3 - 20 Progress of the Nuclear Astrophysical Research at IMP

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The nuclear astrophysical research program at IMP primarily focuses on the nuclear processes happening in stellar environments. Our main research activities in 2022 included the analysis of the ^{13}C(α, n)^{16}O reaction at stellar energies, and the ^{12}C, ^{19}O+^{12}C reactions above the Coulomb barrier, accomplishing the measurement of the ^{11}C+α reaction using the 4 000 channel Time Projection chamber in collaboration with other teams, calibrating the beam energy at Low Energy Accelerator Facility (LEAF), studying the $E1$ photon strength function relevant to the neutron capture reactions, and the ^{63}Fe-^{63}Mn Urca pair in the crust of neutron star. Research highlights and major achievements in experimental techniques are given below.

(1) First consistent direct measurement of the ^{13}C(α, n)^{16}O reaction at stellar energies: Our consistent measurement, covering a wide energy range, reduces the large uncertainty in the reaction rate down to 13% to 16% for i- and s-process nucleosynthesis. For the first time, we determine the ANC of the threshold state using direct measurement, fix the interference pattern, and determine the screening potential using R-matrix analysis[1].

(2) Studies of the 2α and 3α channels of the ^{12}C+^{12}C reaction using the active target Time Projection Chamber[2]: The ^{12}C+^{12}C fusion reaction was studied in the range of $E_{\mathrm{c.m.}}$=8.9 to 21 MeV using the active-target Time Projection Chamber. The ^{12}C(^{12}C, 3α)^{12}C reaction channel was studied for the first time using exclusive measurement. Our result does not confirm the anomaly behavior reported in the previous inclusive measurement[3].

(3) Study of the Urca Cooling Capacity of ^{63}Fe-^{63}Mn: Our study suggests a large enhancement of the Urca cooling power of ^{63}Fe-^{63}Mn by using a suggested ground state J^{π} from the systematics of nuclear structure.

Our research in 2023 will focus on the measurement of ^{12}C+^{12}C at LEAF, and exotic decay experiment using the MATE TPC. We will further strengthen the collaboration with astronomical and astrophysical communities. Finally, we would like to acknowledge the financial support from Strategic Priority Research Program of Chinese Academy of Sciences (XDB34020200) and National Key Research and Development program (MOST 2016YFA0400501) from Ministry of Science and Technology of China.

References

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