Systematics for the cross-sections of the (n,p), (n,α) and (n,2n) reactions at 14.5 MeV

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Introduction

For the calculation of (n,p), (n,α) and (n,2n) reaction cross-sections at the 14.5 MeV neutron energy, systematics have been obtained by us using the literature data available on EXFOR library [1]. The obtained formulas have been based on the statistical model, considering the odd-even effect and Q-value dependence. When data is not explicitly measured or inconsistent, in such cases, a systematic approach is used to estimate the neutron-induced reaction cross-section data more precisely [2-9]. Neutron-induced reaction cross-section data are essential for many technical applications in nuclear physics and medical fields [10]. In the present work, semi-empirical formulas for odd-A and even-A have been obtained for the (n,p), (n,α) and (n,2n) reaction cross-sections at 14.5 MeV incident neutron energy and the target mass regions $46 \leq A \leq 201$, $23 \leq A \leq 133$ and $45 \leq A \leq 204$ respectively.

Semi-empirical formula for (n,p), (n,α) and (n,2n) reaction cross-section

The reaction cross-sections on the basis of the statistical model can be written as [11]

$$\sigma_{n,j} = \sigma_R (\Gamma_j/\Gamma_n) \qquad (j = p, \alpha, 2n)$$

where, σ_R = reaction cross-section for incident neutrons

Γ_j = decay width for p, α, and 2n emissions

Γ_n = decay width for neutrons

Fitting of the (n,p), (n,α) and (n,2n) reaction cross-sections systematics

For (n,p), (n,α) and (n,2n) reaction cross-sections, the obtained relations are fitted using the Legendre least squares method and experimental values for the cross-sections for odd-A and even-A as input data. For both odd-A and even-A nuclides, there is good agreement between the present systematics and the experimental values in $46 \leq A \leq 201$, $23 \leq A \leq 133$ and $45 \leq A \leq 204$ mass region. The cross-section values have been obtained with the help of the following expressions –

$\sigma_{n,p} = (1+A^{1/3})^2\ \alpha\ \exp(\beta(N-Z)/A)$

$\sigma_{n,\alpha} = (1+A^{1/3})^2\ \phi\ \exp(\Theta(N-Z)/A)$

$\sigma_{n,2n} = (1+A^{1/3})^2\ \rho\ \exp(\gamma(N-Z)/A + \lambda(N-Z)^2/A^2)$

where α, β, ϕ, Θ, ρ, γ and λ are fitting parameters.

Results and Discussion

TABLE 1: Systematic formulas proposed by us for (n,p), (n,α) and (n,2n) reactions

Formula	**Mass Region**
$\sigma_{n,p}=10.49(1+A^{1/3})^2\exp(-15.99(N-Z)/A)$	$47\leq A\leq 201$ (Odd-A)
$\sigma_{n,p}= 52.01(1+A^{1/3})^2\exp(-3.48(N-Z)/A)$	$46\leq A\leq 200$ (Even-A)
$\sigma_{n,\alpha}=21.79(1+A^{1/3})^2\exp(26.49(N-Z)/A)$	$23\leq A\leq 133$ (Odd-A)
$\sigma_{n,\alpha}=18.17(1+A^{1/3})^2\exp(-23.82(N-Z)/A)$	$26\leq A\leq 110$ (Even-A)
$\sigma_{n,2n}=5.58(1+A^{1/3})^2\exp(22.85(N-Z)/A-63.51(N-Z)^2/A^2)$	$45\leq A\leq 203$ (Odd-A)
$\sigma_{n,2n} = 8.93(1+A^{1/3})^2\exp(8.76(N-Z)/A)$	$46\leq A\leq 204$ (Even-A)

It can be concluded from the FIG. 1 (a), (b) and (c) that σ(n,p) for even-A, σ(n,α) for odd-A and σ(n,2n) for even-A are well reproduced by the systematics proposed by us. For odd-A (n,p), even-A (n,α) and odd-A (n,2n), systematic fitting of reaction cross-sections and a comparative study with existing literature systematics proposed by different authors Levkovski [12], Ait-Tahar [13], Doczi et al. [14], Chatterjee et al. [15] etc. will be presented during the conference.

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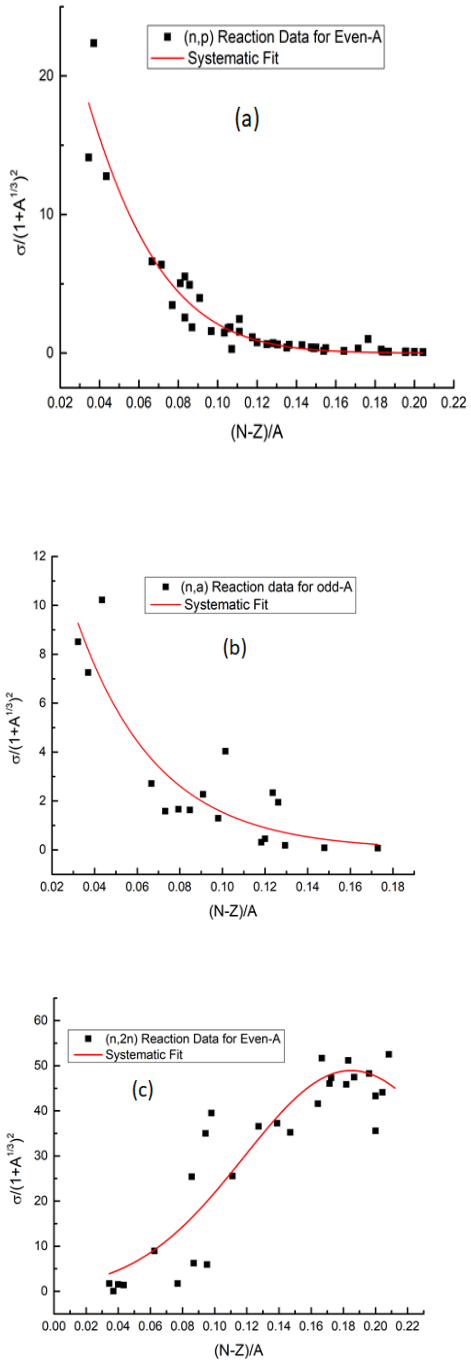

FIG. 1: Systematic fitting of the even-A (n,p), odd-A (n,α) and even-A (n,2n) reaction cross-sections at 14.5 MeV incident neutron energy.

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