The Lowest Excited States of ^{13}O and Astrophysical Implications

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Quantum characteristics of excited states in A=13 T=3/2 nuclei were unknown before this work. Hence there was no knowledge about their nuclear structure.

The nuclear structure of ^{13}O is important for evolution of very low-metallicity massive stars [1]. It has been shown that ^{12}N can be depleted into ^{12}C through β^+ decay or by photodisintegration $^{12}N(\gamma,p)^{11}C$. However, ^{12}N may capture a proton to form ^{13}O through the process $^{12}N(p,\gamma)^{13}O$. This process can compete with β^+ decay and photodisintegration of ^{12}N at some temperatures and densities. It is important

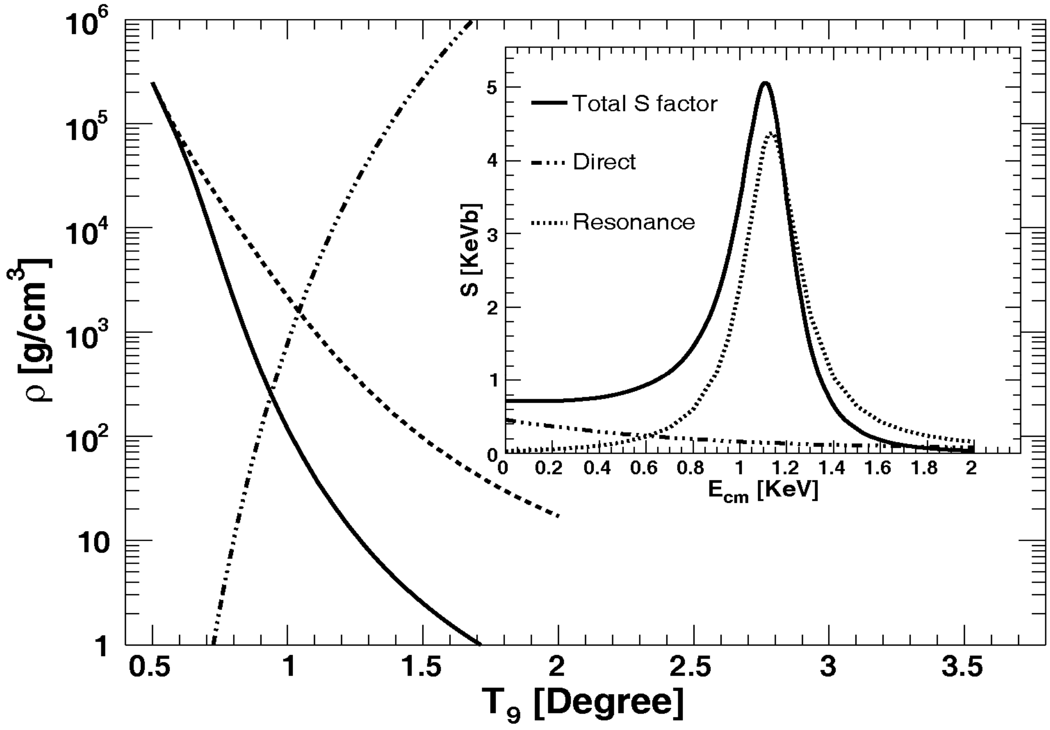

Figure 1. The temperature and density conditions where the $^{12}N(p,\gamma)$ reaction is important. The solid line (new results) and dashed line Ref. [1] show where the rates for ^{12}N proton capture and beta decay of ^{12}N will be equal. In addition, the density should be above the dashed-dotted line to produce ^{13}O faster than it can be photo-dissociated. The inserted figure shows astrophysical S factor calculations: the solid line is total S factor; the dashed line shows only resonance capture; the dashed-dotted line shows only direct capture

to evaluate the density and temperature regime where that occurs.

In this work, we present results for ^{12}N+p scattering at several angles using thick target inverse kinematics method [2]. We obtained definite information on the spin-parity ($½^+$), width (Γ=0.45±0.1 MeV), and nuclear structure ($S_{s.p.}$~0.7) of the first excited state of ^{13}O. We also identify for the first time a second excited state at excitation energy of 3.29 MeV with quantum characteristics $J^{\pi}=½^-$ or $3/2^-$ and with Γ=0.075±0.03 MeV. These results were obtained by using the ***R*** matrix analysis of the experimental data, and were supported by application of a potential well approach to the isobaric level shifts.

We examined the impact of new experimental information of the first excited state $½^+$ on ^{12}N(p,γ)^{13}O reaction which might play important role in nucleosynthesis reactions of low-metallicity stars. Fig.1 presents the temperature and density conditions, where the ^{12}N(p,γ) reaction is important, together with the astrophysical S factor calculated for both direct capture and capture through the resonance in question.

[1] M. Wiescher *et al.*, Astrophys. J. **343**, 352 (1989).
[2] K.P. Artemov *et al.*, Sov. J. Nucl. Phys. **52**, 406 (1990).