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Understanding ^{22}Na cosmic abundance

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Simulations of explosive nucleosynthesis in novae predict the production of the radioisotope ^{22}Na . Its half-life of 2.6 yr makes it a very interesting astronomical observable by allowing space and time correlations with the astrophysical object. This radioisotope should bring constraints on nova models. It may also help to explain abnormal ^{22}Ne abundance observed in presolar grains and in cosmic rays. Its gamma-ray line at 1.275 MeV has not been observed yet by the gamma-ray space observatories. Accurate yields of ^{22}Na are required. At peak nova temperatures, the main destruction reaction $^{22}\text{Na}(p, \gamma)^{23}\text{Mg}$ has been found dominated by a resonance at $E_R=0.204$ MeV corresponding to the $E_x=7.785$ MeV excited state in ^{23}Mg . However, the measured strengths of this resonance disagree by more than a factor 3, see Ref. [1, 2].

An experiment was performed at GANIL facility to measure both the lifetime and the proton branching ratio of the key state at $E_x=7.785$ MeV. The principle of the experiment is based on the one used in [3]. With a beam energy of 4.6 MeV/u, the reaction $^3\text{He}(^{24}\text{Mg}, \alpha)^{23}\text{Mg}^*$ populated the state of interest. This reaction was measured with particle detectors (spectrometer VAMOS++, silicon detector SPIDER) and gamma tracking spectrometer AGATA. The expected time resolution with AGATA high space and energy resolutions is 1 fs. Several Doppler based methods were used to analyse the lineshape of γ -ray peaks.

Our new results will be presented. Doppler shifted γ -ray spectra from ^{23}Mg states were improved by imposing coincidences with the excitation energies reconstructed with VAMOS. This ensured to suppress the feeding from higher states. Lifetimes in ^{23}Mg were measured with a new approach. Proton emitted from unbound states in ^{23}Mg were also identified. With a higher precision on the measured lifetime and proton branching ratio of the key state, a new value of the resonance strength $\omega\gamma$ was obtained, it is below the sensitivity limit of the direct measurement experiments. The $^{22}\text{Na}(p, \gamma)^{23}\text{Mg}$ thermonuclear rate has been so reevaluated with the statistical Monte Carlo approach. The amount of ^{22}Na ejected during novae will be discussed as a tool for better understanding the underlying novae properties. The detectability limit of ^{22}Na from novae and the observation frequency of such events will also be discussed with respect to the next generation of gamma-ray space telescopes.

References

- [1] A.L. Sallaska *et al.*, Phys. Rev. L **105**, 152501 (2010).
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- [3] O.S. Kirsebom *et al.*, Phys. Rev. C **93**, 1025802 (2016).

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