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Nonequilibrium quantum dynamics of a charge carrier doped into Mott insulator

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We study real-time dynamics of a single carrier moving in a strongly-correlated medium under a constant electric field described by a two-dimensional t-J system, i.e., a ladder and 2D square lattice. The understanding of this subject does not only provide an extension of equilibrium studies of a charge carrier doped into the antiferromagnetic (AFM) background, but it primarily represents a fundamental problem of a quantum particle moving in a dissipative medium where the picture of Bloch oscillations breaks down and a particle acquires a constant non-zero velocity.

Three most important findings of our study are the following:

(i) By applying exact-diagonalization technique for a ladder, we present a scaling which effectively singles out the heating of the spin background when the carrier repeatedly encircles the ladder. As a consequence, a linear current-voltage (I-V) characteristics emerges and a carrier mobility is calculated.

(ii) For 2D lattice, we show how the application of a novel numerical method designed to describe properties of a doped charge carrier moving in AFM background, enables calculations of real-time quantum dynamics and can reach quasistationary conditions for different F.

(iii) We calculate I-V characteristics for 2D lattice which reveal regimes of positive and negative differential resistivity. The former regime provide estimation of carrier mobility while in the latter regime the current decreases with increasing field as 1/F.

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