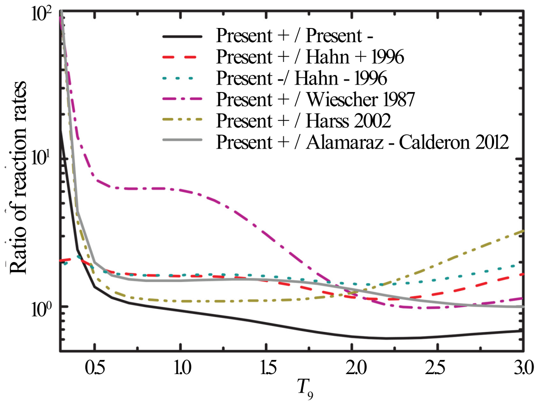

Fig. 1 (color online) Ratios between the present reaction rates and previous calculations.

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

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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.

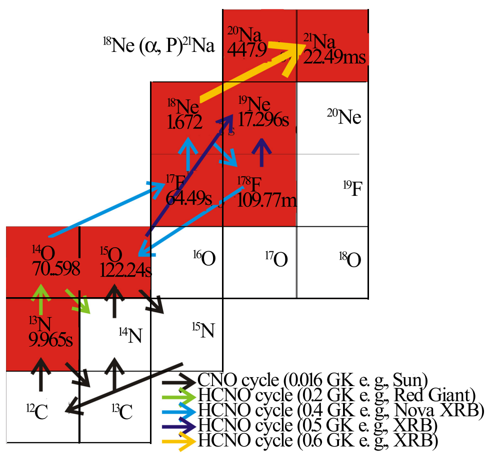

Fig. 1 (color online) The important role of the ^{18}Ne(α,p)^{21}Na reaction in the stellar evolution.

Explosive hydrogen burning is thought to be the main source of energy generation and a source of nucleosynthesis in X-ray burst and nova[1,2]. For example, XRBs are characterized by a sudden increase of X-ray emission within only a few seconds to a total energy output of about 10^{40} ergs, which is observed to repeat with some regularity. The recurrence time for single bursts can range from hours to days at the typical temperature of 0.4∼2 GK. The bursts have been interpreted as being generated by thermonuclear runaway on the surface of a neutron star that accretes H- and He-rich material from a less evolved companion star in a close binary system. As shown in Fig. 1, under its typical temperature, the hydrogen burning in X-ray burst occurs from the hot CNO cycle:

$$^{12}\mathrm{C}(\mathrm{p},\gamma)^{13}\mathrm{N}(\mathrm{p},\gamma)^{14}\mathrm{O}(\mathrm{e}^{+}\ \mathrm{v})^{14}\mathrm{N}(\mathrm{p},\gamma)^{15}\mathrm{O}(\mathrm{e}^{+}\ \mathrm{v})^{15}\mathrm{N}\ (\mathrm{p},\alpha)^{12}\mathrm{C},$$

while the reaction ^{13}N(e^{+} v)^{13}C in CNO cycle is bypassed by ^{13}N(p, γ)^{14}O. As the compressing and exothermic nuclear reactions proceeding, the temperature of the accretion disk becomes higher. When it reaches about 0.4 GK, the second hot CNO cycle becomes dominant:

$$^{12}\mathrm{C}(\mathrm{p},\gamma)^{13}\mathrm{N}(\mathrm{p},\gamma)^{14}\mathrm{O}(\alpha,\mathrm{p})^{17}\mathrm{F}(\mathrm{p},\gamma)^{18}\mathrm{Ne}(\mathrm{e}^{+}\ \mathrm{v})^{18}\mathrm{F}(\mathrm{p},\alpha)$$

$$^{15}\mathrm{O}(\mathrm{e}^{+}\ \mathrm{v})^{15}\mathrm{N}(\mathrm{p},\alpha)^{12}\mathrm{C},$$

It is predicted[1,2] that the ^{18}Ne waiting point in the second hot CNO cycle can be bypassed by the ^{18}Ne(α,p)^{21}Na reaction at T ∼0.6 GK, and subsequently the reaction-chain breaks out to the rp-process, so it is very important to study this reaction rate.

The experimental setup and data analysing was illustrated in Ref. [3], we will mainly discuss the most present result here. In this work, the thermonuclear ^{18}Ne(α, p)^{21}Na rate was calculated using a narrow resonance formalism:

$$N_A<\sigma v>=1.54\times 10^{11}(\mu T_9)^{-3/2}\sum\nolimits_i(\omega\gamma)_i\times\exp(\frac{-11.605E_i}{T_9})(\mathrm{cm}^3\cdot\mathrm{s}^{-1}\cdot\mathrm{mol}^{-1})\ ,$$

where μ is the reduced mass in units of amu, E_i and $(\omega\gamma)_i$ (both in units of MeV) are the energy and strength of individual resonance, and T_9 is the temperature in units of 10^9 K (*i.e.*,GK).

The calculated reaction rate $N_A<\sigma v>$ rate and corresponding errors are summarized in Table 1. Previous results were considered in our calculation and error estimation, the details can be found in Ref. [5]. The present result is much lower than previse ones, and the astrophysical impact of our new rate is being investigated.

Table 1 Calculated ^{18}Ne(α, p)^{21}Na reaction rate in units of (cm^3·s^{-1}·mol^{-1})

T_9	$N_A<sv>$	Upper	Lower
0.1	2.96×10^{-27}	5.38×10^{-27}	1.62×10^{-27}
0.2	2.02×10^{-15}	3.67×10^{-15}	1.10×10^{-15}
0.3	4.88×10^{-11}	8.87×10^{-11}	2.66×10^{-11}
0.4	1.41×10^{-8}	2.57×10^{-8}	7.70×10^{-9}
0.5	7.84×10^{-7}	1.43×10^{-6}	4.28×10^{-7}
0.6	1.73×10^{-5}	3.15×10^{-5}	9.45×10^{-6}
0.7	2.09×10^{-4}	3.79×10^{-4}	1.14×10^{-4}
0.8	1.70×10^{-3}	3.09×10^{-3}	9.27×10^{-4}
0.9	1.03×10^{-2}	1.87×10^{-2}	5.62×10^{-3}
1.0	4.84×10^{-2}	8.81×10^{-2}	2.64×10^{-2}
1.1	1.83×10^{-1}	3.32×10^{-1}	9.96×10^{-2}
1.2	5.73×10^{-1}	1.04	3.13×10^{-1}
1.3	1.55	2.81	8.44×10^{-1}
1.4	3.70	6.73	2.02
1.5	8.03	1.46×10^{1}	4.38
1.6	1.61×10^{1}	2.92×10^{1}	8.77
1.7	3.02×10^{1}	5.49×10^{1}	1.65×10^{1}
1.8	5.37×10^{1}	9.76×10^{1}	2.93×10^{1}
1.9	9.14×10^{1}	1.66×10^{2}	4.99×10^{1}
2.0	1.50×10^{2}	2.73×10^{2}	8.18×10^{1}

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