Neutron–induced fission of actinides at energies up to 200 MeV: Problems of describing fission cross sections and angular anisotropy of fission fragments

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The standard description of the total σ_f and differential $d\sigma_f/d\Omega$ fission cross sections of nuclei is based on the use of A.Bohr's concept of transition states of a nucleus at fission barriers. The ratio of the differential to the total cross section determines the angular distribution of fission fragments $dw(\theta)/d\Omega = (d\sigma_f/d\Omega)/\sigma_f$. Since the non-isotropic component in the expansion of the angular distribution in terms of Legendre polynomials is usually determined by the 2nd polynomial, $dw(\theta) = (1+A_2P_2(\cos\theta))/(4\pi)$, then the angular distribution is actually specified by the A_2 parameter. In practice, it is convenient to use the angular anisotropy $w(0°)/w(90°) = (1 + A_2)/(1 - A_2/2)$.

Using currently available software packages, which include, in particular, TALYS [1], it is possible to calculate the energy dependence of the cross sections for fission of heavy nuclei by projectile particles, including neutrons at low and intermediate energies (up to 200-300 MeV). The calculations use a model description of fission barriers and the density of transition states as a function of spin J and its projection K onto the deformation axis of the nucleus. In fact, everything that we know about fission barriers and transition states was obtained from the analysis of data on fission cross sections, since none of the available software packages contain the possibility of calculating the angular distribution of fragments. Meanwhile, an analysis of the available data on the angular anisotropy of fission fragments can provide additional information both on the fission mechanism of various isotopes, including those far from stability, and on the relationship between equilibrium and preequilibrium processes at different energies [2].

We have modified the TALYS complex to be able to calculate the angular distribution of fission fragments along with the total fission cross section in the framework of A.Bohr's model of transition states. This work is a continuation of our experimental studies of the angular distributions of fragments from fission of nuclei ^{nat}Pb, ^{209}Bi, ^{232}Th, ^{233}U, ^{235}U, ^{238}U, ^{237}Np, ^{239}Pu, ^{240}Pu by neutrons with energies up to 200 MeV (see [3,4] and references therein); recently, measurements were carried out for the ^{236}U isotope. The first results on a joint description of the fission cross sections and angular distributions of fission fragments for ^{237}Np and ^{240}Pu actinide nuclei are presented in [3,4]. This work is devoted both to a discussion of the problems arising in such a description and to the new results we obtained.

1. A.J. Koning, S. Hilaire, M.C. Duijvestijn, "TALYS-1.0", Proc. Int. Conf. on Nuclear Data for Science and Technology, 2007, Nice, France; EDP Sciences, 2008, p. 211.
2. I.V. Ryzhov et al. Nucl. Phys. A 760, 19 (2005).
3. A.S. Vorobyev et al. JETP Lett. 110, 242 (2019).
4. A.S. Vorobyev et al. JETP Lett. 112, 323 (2020).