**Role of excited states in the sub-barrier fusion of light nuclei**

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The fusion cross sections σ(E) and the corresponding modified S*factors of the seven light nuclear reaction systems, α + α, α + $^{8}$Be, $^{8}$Be + $^{8}$Be, $^{6}$Li + $^{6}$Li, $^{12}$C + $^{12}$C, $^{12}$C + $^{16}$O, and $^{16}$O + $^{16}$O, at sub-barrier energies are evaluated using the neck model[1]. The effects of excited states of the compound nucleus in the reaction energy range on the cross section are considered. The results show that the excited states of the compound nucleus can significantly enhance the fusion cross section in the resonant energy region, which, in turn, impacts stellar processes. A notable increase in the reaction rate has also been observed after incorporating the contributions from the excited states at a given temperature. We conclude that the contributions of different excited states on the reaction rate are closely associated to their energies and angular momenta.

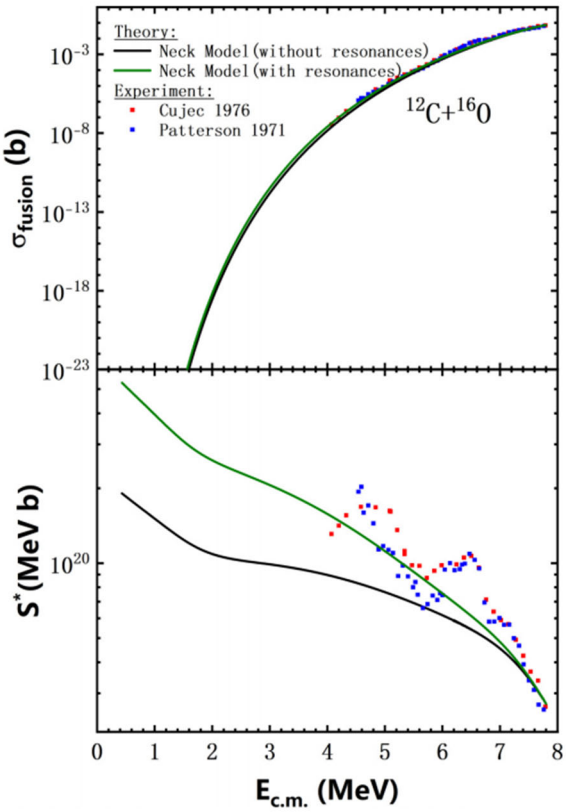


**Fig. 1**. (Color online) The cross section **σ** and the corresponding S*factor versus the center of mass energy for the $^{12}$C + $^{16}$O reaction with and without contributions from resonances of the compound nucleus. The symbols are the experimental data.

As an exmaple, Fig. 1 shows the cross section σ and the corresponding S*factor versus the center of mass energy for the $^{12}C + ^{16}O$ reaction with and without contributions from resonances of the compound nucleus. Due to the large widths of the giant resonances, the green line does not show a clear peak but rather increases gradually comparing to the results without contributions from giant resonances.

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