A Quantal Transport Theory for Nuclear Collective Motion: the Merits of a Locally Harmonic Approximation

H. Hofmann

A transport theory has been developed for Brownian motion of self-bound systems. It includes a treatment of the dynamics of fluctuations on a quantal level. If applied to nuclear fission this method allows one to incorporate quantum corrections to Kramers' rate formula. Collective variables are introduced as shape parameters, self-consistency with respect to the nucleonic degrees of freedom is implemented at various important stages. It governs the definition of the transport coefficients appearing in the equations for collective motion. Various limits are considered like those for large temperature and size ("macroscopic limit").

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Monopole Giant Resonances and Nuclear Compressibility in Relativistic Mean Field Theory

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Isoscalar and isovector monopole oscillations that correspond to giant resonances in spherical nuclei are described in the framework of time-dependent relativistic mean-field (RMF) theory. Excitation energies and the structure of eigenmodes are determined from a Fourier analysis of dynamical monopole moments and densities. The generator coordinate method, with generating functions that are solutions of constrained RMF calculations, is also used to calculate excitation energies and transition densities of giant monopole states. Calculations are performed with effective interactions which differ in their prediction of the nuclear matter compression modulus K_{nm}. Both time-dependent and constrained RMF results indicate that empirical GMR energies are best reproduced by an effective force with $K_{\mathrm{nm}} \approx 250 - 270$ MeV.

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A Giant Halo at the Neutron Drip Line

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Relativistic Hartree-Bogoliubov (RHB) theory in coordinate space is used to describe the chain of Zirconium isotopes reaching from ^{116}Zr to the drip line nucleus ^{140}Zr. Pairing correlations are taken into account by a density dependent force of zero range. For neutron numbers larger than the magic number $N = 82$ a giant neutron halo outside the core of ^{122}Zr is predicted. It is formed by up to six neutrons.

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Application of Finite Element Methods in the Relativistic Mean-Field Theory: Spherical Nucleus

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A C++ code is used to calculate ground state properties of spherical nuclei. The nuclear system is described in the framework of relativistic mean field theory: Nucleons are coupled to exchange mesons and photons through an effective Lagrangian. Finite element methods are used in the self-consistent solution of the coupled system of partial differential equations for the nucleons and for the meson fields. Using a formulation based on weighted residuals, the coupled system of Dirac and Klein-Gordon equations is transformed into a generalised algebraic eigenvalue problem, and systems of linear and non-linear algebraic equations, respectively.

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