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Nonequilibrium statistical quantum-field theory of collective motion in microscopic Fermi systems

The dynamic equation for the collective coordinate characterizing the shape of the composite system formed in the low-energy nucleus-nucleus collisions is derived from the nonequilibrium statistical quantum field theory of microscopic Fermi systems, whose dimensions are comparable with the particle mean free path. To facilitate this derivation, the time evolution of the system is presented as a succession of quasiequilibrium stages, characterized by the statistical matrix ρ_χ, describing complete thermal equilibrium at fixed values of the expectancies of the operators Q, P, $\mathcal{M}$ of coordinate, momentum and mass of slow collective mode. Explicit expression for Q is chosen so that its expectancy with ρ_χ describes the elongation of the composite system. Explicit expressions for ρ_χ, P, $\mathcal{M}$ are obtained using the idea that collective motion in hot nuclei emerges because the randomly distributed phase of the nucleon field operator acquires a regular component $\chi_{\mathbf{x}}$. Starting from the time evolution equations for the expectancies of Heisenberg operators Q_t, P_t, $\mathcal{M}_t$, we work out the dynamic equation for the collective coordinate $q_t = \mathrm{tr}\,(Q_t\rho_\chi)$ of the same form, as the dynamic equation of a phenomenological collective model. This allows us to identify the microscopic expressions for collective mass, deformation force, and friction coefficient. To make these expressions tractable, the thermally equilibrated single-particle motion is modelled in terms of the temperature-dependent Hartree-Fock equations with the Skyrme force. The report is based on Refs. [1, 2, 3, 4, 5, 6].

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