Angular Distribution of Fission Fragments from the ^{236}U(d,pf) Reaction ◇

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Due to improved experimental techniques significant progress could recently be achieved in the understanding of strongly deformed nuclei in the (superdeformed) second and (hyperdeformed) third minimum of the multiple-humped fission barrier [1]. Using transmission resonance spectroscopy following the ^{235}U(d,pf) reaction (E_d = 10 MeV) the existence of a deep third minimum in ^{236}U (E_{III} =2.7(4) MeV) could be established [2]. However, due to the restrictions imposed by the experimental setup for the fission fragment detectors in this experiment, the assignment of spins and K values had to rely on rather old angular correlation data from the same reaction [4,5]. It was the goal of our most recent experiment to focus on the measurement of fission fragment angular correlations with significantly improved statistics.

The experiment was performed at the MLL Tandem accelerator, where the ^{235}U(d,pf) reaction (E_d = 13 MeV onto a $d \approx 90\mu g/cm^2$ $^{235}U_2O_3$ target on a $28\mu g/cm^2$ C backing) was used to study hyperdeformed transmission resonances. The energy of the proton ejectiles was analyzed by the Q3D magnetic spectrograph. The Q3D was placed at $\Theta_L = 139.4°$ relative to the beam direction. The position of the analyzed particles in the focal plane was measured with a light ion position sensitive focal-plane detector achieving an energy resolution of about 5 keV. Fission fragments were detected by two position-sensitive avalanche detectors (PSAD) having two wire planes corresponding to horizontal and vertical directions. Thus the spatial positions of the fragments and their angular correlation with respect to the recoil axis could be determined. The fission detectors covered the range of $\theta = 0° - 100°$ relative to the recoil axis with a solid angle coverage of 20% of 4π (without double-counting of fission fragments).

The measured high-resolution proton energy spectrum is shown in Fig. 1a). Containing more than twice the statistics compared to the previous experiment, the hyperdeformed resonance structures previously identified and resolved could exactly be reproduced, even with improved resolution.

Our preliminary analysis of the corresponding fission fragment angular correlations with respect to the recoil axis indicates promising results to deduce the spin and K values of the observed resonances. The angular correlations have been parameterized in the usual way with coefficients a_2 and a_4 of even Legendre polynomials. Fig. 1 b) and c) show the a_2 and a_4 coefficients belonging to the different resonances. We are especially interested in the 5.1 MeV energy region, where we recently identified hyperdeformed resonances in contrast to the superdeformed interpretation so far published [3]. Horizontal lines indicate the theoretical angular correlation coefficients for different K values.

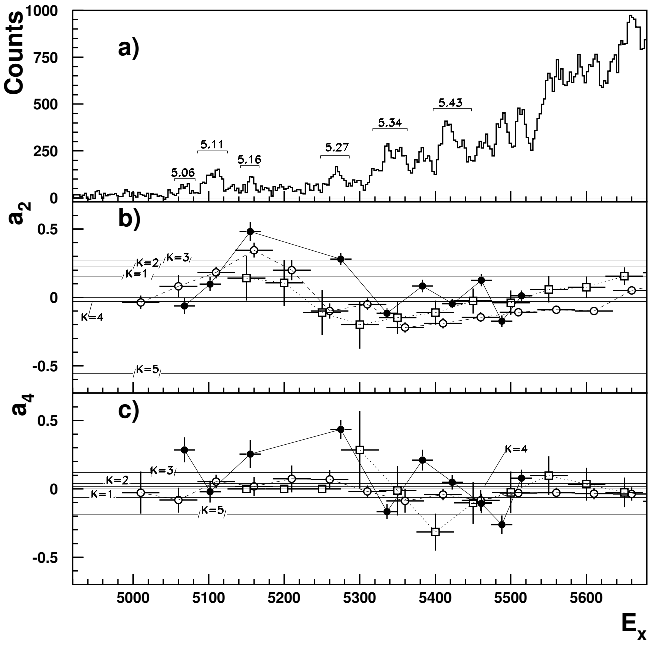

Fig. 1: (a) Proton energy spectrum in coincidence with fission fragments following the ^{235}U(d,pf) reaction. Known hyperdeformed resonance regions are marked. (b),(c) Full dots represent the $a_2(a_4)$ fission angular distribution coefficients determined in this measurement, open circles and squares show $a_2(a_4)$ coefficients determined by Just et al. [4] and Britt et al. [5], respectively. The horizontal lines indicate theoretical values for different K values.

Already our preliminary analysis shows fair agreement of the measured angular correlations with the older data measured by Just et al. at a beam energy of 11 MeV [4] (open circles) and Britt et al., measured at 18 MeV beam energy [5] (squares), respectively.

A combined analysis of the energy spectrum and the angular distribution coefficients proves that the resonances in the 5.1 MeV region correspond to resonances in the hyperdeformed third minimum rather than in the superdeformed second well of the potential energy surface [2].

References

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