2 - 9 Progress of the Nuclear Astrophysical Research at IMP

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The nuclear astrophysical research program at IMP focuses on the nuclear process happening in stellar environments. Our research has been taken place using the facilities such as HIRFL at Lanzhou, 3 MV Tandem accelerator lab in Bucharest, China JinPing deep underground Lab in Sichuan. Research highlights and major achievement in experimental techniques are given below:

1) One of the longstanding problems of the big bang theory is that the theory overpredicted the ^{7}Li abundance. It was found that the observed primordial abundances of deuterium, helium, and lithium could be explained simultaneously using a slightly modified version of the classical distribution (non-extensive statistics).

2) The ^{12}C+^{13}C fusion reaction is studied down to 2.323 MeV, the lowest energy ever reached for this reaction. This cross section measured at such a low energy rules out the prediction of hindrance model while it confirms the predicted trend of S-factor by other models, such as CC-M3Y+Rep, DC-TDHF, KNS, SPP and ESW.

3) A X-ray burst calculation using the new experimental mass data of ^{82}Zr and ^{84}Nb eliminates the existence of the previously proposed Zr-Nb cycles.

4) Time Projection Chamber (TPC) is a key instrument for the reaction study with radioactive ion beams. A 240-channel TPC has been built to realize the study the fusion reaction with neutron rich beams.

5) The alpha background in the ^{3}He counter is an important parameter for the experimental study of the ^{13}C(α,n)^{16}O reaction at the China JinPing deep underground Lab. The lower background was found to be 0.6 cnt/day/counter for a GE commercial counter. A coincidence technique between the ^{3}He counter and the surrounding scintillator is being developed to realize the desired background by suppressing this background by a factor 10.

Our research in 2018 will continuously focus on the ^{12}C+^{12}C fusion reaction at stellar energies, studying the fusion reaction using active target technique. We also will strengthen the collaboration with astronomical and astrophysical communities. Finally, we would like acknowledge the financial supports from MOST, NSFC and CAS.

2 - 10 An R-Matrix Reanalysis Based on the ^{15}O(α, α)^{15}O Data*

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Novae emit gamma rays during the first several hours after the explosion at energies of 511 keV and below[1]. ^{18}F is the most important gamma-ray source because of its relatively large abundance and long half-life ($t_{1/2}$ = 109.8 m). The ^{18}F(p, α)^{15}O is the main destruction reaction of ^{18}F, which may constrain the amount of ^{18}F severely. However, the reaction rate of ^{18}F(p, α)^{15}O is still very uncertain.

The reaction rate of ^{18}F(p, α)^{15}O is determined by the properties of relevant levels in the ^{19}Ne compound nucleus. It was previously thought that the primary uncertainty arose from the unknown interference sign between the $3/2^+$ states[2]. However, a recent theoretical study[3] predicted that a broad $1/2^+$ level near E_x = 7.9 MeV (Γ_α = 139 keV) would interfere with a subthreshold $1/2^+$ resonance (E_x = 6.0 MeV, Γ_α = 231 keV) to reduce the influence of $3/2^+$ resonance contributions.

A measurement of ^{15}O(α, α)^{15}O was performed by Torresi, *et al.*[4] at LNL in Italy recently. The excitation function at $\theta_{c.m.}$ = 180° has been analysed using an R-Matrix code AZURE2[5]. They discovered 7 new levels and extracted the Γ_α of observed levels for the first time. It should be noted that the spin and parity assignments could be uncertain because of the absence of excitation functions at other angles. To check the reliability of their data and search for the predicted $1/2^+$ states, we reanalysed the excitation function using the same R-Matrix code AZURE2. It was strange we could not repeat Torresi's fit based on their fit parameters, see Fig. 1(a). In a conference article[6] written by the same authors, the shown data of excitation function was extended to $E_{c.m.}$ = 6 MeV. However, there was no explanation for these discarding data in the regular paper Ref. [4]. For clarity and integrity, we adopted the data from Ref. [6] to make the R-Matrix analysis, the fit is shown in Fig. 1(b). The fit results are summarized in Table 1, and the Torresi's fit parameters are also listed for comparison.

It can be seen from Table. 1, the locations of two $1/2^+$ states in **bold** are close to the predicted region. However, the 6.277 MeV state is with a significant narrow α width compared to the theoretical prediction. Recently, a 6.286