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ORIGINAL ARTICLE

194.1 keV resonance contribution on $^{17}O(p,\alpha)^{14}N$ reaction rate using R matrix code

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Abstract Recently, a new resonance at $E_{Rlab} = 194.1$ keV corresponding to a level in ^{18}F at $E_x = (5789.8 \pm 0.3)$ keV has been observed for the first time. In view of these new parameters, we propose here to examine this reaction using a numerical code based on the R-matrix method to show its contribution to the $^{17}O(p,\alpha)^{14}N$ reaction rates. We also study the cross section as well as the differential cross section of the $^{17}O(p,\alpha)^{14}N$ reaction. It is found that this resonance predominates the reaction rates in all the range of the stellar temperature for classical novae explosions. Our results are in good agreement with those of a recent experimental study.

Keywords Nuclear reaction · Nucleosynthesis · R-matrix · Stellar sites · Classical novae · Giant stars

1 Introduction

The $^{17}O(p,\alpha)^{14}N$ and $^{17}O(p,\gamma)^{18}F$ reactions are parts of the carbon-nitrogen-oxygen (CNO) cycles. Precise knowledge of their thermonuclear rates is of paramount importance for understanding hydrogen-burning nucleosynthesis in stellar sites. Knowledge of the $^{17}O(p,\alpha)^{14}N$ reaction rates is required for evaluating elemental abundances in a number of hydrogen-burning stellar sites. This reaction is particularly important for nucleosynthesis of the rare oxygen isotope ^{17}O. Classical novae are thought to be a major source of ^{17}O in the Galaxy and produce the short–live radioisotope ^{18}F whose β^+ decay is followed by a gamma ray emission which could be observed with satellites such as the INTEGRAL observatory.

As the $^{17}O(p,\alpha)^{14}N$ and $^{17}O(p,\gamma)^{18}F$ reactions govern the destruction of ^{17}O and the formation of ^{18}F, their rates are decisive in determining the final abundances of these isotopes. Stellar temperatures of primary importance for nucleosynthesis are typically in the ranges T = 0.01–0.1 GK for red giant, AGB, and massive stars, and T = 0.1–0.4 GK for classical nova explosions.

The rates of $^{17}O(p,\alpha)^{14}N$ and $^{17}O(p,\gamma)^{18}F$ reactions are important for understanding giant stars and novae. The abundances of the oxygen isotopes have been used to constrain the age of the Galaxy (Nittler and Cowsik 1997). The ^{17}O isotope is also abundantly produced in novae. The $^{17}O(p,\gamma)^{18}F$ reaction leads to the production of ^{18}F, a dominant source of potentially observable gamma rays in novae, while $^{17}O(p,\alpha)^{14}N$ reaction bypasses ^{18}F production (Hernanz and José 2004).

The stellar temperature ranges of primary interest amount to 0.1–0.4 GK for classical novae. According to the Nuclear Astrophysics Compilation of Reaction Rates (NACRE) (Angulo et al. 1999), the thermonuclear rates for both of these reactions carry large uncertainties. Such large errors introduce significant variation in C, N, O and F isotope abundance that are predicted by hydrodynamical nova simulation. The variations, in turn, have far reaching implications for the galactic synthesis of the ^{17}O, the stellar production of the radioisotope ^{18}F, and predicted oxygen isotope ratios in nova ejecta (Fox et al. 2004; Chafa et al. 2007).

The properties of a resonance at $E_{cm} = 183.3$ keV, corresponding to the energy level in ^{18}F at $E_x = 5789$ keV, are important for understanding the $^{17}O(p,\alpha)^{14}N$ and

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