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The nucleosynthesis of heavy elements in Stars: the key isotope ^{25}Mg

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The slow neutron capture process (s process) in stars is responsible for the production of about half of the elemental abundances beyond iron that we observe today [1, 2]. Most of the s-process isotopes between iron and strontium ($60 < A < 90$) are produced in massive stars [3] ($M > 10$-$12\ M_{sun}$) where the ^{22}Ne(α ,n)^{25}Mg reaction is the main neutron source. Beyond strontium, the s-process abundances are mostly produced in low mass Asymptotic Giant Branch stars [4] ($1.2\ M_{sun} < M < 3\ M_{sun}$), where the neutrons are provided by the ^{13}C(α, n)^{16}O reaction and by the partial activation of the ^{22}Ne(α ,n)^{25}Mg reaction. In stars with an initial metal content similar to solar, ^{25}Mg is the most important neutron poison via neutron capture on ^{25}Mg in competition with neutron capture on ^{56}Fe that is the basic s-process seed for the production of the heavier isotopes. For this reason, a precise knowledge of the ^{25}Mg(n,γ)^{26}Mg is required to properly simulate s-process nucleosynthesis in stars.

In addition the ^{25}Mg(n,γ)^{26}Mg reaction cross-section gives important constraints for the yet uncertain reaction rate of the important neutron source ^{22}Ne(α ,n)^{25}Mg. The relevant information in this respect are the spin and parity of the neutron resonances formed in the (n,γ) reaction, which can be deduced from a combined resonance analysis of neutron capture and total cross section data.

Taking advantage of the innovative features of the neutron time-of-flight facility n_TOF [5] at CERN, i.e. the high instantaneous flux, the high energy resolution and low background, measurements of the (n,γ) cross section have been performed in 2003 [6] and - with an improved experimental setup - in 2012. The combined results of the ^{25}Mg(n,γ)^{26}Mg measurements at n_TOF, are providing the required accuracy for a substantially improved discussion of the astrophysical implications mentioned above.

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