Direct measurement of ^{7}Li (γ,α)t cross sections

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Introduction

The cosmological lithium problem remains as an unsolved puzzle, despite numerous advancements in nuclear astrophysics. Hence there is a regained focus on the Li production and destruction reaction channels. There are neumorous efforts to imporove the nuclear physics understanding of the problem, by improving the measurement methodology and the picture of reaction systematics.

Considerng the nuclear origin of cosmological litium production, the formation of ^{7}Li is prodominently governed by the ^{3}H$(\alpha,\gamma)^7$Li reaction, where the inverse reaction ^{7}Li$(\gamma,\alpha)^3$H acts as the destruction of ^{7}Li, utilizing the high energy tail of the BBN γ spectrum, as well as the prompt γ spectrum generated by other capture reactions. The current accelerator thechnology, detectors and the terrestial background condition inhibit a direct measurement of ^{3}H$(\alpha,\gamma)^7$Li, as the cross sections predicted for this is much below the current minimum detection limit. Hence these cross sections are being determined by measuring the inverse reaction followed by introduction of time reversal operation, implemented through detailed balance method [1].

There are several measurements existing for ^{7}Li$(\gamma,\alpha)^3$H, . However, they vary significantly, due to limitations in flux, systematic uncertainties, normalisation issues etc. Hence the measurement of photodissosiation of ^{7}Li has been employed in the present study, for generatig the excitation function with improved quality. High intensity bremsstrahlung is being employed with energy tagging, to generate cross sections in a closer intervel. Details are presented in the following sections.

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Materials and Methods

The experment has been performed by utilizing 14.8 MeV endpoint energy bremsstrahlung from Varian Clinac-iX medical linear accelerator at the Malabar Cancer Centre (MCC), Thalassery. The experimental set up is given in Fig.1.

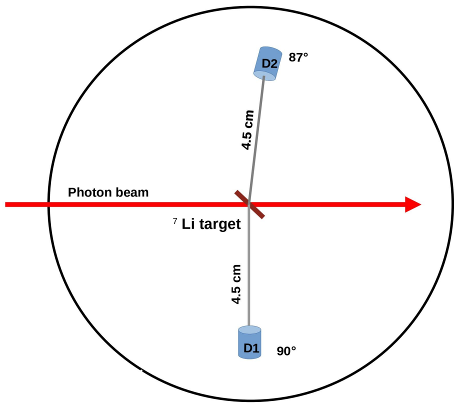

FIG. 1: Experimental setup.

The bremsstrahlung photons were fired on a LiF target having thickness of $100\mu g/cm^2$. the α and t produced from the target were detected in coincidence with the 1500μm silicon SSB. The signals were collected using CAEN DT5743 digitizer, and particle identification were performed based on pulse raising time.

Inorder to reject the junk, trigger for the DAQ is selected as a multiplicity trigger of 2. The $\alpha - t$ correlation events were added to generate the sum energy and is further added with the Q value to reconstruct the beam energy, assuming the energy lose by the kinematics is minimal in the folding angle and below the detector energy resolusion.

The flux of the photon beam is determined through the dosimetry technique, as the dosimetric quantities are well measured with minimum covariance uncertainties. The experimet has been conducted with a photon flux of $\approx 10^{13}$ /cm^2. The event yields were converted to cross sections by accounting the bremsstrahlung weight factors for each energy bin, kinematic efficiencies and the incident flux. Bremsstrahlung weights were derived through segmental integration of the bremsstrahlung spectrum [2]. the obtained cross sections were compared with previous measurements and evaluations.

Results and Discussions

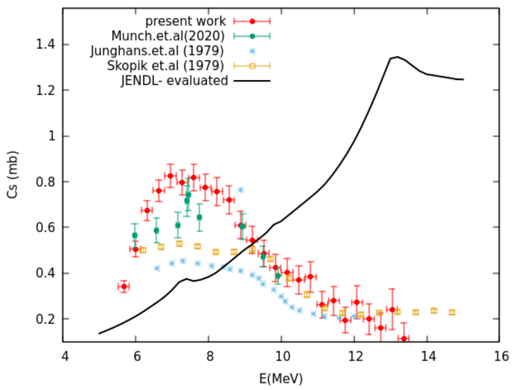

FIG. 2: Comparison of cross section data from various literatures and the present work.

The present measurement of ^{7}Li$(\gamma,\alpha)^3$H cross sections are presented as locally averaged effective histogram values in FG.2, along with previouis measurements and evaluations. The present measurement is in well agrement with Munch et.al.[3], at the energies above 8 MeV, however, there exists a mismatch below that. The other measurements are quite random in this energy range.

The black solid line illustrates the JENDL-02 evaluation of ^{7}Li$(\gamma,\alpha)^3$H reation, presented as total tritium production cross sections. However, the behaviour is completely differ from the experimental results. JENDL evaluation adapts the GDR component for the photon absorption, makes the wrong biasing of the theory, as it is primarly a direct electromagnetic transition to the breakup states. The present study, in comparison with evaluation proves that GDR processes are not at all coupled to the ^{7}Li$(\gamma,\alpha)^3$H reaction channel.

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