Measurements of absolute cross sections of ^{12}C(α, $\alpha'\gamma$)^{12}C and ^{16}O(α, $\alpha'\gamma$)^{16}O reactions

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Introduction

Inelastic scattering experiments using both proton and heavier composite projectiles provide crucial insights in structures of the target nuclei and also nucleon-nucleus and nucleus-nucleus interatcions. The theoretical reproduction of the experimental data is rather challenging due to the interplay of various factors, such as deformations, channel couplings, compound nuclear resonances, etc. Apart from the studies in fundamental nuclear physics, inelastic scattering is also important for γ-ray astronomy and various practical applications such as material composition analysis. Deeper insight into the underlying mechanisms of inelastic scattering processes demands advanced theoretical models and accurate experimental data to better constrain the theoretical models [1].

In this regard, we have already performed a series of proton inelastic scattering reactions, namely, ^{12}C(p,p$'\gamma$)^{12}C, ^{16}O(p,p$'\gamma$)^{16}O, ^{10}B(p,p$'\gamma$)^{10}B and ^{11}B(p,p$'\gamma$)^{11}B [1–3] . We also attempted to develop a detailed theoretical model based on Optical Model Potential(OMP) formalism to reproduce the finer structures in the cross-section data for ^{16}O(p,p$'\gamma$)^{16}O reaction [1].

Continuing our investigation, we wanted to study the effect of projectile isospin on the cross-sections. Hence, we performed ^{12}C(α,$\alpha'\gamma$)^{12}C and ^{16}O(α,$\alpha'\gamma$)^{16}O reactions to compare them with our previous measurements of ^{12}C(p,p$'\gamma$)^{12}C and ^{16}O(p,p$'\gamma$)^{16}O reactions, respectively.

In this paper, we report our measurements of absolute cross-section of γ-rays from ^{12}C(α,$\alpha'\gamma$)^{12}C and ^{16}O(α,$\alpha'\gamma$)^{16}O reactions. The cross sections, so obtained, are compared with our previous measurements using proton beams of similar energies per nucleon for ^{12}C and ^{16}O targets.

Experimental Details

The measurements were performed at the Variable Energy Cyclotron Centre, Kolkata. with K-130 cyclotron. A mylar foil of thickness 2.2 mg cm^{-2} was bombarded with α-particles of energy 28 to 42 MeV in steps of 2 MeV. In addition, a pure carbon target of thickness 700 μg cm^{-2} was also bombarded with α-particles of energy 30, 32, and 42 MeV. The γ-rays produced from inelastic scattering of α-particles were detected using a large volume 3.5″×6.0″ $LaBr_3$:Ce scintillation detector kept at 35 cm from the centre of the target. The total number of incident particles was determined from the total charge measured using a beam current integrator

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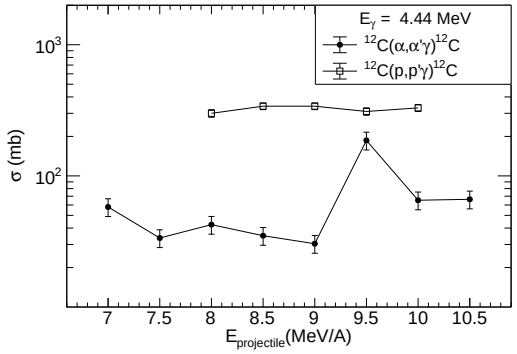

FIG. 1: Comparison of cross-sections of 4.44 MeV γ-rays from ^{12}C.

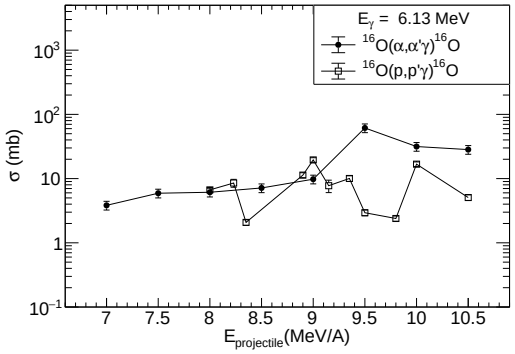

FIG. 2: Comparison of cross-sections of 6.13 MeV γ-rays from ^{16}O.

connected to the beam dump. The angular distribution of the emitted γ-rays was also measured at 40 MeV by detecting the γ-rays at seven angles with respect to the beam direction. The Mylar target was changed at regular intervals in order to avoid any loss in the yield of the γ-rays due to possible degradation of the target.

Results and Discussion

We have extracted the absolute production cross sections of the prominent low lying transitions from both ^{12}C and ^{16}O nuclei. Figures 1, 2 and 3, present the cross-sections of 4.44, 6.13 and 6.92 MeV γ-rays. The cross sections obtained from our previous measurements using protons beams of similar energies per nucleon are also presented in the same plots. It is observed that the proton and alpha induced cross sections are significantly different for all the transitions. While proton induced cross sections are higher than alpha induced cross sections for ^{12}C target, for ^{16}O the cross sections due to alpha particles are much higher than proton induced cross sections. This difference in the scattering cross sections can possibly, at least partly, be ascribed to the isospin dependence of the target projectile interactons. A detailed theoretical analysis is in progress and will be reported elsewhere.

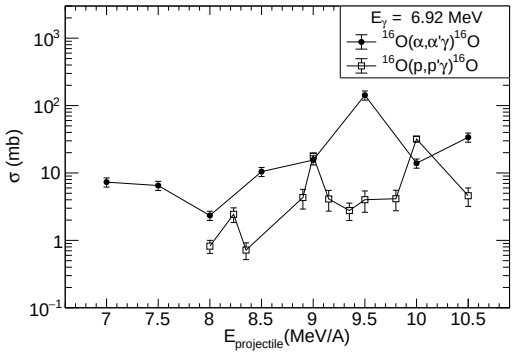

FIG. 3: Comparison of cross-sections of 6.92 MeV γ-rays from ^{16}O.

Acknowledgments

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