Measurement of the ^{25}Mg(p,γ)^{26}Al Reaction at Stellar Energies

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The detection of the cosmic 1.809 MeV γ-line in 1982 [1] triggered an increasing interest in determining the stellar production of ^{26}Al .

This radiation, originating from ^{26}Al ($T_{1/2}$=0.716 Myr) nuclei which have been ejected from stars, is detected by γ-ray telescopes, allowing the identification of the ^{26}Al production sites within our galaxy [2].

The ^{25}Mg(p,γ) reaction is the main production mechanism for ^{26}Al in astrophysical scenarios at energies in the range of E^{CM}=100–400 keV [3]. At these energies, well below the Coulomb barrier (E^{CM}=2.86 MeV), the cross sections are extremely small and the production is dominated by narrow resonances (see fig. 1).

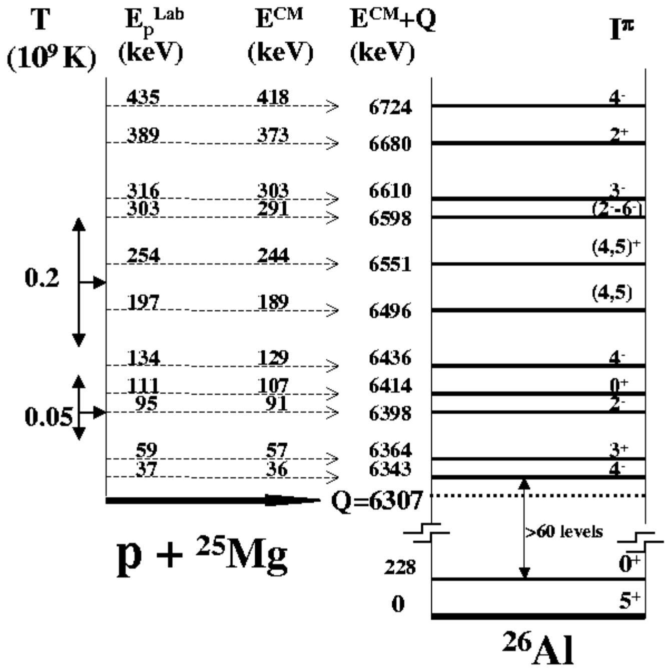

Fig. 1: Level structure of ^{26}Al above the p+^{25}Mg threshold. Resonance energies [4] are those for which E^{CM} + Q equals an excited level of ^{26}Al . The correspondence to stellar temperatures is also shown.

The strength of these resonances have been measured down to E^{CM}=189 keV applying the common on-line detection of prompt γ-rays originating from the deexcitation of ^{26}Al compound nuclei [5,6].

In order to avoid the problems of interfering γ–backgrounds of on-line measurements we propose the determination of the produced ^{26}Al nuclei using the AMS technique: MgO targets are bombarded with proton beams (0.1–1 mA) at each resonance energy using an implanter [9] at the Forschungszentrum Rossendorf. These targets are then dissolved in HCl acid and, after adding ^{27}Al which acts as a carrier, multiple precipitations with NH_3 are carried out in order to separate Al from Mg. Finally, these samples are used directly as sputter material at the accelerators ion source. The small amount of produced ^{26}Al nuclei can be counted by means of the AMS technique [10].

The AMS measurements are performed extracting molecular AlO^- from the ion source, since the efficiency of producing this negative ion is about 20 times higher than the corresponding for Al^-. The latter is however more frequently used in AMS experiments because atomic Mg does not form stable negative ions. But MgO^- is also formed readily in the ion source. Hence, extracting AlO^-, a highly selective chemical separation of Mg in conjunction with an efficient AMS system is required in order to supress the interfering isobar ^{26}Mg.

Chemical separation down to 5 ppm of ^{26}Mg was achieved on 0.5 mg Al samples. In combination with the Gas Filled Magnet separation system (GAMS [11]), measurements down to ^{26}Al/^{27}Al$\sim 10^{-14}$, i.e. 10^5 ^{26}Al atoms, are possible.

Another approach being tested is the reaction in inverse kinematics [12] H(^{25}Mg,γ)^{26}Al . In this case, a methane (CH_4) gas stripper at the terminal of the tandem accelerator acts as target. Injecting $^{25}MgH^-$, $^{25}MgO^-$ or $^{25}MgF_3^-$ at the low energy side of the tandem, the reaction energies of interest can be reached applying terminal voltages between 7.6 and 12.7 MV. The ^{26}Al produced in the gas stripper is further accelerated on the high energy side and the most probable charge state is selected by the analysing magnet, while interfering ions (^{25}Mg as well as spurious ^{26}Mg) are separated by common AMS techniques.

Initial tests of both methods are carried out presently for the ^{25}Mg(p,γ)^{26}Al reaction at resonance energies of E^{CM}= 418, 373 and 303 keV.

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