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Dissipative motion of Gaussian wavepackets: free propagation and transmission through a rectangular barrier

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Abstract

Ignoring thermal fluctuations of the environment, taking into account only its dissipative effects, free propagation of a Gaussian wavepacket is studied in the framework of the linear Caldirola-Kanai (CK) equation and as well as non-linear equations, the Schrödinger-Langevin (SL) equation, known as Kostin equation, and the Schuch-Chung-Hartmann (SCH) equation. By a Gaussian ansatz for the probability density one obtains two equations, one for the evolution of the center of the wave packet which is just the classical Langevin equation and one for the evolution of the width of the wavepacket. This last equation has different forms in different approaches having only an analytic solution in the CK and SCH frameworks. Computations show that for a given friction, the width of the wavepacket increases with time in all approaches. In a given time, it reduces with friction in both CK and SL approaches revealing localization effects of dissipation, while has opposite behavior in the SCH approach. Furthermore, energy expectation value and its time-derivative are computed and compared in all approaches. It is shown that the rate of energy is given by the expectation value of momentum field in the SL framework. Finally, transmission of a Gaussian wavepacket from a rectangular barrier is numerically studied in the context of CK and compared to the non-dissipative case. The transmission decreases considerably with the dissipation.

Keywords: dissipation, Caldirola-Kanai equation, Schrödinger-Langevin (Kostin) equation, Schuch-Chang-Hartmann equation, Gaussian wave-packet

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