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Experimental Study of the $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ for understanding elemental anomalies in Globular Clusters

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Globular clusters are key grounds for models of stellar evolution and early stages of the formation of galaxies. Abundance anomalies observed in the globular cluster NGC 2419, such as the enhancement of potassium and depletion of magnesium [1] can be explained in terms of an earlier generation of stars polluting the presently observed stars [2]. However, the nature and the properties of the polluting stellar sites are still debated. The range of temperatures and densities of the polluting sites depends on the strength of a number of critical thermonuclear reaction rates. The $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ reaction is one of the few reactions that have been identified to have an influence for elucidating the nature of polluting sites in NGC 2419 [3]. The current uncertainty on the $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ reaction rate has a strong impact on the range of possible temperatures and densities of the polluter sites.

Hence, we investigated the $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ reaction with the aim to reduce the uncertainties associated to its reaction rate by determining the strength of resonances of astrophysical interest. In this talk, I will present the study of the reaction $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ that we performed via the one proton $^{30}\text{Si}(^3\text{He,d})^{31}\text{P}$ transfer reaction at the Maier-Leibnitz-Laboratorium Tandem, using the high resolution Q3D magnetic spectrograph to measure the angular distributions of the light reaction products. These angular distributions are interpreted in the DWBA (Distorted Wave Born Approximation) framework to determine the proton spectroscopic factor information needed to deduce the proton partial width of the states of interest. This information was used to calculate the $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ reaction rate. The uncertainties on the reaction rate have been significantly reduced, and key remaining uncertainties have been identified [4]. Complementary direct measurements of $^{30}\text{Si}+p$ resonance strengths, performed using the DRAGON recoil spectrometer at TRIUMF, will be presented as well. Finally, I will present post-processing calculations showing that the $^{30}\text{Si}(p,\gamma)^{31}\text{P}$ reaction rates are now sufficiently constrained. Further efforts to unravel the nature of the stellar sites at the origin of the abundance anomalies in globular clusters should now be focused on the other identified key reactions.

- [1] C. Iliadis et al., *The Astrophysical Journal*, 470:140 (2016)
- [2] R. G. Gratton et al., *The Astronomy and Astrophysics Review* 20:50 (2012)
- [3] J. R. Dermigny and C. Iliadis, *The Astrophysical Journal* 848:14 (2017)
- [4] D. S. Harrouz et al., *Physical Review C* 105:015805 (2022)

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