Comment on "Absence of Localization in a Nonlinear Binary Alloy"

In a recent interesting paper, Molina and Tsironis [1] considered the transport properties of an electronic nonlinear random binary one-dimensional system. They studied the mean-square displacement as a function of time. They also considered the scattering properties of a plane wave off a disordered nonlinear sample of length L, and found evidence for having a power law decay for the transmission coefficient $T \sim L^{-\gamma}$. They claimed that γ was seemingly independent of the strength of the nonlinearity. In this Comment we point out that when doing a more extensive calculation in a similar model, we find a γ that does *depend* on the amount of nonlinearity and thus this behavior differs from the one obtained in [1], as well as that of previous studies [2].

We consider a somewhat more general model than the one studied in [1]. The model is that of an electron with energy E moving along a one-dimensional lattice with equally spaced delta function potentials of random strength β_n plus cubic nonlinearity [3]. The model is defined by

$$\Psi_{n+1} = \left[2\cos k + \frac{\sin k}{k}(\beta_n + \alpha|\Psi_n|^2)\right]\Psi_n - \Psi_{n-1}. \tag{1}$$

Here Ψ_n is the value of the wave function at site n, α measures the strength of the nonlinearity $k = \sqrt{E}$, and β_n is a random variable with a uniform distribution of width q and centered about the origin. This model differs from the one studied in [1], which includes the disorder in the nonlinearity. As they also mentioned the physics must be generically similar. We analyze the situation in which we have an incoming and a reflected wave at $x \geq L$, $\psi(x) = r_0 e^{-ik(x-L)} + r_1 e^{ik(x-L)}$, while for $x \leq 0$ we have a transmitted wave $\psi(x) = te^{-ikx}$. In order to have a uniquely defined problem, we proceed by fixing the output $|t|^2 = 1$ and calculate the corresponding input r_0. To solve these equations we take as initial conditions $\Psi_0 = t$ and $\Psi_{-1} = te^k$. The coefficient r_0 is given by $r_0 = e^{3ik}[(\Psi_{L+1} - e^{-k}\Psi_{L+2})/(e^{2ik} - 1)]$ and the transmission coefficient by [3] $T = |t|^2|e^{2ik} - 1|^2/|\Psi_{L+1} - e^{-ik}\Psi_{L+2}|^2$. The computational procedure consists of generating an ensemble of chains (200 members for the most part) and calculating $\langle \log T\rangle$, the ensemble average of $\log T$ as a function of α and L. This is the standard procedure used in linear localization studies [4].

In Fig. 1 we show the results for $\langle \log T\rangle$ vs $\log L$, for different values of $\alpha < 0$. We note that for very small values of α the curves yield $T \sim e^{-\lambda L}$, while for values $\alpha \geq 10^{-5}$ there is a crossover behavior to $T \sim L^{-\gamma(\alpha)}$. As $|\alpha|$ increases, γ decreases monotonically, as shown in the inset of the figure. If we increase L to larger values than those shown in the figure, we begin to get chains in the ensemble that contribute very large values for $-\log T$, indicating that we are in a nonpassing region of the E vs α spectrum, and the ensemble average is no longer meaningful. Eventually, for $|\alpha|$ or L large enough, we go to a regime where T decreases as e^{-3^L}, as pointed out previously [2]. In the case when $\alpha > 0$ we get to the latter regime very rapidly, and the power law behavior is not observed. A more extensive discussion of this and related problems will be given elsewhere [5].

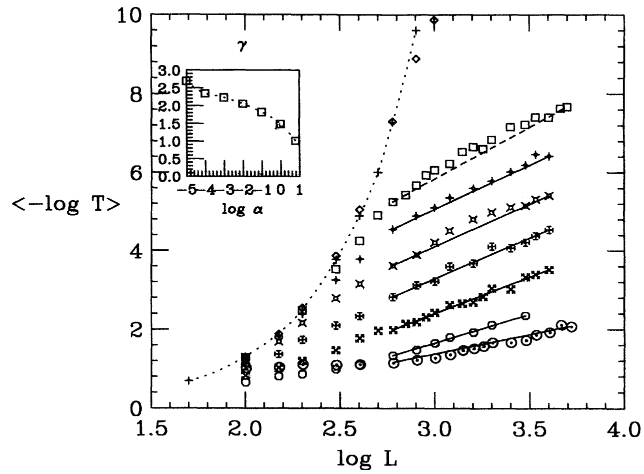

FIG. 1. $\langle \log T\rangle$ vs $\log L$ for different $\alpha(<0)$'s. Here $q = \sqrt{12}$ and $E = 5$. The exponential behavior has $|\alpha| = (0, 10^{-15}, 10^{-10})$. The solid lines are linear fits for different α's increasing in powers of 10, starting with 10^{-5} (squares) through 1 (circles), and the circle with the dot is for 8. The inset shows the $\gamma(\alpha)$ obtained from the fits.

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