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Effects of the temperature on nuclear deformation energy and the predictions of fission observables calculated within the Langevin approach

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Predictions of fission observables by solving the Langevin equations are highly dependent on the potential energy surface along which the shape configuration of the nucleus evolves. This potential energy surface is calculated by adding together the liquid drop deformation energy and the shell correction energy. In our recent four-dimension (4-D) Langevin approach 1, the shell corrections [2,3] are calculated using the single particle energies derived from the deformed Wood-Saxon potential of Pashkevich [4]. Usually, the shell correction is calculated for zero temperature and the dependence on the excitation energy is taken into account by Ignatyuk prescription [5], $\delta E(E^*) = \delta E(0)e^{-E^*/E_d}$. In the present work we have calculated the temperature dependence of the shell correction to the macroscopic nuclear energy directly starting from their formal definitions without any approximation. We have found out that below critical temperature when the pairing effects are important, both shell correction to energy and the shell correction to the free energy differ substantially from the approximation of [5]. We propose the approximations for the shell corrections to the energy δE and free energy δF that reproduce rather accurately the average dependence of δE and δF on the temperature (excitation energy). These approximations rely on the quantities calculated at zero temperature like $\delta E_{shell}(0)$ and $\delta E_{pair}(0)$ and few fitted constants. The accuracy of approximation for δF is demonstrated in Fig. 1. In the current work, we will employ this temperature dependent potential energy surface on our 4-D Langevin calculation.

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