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Direct Measurement of Resonance Properties of 23Mg (p, γ)24Al reaction Occurring in Classical Novae using the DRAGON Recoil Separator and an optimized Array of LaBr3, CeBr3 and BGO Gamma Detector Array

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Classical novae are significant contributors to the cosmic abundance of several isotopes, including, 13C, 15N, 26Al and the radioactive 22Na. Observations of these elements in the ejected material help astrophysicists study the processes governing stellar evolution and nucleosynthesis. One particular nucleosynthesis site is classical novae, which are explosions resulting from accretion of hydrogen-rich material onto White Dwarf star are responsible for the formation of a significant number of nuclides lighter than calcium. One of the main reactions that has an observable effect on classical nova nucleosynthesis is the proton capture on radioactive 23Mg, resulting in 24Al recoil and a gamma ray. The 23Mg(p, γ)24Al reaction has been investigated through a variety of experimental and theoretical means in the past. These investigations include a direct measurement of the strength and energy of the dominant resonance in this reaction, using a radioactive 23Mg beam at the DRAGON facility at TRIUMF in 2010. Although this measurement effectively detected the 24Al recoils in coincidence with γ rays, the beam energy was slightly too low. Hence it is possible that beam might have reached the resonance energy in non-equilibrium region of the target, invalidating the results. This was evident in 2015, when a high-resolution mass measurement of 24Al suggested a resonance energy that is inconsistent with the DRAGON result.

Due to the existing inconsistency in resonance energy of the 23Mg(p, γ)24Al reaction, this research aimed to investigate the resonance properties of the reaction by using a higher 23Mg beam energy coupled to an array of newly installed hybrid fast timing Lanthanum Bromide (LaBr3), Cerium Bromide (CeBr3) and Bismuth Germanate (BGO) detectors for detecting γ- rays. This newly installed detector array allowed a precise measurement of the strength of the resonant state, extracting a value of 35 ± 5 meV, which is in excellent agreement with the Erickson et al., experimental resonance strength of 38_(-15)^(+12) meV. The newly determined reaction rate is incorporated into NuGRID nova simulation code to study its impact on nucleosynthesis and isotopic abundances in classical novae.

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Keyword-2

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Keyword-3

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