Dynamical Quantum Phase Transitions of the Creutz Model with Long-Range Hopping

Jhonata Amado da Silva*
José Cândido Xavier†

Keywords: Creutz Model, Dynamical Quantum Phase Transition, Yang-Lee-Fisher Zeros, Long-Range Hopping, Peierls Phases

Abstract

In this work, we study the Creutz model: free fermions in the presence of a magnetic field B in a two-leg ladder geometry. Due to the presence of the magnetic field, the hopping amplitude between the sites k and j depends on the value of B, i.e., $t_{k,j} = t_{k,j}(B)$. We consider the Peierls substitution, whose hopping amplitude is given by $t_{k,j}(B) = e^{i\frac{q}{\hbar}\int_k^j \vec{A}\cdot\vec{dl}} t_{k,j}(0)$, where $\vec{A}$ is the potential vector. Due to this simplification, we diagonalize exactly, by Fourier series, the Creutz model with long-range hopping that decays with the distance with an exponent ν and has range D. We determine analytically the dynamic free energy $f(t) = -\frac{1}{N}\ln\left(|Z(t)|^2\right)$, where $Z(t) = \left\langle \psi_0 \left| e^{-\frac{i}{\hbar}H(B_2)t} \right| \psi_0 \right\rangle$ is the return probability and $|\psi_0\rangle$ is the ground state of the Hamiltonian $H(B_1)$. We also find that the $f(t)$ has non-analyticities at some critical times t_c. We also intend to present those times by analyzing the Yang-Lee-Fisher (YLF) zeros.

*Master's Student in Physics, Federal University of Uberlândia, Institute of Physics, C. P. 593, 38400-902 Uberlândia, MG, Brazil

†Professor, PhD in Physics, Federal University of Uberlândia, Institute of Physics, C. P. 593, 38400-902 Uberlândia, MG, Brazil