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Title: Quantum transport on the Bethe lattice with non-Hermitian source and drain

Abstract: We here consider quantum transport in a tight-binding model on the Bethe lattice (Fig. 1), which may model the energy transport in light-harvesting molecules. As a new feature to analyze the quantum transport, we add complex potentials $+i\gamma_N$ for sources on all the peripheral sites on the outermost Nth generation of the Bethe lattice and $-i\gamma_0$ for a drain on the central site 0 on the zeroth generation. These constant imaginary potentials can result from a Markov approximation of environmental degrees of freedom.

We find that the number of the extended eigenstates that penetrate from the peripheral sites to the central site is quite limited; most eigenstates cannot reach the origin site, being localized on the outer sites. More specifically, only $N+1$ pieces of eigenstates can contribute to the current carrying from the source at the peripheral sites to the drain at the central site.

For $N = 1$ and $N = 2$, we found analytically that the maximum of the current expectation

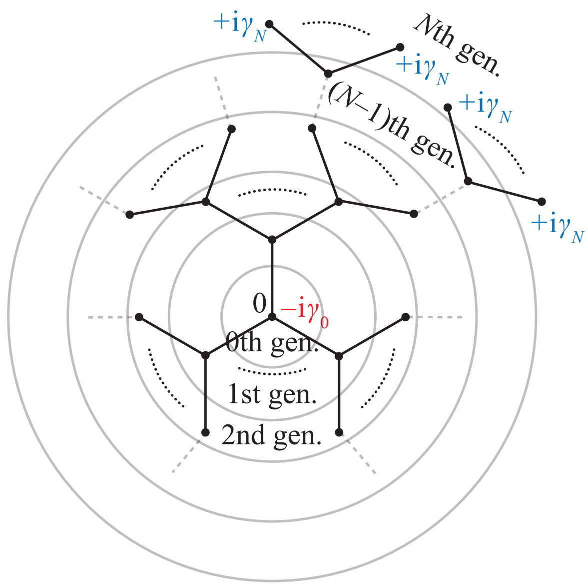

Figure 1: A schematic view of the present lattice. The source potentials $+i\gamma_1$ (marked blue) are added to the peripheral sites, while the drain potential $-i\gamma_0$ (marked red) is added to the central origin site 0.

value is achieved at an exceptional point of the zero eigenvalues of the extended eigenstates. In defining the expectation value of the current for each eigenstate, we sandwich the current operator with the right eigenvector and its Hermitian conjugate, not the left eigenvector. This is because we regard the present system as an open quantum system, not a closed non-Hermitian system. In the former, the non-Hermiticity emerges owing to the elimination of environmental degrees of freedom. Since the present system is regarded as a part of the whole Hermitian system, the expectation value of a local operator should be calculated in the way of the standard quantum mechanics, despite that the right eigenvectors are generally not orthogonal to each other, which is again because each right eigenvector of the present system is regarded as a part of the eigenvector of the whole Hermitian system. If we computed the current expectation value in terms of the right and left eigenvectors, which constitute a biorthogonal set, the result would be zero because the system is then regarded as a closed one.

This is a collaborative work with Hosho Katsura (Department of Physics, Graduate School of Science, The University of Tokyo, Japan) and Kohei Kawabata (Department of Physics, Princeton University, U.S.A.).