Revisiting prompt emission of ^{252}Cf(SF) with focus on post-neutron fragment distributions and different correlations

Anabella Tudora

University of Bucharest, Faculty of Physics, str. Atomistilor 405, Magurele, Ro-77125, Romania

anabellatudora@hotmail.com

Abstract: The present investigation, focusing on post-neutron fragment distributions and different correlations between pre- and post-neutron fragment quantities and their distributions, is performed by using the Deterministic Sequential Emission (DSE) model developed at the University of Bucharest. The impact of energy partition in fission on prompt emission and post-neutron fragment distributions is investigated by using two different methods: one is based on modeling at scission and another consists of the sharing of total excitation energy (TXE) according to the temperature ratio $R_T=T_L/T_H$ of fully accelerated complementary fragments, which is parameterized as a function of A_H (by a few jointed segments). Three pre-neutron fragment distributions Y(A,TKE), measured during the time at JRC-Geel (i.e. by Hambsch and Oberstedt in 1997, Göök et al. in 2014 and in the VESPA experiment in 2021) are used in order to investigate their influence on post-neutron fragment distributions and different correlations.

The model calculations are validated by the good description of all experimental prompt neutron and γ-ray data of ^{252}Cf(SF) by the DSE results obtained with both TXE partitions and three Y(A,TKE) data. The results of independent FPY $Y(Z,A_p)$ and $Y(A_p)$ are also in good agreement with the experimental data from EXFOR. Compared to the previous investigated case of $^{235}U(n_{th},f)$ [1], the influence of Y(A,TKE) on post-neutron fragment yields is more pronounced, different Y(A,TKE) data leading to changes of both the position and the magnitude of visible peaks and dips in the $Y(A_p)$ structure. The even-odd effect in fragment charge still plays a role in the $Y(A_p)$ structure but it is less pronounced than in Ref.[1] because the even-odd effect in Y(Z) is 10 times lower in the case of ^{252}Cf(SF) compared to $^{235}U(n_{th},f)$. The correlation between the excitation energy E* of fully accelerated pre-neutron fragments and the kinetic energy KE_p of post-neutron fragments, ascertained in Ref.[2], is maintained in the case of ^{252}Cf(SF), too.

The investigation is extended to the distributions of pre-neutron fragment energies $Y_\nu(E^*)$ leading to the number of emission sequences (or prompt neutrons) ν = 0, 1, 2, 3, 4, etc. The correlation between E* and ν is well reflected in the almost linear increase exhibited by the first moments of these distributions $\langle E^*\rangle$ (all fragments) and $\langle E^*\rangle_{L,H}$ (separately for light and heavy fragments) as a function of ν. The slope of $\langle E^*\rangle_H(\nu)$ being visible lower than that of $\langle E^*\rangle_L(\nu)$.

The mass, charge and TKE distributions of pre-neutron fragments ($Y_\nu(A)$, $Y_\nu(Z)$, $Y_\nu(TKE)$) which lead to each number of emission sequences (or prompt neutrons) ν = 0, 1, 2, 3, etc. are also investigated, showing that the highest $Y_\nu(A)$, $Y_\nu(Z)$, and $Y_\nu(TKE)$ distributions are those corresponding to ν = 2, 3 and 4. This fact confirms the Gaussian shape of experimental P(ν) data which is centered on $\langle\nu\rangle$ values placed between 3.7 and 3.8. The differences between the three Y(A,TKE) data are reflected in visible differences between the DSE results of $Y_\nu(A)$, $Y_\nu(Z)$, and $Y_\nu(TKE)$, respectively. It is also observed that in all cases the $Y_\nu(A)$ and $Y_\nu(Z)$ distributions of light fragments are higher than those of heavy fragments confirming again the usual statement that the light fragment group emits more prompt neutrons than the heavy fragment group.

[1] A.Tudora, Eur.Phys.J.A 58 (2022) 126

[2] A.Tudora, Eur.Phys.J.A 58 (2022) 258