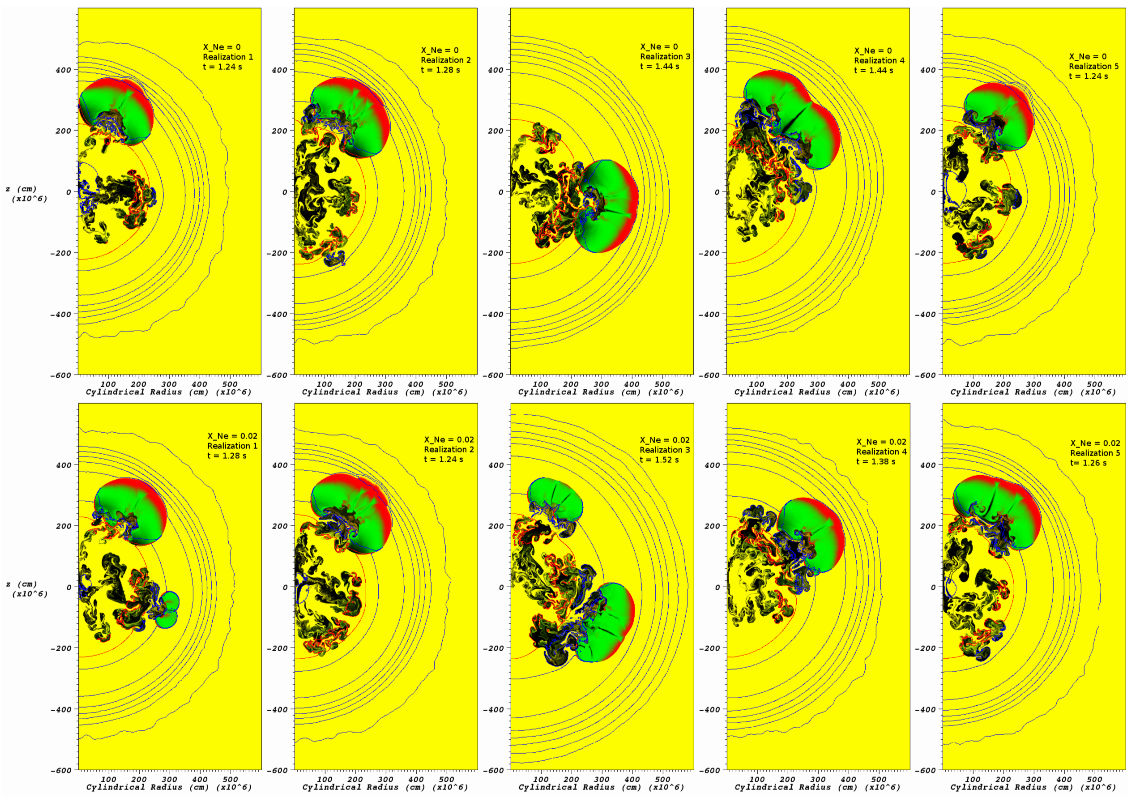
Systematic Influence of ^{22}Ne on Type Ia Supernovae Dynamics



The present accuracy of Type Ia supernovae light curve calibrations, ~10%, has been sufficient for discovering the dark energy, but it must be improved to perhaps 1–2% in order to study properties of dark energy quantitatively.

This is a formidable task which requires increasing the accuracy of supernovae light curve fitting procedures to account for systematic effects such as from the exploding star's initial composition. For example, supernovae in elliptical galaxies are systematically dimmer. Our research is attempting to answer this and related questions.

We have developed a framework to explore systematic effects in Type Ia supernovae models. The framework is developed from a randomized initial condition that leads to a sample of model supernovae whose ^{56}Ni masses have a similar average and range to those observed, and have many other modestly realistic features such the velocity extent of intermediate mass elements. The intended purpose is to enable statistically well-defined studies of both physical and theoretical parameters of the explosion model. Our first use of this framework to assess the influence of ^{22}Ne, which is a key trace element in the progenitor white dwarfs, on the ^{56}Ni yields that powers the light curves.

The figure above shows the burning products ~ 0.1 seconds after the first detonation is launched for different 2D realizations of the initial burning surface (columns) and ^{22}Ne abundance (rows). Fuel and burning products are: unburned C, O, Ne (yellow), O-Si (red), Si-group (green), and Fe-group (black). Density contours are logarithmically spaced at powers of 10 starting from 10 g/cm^3 at the outside. One extra contour (red) is added at a density of 20 million g/cm^3 .

While the outcome following from any particular ignition condition can change dramatically with ^{22}Ne content, with a sample of 20 ignition conditions we find that systematic changes in the expansion of the star prior to detonation are not large enough to compete with other known metallicity dependences. This points to the morphology of the ignition condition as being a dominant dynamical driver of explosion's ^{56}Ni yield. Variations in the density where the detonation occurs, which were specifically excluded here and are being studied in ongoing work, are also expected to be important and to depend systematically on ^{22}Ne content.

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