Determination of the excitation function for (p,2n) reaction on ^{241}Am from threshold to 16 MeV

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Abstract

The excitation function of ^{241}Am (p,2n) ^{240}Cm reaction is determined by Back-shifted Fermi gas model for level densities from threshold to 16 MeV using the nuclear reaction codesTALYS-1.8. The calculated cross sections were agreed well with experimental data from EXFOR database and also compared with the evaluated data files (TENDL2009, TENDL2014).

Introduction

The cross section data are necessary for energy production in nuclear reactors. The energy production using americium (Am) isotope is one of the recent interest in defence research. Americium isotope has been proposed as an active element of radioisotope used in thermos-electric generators in space craft. Another proposed space related application of Am is a fuel for space ships with different nuclear proportion.^{241}Am is being studied as RTG (radioisotope using in thermoelectric generators) fuel by European Space Agency (ESA). The evaluation of cross section data for the nuclear reactions induced by particles like neutron and proton is required for several applications in the nuclear energy field. In the present work, the excitation function of ^{241}Am (p, 2n) ^{240}Cm from the reaction threshold energy to 16 MeV is calculated by invoking the compound nucleus model, Back-shifted Fermi gas model using TALYS1.8 nuclear reaction code. Theoretically calculated results were compared with the experimental data taken from the EXFOR [1] database and evaluated data files (TENDL).

Theoretical Model and parameters

TALYS 1.8 is a computer code system for the analysis and prediction of nuclear reactions which involve neutrons, photons, protons, deuterons, tritons, 3 He- and alpha-particles, in the energy range between 1 keV and 200 MeV with the target nuclides of mass≥12. In TALYS nuclear structure and model parameters are implemented through internal subroutines (internal reference library). Projectile, target nucleus, target mass and incident projectile energy parameters were defined in the input file. However, the input file includes appropriate key word to vary the nuclear models such as optical model, compound nucleus reaction, pre-equilibrium mechanisms and parameters.

Binary compound cross section and angular distribution

The compound nucleus formula for Binary cross section is given by,

$$\sigma_{\alpha\alpha'}^{comp} = D^{comp}\frac{\pi}{k^2}\sum_{J=\mathrm{mod}(I+s,1)}^{l_{\max}+I+s}\sum_{\Pi=-1}^{I}\frac{2J+1}{(2I+1)(2s+1)}\sum_{j=|J-I|}^{J+I}\sum_{l=|j-s|}^{j+s}\sum_{j'=|J-I'|}^{J+I'}$$

$$\times\sum_{l'=|j'-s'|}^{j'+s'}\delta_{\pi}(\alpha)\delta_{\pi}(\alpha')$$

$$\frac{T_{\alpha lj}^{J}(E_a)\left\langle T_{\alpha' l' j'}^{J}(E_{a'})\right\rangle}{\sum_{\alpha'',l'',j''}\delta_{\pi}(\alpha'')\left\langle T_{\alpha'' l'' j''}^{J}(E_{a''})\right\rangle}W_{\alpha lj\alpha' l' j'}^{J}$$

In the above expression, E_a , s,π_0, l,j denotes the energy, spin, parity, orbital angular momentum and the total angular momentum of the projectile. Here, W represents the width fluctuation correction (WFC) factor.

Level densities

In statistical models for predicting cross sections, nuclear level densities are used at

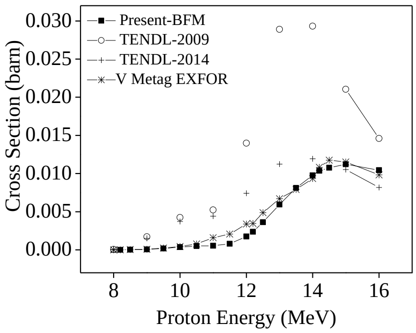

Fig. 1. The excitation function of 241Am (p, 2n) 240Cm reaction along with experimental EXFOR data and evaluated data files TENDL

excitation energies where discrete level information is not available or incomplete. Level density over spin and parity as

$$\rho_{tot}(E_x) = \sum_J \sum_\Pi (E_x, J, \Pi)$$

Back-shifted Fermi gas model (BFM)

The expression for the total BFM level density [2] is

$$\rho_{BFM}(E_x, J, \Pi) = \frac{1}{2}\frac{2J+1}{2\sigma^2} \exp\left[-\frac{\left(J+\frac{1}{2}\right)^2}{2\sigma^2}\right]\rho_{BFM}^{tot}(E_x)$$

Results and discussion

The excitation curve of the nuclear reaction ^{241}Am (p, 2n) ^{240}Cm from threshold to 16 MeV is simulated using TALYS 1.8 codes and is given in Fig.1and Fig.2.The plot also contains experimentally predicted data from EXFOR database and evaluated data files TENDL 2009, TENDL 2014, (TENDL is a nuclear data library which provides the output of the TALYS nuclear model code) for comparison. This calculation is done by using the compound nucleus model by adjusting the width fluctuation correction, HFB- Gogny model for nuclear mass, Goriely liquid drop mass used for shell correctionand Back-shifted Fermi gas model for level densities. Fig. 2 illustrates the TALYS default calculation,

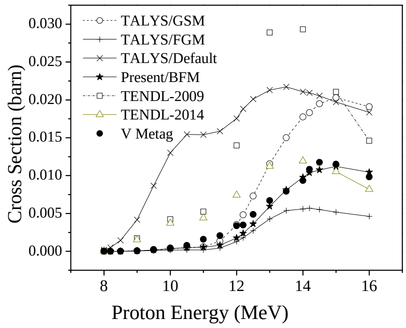

Fig. 2. The excitation function of 241Am (p, 2n) 240Cm reaction along with experimental EXFOR data and evaluated data files TENDL 2009, TENDL 2014, present work with BFM model, TALYS default calculated excitation function, TALYS calculated excitation

TALYS calculation using Generalized super fluid model (GSM), Fermi gas model (FGM) and the present calculation using Back-shifted Fermi gas model (BSM). Among these the present calculation with Back-shifted Fermi gas model gives reasonable agreement with the EXFOR experimental data. Also present calculation provides better fit with EXFOR data when compared with available evaluated data TENDL2009, TENDL2014.

References

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