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Efficient Quantum Transport in Disordered Networks with Vibrations

Abstract: The potential role of quantum coherence in the fast and efficient energy transport observed in light-harvesting complexes of photosynthetic organisms has been a topic of extensive research in recent years. In these systems, an excitation is conveyed by a small number of dipole- coupled molecules which form a network. Such networks exhibit statistical variations from one realisation to another, as well as fluctuations due to coupling with their environment. This motivates the search for structural design principles of the networks that ensure good transport despite this variability. Walschaers et al. proposed a model for efficient quantum transport across disordered networks relying on centrosymmetry of the network and a dominant doublet spectral structure. Here, this model is extended to take into account large energy differences between the sites of the network as well as an explicit time-dependence due to coupling to a vibrational mode. With the aid of Floquet theory, symmetries of the network in space as well as in time are considered. Analytical calculations, along with numerical simulations, result in the proposal of the generalised design principles Floquet-antisymmetry and dominant Floquet doublet, which are shown to lead to fast and efficient vibrationally-assisted quantum transport