

Improved Empirical Parametrization of Fragmentation Cross Sections

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A useful tool to predict production cross sections of exotic nuclei in high-energy fragmentation reactions is a universal analytical formula called EPAX [1, 2]. This formula allows to calculate the yields from fragmenting all non-fissile projectiles in the range of projectile masses between about 40 to 209. The cross sections are assumed to be energy-independent and appear to be reliable at incident energies above $\approx 100 A$ MeV. The EPAX parametrization aims at reproducing the bulk of the measured cross sections within a factor of about two for fragment masses down to about half the projectile mass.

The previous version of the formula, EPAX 2 [2], has proven to give rather realistic estimates of many production cross sections of exotic nuclei, for some neutron-deficient fragments even down to the sub-nanobarn regime [2]. However, large discrepancies with measured data were found for extremely neutron-rich nuclei like, e.g., fragment yields from $1 A$ GeV $^{136}\text{Xe}+^9\text{Be}$, which were overestimated by EPAX by up to two orders of magnitude.

A new version of the EPAX formula has therefore been proposed which maintains the relatively good agreement with measured data on the neutron-deficient side and improves the agreement on the neutron-rich side of the line of β -stability. A detailed description of this version (EPAX 3) and its differences with respect to the previous one has been given in a recent publication [3]; coded versions in FORTRAN [4] and C [5] language can be downloaded from the GSI Document Server.

An example of the improvement provided by EPAX 3 for neutron-rich fragments is given in Fig. 1. It plots the measured cross sections for proton-loss channels in the reaction $1 A$ GeV $^{136}\text{Xe}+^9\text{Be}$ [6] for a loss of up to 6 protons, covering about nine orders of magnitude in cross section. The full curve in this figure denotes the predictions of the new formula, EPAX 3, whereas the dashed one results from the previous version. The slope of the new curve fits much better to the measured data. The agreement is also comparable to the quality of a physical model, the “cold fragmentation” model, COFRA, by Benlliure *et al.* [7].

Figure 2 shows that the good agreement with experimental data for neutron-deficient fragments has been maintained. This figure also shows that the empirical scaling factor with target mass (Eq.(3) in Ref. [3]) is appropriate.

References

- [1] K. Sümmerer *et al.* Phys. Rev. C **42**, 2546 (1990).
- [2] K. Sümmerer and B. Blank, Phys. Rev. C **61**, 034607 (2000).
- [3] K. Sümmerer, Phys. Rev. C **86**, 014601 (2012). Errors in Eqs.(5), (6), and (19) of that article have been corrected in an Erratum (Phys. Rev. C, to be published).

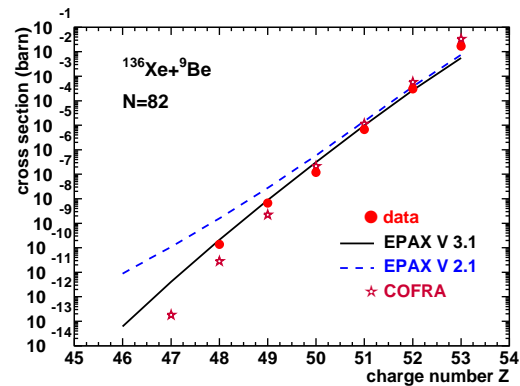


Figure 1: Experimental cross sections of proton-loss channels for the reaction of $1 A$ GeV ^{136}Xe on ^9Be (dots, Ref. [6]) in comparison with EPAX 3 (full line), EPAX 2 (dashed curve) and with the physical “cold fragmentation” model COFRA [7] (stars).

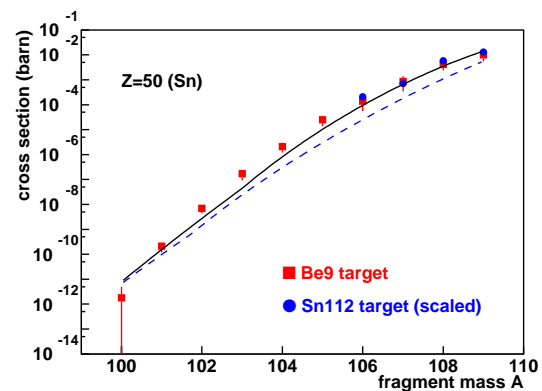


Figure 2: Experimental Sn fragment cross sections from the reaction of $1 A$ GeV ^{112}Sn on ^9Be (squares, Ref. [8]) and ^{112}Sn (dots, Ref. [9]) targets in comparison with EPAX 3 (full line) and EPAX 2 (dashed curve). The Sn-target data points have been scaled by a factor of 0.65.

- [4] <http://www.gsi.de/documents/FRS-reference-2012-001.html>.
- [5] <http://www.gsi.de/documents/FRS-reference-2012-002.html>.
- [6] J. Benlliure *et al.*, Phys. Rev. C **78**, 054605 (2008).
- [7] J. Benlliure *et al.*, Nucl. Phys. **A660**, 87 (1999).
- [8] A. Stolz *et al.*, Phys. Rev. C **65**, 064603 (2002).
- [9] V. Föhr *et al.*, Phys. Rev. C **84**, 054605 (2011).