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Unraveling the role of carbon-alpha reaction rate for radioactive nickel synthesis in pair-instability supernovae

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Pair-instability supernovae (PISNe) are phenomena that are the final fates of very massive stars with an initial mass ranging from 140 to 260 $M_{\odot}$. Unlike other supernovae, PISNe do not leave behind compact objects. Stellar evolution theory predicts that there is a gap in the distribution of black hole masses due to PISNe. Recent works suggested that the location of this gap may be influenced by the uncertainty in the $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ reaction rate. In our study, we investigate how the $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ reaction rate affects PISNe profiles, particularly in terms of nucleosynthesis and explosion energy. We find a correlation between the $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ reaction rate and the amount of radioactive $^{56}\mathrm{Ni}$, which determines the peak luminosity of supernovae. This correlation is attributed to the intensity of burning during the carbon burning phase, which changes the structure of the star. In this presentation, I will provide a detailed report of our findings.

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