Thick target neutron yield at low energies : A computational analysis with code NeuCBOT

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Introduction

Contamination of ^{232}Th, ^{235}U, ^{238}U and their daughters in the detector materials generates α-particles. This α-particles can induce (α,n) reactions on the detector materials. Thus thick target neutron energy spectra resulting from the α bombardment of various light elements are of great significance. The computations of these spectra are conducted for elements such as Magnesium, Aluminium and Silicon at four different mono energetic α -particle energies 4.0, 4.5, 5.0 and 5.5 MeV, using the NeuCBOT code. NeuCBOT calculates the neutron yield using TALYS and the mass stopping power are read from a library generated by SRIM, the spectrum is compared with the angle integrated neutron energy spectra(and their integrals; n/α-values) from time-of-flight measurement by G.J.H. Jacobs et.al.[1].

Methodology

Calculations of angle-integrated neutron yield using the model code NeuCBOT were made for Magnesium. These data, together with linear stopping powers were used to construct angle-integrated spectrum. This is compared with the literature data [1][2][3][4] and are plotted in Fig. 1 for various alpha energies. Generalised Super fluid model is found to be best suitable level density model that reproduces the experimental data satisfactorily. Here the results of Liskien and Bair[4][3] were obtained from calculation, whereas by West and G.J.H. Jacobs [1][2] are from measurement. The integral n/α - values are shown in Table. I. In Similar way, the angle integrated neutron energy spectra for thick targets of Aluminium and Silicon(1.5mm and 0.4mm) are also determined at four different α - particle energies 4.0, 4.5, 5.0 and 5.5 MeV. The integrated yield are thus calculated for Aluminium, Magnesium, and Silicon as integrated over isotopic abundunce

Table 1: The integral n/α values for thick targets of Magnesium at four different α-particle energies obtained from literature and from the code NeuCBOT

Eα(MeV)	5.5	5	4.5	4	Ref
In unit of 10^{-7} n/α	–	5.8	2.7	1.0	Lis 77[4]
	12.6	6.4	2.63	0.77	Bai 79[3]
	13.7	7.04	2.93	*0.83*	Wes82[2]
	13.3	6.65	2.60	0.73	Jacobs[1]
	14.7	7.39	3.09	0.99	NeuCBOT

Result and discussion

It is observed that for Magnesium, maximum possible neutron energy produced by 5.5 MeV α-particles is 8.0 MeV. Similarly, for Aluminium it is 2.6 MeV and that for Silicon is 3.7 MeV. The neutron spectra generated by NeuCBOT reproduces the experimental spectra satisfactorily with in the limit of systematic uncertainties. Peaks corresponds to various level transitions are also more or less well represented. In order to get the total neutron production the integral neutron yields were calculated corresponding to different α energies, forall the elem ents, accounting their natural isotopic abundance, and are plotted in Fig. 2 . It can be seen that the NeuCBOT calculation for ntegral neutron yield for different alpha energies reproduces finely for all the cases under study.

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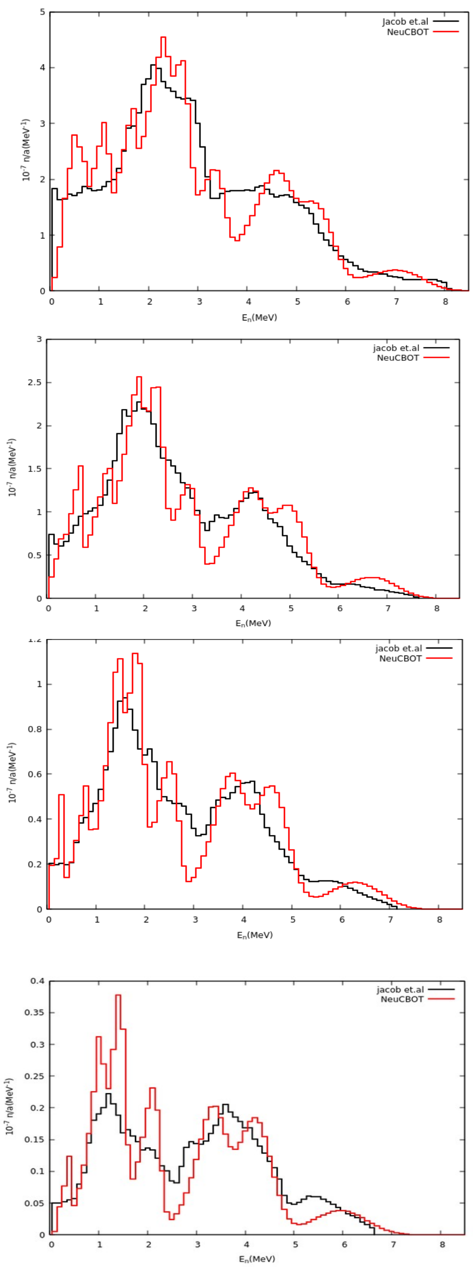

Fig. 1 The angle integrated neutron energy spectra for thick targets of Magnesium at four different α-particle energies, determined from time of flight measurements(black line), The red line represents the result obtained from NeuCBOT. From top to bottom of the figure: 5.5MeV, 5MeV, 4.5MeV, and 4MeV

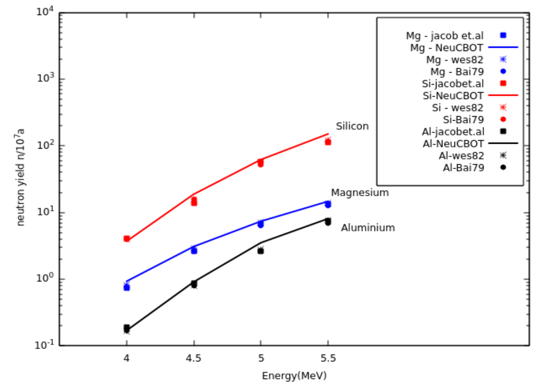

Fig. 2 Integrated Neutron yield for elements Si, Mg and Al is calculated by code NeuCBOT in comparison with literature data for energies 4, 4.5, 5 and 5.5 MeV respectively.

Conclusion

Above analysis concluded that in low energy neutron emission studies NeuCBOT code gives a better agreement with experimental data as it can calculate energy loss in case of thick targets. Thus code NeuCBOT is capable of producing the integral neutron energy spectra for thick targets.

Acknowledgments

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