α-elastic scattering on ^{113}In nucleus for p-process study

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1. Introduction

In the star, heavier nuclei are thought to be synthesized by the neutron capture and β-decay processes. But the origin of some proton rich nuclei(known as p-nuclei) is not explained by this process. Many different processes are proposed and the most convincing method to explain the production process of these nuclei is the γ-induced process. In these processes, p-nuclei are formed either by the (γ, n) reaction from neutron rich nuclei or by the (γ, p) or (γ, α) reaction. Hauser Feshbach (HF) statistical model is used to obtain the reaction rates of γ-process from the reaction cross-section. It is difficult to perform γ-induced reaction. So γ-induced cross-section is calculated from inverse reaction cross-section using the principle of detail balance technique. HF calculation is sensitive to the choice of the nuclear input parameters. One of the sensitive input parameters is the entrance channel optical potential. The role of the α-optical potential is significant for the study of the (α, γ) reaction.

Various global alpha optical model potentials are available[1, 2], but these are fails to explain the (α, γ) reaction data. In this work, ^{113}In$(\alpha, \alpha)^{113}$In elastic scattering has been performed and obtained local Wood-Saxon optical potential parameters. The study on ^{113}In has special importance. The maximum p-nuclei are even-even, however, ^{113}In is an odd A p-nucleus and has a non-zero ground state spin parity ($9/2^+$). Furthermore, the ^{113}In production process is still not properly understood. Therefore, accurate determination of the α-optical potential is required for the ^{113}In(α, γ) reaction.

2. Experimental Procedure

The experiment was carried out at the K-130 cyclotron of VECC, Kolkata.

Enriched ^{113}In on Al backing targets were prepared by vacuum evaporation technique. The thickness of the target was obtained by measuring the energy loss of α particle from a known 3-line α source (^{239}Pu, ^{241}Am, ^{244}Cm). The measured thickness of Indium was ≈ 86 μg/cm^2, which is approximately equivalent to 4.25×10^{17} atoms/cm^2 and ≈ 730 μg/cm^2 for Aluminum backing. The uncertainty of the target thickness is about 10%. The presence of Indium in the target material has been confirmed by X-ray photoelectron spectroscopy (XPS).

The experimental setup is shown in Fig.1. Elastic scattering data between $\theta = 25$ - 140 deg angular range was measured at three different energies (E = 26, 29, 32 MeV) above the Coulomb barrier. A collimator of diameter 3 mm was used in the beam line. In this experiment, four silicon surface barriers (SSB) ΔE-E telescopes were used to measure the cross-section at a forward angle, and for the backward angle used 16 channel silicon strip ΔE-E telescope. SSB detectors used as ΔE are 150 μm thick, while detectors used as E range in thickness from 500 to 3000 μm. For strip telescope, detectors with thicknesses of 52 μm and 1034 μm are used as ΔE and E re-

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spectively. The SSB telescopes were placed on the upper turntable and there is a 10^0 angle of separation between each telescope. On the lower turntable, a strip telescope was placed and angular separation between each strip is 1^0. Circular slits of diameter of about ∼4 mm were used as a collimator for the SSB telescope. Each strip has a collimated area of 6×3 mm^2. Solid angles for SSB telescope are between 1.03×10^{-4} and 3.10×10^{-4} sr and 5.21×10^{-4} for Strip telescope.

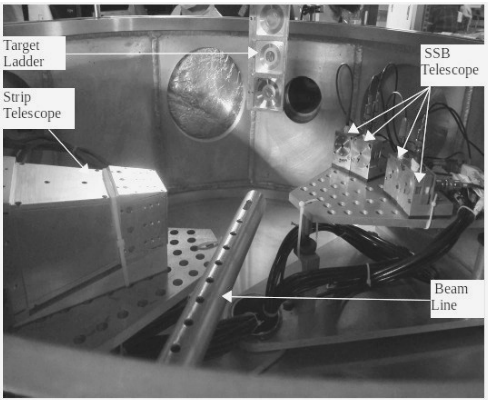

FIG. 1: Experimental setup for elastic scttering

3. Data analysis and Results

Differential cross-sections for each angle of the ^{113}In(α, α) reaction are calculated by the given formula

$$\frac{d\sigma}{d\Omega} = \frac{PeakArea}{NI\Omega} \tag{1}$$

Where N is the surface density of the target material and Ω is the solid angle of the detector. I is equal to the number of incident α-particles bombarding the target material. Energy spectra for two different angles at E$_{lab}$ = 29 MeV are shown in Fig.2. Beam current varies between ∼10-15 in the experiments.

Energy calibration has been done by using elastic scattering with ^{197}Au target at E$_{lab}$ = 26,29, 32 and 40MeV and ^{229}Th α-source (4.9, 5.8, 6.3, 7.1 and 8.4 MeV).

The experimental angular distribution data will be analyzed with the theoretical calculations using the code SFRESCO[3] and local Wood-Saxon optical model potential parameters will be obtained. This new local potential can be used in the ^{113}In(α, γ) reaction calculation for understanding the uncertainty of ^{113}In production process.

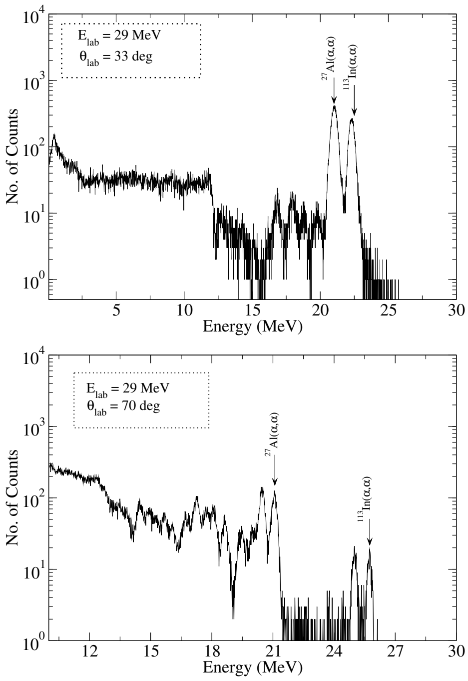

FIG. 2: Energy Spectra for ^{113}In(α, α) reaction at 29 MeV

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