreducible (2PI) strong-coupling approach to out-of-equilibrium dynamics in the BHM we calculate both the group and phase velocities for the spreading of single-particle correlations in one, two, and three dimensions as a function of interaction strength in the Mott insulating phase. Our results are in quantitative agreement with recent 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. Our results establish the 2PI strong-coupling approach as a powerful tool to study out-of-equilibrium dynamics in the BHM in dimensions greater than one.

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