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Role of Macroscopic Effects in Dynamics of Nuclear Fission

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Mass-asymmetric fission in nuclear fission processes has traditionally been considered a consequence of microscopic properties associated with the internal structure of the nucleus. However, dynamical model calculations indicate that the competition between mass-asymmetric and mass-symmetric fission in induced fission is strongly governed by liquid-drop–like properties, i.e., macroscopic effects, that develop during the fission process. On the basis of these results, an interpretation of the dynamical description of induced nuclear fission is discussed.

As a representative example of induced nuclear fission, we consider the fission reaction of 235U induced by thermal neutrons. The kinetic energy brought into the compound nucleus by the incident thermal neutron is converted into internal excitation energy, causing the compound nucleus to undergo strong thermal fluctuations that enable it to overcome the fission barrier. The interpretation of the fission process driven by such thermal fluctuations is consistent with the physical picture of Brownian motion, and the nuclear fission process has therefore been described using the Langevin equation [1,2]. The transport coefficients appearing in this equation, namely, the inertia tensor and the friction tensor calculated within macroscopic models, strongly influence the dynamical behavior. Recent dynamical calculations have revealed that these tensor quantities exhibit characteristic properties [3].

The dynamics governing which saddle point is selected by a trajectory are of crucial importance and depend sensitively on the description of thermal fluctuations of the nuclear shape. The trajectory evolution is not determined solely by the structure of the potential-energy surface, but is also strongly influenced or constrained by the directional properties of these tensor quantities. In this work, we address the liquid-drop–like characteristics of the transport coefficients and discuss their role in the mechanism of induced nuclear fission.

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