Spontaneous Fission Properties of ^{259}Sg and ^{255}Rf *

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In a recent study decay properties of ^{259}Sg, produced in the reaction ^{206}Pb(^{54}Cr,n)^{259}Sg, were investigated at SHIP [1]. Alpha decay from two nuclear states in this isotope was observed: a) the ground state having a half-life of 411 ms and attributed to the Nilsson level 11/2$^-$[725]; b) an isomeric state located at $E^* \approx 92$ keV with a half-life of 254 ms, assigned as 1/2$^+$[620]. Search for spontaneous fission branches was rendered more difficult by the fact that the α-decay daughter ^{255}Rf has a fission branch of 52% and a half-life of 1.64 s [2]. Thus we searched for spontaneous fission events following the implantation of an evaporation residue (ER) within 10 s and not being preceded by an α-decay neither with full energy release nor with partial energy release in the focal plane detector. A probability $p_w < 0.05$ that a preceding α decay could have been missed and thus an sf event of ^{255}Rf wrongly assigned as an sf event of ^{259}Sg was estimated from the number of correlations α(^{259}Sg) – α(^{255}Rf) – α(^{251}No), α(^{259}Sg) – α(^{251}No) (without observation of α's of ^{255}Rf), and an ≈20% probability to observe only the escaping α-particle as obtained from α – γ - measurements.

Altogether 24 sf events not preceded by an α-decay were observed. Their time distribution (Δt(ER-sf)) is shown in fig. 1. A half-life $T_{1/2} = 235\ {}^{+62}_{-41}$ ms was obtained. As the half-life is in-line with that of the α activity attributed to the decay of the 1/2$^+$[620] level, the sf activity is also assigned to it. From the number of α decays and spontaneous fission events a branching ratio $b_{sf} = 0.06 \pm 0.015$ was obtained, resulting in a partial half-life of $T_{sf} \approx 3.9$ s. Our branching ratio is in-line with $b_{sf} \approx 0.11$, obtained from each one α-sf – correlation in decay studies of ^{263}Hs [3,4].

A hindrance of fission in nuclei having odd proton and/ or neutron numbers compared to neigbouring even-even nuclei is well known. The degree of hindrance can be expressed by a hindrance factor HF defined as $HF = T_{sf}/T_{sf}(unh)$, with the partial fission half-life T_{sf} and the hypothetical 'unhindered' fission half-life $T_{sf}(unh)$, usually obtained as the geometric mean of the fission half-lives of the neighbouring even-even nuclei [5]. Using the known values for the neighbours ^{258}Sg (2.6 ms) [6] and ^{260}Sg (7.0 ms) [7] we obtain $T_{sf}(unh)$(^{259}Sg) = 4.3 ms, and thus HF ≈ 907, which is about an order of magnitude lower than the value for the daughter ^{255}Rf.

Striking differences have also been observed for the measured 'fission energies', which are displayed in fig. 2. It should be noted, that the probability to stop both fission fragments in the focal plane detector is only 30%. So in most of the cases the observed 'fission energy' represents the sum of the kinetic energy of one fragment and the energy loss of the other fragment. We observed for ^{259}Sg an about 10% higher mean energy value and a narrower distribution of the fission energies than for ^{255}Rf. This is presently regarded as sign of two components in the mass distribution of the fission fragments of ^{255}Rf, but only one component in that of ^{259}Sg, i.e. a transition from asymmetric fission of ^{255}Rf to symmetric fission of ^{259}Sg.

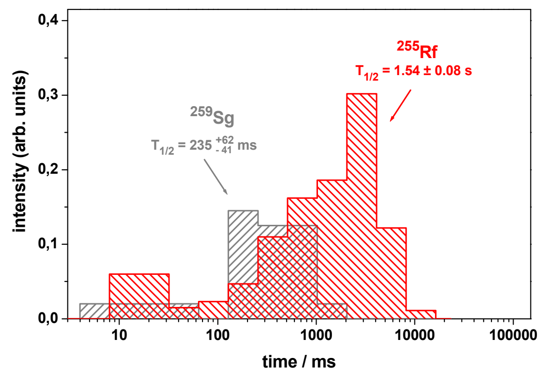

Figure 1: Time distributions Δt(ER-sf) of fission events not preceded by an α decay (^{259}Sg) and Δt(α-sf) of fission events preceded by an α decay (^{255}Rf)..

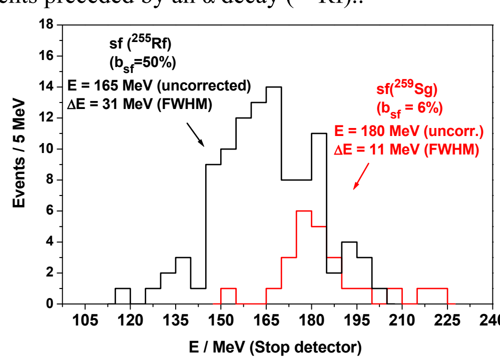

Figure 2: Energy distributions of fission events assigned to ^{255}Rf and ^{259}Sg. Given energy values are not corrected for pulse height defect.

References

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