Addendum to "Measurement of ^{23}Mg(p, γ)^{24}Al resonance energies"

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Using recent data we reduce the systematic uncertainty in our measurement [Phys. Rev. C **76**, 065803 (2007)] of the excitation energy of the second level above the proton threshold in ^{24}Al and find it to be 2523(3) keV, a factor of two improvement over our previously reported value of 2524(6) keV.

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In Ref. [1] we determined resonance energies for the astrophysically important ^{23}Mg(p, γ)^{24}Al reaction by measuring excitation energies in ^{24}Al via the ^{24}Mg(^{3}He,t)^{24}Al reaction using the ^{28}Si(^{3}He,t)^{28}P reaction as a calibration. For the two levels immediately above the proton-emission threshold of 1872(3) keV in ^{24}Al [2], and for those below, the uncertainty in the measurement (5.9 keV) was dominated by a 5.1 keV systematic uncertainty consisting of 3.0 keV from the relative target thickness, and 4.1 keV from the relative Q values [2] of the ^{24}Mg(^{3}He,t)^{24}Al and ^{28}Si(^{3}He,t)^{28}P reactions. In the present addendum we use recent high precision γ-ray measurements [3] to eliminate this systematic uncertainty and adjust our 2524(6)-keV measurement of the excitation energy of the second level above the proton threshold in ^{24}Al.

The 2524(6)-keV level, corresponding to a ^{23}Mg $+ p$ resonance at a center of mass energy $E_r = 652(6)$ keV [1], is expected to contribute to the thermonuclear ^{23}Mg(p, γ)^{24}Al reaction rate increasingly with stellar temperature; for example, it has been estimated to make a 40% contribution at $T = 2$ GK [1,4]. A measurement [5–7] of its strength with the DRAGON facility [8,9] at TRIUMF-ISAC is scheduled that will use a mixed ^{23}Na/^{23}Mg beam with an intensity ratio of ≈500/1 [10]. A resonance in the ^{23}Na(p, γ)^{24}Mg reaction at $E_p^{\mathrm{lab}} = 676.7(4)$ keV [11] [$E_r = 648.3(4)$ keV] with a strength $\omega\gamma = 640$ meV [11] (to be compared with the predicted strength $\omega\gamma = 58$ meV [1,4] of the 652-keV ^{23}Mg(p, γ)^{24}Al resonance) will present a challenge to that experiment. A more precise energy for the $E_r = 652(6)$-keV resonance will therefore be useful to its planning and interpretation.

A recent precision measurement [3] using Gammasphere resulted in a complete ^{24}Al level scheme up to the $E_x = 2345.1(14)$-keV level, which is the first level above the proton threshold and corresponds to the most important resonance for the thermonuclear ^{23}Mg(p, γ)^{24}Al reaction at nova temperatures (<0.4 GK). The Gammasphere work confirmed our measurement of $E_x = 2346(6)$ keV, which was not in good agreement with previous measurements [12,13], and improved upon its precision. Other levels measured in that work at $E_x = 1538.5(2)$, 1548.4(5), and 1617.0(8) keV are also of interest to the adjustment in the present addendum. These levels may potentially be identified with the peaks in our ^{24}Mg(^{3}He,t)^{24}Al spectra measured at $E_x = 1543(6)$ and 1619(6) keV.

We use only the 1617.0(8)- and 2345.1(14)-keV levels from Ref. [3] to adjust our calibration since our 1543(6)-keV peak may consist of contributions from both the 1538.5(2)- and 1548.4(5)-keV levels. Considering statistical uncertainties only, we had measured 1618.7(2) and 2345.6(7) keV for the excitation energies of the 1617.0(8)- and 2345.1(14)-keV ^{24}Al levels [3], respectively, corresponding to shifts of $\Delta E_x = 1.7(8)$ and 0.5(16) keV, respectively. A weighted average of these yields an overall shift of $\Delta E_x = 1.5(7)$ keV, which is a measure of the systematic effects that previously carried a 5.1-keV uncertainty. This value may be subtracted from all of our excitation-energy numbers in Ref. [1] to adjust them.

In particular, we had measured $E_x = 2524.2(6)$ keV for the second level above the proton threshold where the statistical uncertainty only is quoted. Subtracting the 1.5(7)-keV correction yields $E_x = 2522.7(9)$ keV. Applying the global reproducibility uncertainty deduced in our previous evaluation yields $E_x = 2523(3)$ keV, a factor of two improvement over our previous value of 2524(6) keV and a factor of four improvement over the accepted value of 2534(13) keV [4,14] that was derived from two previous (^{3}He,t) measurements of 2521(10) [13] and 2546(7) keV [12]. Our new value corresponds to a ^{23}Mg(p, γ)^{24}Al resonance energy of $E_r = 651(4)$ keV, in exact agreement with the deduction of Kubono *et al.* [13] and with substantially reduced uncertainty.

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