# Angular Distribution of Fission Fragments from Hyperdeformed Transmission Resonances in $^{236}$U ◇

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$^{236}$U is so far the only isotope in the actinide region where hyperdeformed transmission fission resonances have been observed [1], while at the same time a superdeformed fission isomer is well-established [2]. In a recent experiment we succeeded to establish the existence of a deep third minimum in the potential energy surface of $^{236}$U, in agreeement with theoretical predictions [4] and our results for the neighbouring $^{234}$U. The resulting multiple-humped fission barrier landscape for $^{236}$U is displayed in Fig. 1, revealing that the third minimum in this nucleus is even deeper than the second potential well.

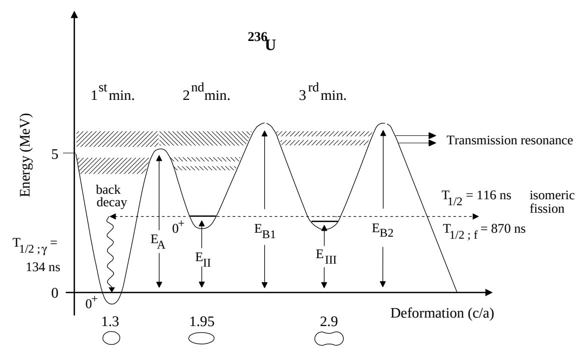


Fig. 1: Potential energy curve of $^{236}$U as a function of the nuclear deformation as determined in Ref. [3].

Nevertheless our analysis of the first experiment suffered from a limited coverage of the angular range of the fission angular correlation, forcing us to use older angular data points published in [5] for the comparison with our J- and K-dependent description of the rotational structure resolved in the $^{236}$U transmission resonance groups around excitation energies of 5.1 MeV and 5.3 MeV, respectively. The aim of our most recent experiment on $^{236}$U was to overcome this limitation by measuring the angular distribution of the fission fragments in order to determine the spin and K-values of the rotational structure underlying the transmission resonances. The experiment used the $^{235}$U(d,pf) reaction at a bombarding energy of 13 MeV. A $^{235}U_2O_3$ target was used with a thickness of 90 $\mu$g/cm$^2$ on a 28 $\mu$g/cm$^2$ carbon backing. The energy of the proton ejectiles was analysed by the Q3D magnetic spectrometer, set to 139.4°. An energy resolution of $\Delta$E=5 keV was achieved. Fission fragments were detected by two position sensitive avalanche detectors (PSAD), which consisted of two perpendicular wire planes, thus allowing for a detection of the fission fragment angular correlation with respect to the recoil axis. The fission detectors covered a wide range of $\Theta = 0° - 100°$ relative to the recoil axis with a solid angle coverage of 20% of $4\pi$ (without double-counting of fission fragments). The angular correlation was analyzed by fitting it with even-order Legendre-polynomials.

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Fig. 2a) displays the low-energy part of the fission probability spectrum around E$^*$ =5.1 MeV, where our previous analysis revealed a hyperdeformed configuration in contrast to older findings [6]. Since the higher-energetic resonance region around E$^*$ =5.3 MeV has been identified consistently in all exeriments as being hyperdeformed, we do not discuss this region in the present analysis. In the analysis of the angular correlation data the angular coefficient $a_2$ was determined for the most prominent structures in Fig. 2a) parameterized by a series of rotational bands with K-value assigments as indicated in the figure. Within errors our new angular data points (circles) agree with the older data from Just et al. [5] (squares) as can be seen in Fig. 2b). The high-resolution excitation energy spectra deduced from the proton spectrum in Fig. 2a) in combination with the analysis of the angular distribution measurement in a consistent description confirm the interpretation of the transmission resonance structures around 5.1 MeV as hyperdeformed rotational bands as published in [3].

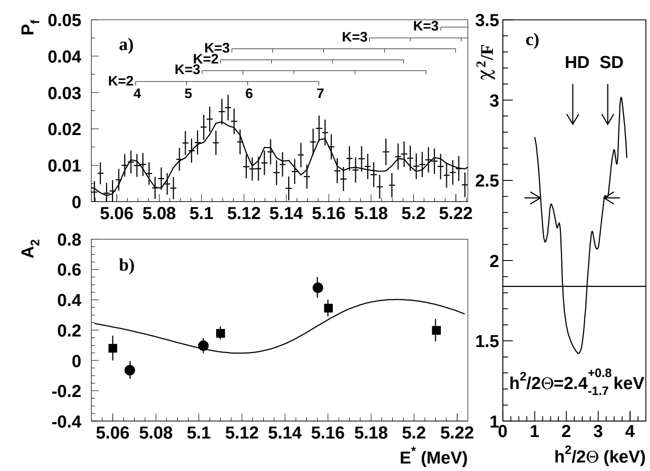


Fig. 2: a) Fission probability spectrum around E$^*$ =5.1 MeV fitted with rotational bands and b) the corresponding calculated fission fragment angular distribution on the experimental points measured in this work (circles) and previously by Just et al. (squares). c) Result of the $\chi^2$-analysis, proving the hyperdeformed structure of this resonance region.

The rotational parameter was determined as $\hbar^2/\Theta = 2.4^{+0.8}_{-1.7}$ keV based on the $\chi^2$ test shown in Fig. 2c),in good agreement with our previous result from Ref. [3].

## References

[1] A. Krasznahorkay *et al.*, Phys.Rev.Lett. **80** (1998) 2073
[2] P.G. Thirolf and D. Habs, Prog.Part.Nucl.Phys. **49** (2002) 325
[3] M. Csatlós *et al.*, Phys.Lett. **B615** (2005) 175
[4] S. Ćwiok *et al.*, Phys.Lett. **B322** (1994) 304
[5] M. Just *et al.*, Proc. of the Int. Symp. on the Phys. and Chem. of Fission, Jlich, IAEA (1979) 71
[6] P.D. Goldstone *et al.*, Phys. Rev. **C18** (1978) 1706