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39Ca and its relevance in nuclear astrophysics

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Elemental abundances are excellent probes of classical novae (CN). Sensitivity studies show that ^{38}K(p,γ)^{39}Ca reaction-rate uncertainties modify the abundance of calcium by a factor of 60 in CN ejecta. Existing direct [1,2] and indirect measurements [3,4] are in contradiction concerning the energies and strengths of important resonances in the ^{38}K(p,γ)^{39}Ca reaction. Direct measurements of the lowest three known ℓ = 0 resonances at E_{r} = 386, 515, and 679 keV have greatly reduced the uncertainties on the reaction rate for this reaction [1,2]. However, considerable uncertainty remains in the spectroscopy of ^{39}Ca and subsequently, in the ^{38}K(p,γ)^{39}Ca reaction rate. A subsequent ^{40}Ca(^{3}He,^{4}He)^{39}Ca experiment using the SplitPole at TUNL [3] concluded that one of the resonances (E_{r} = 701.3 or E_{r} = 679 keV depending on the source of the nuclear data) may have been misplaced in the DRAGON target during the direct measurement and that tentative new states at E_{x} = 5908, 6001, and 6083 keV (E_{r} = 137, 230, and 312 keV) could correspond to important resonances in ^{38}K(p,γ)^{39}Ca. Resonance energies have an exponential effect on the reaction rate and the possible new resonances induce a 40\% uncertainty in the ^{38}K(p,γ)^{39}Ca reaction rate [3]. To resolve these, ^{39}Ca was studied using the ^{40}Ca(p, d)^{39}Ca reaction at forward angles with a proton beam energy of 66 MeV using the K600 magnetic spectrometer. These measurements are aimed at verifying the properties of levels in the region where discrepancies between various experiments persist. Preliminary results from the measurements will be presented.

[1] Lotay et al. PRL 116,132701 (2016)
[2] Christian et al. PRC 97 025802 (2018)
[3] Setoodehnia et al. PRC 98 055804 (2018)
[4] Hall et al. PRC 101, 015804 (2020)

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