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Extended Abstract

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A unitary relativistic quantum theory of the dissipative tunneling

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About 25 years ago, the author found that by a dissipative coupling, the penetrability of a potential barrier is increased, not decreased as it was believed before. A dissipative coupling includes two physical effects: (1) an increase of the action of the system, which leads to a decrease of the barrier penetrability, as it was shown by Caldeira and Leggett, and (2) additional transitions resulting from the dissipative terms of Lindblads master equation, which lead to a penetrability decrease. With the tunneling and momentum operators in Lindblads dissipative term, the author found a good agreement of the theoretical results with the experimental spectra of some cold fission modes. However, later, important theoretical progresses appeared. First of all, he found Lindblads theory very unsatisfactory, including a large number of unspecified parameters. Using a method of Ford, Lewis, and O2Connell for the reduced dynamics, he obtained a quantum master equation with explicit, analytical parameters, depending on the dissipative potential matrix elements, densities of the environment states, and occupation probabilities of these states, for a complex environment of other fermions, bosons, and a free electromagnetic field. More than that, he found that a particle wave function includes the Lagrangian in the time dependent phase of a particle wave function, instead of the Hamiltonian of the conventional Schrdinger equation. In this case, the wave equation includes an additional term depending on momentum and velocity, and the penetrability of a potential barrier takes an explicit form, depending on physical characteristics, velocity, and spin.

The problem of escape of a thermal equilibrium Brownian particle was considered by Kramers more than 50 years ago, and this work has a very special status: not enough classical to be noncited, but yet quite well-known to have more than 100 citations a year. The problem is immediately related to many physical systems, there is a huge number of experiments, including very recent ones, although initially it was formulated in chemistry as the problem of a chemical reaction rate. Let us first analyze it qualitatively.

A relativistic conservation equation is obtained for the matter flow four-vector. For a quantum particle interacting with an electromagnetic field in a system of curvilinear coordinates, a relativistic Hamiltonian depending on the metric elements is obtained. For an electromagnetic wave interacting with a matter system in a gravitational wave, we obtained an oscillation of the electromagnetic wave vector induced by the gravitational wave; we found a description of a gravitational wave as an oscillation of the transmission coefficient of an active Fabry-Perot cavity.

For a quantum particle, with the Schwarzschild solution for a central gravitational field, we obtained the acceleration as the Newton gravitational acceleration with a relativistic factor, and the radial velocity, which, at the boundary of a black hole, become null – no matter element can pass the boundary of a black hole in the approximation of a constant gravitational field.

However, in the realistic cases, absorption and evaporation processes arise at the boundary of a black hole, by two effects: 1) A quantum effect, as the gravitational field applied to a matter differential element of a quantum particle is perturbed by the other matter elements of this particle, and 2) A statistical effect, by the gravitational fluctuations induced by the neighboring quantum particles. For a quantum particle in a gravitational wave, in the first order approximation of the metric tensor, we found an acceleration under the action of this wave, as in the second-order approximation, a quantum particle vibrates under the action of this wave.

Investigation of transport phenomena is a very important area of physics. Many quantities that are measured in experiment are immediately related to transport—whether this is conductivity, which is determined by electron transport in a conductor, or light absorption spectrum, etc. In a naive picture of transport there is something that moves and “carries” what is transported. For example, an electron is diffusing through a conductor and carries electric charge.

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