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Angular anisotropy in pre-fission neutron spectra and PFNS of 238, 239,240,241,242Pu(n, F)

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Angular anisotropy of secondary neutrons was evidenced in neutron emission spectra (NES) of 239Pu+n in 1972, and in prompt fission neutron spectra (PFNS) of 239Pu(n, F) in 2019, it might be predicted for 238,40,241.242Pu(n, F) PFNS. In case of NES angular anisotropy is due to direct excitation of collective levels and pre-equilibrium/semi-direct mechanism (states in the continuum are excited) of neutron emission in inclusive first neutron spectra in (n, nX)1 reaction [1]. In case of PFNS it is due to exclusive spectra of pre-fission neutrons of (n, xnf)1,⋯x reactions. In 239,241Pu(n, xnf) and 238,240,242Pu(n, xnf) reactions observed PFNS envision different response to the emission of first pre-fission neutron in forward or backward semi-spheres with respect to the momentum of incident neutrons. Since energies of (n, nf)1 neutrons and their average values depend on the angle of emission θ with respect to the incident neutron momentum, the observed PFNS, average prompt fission neutron multiplicity, fission cross section, average total kinetic energy TKE, etc. also would be quite dependent on angle θ. Exclusive spectra of (n, xnf)1,..x neutrons at θ~90o are consistent with 238,239,40,241,242Pu(n, F) and 239Pu(n, 2n)) cross sections and neutron emission spectra of 239Pu+n interaction at En≅20 MeV. The correlations of the angular anisotropy of PFNS with the relative contribution of the (n, nf) fission chance to the observed fission cross section and angular anisotropy of pre-fission neutron emission are ascertained. The exclusive spectra of 238,239,240,241,242Pu(n, xnf)1,..x, 238,239,240,241,242Pu (n, xn)1,..x and 240,241,242Pu(n, nγ) reactions are calculated simultaneously with 238,239,240,241,242Pu(n, F) and 238,239,240,241,142Pu(n, xn) cross sections with Hauser-Feshbach formalism, angular anisotropy of (n, nX)1 neutron emission being included [1]. The influence of forward and backward emission of 241Pu(n, xnf) 1,..x pre-fission neutrons on observed PFNS are predicted to be stronger than observed for PFNS of 239Pu(n, F) (see Fig.). Calculated PFNS average energies are consistent with measured data up to the threshold of 240Pu(n, 2nf) reaction, at higher En sloping down of measured data remains unconfirmed [2].

<img src="https://indico.spbu.ru/event/1/attachments/2/54/eavpuall2025.png" width="200" height="200">

1. Maslov V. M., Yadernaya Fizika, 2023, 86, No.5, pp. 562-604.
2. Maslov V. M., Fizika Elementarnykh Chastits I Atomnogo Yadra, 2025, 56, No.1, pp. 88-121.

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