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Measurement of the $E1$ and $E2$ partial cross sections of the $^{12}C(\alpha,\gamma)^{16}O$ reaction at $E_{c.m.}$=1.2 and 1.5 MeV

Abstract

Precise knowledge of the He burning in stars is important in understanding the stellar nucleosynthesis. Among nuclear fusion reactions relevant to the He burning, the reaction rate of the $^{4}He(\alpha,\gamma)^{8}Be(\alpha,\gamma)^{12}C$ reaction is well known. We have to determine the cross section of the $^{12}C(\alpha,\gamma)^{16}O$ reaction within a precision of at least 10% at $E_{c.m.} \approx$ 1 MeV to accurately determine $\sigma(E_{c.m.}$ = 300 keV). But due to the existence of $J_i^{\pi}= 2^{+}$ and $J_i^{\pi}=1^{-}$ sub-threshold resonance states in ^{16}O, the reaction rate of $^{12}C(\alpha,\gamma)^{16}O$ is still uncertain despite many extensive works. Since the energy dependence of E1 part of the reaction cross section differs from that of E2 part, it is difficult to accurately determine the cross section of $^{12}C(\alpha,\gamma)^{16}O$ at Gamow energy of $E_{c.m.}$=300 keV. The accuracy of the cross section obtained from previous works is far from this goal.

In the present work, we have carried out the measurement of the $^{12}C(\alpha,\gamma)^{16}O$ reaction cross section at $E_{c.m.}$=1.467 and 1.223 MeV at the 3.2 MV Pelletron accelerator laboratory at Tokyo Institute of Technology. In the measurement, we used an intense pulsed α-beam and enriched ^{12}C targets to discriminate true events due to the reaction from neutron induced background events from the $^{13}C(\alpha,n)^{16}O$ reaction, and four high efficiency anti-Compton NaI(Tl) spectrometers to obtain a sufficient reaction yield. We have succeeded to accurately determine the cross section.