Proposal for the Measurement of Resonance Properties in $^{26}\text{Mg}$ of Critical Importance in Neutron Production for the Astrophysical s-process

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Abstract

The $^{22}\text{Ne}(\alpha,n)$ reaction rate is of critical importance for the calculation of the available neutron flux in s-process nucleosynthesis scenarios. Precision of the reaction rate is mainly hampered by the limited knowledge of the resonances from the neutron threshold ($S_n=11.093$ MeV) up to $E_x=11.7$ MeV. The HI$\gamma$S facility offers a unique possibility for studying these resonances via the $^{26}\text{Mg}(\gamma,n)$ reaction.

This proposal is motivated by and is complementary to our successfully completed $^{26}\text{Mg}(\gamma,\gamma)$ experiment at HI$\gamma$S with a shifted concentration to the neutron channel. The main goals of the proposed experiment are two fold: investigate possible doublets near $E_x=11.15$ MeV and 11.32 MeV, and search for other neutron resonances between these energies. A resonance was observed at 11.152 MeV in our recent experiment while another resonance has been observed directly at $E_x=11.318$ MeV via $^{22}\text{Ne}(\alpha,n)$ and $^{22}\text{Ne}(\alpha,\gamma)$. Uncertainties in the energies, widths, spins, and parities of resonances in this energy region have a significant effect on the reaction rate calculation.

The experimental setup will consist of two parts. The first will utilize a high efficiency $4\pi$ neutron detector to make a rough scan of the excitation curve for the purpose of resonance region identification and count rate confirmation. The second part will use a Time-of-Flight technique using four $^6\text{Li}$-doped glass scintillator detectors mounted $\sim$50 cm from the beam axis at a polar angle of 90° and at azimuthal angles of 0°, 90°, 180°, and 270° with respect to the beam direction [1]. Four detectors provide angular information for spin-parity assignments as well as augment the geometric efficiency. The target is 10g of $^{26}\text{Mg}$ in the form of 99.4% enriched MgO powder. Count rate estimates for neutrons, based on the recent $^{26}\text{Mg}(\gamma,\gamma)$ intensities, for the $E_x=11.152$ MeV resonance for the $4\pi$ neutron detector is 20 counts/s and for the glass scintillator detectors at $\sim$50 cm the rate is 5 counts/hour.