Single atom counting of ^{55}Fe for explosive stellar nucleosynthesis studies

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Explosive stellar burning is a major contributor to the nucleosynthesis of elements in the mass region around iron. Relevant reactions for these stellar scenarios (e.g. α- or p-capture), involve charged particles at energies in the low MeV range. Proper tuning of theoretical nuclear models and astrophysical network calculations, aiming to reproduce elemental and isotopic abundance rely on the availability of experimental cross section data. In particular cross sections of charged particle-induced reactions near the reaction threshold are very sensitive to model parameters but experimental data is often limited. For example, no suitable experimental data are published for the ^{52}Cr(α,n)^{55}Fe reaction. Although ^{55}Fe is rather short-lived [$t_{1/2}$=(2.744±0.009) a][1] the small cross sections at the relevant particle energies and weak γ-transitions in the ^{55}Fe decay, make decay counting very challenging.

A combination of α-particle irradiation and Accelerator Mass Spectrometry (AMS) measurements was used to determine the cross section for the reaction ^{52}Cr(α,n)^{55}Fe for astrophysically important energies. Thin layers of Cr, evaporated on Al foils, were irradiated with α-particles of 4.5-10 MeV from the cyclotron accelerator at Atomki. Following irradiation, the Cr-Al foils were dissolved, spiked with natural Fe carrier and converted into Fe_2O_3. The ^{55}Fe/^{56}Fe ratio of the samples was determined by AMS and cross sections as low as 3 μb are reported.

Our results for energies above 6 MeV are in excellent agreement with theoretical predictions. At lower energies the experimental data suggest smaller cross sections than theory, by up to a factor of three. The new experimental data provide anchor points for alpha capture reactions in the Fe mass region near their reaction thresholds and also helps to study the alpha nucleus optical potential.

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[1] H. Junde, *Nucl. Data Sheets* **109**, 787 (2008).