Energy Relaxation Dynamics in Harper Model coupled with a Small Number of Phonon Modes

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Energy relaxation dynamics in Harper model coupled with small number of phonon modes is numerically investigated[1,2]. The time-dependent Shrődinger equation that we simulate is

$$
\begin{aligned}
-i\hbar\frac{\partial \Psi(n,\{q_j\},t)}{\partial t} &= \Psi(n+1,\{q_j\},t)+\Psi(n-1,\{q_j\},t)+ \\
\{\sum_{j=1}^{M}\left(\frac{\hat{p}_j^2}{2}+\frac{\omega_j^2\hat{q}_j^2}{2}\right) &+ \sum_{n=1}^{N}\sum_{j=1}^{M} b_j V(n)\hat{q}_j + V(n,t)\}\Psi(n,\{q_j\},t), \quad (1) \\
V(n,t) &= V(n)(1+\frac{\epsilon}{\sqrt{L}}\sum_{i=1}^{L}\cos(\Omega_i t+\theta_i)), \quad (2)
\end{aligned}
$$

where the $\Psi(n,\{q_j\},t)$ represent the wave function of the whole system in a site basis. As a non-perturbed electronic system($M=0, L=0$), we use Harper model, i.e. $V(n)=2V_0\cos(2\pi\alpha n)$, where the α is inverse golden mean ($\alpha=\frac{\sqrt{5}-1}{2}$). It is well-known that without the interaction with phonon modes, i.e. the Harper model, all eigenstates are localized when the potential strength V_0 is larger than unity and are extended when V_0 is smaller than unity. In the present simulation we set M =0 or 1 and/or L =0 or 1.

We initially prepare an electron in a highly excited state and the harmonic oscillator to the ground state of the Fock state, and compute the time-dependent electronic energy and the phononic energy by the time-dependent wave packet. Effect of the localization or randomness in the potential sequence $V(n)$ on the energy transfer between the electron and the phonon mode is investigated, in comparing to periodic or disordered systems[1-5]. The coherent state representation of the phonon mode during the relaxation of the energy will be shown to confirm the process of the phase randomization[2].

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