MEASUREMENT OF PROTON CAPTURE CROSS SECTIONS ON $^{116,119}Sn$

OBJECTIVE:

Sn is a very useful element to check the validity of the predictions of the Hauser Feshbach cross sections. Owning many isotopes, a systematic study of capture cross sections on the whole isotope family of Sn could prove to be useful to provide a set of global parameters which could then be used to predict the cross sections for the nuclei for which measurements are impractical. As known widely, the stellar temperatures translate to lower energies where cross sections go down because of the reduced transition probability for charged particle induced reactions. So, the experimental database of charged particle induced cross sections is scarce. Experimental determination of the (p,γ) cross sections has been playing an important role in putting strong constraints for reaction models to improve and guarantee reliable results for the gamma process calculations.

The discrepancy with stellar abundance of Sn isotopes is very much alive. The odd isotopes of Sn, $^{115\text{-}117}Sn$ are underproduced by *s*-process calculations [1]. ^{116}Sn is one of the few nuclides that are produced solely by the s-process. It is one of the promising candidates for the calibration of *s*-process models [2]. In this respect, measurements of (p,γ) cross sections on proton rich Sn isotopes gives insight into the (γ,p) cross sections and implicitly into the dilemma involving the *p*-process contribution to the formation of these nuclei. Also, since the nuclear level density decreases for closed shell nuclei, reactions involving such nuclei are good candidates for the statistical model assumptions at energies pertinent to stellar temperatures. Furthermore, extending experimental measurements to proton capture cross sections on Sn isotopes would provide a higher reliability in deriving global optical model parameters for the nuclei in this mass range. After the measurements of cross sections, astrophysical S-factors will be calculated and reaction rates will be obtained. The results will be compared with the statistical model calculations using the statistical model code TALYS [3].

The cross sections will be used to determine (p,γ) rates to confirm the predictability of TALYS [3] and NON-SMOKER [4] nuclear codes and predict realistic theoretical predictions for the gamma process. Natural Tin is composed of 10 isotopes with mass numbers from 112-124. The coulomb barrier for the two reactions are around 10 MeV. Using natural or enriched, Sn targets above the (*p,n*) reaction thresholds, (*p,n*) and (p,γ) reaction channels cannot be distinguished, and the resulting cross section is the weighted sum of the two cross sections. One way to extract the (p,γ) cross sections is to employ two kinds of targets with different isotopic abundances [5]. By coupling the (p,γ) and (*p,n*) channels to the same radioactive daughter nucleus, the individual cross section can be deduced in case of good statistics. With the abundance distribution in the two targets of different isotopic abundances, we can determine the cross sections for all the (*p,n*) reactions of the proposed Tin isotopes.

The reactions $^{115,116,119}Sn(p,\gamma)$ will be included in the PhD thesis of Ms. Munmun Twisha. A proposal for the measuring the cross sections for these reactions in the energy domain 3-12 MeV and also the importance of these measurements was already presented in the last BTR cycle, June 2023. Only 12 shifts of beamtime have been approved. It is expected that within this time period we can perform the reactions $^{115}Sn(p,\gamma)$ and $^{nat}Sn(p,\gamma)$ and $^{119}Sn(p,\gamma)$. It needs to be mentioned that $^{nat}Sn(p,\gamma)$ cross sections have to be measured at each energy point for both the reactions to correct for the (p,n) contributions. So, in this cycle, we propose to perform the reactions $^{116}Sn(p,\gamma)$ and $^{nat}Sn(p,\gamma)$. Also $^{119}Sn(p,\gamma)$ cross sections will be measured at a few energy points, mostly as repeat measurements to confirm the reliability of $^{116}Sn(p,\gamma)$ measurements. A literature survey on proton capture cross sections for tin isotopes shows that for the case of ^{116}Sn, there are two groups who have worked on $^{116}Sn(p,\gamma)$ ^{117}Sb system, over the energy range of 2.63 to 4.17 MeV by N.Ozkan et al. [9] and 2.21 to 3.59 MeV by M.A.Famiano [10], but the collective data are scattered. Hence, in this run, the $^{116}Sn(p,\gamma)$ cross sections will be measured in the energy range 3 to 12 MeV.

References:

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