Trends in (n,γ) reaction with atomic number(6 to 109) for most abundant isotope of each element using TALYS and EXFOR

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Introduction

In the present work the study on the variation of the trend of the cross-section of the radiative neutron capture reaction for the most abundant isotope of an element of atomic number in the range 6 to 109 with mass varying from 12 to 268 was observed. The values of cross-sections were obtained at 14 MeV neutron energy using the nuclear code TALYS [1] Further, for the elements from atomic number 110 to 118, no calculations were carried out as the parameters required for the same are yet to be incorporated in the code. The corresponding available experimental data, if any, was also studied using the EXFOR database [2]. For (n,p), (n,alpha) etc. reactions, the number of experimental values are higher compared to (n,gamma) reaction The experimental values were available for the isotopes Na-23, Al-27, Si-28, P-31, Ar-40, Ca-40, Sc-45, Ti-48, V-51, Cr-52, Mn-55, Fe-56, Co-59, As-75, Sr-88, Y-89, Nb-93, Rh-103, Te-130, Cs-133, La-139, Pr-141, Gd-158, Tb-159, Ho-165, Ta-181, Re-187, Au-197, Tl-205,Pb-208, Bi-209, Th-232, U-238 in the energy range 14-14.8 MeV. In general, the values of the cross-section obtained using TALYS were found to be lower than the experimental values obtained from EXFOR.

The radiative neutron capture is important for neutron balance and now for breeding in nuclear reactors as this reaction gives rise to heavy unstable nuclei which may decay into a fissile material. A general trend of variation of (n,g) cross-section with incident neutron energy for U-238 isotope is given in Fig.1[3]

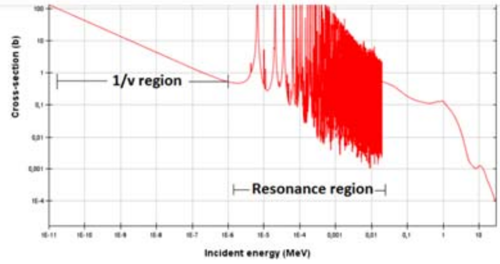

Fig.1 Variation of (n,g) cross-section with incident neutron energy for U-238

Related work already carried out

Similar studies has been carried out for variation of (n,g) cross-section with either varying mass of all isotopes of one particular element or varying incident neutron energies for one particular isotope of an element. A variation of (n,g) reaction with atomic mass using activation data and spectrum data was presented by Qaim et al[4] using the method of Cvelbar et al[5] as shown in Fig.2.

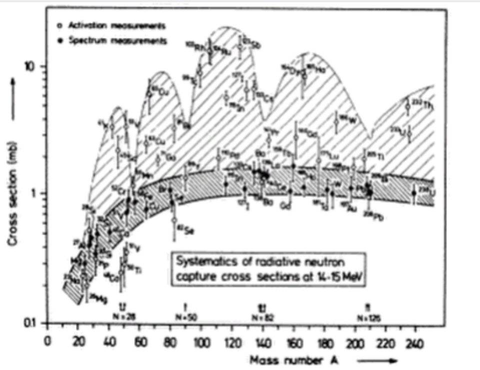

Fig. 2 Systematics of radiative neutron capture reaction presented by Qaim et al(1975)

Results and Discussions

The results obtained using the TALYS and EXFOR data are shown in Fig.3. As the error was sometimes as high as 25%, the error bars of the same value has been considered and it was found that within these limits, the experimental and theoretical values agreed except for Gd-158 and Os-192.

From atomic number 6 to 50, there is an increase in cross-section value for both experimental values, from 0.19mB to 1.39mB and the values obtained from TALYS, from .0005mB to 1.38mB. From atomic number 50 to 100, the cross-section value varies from 0.85mB to 1.78mB for the values obtained from TALYS and the experimental values varied from 0.58mB to 2mB in a random manner without a trend of increase or decrease. Between the atomic number 100 and 150 the experimental cross-section varied from 1.21mB to 3.41mB and the values obtained from TALYS varied from 1.05mB to 1.5mB and again in a random manner. From atomic number 150 to 200, the experimental values varied from 1.09mB to 1.57mB in a decreasing trend and the TALYS value varied from 0.98mB to 1.55mB in a random manner. Above 250 experimental values are not available in the neutron energy range 14-15MeV. And the values from TALYS varied from 1.29mB to 0.66mB in a decreasing manner.

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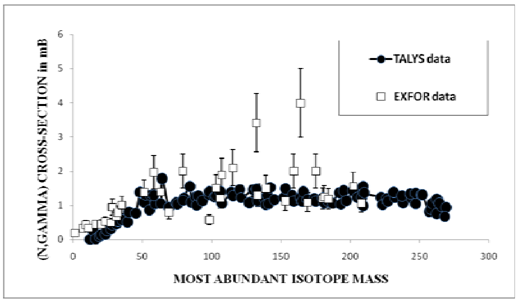

Fig. 3 Variation of (n,g) reaction cross-section with mass of the most abundant isotope of an element obtained using TALYS code and the EXFOR experimental values.

The following reasons can be given to account for the discrepancies between the values obtained from TALYS code and the experimental values taken from EXFOR:

1) The values in TALYS were calculated at 14 MeV whereas the EXFOR values were taken over a range of 14 to 15 MeV.
2) The differences are more when the nucleon number is away from the magic numbers.
3) The purity of the sample activated can also make a difference.
4) The cross-section value is higher at lower neutron energy, so slowing down of neutrons can result in increase of cross-section value.
5) Compared to the initial work carried out to study this variation, the discrepancies between theoretical and experimental are lower now due to improved method of the experimental techniques used reducing uncertainties in the obtained results.

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