The ^{59}Cu(p,α) cross section and the heavy element nucleosynthesis in core collapse supernovae

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A long standing problem in stellar evolution concerns the production mechanism for proton-rich heavy elements. These p-nuclei are thought to be produced in supernova explosions via photodisintegration of heavy elements. However, current stellar models fail to reproduce the observed abundances of lighter p-nuclei such as ^{92}Mo and ^{96}Ru [1]. An alternative possibility for production of the light p-nuclei may be the νp-process that is thought to occur in core collapse supernovae [2]. A recent study found that the efficiency of heavy element production depends on the strength of the ^{59}Cu(p,α) reaction that may hinder the process by recycling material back to ^{56}Ni, creating a closed NiCu cycle [3]. Therefore, the ^{59}Cu(p,α)^{56}Ni reaction cross-section is important in order to calculate the efficiency of the νp-process in producing the heavy elements. In addition, this reaction is also of importance for explaining the light curve of X-ray bursts, and affects the composition of burst ashes on the surface of the neutron star significantly [4].

Currently, there is no direct measurement of the ^{59}Cu(p,α)^{56}Ni reaction cross section. We present the preliminary results of a first such measurement. The experiment was performed at the HIE-ISOLDE facility at CERN in inverse kinematics by impinging the ^{59}Cu beam on CH_2 target. The reaction products, the α-particles and the ^{56}Ni recoils, were detected in coincidence using a set of three annular silicon strip detectors. The measurement was made possible by using a purpose-built detection system provided by the University of Edinburgh and by taking advantage of the high intensity radioactive ^{59}Cu beam available at HIE-ISOLDE. The upgrade to HIE-ISOLDE was needed to be able to perform this measurement at the beam energies that correspond to the temperatures of the stellar environment. The reaction has been studied at five different beam energies between 3.6 MeV/u and 5.0 MeV/u. I will present the scientific motivation, the experimental setup and running, and the first data.

References

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