Neutron Capture Reactions of ^{84}Kr, ^{20}Ne and ^{22}Ne and Stellar Nucleosynthesis

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Since elemental abundance patterns are considered to give relevant information about the chemical evolution of the universe, efforts involving both observations and yield estimation of the elements have been made for a wide range of metallicities of stars and stellar masses. Elemental and isotopic abundances obtained from meteoritic silicon carbide grains give us very useful information to construct the stellar nucleosynthesis models, since these grains are identified to be of pre-solar origin. Isotopic ratios of Kr isotopes thus obtained show isotopic anomalies, where the spread of ^{86}Kr/^{82}Kr ratio with the grain size has been one of the challenging problems in the construction of the nucleosynthesis models in AGB stars [1]. In order to understand the origin of the discrepancy between the measured ^{86}Kr/^{82}Kr ratio and the calculated one based on the AGB nucleosynthesis models, it is strongly required to carry out the accurate measurement of the neutron capture cross section of Kr isotopes, especially ^{84}Kr. Furthermore Ne isotopes are claimed to be a neutron poison for the s-process nucleosynthesis and thus the neutron capture cross section of the Ne isotopes is considered to affect the production yield of ^{86}Kr. Hence in the present work, the cross sections of ^{84}Kr(n,γ)^{85}Kr, ^{20}Ne(n,γ)^{21}Ne and ^{22}Ne(n,γ)^{23}Ne have been measured in the keV energy region.

The measurement has been carried out using pulsed keV neutrons together with a prompt γ-ray detection method. Since the neutron capture cross sections of Kr and Ne isotopes are considered to be small, we have made special target vessels for these isotopes to obtain the large signal-to-noise ratio during the measurement.

In this work, the discrete γ-rays emitted promptly from neutron capturing states of ^{84}Kr, ^{20}Ne and ^{22}Ne were for the first time measured in the keV energy region (Fig. 1). The measured cross section of the ^{84}Kr(n,γ)^{85}Kr reaction is lower than the previous one by about 30 % (Fig. 2). Concerning the Ne(n,γ) reaction the discrete γ-rays from the neutron capturing states of ^{20}Ne and ^{22}Ne have been observed for the first time and thus the

Maxwellian-averaged cross sections were determined by considering the appropriate energy dependences. The measured cross sections of these isotopes of ^{20}Ne and ^{22}Ne are larger than previously measured values. Hence the present results could solve the problem of the discrepancy of ^{86}Kr/^{82}Kr ratio between the observed value and estimated one.

In order to extend further the neutron capture reaction of a nucleus using more intense neutrons with continuous energy from the astrophysical interest we have investigated the properties of the neutrons produced by the spallation reaction [2].

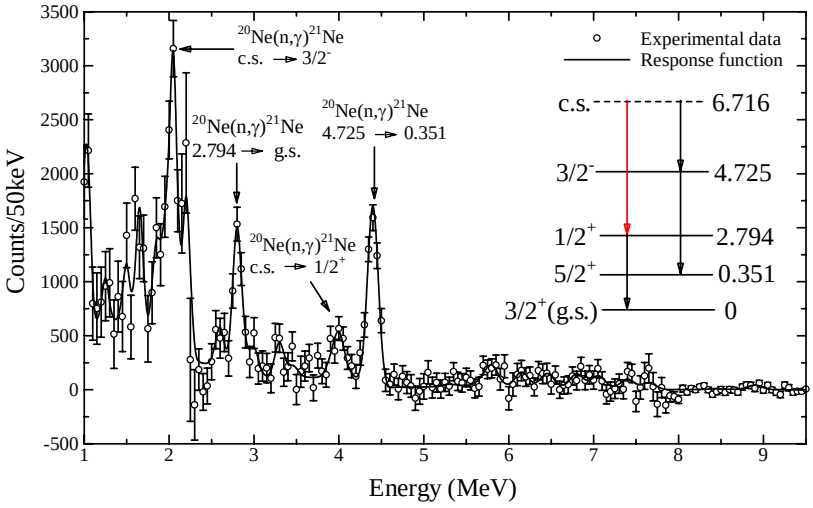

Fig. 1 Net γ-ray spectrum for an enriched ^{22}Ne sample (E_n = 41 – 60 keV)

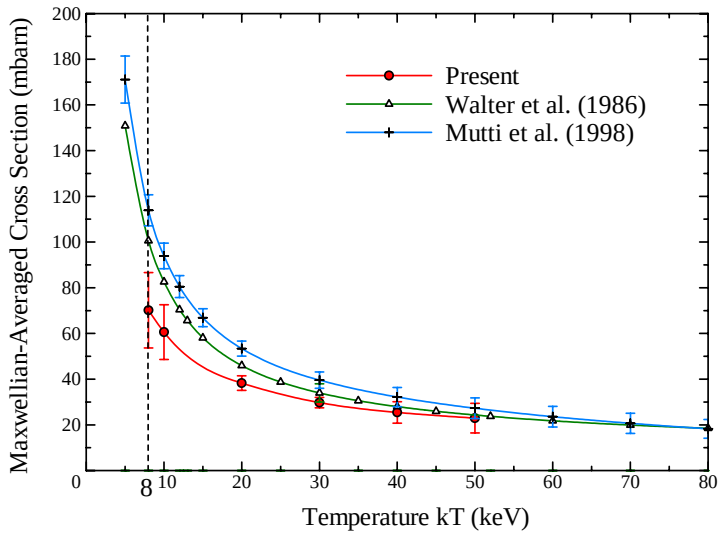

Fig. 2 Maxwellian-Averaged Capture cross section of ^{84}Kr(n,γ)^{85}Kr

References

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