MEASUREMENT AND EXTRAPOLATION OF TOTAL CROSS SECTIONS OF $^{12}C+^{16}O$ FUSION AT STELLAR ENERGIES

Abstract

by

Xiao Fang

Carbon burning and oxygen burning in massive stars ($M \geq 8M_{\odot}$) are important burning phases in late stellar evolution following helium burning. They determined the nucleosynthesis phases and the initial matter distribution. Hydrostatic burning of ^{12}C and ^{16}O at lower temperatures remains an important feature. The critical reactions are the $^{12}C+^{12}C$, $^{12}C+^{16}O$ and $^{16}O+^{16}O$ fusion processes. Extensive effort, both experimentally and theoretically, has been invested in the determination of the reaction rates for all reaction channels. Despite this effort, there remain large uncertainties in the predicted results that rely primarily on the extrapolation of the data into the Gamow range. The predicted results depend sensitively on the adopted model parameters, hindrance effects, and the possibility of resonances at relevant energies. The astrophysical important energy range of the $^{12}C+^{12}C$ fusion reaction spans from 1.0 MeV to 3.0 MeV. However, its cross section has not been determined with enough precision, despite numerous studies, due to the extremely low reaction cross sections and the large experimental background. The $^{12}C+^{16}O$ is difficult for experimental measurement due to the same reason. To allow measurements of the $^{12}C+^{12}C$ and $^{12}C+^{16}O$ fusions at astrophysical energies, a large-area silicon strip detector array was developed. The total cross section of the $^{12}C+^{16}O$ fusion has been measured at low energies using the St Ana 5MV accelerator at the University of

Notre Dame. A high-intensity oxygen beam was produced impinging on a thick ultra-pure graphite target. Protons and γ-rays have been measured simultaneously in the center-of-mass energy range of 3.64 to 4.93 MeV, using silicon and HPGe detectors. Statistical model calculations were employed to interpret the experimental results. This provides a more reliable extrapolation for the ^{12}C+^{16}O fusion cross section reducing substantially the uncertainty for stellar model simulations.