The Impact of Initial Flame Conditions on Thermonuclear Supernova Simulations

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Type Ia supernovae are thermonuclear explosions that may occur when a white dwarf (WD) star approaches the Chandrasekhar mass due to accretion from a companion star. Simulating these explosions relies on model flames to account for the scale disparity between the flame laminar size (~1cm) and the progenitor size (10^8 cm), and there is significant uncertainty regarding initial conditions of the burning. The FLASH code was used to perform suites of simulations of Type Iax supernovae (modeled as a deflagration in a hybrid C-O-Ne WD) and Type Ia deflagration-to-detonation transition (DDT) simulations of the same WD. It was explored how the results varied when doubling or halving the baseline initial burned region (the 'match head'). Influence of the initial model flame radius on 56Ni yield (peak brightness), ejecta kinetic energy, and ejecta mass of these simulations was investigated. Results were then compared to observational characteristics of known Type Iax supernovae events over the past 15 years, finding that the baseline match head radius does not optimally align with observational data. Results also varied greatly based on initial conditions; as the match head radius increased, supernovae became dimmer and less energetic. Additionally, results demonstrated a potential mechanism to explain hypervelocity metallic rogue stars that wander between galaxies, and point to the existence of a new subclass of Type Iax events.

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