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MECHANISMS OF MULTY-STAGE NUCLEAR DECAYS WITH TAKING INTO ACCOUNT REAL AND VIRTUAL STATES OF INTERMEDIATE NUCLEI

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The sequential n-stage ($n \geq 2$) decay of the compound nucleus A: $A \to b_1 + A_1 \to \ldots \to b_1 + \ldots + b_n + A_n$ with the formation of the real particles $b_1, \ldots, b_n$, intermediate nuclei $A_1, \ldots, A_{n-1}$ and the final nucleus A_n with internal energies $E_{b_1}, \ldots, E_{b_n}$ and $E_{A_1}, \ldots, E_{A_n}$, correspondingly, has been considered. It has been proved that the width of mentioned decay can be presented by the integral of productions of the i-stage widths, corresponding to the real and virtual processes. If the i-th stage of the decay has the decay heat $\left(E_{A_i} - E_{A_{i+1}} - E_{b_{i+1}}\right) < 0$, then this decay stage has virtual character and can be described using the formalism [1]. If the i-th stage of the decay has the positive decay heat $\left(E_{A_i} - E_{A_{i+1}} - E_{b_{i+1}}\right) > 0$, then this decay is really observed and can be described by the R-matrix theory of nuclear reactions [2].

In [3] it was shown that the experimental characteristics of spontaneous ternary fission of ^{248}Cm, ^{250}Cf, ^{252}Cf [4] with emission of $\alpha-$particle as the third particle, are adequately described using the representation about two-stage character of this fission, when on the first stage the long-ranged α-particle is emitted from the neck of the fissile nucleus A and the virtual state of the intermediate nucleus $(A - 4)$ is formed, and on the second stage this nucleus $(A - 4)$ decays onto two fission fragments. In present paper by usage of methods [3] it has been demonstrated that the characteristics of the induced by thermal neutrons ternary fission of ^{233}U and ^{235}U are successfully described on the base of virtual mechanism. It has been obtained that fissile nucleus neck radii r_A for induced fission of compound nuclei ^{234}U and ^{236}U are close to the analogous neck radii for spontaneous fission of ^{248}Cm, ^{250}Cf, ^{252}Cf and are in good agreement with the estimations of the theoretical models considering fissile nucleus deformations.

The differential cross section $\sigma(\theta)$ of the ternary fission of actinide nuclei by cold polarized neutrons can be presented as a sum of the terms of null order $\sigma^0(\theta)$ and the first order $\sigma^1(\theta)$ on the neutron polarization vector $\vec{p}_n$: $\sigma(\theta) = \sigma^0(\theta) + \sigma^1(\theta)$ (1), where θ is an angle between the directions of flights of the third particle and light fragment. In general case $\sigma^1(\theta)$ can be presented as sum of the triple $\sigma_3^1(\theta)$ and quinary $\sigma_5^1(\theta)$ correlators, which satisfy the conditions: $\sigma_3^1(\theta) = \sigma_3^1(\pi - \theta), \sigma_5^1(\theta) = -\sigma_5^1(\pi - \theta)$ (2). These components $\sigma_3^1(\theta)$ and $\sigma_5^1(\theta)$ can be calculated using experimental differential cross sections $\sigma(\theta)$ and $\sigma^0(\theta)$ in (1) and formula (2). In quantum fission theory [5,6] $\sigma_3^1(\theta)$ and $\sigma_5^1(\theta)$ have forms:
$\sigma_3^1(\theta) = \Delta^{odd} \frac{d\sigma_0^{odd}(\theta)}{d\theta}$, $\sigma_5^1(\theta) = \Delta^{even} \frac{d\sigma_0^{even}(\theta)}{d\theta}$ (3), where $\sigma_0^{odd}(\theta)$ and $\sigma_0^{even}(\theta)$ are components of σ_0 defined by sums over spherical functions with odd and even orbital momenta, correspondingly, and Δ is an angle, which characterizes the changing of the angle θ, which takes into account the influence of the connected with the collective rotation of the fissile nucleus Coriolis interaction on the directions of the light fragment and ternary particle flight. Using the experimental values of the cross section $\sigma^0(\theta)$ it is possible to calculate by formulae (3) the angles Δ^{odd} and Δ^{even} for various ternary fission types. In [5,6] it has been shown that for the ternary fission of ^{233}U and ^{235}U with the emission of the α-particle the angles Δ_α^{odd} are positive, but the angles Δ_α^{even} change their sign under the transition from ^{235}U to ^{233}U. At the same time the calculation on the base of the trajectory methods [7] use the parametrization: $\sigma_3^1(\theta) = C$; $\sigma_5^1(\theta) = \sigma^1(\theta) - C$, where C is a constant, and $\sigma_5^1(\theta)$ concides with (3), the angles Δ_α^{even} and Δ_α^{odd}, are correctly describe the signs of Δ_α^{odd} for ^{233}U and ^{235}U, but conserve the same signs of Δ_α^{odd} for ^{233}U and ^{235}U that critically contradicts to the fact of sign changing in the experiment. For the ternary fission accompaning with evaporative neutrons and γ-quanta from the fission fragments the σ^0 have only even orbital momenta, and the angles Δ_n^{even} and Δ_γ^{even} are defined by the influence of the Coriolis interaction onto fission fragments because of its small values in the region of these neutrons and γ-quanta emission. Using the experimental data [8] of the Δ_n^{even} and $\Delta_\gamma^{\mathrm{even}}$ change the value under the transition from ^{233}U to ^{235}U, that is in agreement with the experimental sign change of Δ_α^{even} for α-particle. This fact approve the correctness of the experimental results [8].

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Primary authors: KADMENSKY, Stanislav Georgievich (Voronezh State University, Voronezh, Russia); TITOVA, L.V. (Voronezh State University, Voronezh, Russia); LYUBASHEVSKY, D.E. (Voronezh State University, Voronezh, Russia); VERETENNIKOV, A.S. (Voronezh State University, Voronezh, Russia); PISKLYUKOV, A.A. (Voronezh State University, Voronezh, Russia)

Presenter: KADMENSKY, Stanislav Georgievich (Voronezh State University, Voronezh, Russia)

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