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Direct measurement of the ^{4}He (^{12}C, ^{16}O) γ reaction cross section near stellar energies

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The ^{12}C+^{4}He$\rightarrow^{16}$O+γ reaction is one of the key reactions in stellar He-burning, but its total cross section at stellar energy (Ecm = 0.3 MeV) has not been measured yet, in spite of many experiments made in the world for about a half century. At Kyushu University Tandem accelerator Laboratory (KUTL), we have been making direct measurement of the ^{4}He (^{12}C, ^{16}O) γ total cross section below Ecm = 2.4 MeV for about 20 years. We have measured the total cross section at Ecm = 2.4, 1.5 and 1.2 MeV. Now we are preparing to measure the cross section at 1.0 MeV. The direct measurement was made from Ecm = 5 MeV down to 1.9 MeV at Ruhr University, Bochum. We use a pulsed ^{12}C beam and a windowless ^{4}He target, and detect all the ^{16}O recoils in a charge state. A usually continuum ^{12}C beam from our tandem accelerator is pulsed by a pre-buncher, a main buncher, and a beam chopper. Our tandem accelerator was designed to be used at the acceleration voltage of 6-10 MV. For the ^{4}He (^{12}C, ^{16}O) γ experiment we need to use it at 1.3-1.8 MV where beam transmission is very low, then we have invented an acceleration-deceleration method for the tandem accelerator. We have developed a blow-in windowless He target based on an original idea. To separate ^{16}O recoils from the ^{12}C beam, we developed a recoil-mass separator. To reject ^{12}C backgrounds, we developed a long-time chopper, and an ionization chamber. Now, we are preparing to measure time-of-flight of ^{16}O recoils and ^{12}C backgrounds. Many original instruments and the experimental results will be presented. Finally we discuss what are necessary for future direct measurement of the ^{4}He (^{12}C, ^{16}O) γ total cross section below 1.0 MeV, down to 0.7 MeV. A dynamitron accelerator and hard-working researchers may be inevitable.

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