Nuclear Physics Constraints on Possible Resonances in Carbon Fusion Reaction and Its Impact on Type Ia Supernovae

K. Mori[a,b], M. A. Famiano[c], T. Kajino[a,b,d], M. Kusakabe[d] and X. Tang[e]

[a]*National Astronomical Observatory of Japan,* [b]*The University of Tokyo,* [c]*Western Michigan University,* [d]*Beihang University,* [e]*Institute of Modern Physics, Chinese Academy of Science*

The ^{12}C+^{12}C reaction is one of the most important reactions in astrophysics. The reaction ignites type Ia supernovae (SNe Ia) [1], which are used as a standard candle in cosmology and are the major factory of the iron group elements in galaxies. In addition, it is a possible fuel of X-ray superbursts [2], whose ignition mechanism is still unclear.
In spite of its importance, the cross sections of this reaction in astrophysical low energies have not been measured. Especially, unknown resonances in the low energy region can enhance the reaction rate and affect astrophysics. We constrain an upper limit of such resonances with the Wigner limit [3], and find that the astrophysical reaction rate can be enhanced by $\sim 10^3$ times compared with a standard rate if they exist. We study the impact of the enhanced rate on the evolution of white dwarf-white dwarf (WD-WD) binary mergers, which is a hypothetical progenitor of SNe Ia. It is shown that ignition temperature determined by competition between cooling by neutrino emission and heating by carbon burning decreases due to the resonances. Therefore, the number of SNe Ia that comes from WD-WD mergers decreases, while the number of neutron stars increases [4].

References

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