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Particle and wave transport in driven quantum networks

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Particle and wave transport in networks is of importance for broad variety of problems in condensed matter physics, polymers, optics and biophysics. In case of submicron scales, wave dynamics in networks can be described in terms of so-called quantum graphs. The latter is a set of bonds connected to each other at the vertices according to a rule which is called topology of a graph. Quantum mechanical description of particle transport in networks dates back to the Refs. [1-3] which consider electron motion in organic molecules. Recently quantum graphs have attracted much attention in the context of microwave optical fibers, quantum hall effect, and quantum chaos theory. Despite the considerable progress made in the study of quantum graphs, most of the studies are restricted by non-interacting graphs. However, driven quantum graphs are more interesting, both from basic physics and practical applications viewpoints. In this work, we address the problem of a driven quantum graphs by considering, as the driving force, parabolic wells. In other words, we study network of quantum harmonic oscillators by solving the stationary Schrodinger equation on metric graphs in the presence of harmonic oscillator potential with bond-dependent frequency. Such network of quantum harmonic oscillators can be used for modeling of vibrations in discrete or branched systems, such as crystal lattices, molecular chains, polymers, etc. Our approach for the study of quantum harmonic oscillator network is based on considering it as a set of confined harmonic oscillators connected at vertices. Confined or bounded harmonic oscillator presents parabolic potential given at finite interval. To solve Schrodinger equation on harmonic oscillator network we impose for confined harmonic oscillator wave functions the vertex boundary conditions providing continuity of wave function and Kirchhoff rule at the vertex. For such boundary conditions, we explore wave packet dynamics and optical conductivity of system and reveal the conditions for transparent (reflectionless) wave transmission through the network branching points.

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