Beta-decay of proton-rich nucleus $^{23}$Al and astrophysical consequences

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The results of a beta-decay study motivated by a nuclear astrophysics problem are presented. For the first time pure samples of $^{23}$Al were separated with the MARS separator of Texas A&M University. Off-beam beta and beta-gamma coincidence measurements were made using a fast tape-transport system, beta and gamma-ray detectors. The experiment allowed us to measure beta branching ratios and log $ft$ values for transitions to 14 final states in $^{23}$Mg and from them to determine unambiguously the spin and parity of $^{23}$Al ground state as $J^{\pi}=5/2^+$ (see figure). We discuss how this excludes the large increases in the radiative proton capture cross section for the reaction $^{22}$Mg(p,$\gamma$)$^{23}$Al at astrophysical energies which were implied by claims that the spin and parity is $J^{\pi}=1/2^+$ [1]. The lifetime of $^{23}$Al was measured with better accuracy and the log $ft$ for the Fermi transition to its isobaric analog state in $^{23}$Mg is also determined for the first time. A doublet consisting of the IAS and a state 16 keV below it (figure) are observed for the first time well separated in the same experiment, and we solve a number of inconsistencies existing in the literature, excluding strong isospin mixing and allowing a new determination of their resonance strength. Both states are resonances in the $^{22}$Na(p,$\gamma$)$^{23}$Mg reaction at energies important in novae. The radiative proton capture on $^{22}$Na and $^{22}$Mg are considered candidates to explain the absence in spectra taken with space-based gamma-ray telescopes of gamma-rays from the decay of long-lived $^{22}$Na formed in ONe novae explosions [3,4]. These captures would divert some of the flux from the $A=22$ into the $A=23$ mass chain.

Figure 1: Partial decay scheme of $^{23}$Al. Only levels with relevance for the nuclear astrophysics problems are shown.