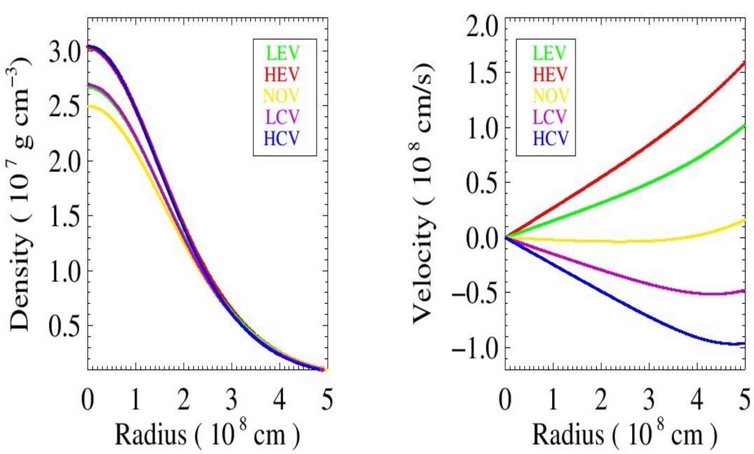
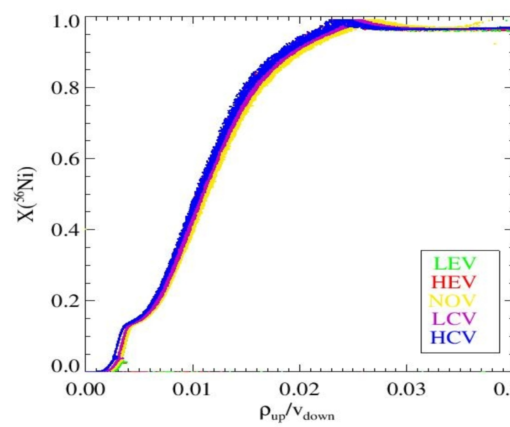
The Consequences to Type Ia Supernovae of the Pre-Detonation Stellar Velocity Profile

A common explosion mechanism of Type Ia supernovae is based on a delayed detonation of a white dwarf. A variety of models differ primarily in the method by which the deflagration leads to a detonation. A common feature of the models, however, is that all of them involve the propagation of the detonation through a white dwarf that is either expanding or contracting, where the stellar velocity profile depends on both time and space. In this work, we investigate the postdetonation expansion of the remnant and its consequences for ^{56}Ni production of pre-detonation stellar velocity profiles. We perform hydrodynamic simulations of the explosion phase on the white dwarf for five different stellar velocity profiles at the onset of a detonation. The profiles are In order to follow the complex flows and to calculate the nucleosynthetic yields, approximately 10,000 tracer particles were added in every simulation. We observe two distinct post-detonation expansion phases: rarefaction and bulk expansion. Almost all the burning to ^{56}Ni occurs only in rarefaction phase and its expansion time scale is influenced by pre-existing flow structure, in particular with the pre-detonation stellar velocity. Additionally, we find the mass fraction of ^{56}Ni is tightly related to an empirical variable ρ_{up}/v_{down}, where ρ_{up} is the mass density immediately upstream of the detonation wave and v_{down} is the velocity of the flow immediately behind the detonation wave. We find that v_{down} depends on the pre-detonation flow velocities. We conclude that the pre-exisiting flow properties, in particular the stellar velocity to the propagating detonation wave, influence the final isotopic composition of burned matter.



*Density and velocity profiles of five one-dimensional models at the time of detonation: the relative ratio (sec^{-1}) between velocity and radius is approximately 1/8 (LEV), ¼ (HEV), -1/8 (LCV), and -1/4 (HCV). In the model-naming scheme, the first letter indicates relatively "**L**ow" and "**H**igh" **V**elocity in either **C**ontracting or **E**xpanding mode, which is designated in the second letter, while "MID" simply means an intermediate velocity range.*



Mass fraction of ^{56}Ni as a function of the ratio of mass density immediately upstream of and the velocity immediately behind the detonation wave. Colors represent four one-dimensional models: HCV (magenta), LCV (blue), HEV (green), and LEV (red).

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