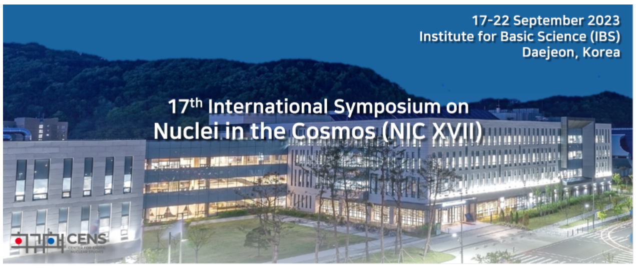

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Understanding the abundance of 22Na in novae by measuring femtosecond lifetimes in 23Mg with a new method

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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. Its γ-ray line at 1.275 MeV has not been observed yet by the γ-ray space observatories. 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. Hence accurate yields of ^{22}Na are required. At peak nova temperatures, the main destruction reaction ^{22}Na$(p,\gamma)^{23}$Mg has been found dominated by a resonance at 0.204 MeV corresponding to the E_x =7.785 MeV excited state in ^{23}Mg. However, the different determinations of the strength of this resonance disagree, resulting in uncertainties of one order of magnitude for the expected mass of ^{22}Na ejected in novae [1].

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 [2]. With a beam energy of 4.6 MeV/u, the reaction ^{3}He(^{24}Mg,α)^{23}Mg* populated the state of interest. This reaction was measured with particle detectors (magnetic spectrometer VAMOS++, silicon detector SPIDER) and γ-ray tracking spectrometer AGATA. The expected time resolution with AGATA high space and energy resolutions is 1 fs. Particle and γ-ray emissions were analyzed with a new simulation code EVASIONS to determine the spectroscopic properties of the key state.

Our new results [3] 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, down to the femtosecond, were measured with a new approach based on particle - γ-ray correlations and velocity-difference profiles. Protons emitted from unbound states in ^{23}Mg were also identified. With an 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 direct measurement experiments. The ^{22}Na$(p,\gamma)^{23}$Mg thermonuclear rate has been reevaluated with the statistical Monte Carlo approach. The amount of ^{22}Na ejected during novae has been proven to be a tool for better understanding the underlying novae properties. Thanks to the highly-accurate rate, derived here, robust estimates of the detectability limit of ^{22}Na in novae have been determined with respect to the next generation of γ-ray space telescopes, and the detection of the ^{22}Na γ-ray line found promising in the coming decades.

References

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