One zone Carbon-Neon shell burning calculation has been performed with NucNet[6] to investigate the impact of the new rate to the ^{60}Fe nucleosynthesis. Table 2 lists the ^{60}Fe abundance after Carbon and Neon shell burning. The strong dependence of the ^{60}Fe abundance on the ^{59}Fe stellar β-decay rate indicates that the β-decay plays an important role in the ^{60}Fe nucleosynthesis. However, the inaccuracy of the experimental GT strength leads large uncertainty in the ^{60}Fe abundance which couldn't provide tight constrain for the study of nuclear astrophysics. Therefore more precise experiment is called for to improve the stellar β-decay rate of ^{59}Fe.

Table 2 ^{59}Fe stellar β-decay rates at 1.2 GK and their impact on ^{60}Fe synthesis.

	^{59}Fe decay rate / s^{-1}	^{60}Fe abundance	relative ratio
g.s.	1.80×10^{-7}	2.47×10^{-6}	1
present work	$\mathbf{1.23\times10^{-5}}$	$\mathbf{4.63\times10^{-7}}$	**18.7%**
FFN	2.64×10^{-5}	7.92×10^{-8}	3.2%
LMP	2.56×10^{-6}	1.37×10^{-6}	55.2%

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2 - 12 Fusion Cross Section of ^{13}C + ^{12}C at Sub-barrier Energies

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Heavy-ion fusion reactions between light nuclei such as carbon and oxygen isotopes have been studied because of their importance in a wide variety of stellar burning scenarios. However, due to extremely low cross sections and signal/background ratio, all the measurements could only be carried out at energies well above the region of astrophysical interest. The reaction rates in stellar environment could be estimated only by extrapolating the existed cross sections or the astrophysical S-factors at higher energies. The situation is even more complicated by the strong, relatively narrow resonances in some reactions, such as ^{12}C+^{12}C, ^{12}C+^{16}O. Traditionally, optical model or equivalent square-well optical model (ESW) were used to fit the average cross section and predict the reaction cross sections at the energies of astrophysical interest[1]. Recently, a new model, the hindrance model, was proposed to provide systematic fits to fusion reaction data at extreme sub-barrier energies[2]. Lacking of experimental data within this energy range, large discrepancies exist among different nuclear reaction models.

In this work, ^{12}C+^{13}C reaction is chosen to test the predictive power of different reaction models. The ^{12}C (^{13}C, p) ^{24}Na reaction cross section was studied with a ^{13}C beam, delivered by the 3 MeV tandem accelerator of IFIN-HH. The ^{13}C beam energy range of 5.2 ∼ 6.8 MeV, in steps of 0.2 MeV and the beam intensity in the range of 2 ∼ 8 pμA were used in different runs. The residual activity of the ^{24}Na ($T_{1/2}$=15 h) was measured by detecting the gamma rays emitted by the beta-decay daughter at two different sites, *i.e.* IFIN-HH Low Background γ-Ray Spectrometry Laboratory (GAMASPEC)[3] and Unirea (Slanic-Prahova) salt mine ultra-low background radiation laboratory (microBq)[4]. Because the background rate in the microBq lab is only 0.016 count/h/kg/keV in the vicinity of E_γ= 1.4 MeV, which is about 59 times lower than that in the GAMASPEC lab, the measurements for the energies below 5.8 MeV ($E_{\rm cm}$=2.78 MeV) were only performed in the microBq lab. The preliminary results are

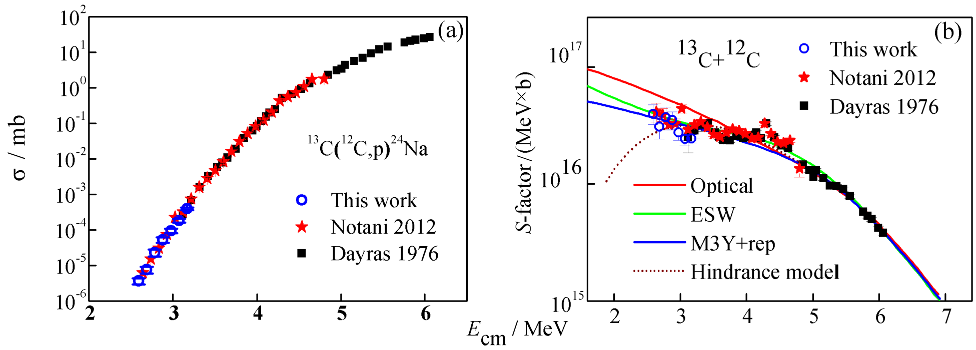

Fig. 1 (color online) The preliminary fusion cross section of $^{12}C(^{13}C, p)^{24}Na$ reaction obtained from the present work (a) and the deduced S-factors for the $^{13}C+^{12}C$ reaction system (b). The results from the previous experiments in Ref. [5, 6] are also shown.

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 $^{14}O(\alpha, p)^{17}F$

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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