Measurement of Cross Sections of the Reaction ^{40}Ar(p,αn)^{36}Cl

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In order to be able to calculate the atmospheric production of ^{36}Cl due to primary and secondary cosmic radiation and the depth and latitude dependence of the production, cross sections of proton induced reactions on argon to ^{36}Cl were measured. The main cosmogenic production channels in air to ^{36}Cl are ^{40}Ar(p,2p3n), ^{40}Ar(n,p4n), ^{40}Ar(p,αn) and ^{36}Ar(n,p). The threshold energy of the first two spallation and nuclear reactions is at 37 MeV. Below this energy with ^{40}Ar as target, only the (p,αn) channel contributes. In this energy range, the solar component of the primary cosmic radiation is dominant.

For the investigation of this (p,αn) channel, argon gas targets were irradiated with protons of 17.1, 19.2, 23.1 and 27.1 MeV at the Munich accelerator laboratory. The gas filled cylinders had lengths of 100 and 120 mm. The entrance and exit foils were 100 μm Al foils and the walls were also covered by Al foils. The produced ^{36}Cl was electrostatically bound to Al without undergoing chemical reactions. After adding NaCl carrier, the Al foils were dissolved in NaOH. With a standard chemical procedure, AgCl targets were obtained as samples for the ion source. ^{36}Cl/Cl ratios were measured with AMS with postaccelerated and completely stripped ^{36}Cl^{17+} ions which were analysed magnetically and detected in a Bragg ionization chamber.

Cross sections were deduced. The results of the cross section measurements are plotted in fig. 1 together with data in the energy range 40 to 1000 MeV [1]. Two peaks are observed: the peak at 23 MeV is due to the fusion reaction ^{40}Ar(p,αn)^{36}Cl and the peak at 100 MeV to the spallation reaction ^{40}Ar(p,2p3n)^{36}Cl. The cross section of the proton induced reaction ^{40}Ar(p,2p3n)^{36}Cl can be used in good approximation for the neutron induced reaction ^{40}Ar(n,p4n)^{36}Cl.

Cross section calculations were performed with a statistical Hauser-Feshbach-Moldauer model (HFM) for the fusion reaction and with semi-empirical parametrisations according to Rudstam and Silberberg&Tsao (fig. 1). The HFM calculations overestimate the data by factor of 4, but are able to give position and width of the peak. The Rudstam calculation overestimates the data by factor of about 1.5, but describes reasonably the energy dependence. The Silberberg&Tsao calculation describes well absolute values at energies around GeV, but does not reproduce the excitation function. It is thus seen how important cross section measurements are for reliable calculations of the production of radionuclides.

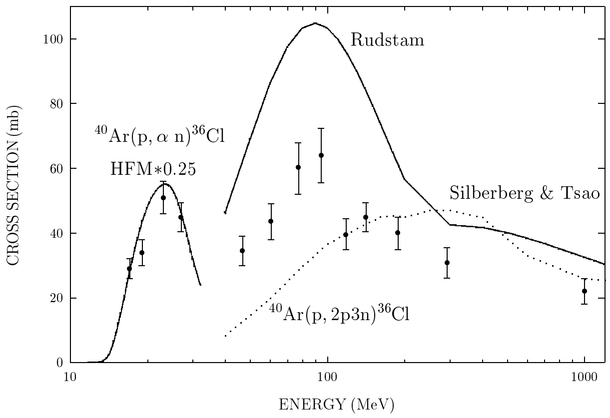

Fig. 1: Measured cross sections of the reactions ^{40}Ar(p,αn)^{36}Cl and ^{40}Ar(p,2p3n)^{36}Cl together with calculations with a statistical HFM model and with semi-empirical parametrisations according to Rudstam and Silberberg&Tsao.

References

[1] D. Huggle, A. Blinov, C. Stan-Sion, G. Korschinek, C. Scheffel, S. Massonet, L. Zerle, J. Beer, Y. Parrat and E. Nolte Planetary and Space Science **44(2)** (1996) 147