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A New Method for Determining the Transverse Vibration Energy of Fission Prefragments

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The study of the dynamics of heavy nuclei fission remains a relevant problem in modern nuclear physics. One of the key questions in this field is the identification of the mechanism of spin formation of the fission fragments, which is still insufficiently studied. In this work, based on studies [1,2], a modelling of the potential energy of the compound fissile system has been performed to analyse the role of transverse oscillations in the spontaneous fission process of the ^{252}Cf nucleus. The focus of the study was directed towards wriggling and bending oscillations, which may play a role in the final spin distribution of the fission fragments.

The calculation method is based on the use of an effective nucleon-nucleon potential [3] to estimate the potential energy of the transverse oscillations. Furthermore, the concept of a "cold" nucleus [4] has been used, which implies that all excitation energy is converted into non-equilibrium deformation energy during the entire fission process, simplifying the analysis of collective oscillations and their influence on the spin distribution. The proposed model includes a number of parameters, including charge and mass asymmetry, distance between fragments, and quadrupole deformations. The frequencies of the oscillations and the stiffness coefficients are calculated numerically, allowing the contribution of each type of oscillation to the final distribution [5,6] of the spins of the fission fragments to be determined. The validity of the model has been verified with experimental data [7] on spin distributions.

The analysis of the results obtained confirms that mentioned types of oscillations make a significant contribution to the process of fission fragments spins formation. Nevertheless, the ratio between the energies of wriggling and bending oscillations remains approximately constant, which is consistent with theoretical predictions for symmetric fission path described in [8]. The findings of this study indicate that the outcomes obtained within the framework of the hydrodynamic approach [9] are more closely aligned with the observed spin values. This confirms the importance of considering collective effects in describing the fission mechanism of heavy nuclei.

In addition, the influence of the initial deformation conditions of the nucleus on the nature of the transverse vibrations and the final distribution of the spins of the fragments has been considered. The inclusion of non-equilibrium deformations allows a more accurate prediction of fission parameters, especially near the scission point. Important correlations between transverse oscillations and angular momentum redistribution processes have been identified, confirming their key role in the formation of fission fragments. Further analysis can be directed towards studying the influence of temperature effects and interactions between fragments in the final stages of fission.

This study contributes to the refinement of the mechanisms of energy and angular momentum transfer in the process of nuclear fission. The results obtained can be used to improve theoretical models and to predict the characteristics of the fission products of other actinide nuclei. In the future, it is planned to extend the research to other heavy nuclei and to use more detailed quantum mechanical models to describe the dynamics of the collective oscillations in the fission process.

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Primary authors: LYUBASHEVSKY, Dmitry (Voronezh State University); Dr KOSTRYUKOV, Pavel (Voronezh State University of Forestry and Technologies / Voronezh State University)

Co-authors: Ms JULIA, Sherbina (Voronezh State University); Mr STANISLAV, Klyuchnikov (Voronezh State University); Mr NIKITA, Volokhin (Novovoronezh NPP)

Presenter: LYUBASHEVSKY, Dmitry (Voronezh State University)

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