Nuclear-fission studies with exotic beams: analysis of fission channels

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The present work reports on a systematic study of fission-fragment element yields in the fission of 70 neutron-deficient actinides and pre-actinides between ^{205}At and ^{234}U within the concept of independent fission channels [1]. The fission channels are characterized by several parameters, e.g. the average mass or charge split, the mass or charge width, and the mean total kinetic energy, respectively the elongation of the scission configuration. We extract the values of these parameters for three fission channels from the measured data of 15 systems [2] which show features of multi-modal fission.

The experiment was performed at GSI Darmstadt: Relativistic secondary projectiles were produced via fragmentation of a 1 *A* GeV primary beam of ^{238}U and identified in *A* and *Z* by the fragment separator FRS. Details of the experimental technique are given elsewhere [2].

In Fig. 1, we compare the parameters of the independent fission channels determined in the present work with the body of previously available data. This allows a systematic view on the variation of position (<*A*>) and width (σ) of the standard I (S1) and standard II (S2) channels, on the width of the super-long (SL) channel and on the relative yields of these three channels as a function of *Z* and *A* of the fissioning system. The data are restricted to spontaneous fission and to initial excitation energies up to a few MeV above the fission barrier. The widths of the S1 and S2 fission channels show fluctuations, which are appreciably larger than the reported statistical uncertainties of the fits. No systematic trend can safely be deduced over the whole mass range. One may only conclude that the width of the S1 fission channel amounts to about 3.5 mass units, while the width of the S2 fission channel is appreciably larger with about 5 mass units. The width of the SL fission channel is rather well determined for the light systems of the present experiment, for which the symmetric fission component dominates, to about 10 mass units over a large mass range, see ref. [2]. Thus, the SL fission channel is much broader than the S1 and S2 fission channels. The values deduced previously for heavier systems fluctuate enormously. These fluctuations are probably explained by the tiny yield of the super-long channel for the heavier systems.

The positions of the S1 and S2 fission channels show a systematic variation as a function of mass number for a given element. This trend is clearly seen for all elements, in spite of some fluctuations. The average slope of the isotopic trend seems to be slightly larger than 0.5. This means that the positions of the S1 and S2 fission channels vary in neutron number and are rather *stable in proton number*. The relative yield of the symmetric SL fission channel shows an exponential decrease with increasing mass number. For systems with $A > 234$, the yield of this channel becomes so low that it could not be determined any more. At the same time, the complementary yield of the lumped asymmetric component increases with increasing mass. Deducing a systematic trend in the competition between the S1 and the S2 fission channels requires a more detailed analysis [3].

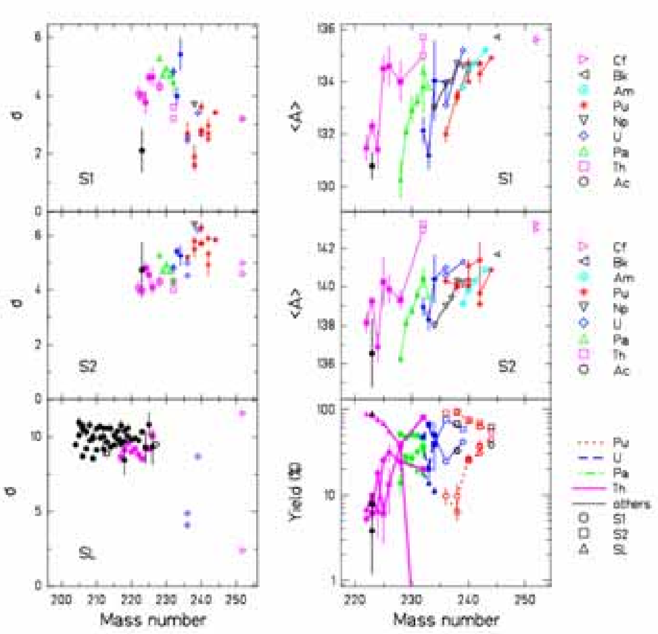

Figure 1: Global view on the parameters of the three independent fission channels standard I (S1), standard II (S2) and super long (SL). The results of the present work (full symbols) are compared with other available experimental data (open symbols) (see ref. [3] for references to other data). All data are given in mass numbers. Values measured in nuclear charge were converted to mass numbers using the unchanged-charge density assumption and neglecting neutron evaporation.

To conclude, the body of data presently available is consistent with the assumption that the parameters of the independent fission channels vary in a smooth and consistent way. Surprisingly, the position of the asymmetric fission channels is found to be constant in atomic number over all systems. More details are given in ref. [3].

References

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