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Measurements for proton capture cross sections on Sn isotopes

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The synthesis of a p-nuclei encompasses a complex reaction network involving several stable and unstable nuclei interconnected by numerous reactions. Measurement of cross sections of all these reactions in terrestrial laboratories is not always possible. Consequently, statistical models are employed to calculate reaction cross sections. However, experimental data remain indispensable for validating these models and fine-tuning their parameters, making it crucial to measure as many reactions as possible. Tin (Sn) isotopes, with a large number of stable isotopes and a proton shell closure at Z=50 that significantly impacts their nuclear structure and reaction rates, serve as an ideal test case for benchmarking nuclear reaction models. Isotopes of Sn has contributions from all three, s-, r- and p-processes. The isotopes ^{112,114}Sn are p-only nuclei, while ^{115}Sn likely has contributions from all p-, r- and s-processes. Discrepancies in the solar abundances of ^{115}Sn and ^{116}Sn [1] highlight the necessity of precise experimental data to refine astrophysical models. The case of ^{115}Sn is particularly intriguing, as it is one of only two odd-A p-nuclei. Odd-A nuclei are generally more susceptible to destruction via (γ,n) reactions compared to even-A nuclei [2], adding further complexity to understanding its astrophysical origin. \\
The proton capture cross sections for the reactions ^{115}Sn(p,γ)^{116}Sb and ^{119}Sn(p,γ)^{120}Sb were measured at the BARC-TIFR Pelletron facility in Mumbai. Since the lowest available proton beam energy at the Pelletron is 8 MeV, graphite degraders of varying thicknesses were used to achieve energies down to 2.5 MeV. The ^{119}Sn(p,γ)^{120}Sb reaction, previously measured by F.R. Chloupek et al. (1999) [3], was repeated at few energies and extended the energy range up to 8 MeV. Enriched Sn targets were prepared using the rolling method at TIFR, with final thicknesses of 1.9±0.34 mg/cm^2 for ^{115}Sn (69\% abundance) and 1.7±0.41 mg/cm^2 for ^{119}Sn (97\% abundance). The target setup included Graphite(1/0.5/0.25 mm) + Enriched Sn (^{115}Sn and ^{119}Sn) + Cu (monitor foils) and was irradiated with a proton beam with beam current of 80 nA over an energy range of 2.5 –8 MeV. Targets were irradiated for four half-lives (1 hour) at each energy, and daughter nuclei (^{116}Sb and ^{120}Sb) were counted using two HPGe detectors with graded shielding. Detector efficiency was calibrated using ^{152}Eu before counting the irradiated targets. Data acquisition was performed using a digitizer and processed with COMPASS software. Half-life calculations were consistent with literature values within the reported error margins. To validate the procedure and analysis, the measurement was repeated at the FOTIA facility (energy of proton beam: 1-5 MeV) in BARC at two energy points, 3.5 MeV and 5 MeV, without using degraders. Total cross sections for the ^{115}Sn(p,γ)^{116}Sb and ^{119}Sn(p,γ)^{120}Sb reactions were measured over an energy range of 2.5 to 8 MeV, nearly covering the entire Gamow window (1.8–4.2 MeV) relevant to p-process nucleosynthesis for these reactions. Since Sn has various isotopes, so the residual nucleus, ^{116,120}Sb were also

populated via (p,n) channel and these contributions have been appropriately subtracted. The measured cross sections were compared with TALYS [4] predictions. the results will be presented at the conference.

References:
[1] K. Wisshak et al.,J, PR/C, 54, (3), 1451, 199609
[2] F.R. Chloupek et al., Nuclear Physics A652, 391-405 (1999).
[3] A. Koning, S. Hilaire, and S. Goriely, TALYS 1.8, A Nuclear Reaction Program, User Manual, 1st ed. (NRG, Netherlands, 2015).

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Author: ., Munmun Twisha (Saha Institute of Nuclear Physics, Kolkata)

Presenter: ., Munmun Twisha (Saha Institute of Nuclear Physics, Kolkata)

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