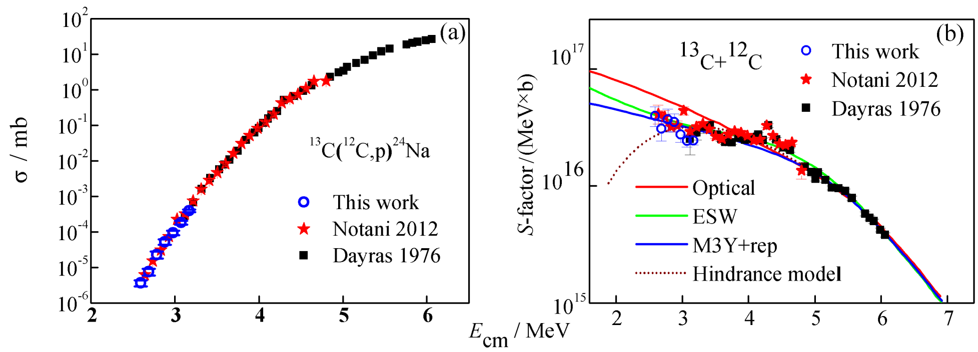

Fig. 1 (color online) The preliminary fusion cross section of $^{12}C(^{13}C, p)^{24}Na$ reaction obtained from the present work (a) and the deduced S-factors for the $^{13}C+^{12}C$ reaction system (b). The results from the previous experiments in Ref. [5, 6] are also shown.

shown in Fig. 1. In this work, the lowest cross section has been measured down to 3 nb as shown in Fig. 1(a). The total cross section of $^{13}C+^{12}C$ was deduced, using the branching ratio predicted by statistical model for the proton emission channel[6]. The total cross sections are converted into the astrophysical S-factors and shown together with the three different extrapolating models in Fig. 1(b). The ESW model and coupled-channels (CC) with M3Y+Rep potential can predict the experimental data very well. The hindrance model also shows a reasonable agreement to the experimental data above 2.7 MeV, but predicts a sharp decrease at lower energies. In order to check the difference between these reaction models, measurements at even lower energies are highly required.

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2 - 13 Stellar Reaction Rate of the $^{14}O(\alpha, p)^{17}F$

Hu Jun, He Jianjun, Xu Shiwei, H. Yamaguchi, Ma Peng, D. Kahl, Su Jun,
Wang Hongwei, T. Nakao, Y. Wakabayashi, J. Y. Moon, T. Teranishi,
H. S. Jung, T. Hashimoto, A. Chen, D. Irvine and S. Kubono

Proton resonant states in ^{18}Ne have been investigated by the resonant scattering of ^{17}F+p with a ^{17}F beam bombarding a thick H_2 gas target. Several resonances have been observed. In particular, the astrophysically crucial state 6.15 MeV was observed as a spin-parity assignment of 1^- with high statistics. The groove-like structure observed in this work is completely different with previous peak one[1]. The confirmation of 1^- on a firm ground clarified this significant discrepancy. In addition, a new state was observed at E_x = 6.85 MeV with a tentative spin assignment of 0, which could be the mirror state of 6.88 MeV, 0^- in ^{18}O, or a bandhead state (0^+) of the six-particle four-hole ($6p$-$4h$) band[2,3]. The resonant parameters have been determined by an R-matrix analysis of the excitation functions.

Based on the new experimental results, the stellar reaction rate of the $^{14}O(\alpha, p)^{17}F$ reaction has been reevaluated. Here, the excitation and resonance energies are adopted from the work of Hahn et al.[4]. Similar to the method utilized by Hahn et al. and Bardayan et al.[5], the $^{14}O(\alpha, p)^{17}F$ total rate has been numerically calculated using the resonance parameters and the direct reaction S factors calculated by Funck and Langanke[6]. Here, the interference between the direct-reaction ℓ= 1 partial wave and the 6.15 MeV (1^-) excited state was included in the calculations; the inelastic branches were also included in the integration. Two different $^{14}O(\alpha, p)^{17}F$ rates were calculated by assuming the constructive ("Present+") and destructive ("Present−") interferences between the direct and resonant captures (for the 6.15 MeV state). These two rates differ by a factor of ≈5 at 0.35 GK and less than 10% at 1 GK. In the temperature region of 0.3∼3 GK, our "Present+" and "Present−" rates are about 1.1∼2.2 times

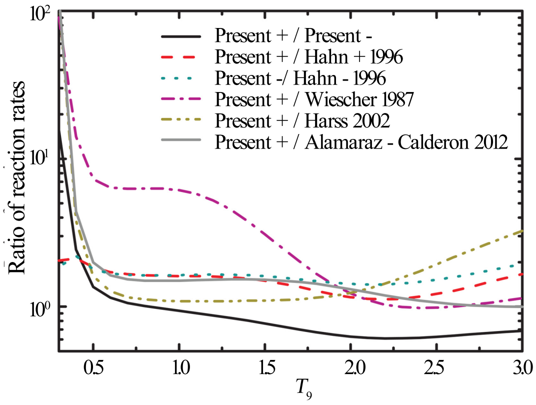

Fig. 1 (color online) Ratios between the present reaction rates and previous calculations.

larger than the corresponding rates from Hahn et al. Our adopted parameters are more reliable than the older ones determined about 20 years ago[1]. It is worth noting that our rates are orders of magnitude greater than those of Refs.[7, 8]. below 0.3 GK, because they did not consider the interference effects and only utilized a simple narrow-resonance formalism to calculate the resonant rate of the 6.15 MeV state. The comparison between our rates and the previous ones are shown in Fig. 1. The 1σ uncertainties (lower and upper limits as utilized below) of the present rates were estimated to be about 10%~30% (for "Present+") and 20%~50% (for "Present−") over 0.1~3 GK. We found that the contribution from the 6.15 MeV state dominates the total rate over temperatures of interest in X-ray bursts.

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2 - 14 Investigation of the Thermonuclear ^{18}Ne(α, p)^{21}Na Reaction Rate via Resonant Elastic Scattering of ^{21}Na + p

Zhang Liyong, He Jianjun, Xu Shiwei, H.Yamaguchi, S. Kubono, Y.Wakabayashi,
Chen Size, Hu Jun, Ma Peng, Y. Togano, T. Hashimoto, D. Kahl, T. Teranishi,
Chen Ruofu, Wang Hongwei, Tian Wendong, Guo Bing, S. Hayakawa,
N. Iwasa, T. Yamada and T. Komatsubara

A nuclear astrophysics experiment was performed at CRIB (CNS low-energy Radioactive-Ion Beam separator) on Mar. 2011. The goal of this experiment is to study the reaction rate of ^{18}Ne(α,p)^{21}Na reaction, which might be a key breakout reaction from the hot CNO cycle to rp-process in X-ray burst and nova. Yet its reaction rate is poorly known.

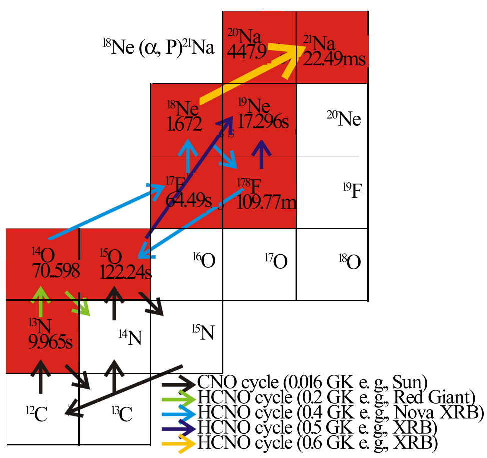

Fig. 1 (color online) The important role of the ^{18}Ne(α,p)^{21}Na reaction in the stellar evolution.