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Properties of Core-Collapse Supernova Progenitors From Monte Carlo Stellar Models

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We investigate properties of core-collapse supernova (CCSN) progenitors with respect to the composite uncertainties in the reaction rates using the stellar evolution toolkit, Modules for Experiments in Stellar Astrophysics (MESA) and the probability density functions in the reaction rate library, STARLIB. In total, 1000 15 solar mass stellar models are evolved from the pre main-sequence to core O-depletion at solar and subsolar metallicities for a total of 2000 Monte Carlo stellar models. In each stellar model, we independently and simultaneously sample 665 forward thermonuclear reaction rates using a robust, in-situ network that follows 127 isotopes from Hydrogen to Zinc. Within this Monte Carlo framework, we survey the remnant O-core mass, composition, and structural properties using a Principal Component Analysis and Spearman Rank- Order Correlation. Relative to the arithmetic mean value, we find the width of the 95% confidence interval to be approximately 1.0 solar mass for the core mass at oxygen depletion, ≈ 0.211 Myr for the age, ≈ 0.047 for the compactness parameter with M = 2.5 solar mass, $\Delta X(^{28}Si) \approx 0.464$, and $\Delta X(^{32}S) \approx 0.73$ for models with solar metallicity. Uncertainties in the experimental $^{12}C + {}^{12}C \longrightarrow {}^{1}H + {}^{23}Na$, $^{16}O + {}^{16}O \longrightarrow n + {}^{31}S$, triple - α, and $^{12}C(\alpha,\gamma)^{16}O$ reaction rates dominate these variations.

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