Searching for Fission Resonances in ^{232}U ◇

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Fission resonances caused by resonant tunneling through the excited states developed in the third minimum appears with measurable probability when the height of the inner and outer barriers have similar height. According to the predictions [1] the energy of the outer barrier is constant for the lighter Th and U isotopes, while the inner barrier decreases, which favors the γ-decay of those hyperdeformed states. This effect can already be seen in ^{232}U as shown in Fig. 1, where predictions of the potential energy curve as a function of the nuclear deformation are displayed. In these calculations Cwiok et al. [1] predicted deep third minima for different values of the reflection-asymmetry (the deeper minimum predicted for the more reflection-asymmetric conguration indicated by the dashed line in Fig. 1, while the dotted line represents the prediction for the less reflection-asymmetric case.)

In our most recent experiment the fission probability of ^{232}U was measured as a function of the excitation energy using the ^{231}Pa(^{3}He,df) reaction on a ^{231}Pa radioactive target in order to get information about the fission barriers of ^{232}U. In the experiment ^{3}He beam at energy of E=38.1 MeV was used, bombarding an enriched (99.8%), 80 μg/cm^2 thick target of $^{231}Pa_2O_3$ on a 22 μg/cm^2 thick carbon backing. The energy of the proton ejectiles was analyzed with a Q3D magnetic spectrograph placed at $\Theta = 35°$ relative to the incident beam (solid angle 10 msr). The position of the particles detected in the focal plane was measured with a light-ion, position-sensitive, cathode-strip focal-plane detector. Fission fragments were detected by a position sensitive avalanche detector (PSAD) equipped with two wire planes with delay-line read-out allowing for a detection of the fission fragment angular correlation with respect to the recoil axis ($\Theta_R = 33° - 93°$ and $\Theta_R = 132° - 192°$) with a solid angle coverage of 10% of 4π.

The experimental fission probability spectrum is shown in Fig. 2a). In contrast to our previous results obtained so far for ^{234}U [2] and ^{236}U [3] a sharp resonance structure has not been observed. This may partly be explained by the asymmetry of the inner and outer fission barrier heights which does not favor the occurrence of the transmission resonances.

The analytical expression for the penetrability derived in the WKB approximation [4] was fitted to the measured fission probability in order to get the fission barrier parameters (assuming five parabolas with height E_{1-5} and curvature energy $\hbar w_{1-5}$) as the free parameters of the fitting procedure (Fig. 2a). Our result on the fission barrier with the deduced parameters is shown in Fig. 1 as the solid curve. A good agreement with the theoretical predicitions was found. The anisotropic interval of the measured angular distribution (Fig. 2b) indicates the energy region of subbarrier fission, while the energy where the angular distribution turns to be isotropic indicates the height of the outer barrier, which also supports our previous results.

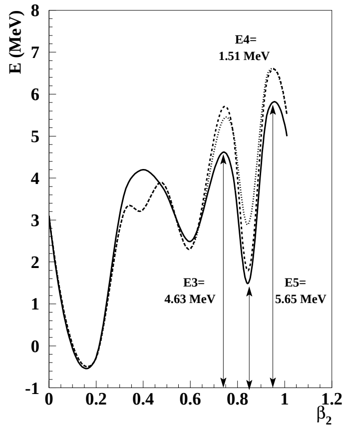

Fig. 1: Potential energy curve of ^{232}U as a function of the nuclear deformation from [1] for different degrees of reflection-asymmetry (dashed and dotted curve) and as determined from the present experimental work (solid line). The potential barrier parameters derived from the fit are indicated.

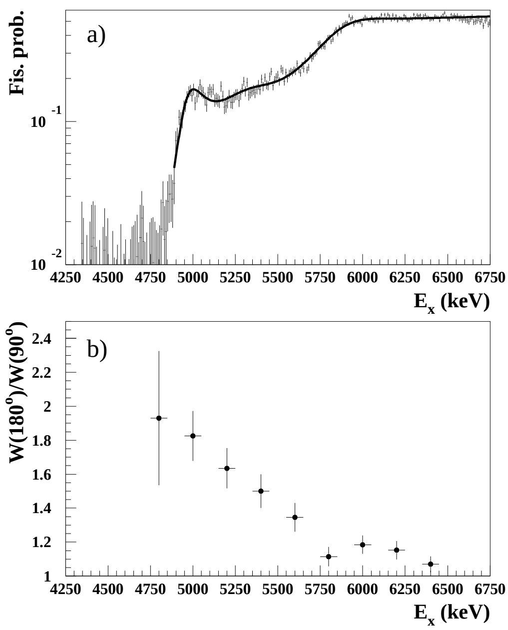

Fig. 2: a) Fission probability spectrum with JWKB calculation. b) Experimental angular distribution as a function of the excitation energy.

References

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◇ Supported by the DFG Cluster of Excellence 'Universe', by DFG under contract HA 1101/12-1 and by OTKA K72566