EXPRESSIONS FOR THE ^{14}O(α,p)^{17}F and ^{17}F(p,γ)^{18}Ne STELLAR REACTION RATES

D. W. Bardayan[1] and M. S. Smith

There are a number of extremely hot, dense astrophysical environments where hydrogen is expected to burn explosively. These include supermassive stars, X-ray bursters, novae, and supernovae. The hot-CNO (HCNO) cycle, ^{12}C(p, γ)^{13}N(p,γ)^{14}O(e$^+\nu_e$)^{14}N(p,γ) ^{15}O(e$^+\nu_e$)^{15}N(p,α)^{12}C, is one reaction chain through which such burning occurs. The energy generation rate of this sequence is limited by the long beta decay lifetimes of ^{14}O and ^{15}O. When the stellar temperatures are high enough ($T_9 \geq 0.3$, where T_n = T/(10^n K)), the beta decay of ^{14}O can be bypassed by the ^{14}O(α,p)^{17}F reaction, and the reaction sequence ^{14}O(α,p)^{17}F(p,γ)^{18}Ne(e$^+\nu_e$)^{18}F (p,α)^{15}O can increase the energy generation rate and alter the abundances of the CNO nuclides. Furthermore, the reaction sequence ^{14}O(α,p)^{17}F(p,γ) ^{18}Ne(e$^+\nu_e$)^{18}F(p,γ)^{19}Ne(p,γ)^{20}Na can provide a path from the HCNO cycle into the rapid proton (rp) capture process where the energy generation rate can increase by two orders of magnitude[2].

An accurate prediction of the thermonuclear energy generation is required to model these complex astrophysical events. Expressions for the relevant reaction rates as analytic functions of the stellar temperature are crucial input for these models. These reaction rates are also required to predict the detailed isotopic composition of nuclei synthesized in such astrophysical events. Both reactions are targeted for measurements at ORNL's Holifield Radioactive Ion Beam Facility in the near future, and this evaluation work is an integral part of our preparation for these measurements.

We have generated analytic expressions for the ^{14}O(α,p)^{17}F and ^{17}F(p,γ)^{18}Ne stellar reaction rates using the most recent indirect experimental measurements of relevant reaction parameters. Our work gives the first complete expression for the ^{14}O(α,p)^{17}F rate incorporating recent experiment information, and corrects an error (as large as 13% at high temperatures) in the previously-published ^{17}F(p,γ)^{18}Ne rate. A paper on this work has been published [3], and the rates have been posted on the WWW [4].

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[1]ORNL Physics Division, Yale University.

[2]R. K. Wallace and S. E. Woosley, Astrophys. J. Suppl **45** (1981) 389

[3]D. W. Bardayan and M. S. Smith, Phys. Rev. **C56** (1997) 1647

[4]http://www.phy.ornl.gov/astrophysics/data/newrates/newrates1.html