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A one-dimensional model for ionization induced by scattering with a heavy particle

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Abstract

The ionization probability for a one-dimensional model atom perturbed by a moving repulsive scatterer is considered. The moving scattering centre is meant to mimic a second quantum particle crossing the region where a much lighter particle is initially bound in the atom. We compute the first three terms (of order $t^{3/2}$, t^2, $t^{5/2}$ respectively) in the expansion for small times of the ionization probability and we deduce that the first term showing explicit dependence on the velocity of the scatterer is of order $t^{5/2}$. A possible application of the model for the description of a quantum particle in a cloud chamber is also outlined.

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1. Introduction

In this paper, we consider the problem of the ionization of a quantum particle of mass m, which at time zero is in a bound state, due to the interaction with another quantum particle with a large mass M.

We shall restrict ourselves to a one-dimensional model and we assume that the binding potential for the particle of mass m is given by an attractive δ-interaction placed at the origin.

The interaction with the heavy particle is phenomenologically described through a time-dependent δ-interaction centred at a point which is moving with constant velocity. The model is meant to be an approximation of the complete two-body problem when the mass M of the heavy particle is very large and its initial state is a properly chosen coherent state.

Under these conditions it is reasonable to expect that the heavy particle is well described by the free evolution of a wave packet while the initially bound particle only 'sees' the centre of the wave packet.

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