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Investigation of ^{31}P levels near the proton threshold by Nuclear Resonance Fluorescence and the impact on the ^{30}Si(p,γ)^{31}P thermonuclear rate

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Globular clusters represent fascinating puzzles for understanding stellar evolution and early galaxy formation. Anticorrelations between Mg and K have been observed in a small number of globular clusters, foremost of which is NGC 2419. It has been shown that the observed abundances of Mg and K were likely produced in a progenitor object, before the current generation of stars. The astrophysical environment of this progenitor nucleosynthesis has not yet been determined. One of the important reactions that can help constrain the potential nucleosynthesis environment is the ^{30}Si(p,γ)^{31}P reaction, where rate uncertainties are still significant in the associated temperature range of interest.

Using the nuclear resonance fluorescence (NRF) technique, we investigated the nuclear structure of ^{31}P near the proton threshold to refine the properties of key resonances in the ^{30}Si(p,γ)^{31}P reaction. The experiment was conducted using the High Intensity γ-ray Source (HIγS) at the Triangle Universities Nuclear Laboratory (TUNL). Excitation energies, spins, and parities were determined for several states, including two unobserved resonances at $E_r = 18.7$ keV and $E_r = 50.5$ keV. Our presented results provide a significant update to the ^{30}Si(p,γ)^{31}P thermonuclear reaction rate, which is substantially lower than previous estimates at temperatures below 200 MK, affecting predictions for silicon isotopic abundances in stellar environments.

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