Nuclear quantum transport for barrier problems

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Often quantum collective motion of damped systems is treated on the basis of the Caldeira-Leggett model [1]. It will be demonstrated that this simple model has features that prohibit its application to self-bound Fermi systems. There, one would like to see the collective variables introduced in some self-consistent fashion, with a microscopic treatment of *all* transport coefficients for inertia, friction and stiffness alike.

One possible way to meet these demands has been formulated in [2] in connection to nuclear physics. Using a real time formulation and a quantum transport equation in barrier regions quantum effects can be accounted for only above a critical temperature T_c. This temperature is larger than the so called "crossover temperature" T_0 which one encounters for imaginary time propagation, e.g. within the Caldeira-Leggett model.

First steps to overcome these deficiencies have been undertaken in [3] by adapting a previously developed imaginary time formalism to evaluate the partition function. We start from the static path approximation (SPA) functional integrals and take into account quantum effects through local RPA [4]. In order to develop an extension that allows to describe also strongly damped phenomena we modify the basic ideas of the Caldeira-Leggett model such that they can be taken over to nuclear problems. Our approach is applicable down to T_0 and the transport coefficients can be extracted from the microscopic theory instead of being restricted to macroscopic input.

Recently we have been able to make further improvements by combining the variational approach of Feynman and Kleinert [5] with ATDHF type approximations. A formulation in terms of functional integrals and response functions is in preparation.

Finally we will present an application of our microscopic transport coefficients to thermal fission and fusion of super-heavy elements. For thermal fission the influence of microscopic transport coefficients which in one way or other are governed by quantum effects has been shown to modify the decay rate considerably [6]. Meanwhile also the importance of microscopic transport coefficients for a description of fusion processes has been examined [7]. At the relevant temperatures quantum effects hidden in the microscopic transport coefficients turn out more important than those of collective motion.

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