ANALYSIS OF NEUTRON ENERGY SPECTRUM FROM ^{241}Am-Be SOURCE

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INTRODUCTION

Neutron spectroscopy is important in nuclear physics and radiation safety. Unlike energy measurements of ionizing radiations, direct measurement of neutron energy is difficult, Radio-active neutron source of the type Am-Be(α,n)are now widely used as standards, particularly for the calibration of neutron detectors. The 5.5MeV α particle from the ^{241}Am source undergo fusion with ^{9}Be to form the compound nucleus of ^{13}C at an excitation energy of around 14.4 MeV. Depending on the thickness of Be the excitation energy of ^{13}C may vary from 10.6 MeV to 14.4 MeV. Neutron from such resonance populate various states of ^{12}C depending on the structure of states. Presently reported data[1,2] does not provide the expected neutron spectrum as above. Hence,Am-Be neutron energy spectra is simulated using Empire 3.2.2, accounting various factors affecting the spectra. Alpha straggling and tunneling are found to be most sensitive.

TOOLS AND METHODS

The neutron spectra from Am-Be source are simulated at various combination of energies and angles using empire 3.2.3 nuclear reaction code. The optical potential was due to Avrigeanu selected and optimized for inverse alpha channel, on the basis of cros section data taken from IRDF-2002 library[3]. The level density is due to Gilbert and Cameron[4] is used to get best fit for the evaluated cross section data. The nuclear structure data required for the simulation is taken from National Nuclear Data Centre(NNDC) [5]. Am-Be source in the form of cylinder of 6.4mm in diameter and 6.4 mm length is taken as the neutron source in accordance with the construction of New England Nuclear USA, in which Am and Be atoms are encapsulated as a perfect 1-1 mixing. Attenuation of alpha particle within the size of source are calculated using SRIM [6], the spectra obtained is shown as dash line in Fig 1. Expected peaks 3.3 MeV and 6.7 MeV are clearly visible as colonies n0,n1. The expected peak at 9.3 MeV and 1.3 MeV are founded to be broadened it is assumed that this broadening is due to straggling effect and the tunneling of alpha particle may cause broadening of the lines converting the peak in to colonies of energy around the peak. Calculation was repeated by accounting tunneling and straggling effects. In this case source was treated as concentric spherical layers of 1.0 μm thick and the energy loss and straggling are calculated accordingly using SRIM. The neutron spectra thus generated is shown in Fig 1 as continuous dark lines . The peaks n_0, n_1, n_2 are visible as colonies of the neutron energy distributions from the ^{9}Be(α,n)^{12}C reaction, leaving the ^{12}C in the states 0 MeV, 4.4MeV, 7.65 MeV and 10.3 MeV respectively along with neutron decay channel of ^{13}C are clearly visible in the corrected neutron spectra.

RESULT AND DISCUSSION

The observed neutron spectra can be interpreted as follows, As the α-beam enters the beryllium target, with energy 5.54 MeV, it produces neutrons in the n_0 group corresponding to an energy $E(n_0)$ near 9.37 MeV. Furthur population of states around 13.5 MeV of ^{13}C causes neutron channels of energy 8.5 MeV. The energy loss due to straggling scatterimg, with in the sample thickness, cause spreading and shifting of neutron energy resulting in n_0 colony with peaks around 9 MeV and 8 MeV respectively, after scattering, straggling and attenuation. Population of 4.439 MeV state of ^{12}C from ^{13}C produces an energy range around 6.5MeV is also included in this colony.

Similarly, the prominent peak observed at neutron energy 3.6 MeV is due to the level excitation of ^{12}C supported by neutron channels of ^{13}C giving energies around 1.9 MeV, 2.2 MeV and 4.8 MeV respectively contribute to the formation of n_1 colony .

The resonances in ^{9}Be crossection at lower alpha energies contribute to the various spikes formed from thermal to 1.5 MeV. This results the formation of n_2 colony.

The resultant spectrum is compared with the spectrum generated by Geiger[2] and J.Pal[1]. In the case of Geiger the reported spectra is averaged distribution without accounting straggling and internal scattering , initial resonance of n_2 colony is also lost here. In the case of J.Pal, n_0 colony is missing as the reported measurement of 4.4 MeV gamma of ^{12}C. There is no straight forward justification could be assigned for shifting of n_1 colony to the lower energy. Further

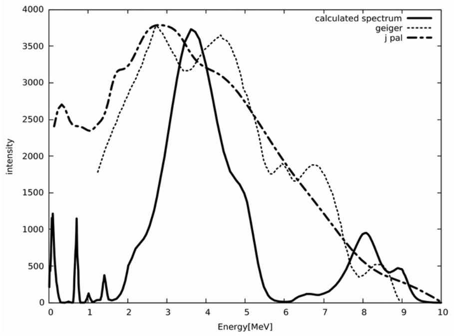

Fig.1

resonance of n_2 colony also seems to be unresolved. The stopping power, energy straggling and alpha tunneling evaluation made a better precision for the present work over the previous works.

The data so produced will be used for calibrating neutron detectors, thereby energy of neutron emitting from various sources can be estimated. The shape of the spectrum is important in the establishment of corrections for absolute neutron source standardization. This is particularly important in the case of radiation therapy and accelerator environment where neutrons of varying energies are produced. The record of neutron spectra thus produced is important for radiation safety and protection.

References

[1] J.PAL, S.SAHA, C.C.DEY, B.K.SINHA, and M.B.CHATTERJEE(1998), "*Neutron energy spectrum of an Am-Be source by gamma gated NTOF technique",*

[2] K.W.Geiger and L.Vanderzwan (1969), "*The Neutron Spectrum of a Am-Be (α, n) Source as Simulated by Accelerator Produced α-Particles"* , International Journal of Applied Radiation and Imtopcs, 1970, Vol. 21, pp. 193-198.

[3] IRDF: IAEA-TECDOC-452(ISBN 92-0-105106-9)

[4]A.Gilbert and A.G.W.Cameron,Can. J.Phys. 43(1965) 1446

[5] Data may be accessed via the NNDC web site http://www.nndc.bnl.gov.

[6] James F. Ziegler , M. D. Ziegler and J. P. Biersack ,"*SRIM – The Stopping and Range of Ions in Matter (2010)"* , United States Naval Academy, Physics Dept., Annapolis, MD, 21402, USA, Ziegler@SRIM.org.