Cellular structure of helium detonation as a trigger of sub-Chandrasekhar mass Type Ia supernovae

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Abstract

Astrophysical detonation encountered in Type Ia supernovae (SNe Ia) has been primarily addressed in the context of near-Chandrasekhar mass explosion in which detonation of carbon/oxygen is initiated directly or through deflagration-to-detonation transition in the core of a white dwarf. Recently, helium detonation on the surface of a white dwarf attracts increased attention instead as a trigger of sub-Chandrasekhar mass SNe Ia, which may overcome the disagreement with observation near-Chandrasekhar scenario has faced, e.g., absence of a bright companion at the explosion site. Sub-Chandrasekhar mass SNe Ia is driven by double-detonation, in which accretion stream from the companion star induces thermonuclear runaway in the helium-rich layer on the surface of the primary star, and helium detonation thereby initiated ignites the core detonation via converging shock. Up until now, several studies have conducted multidimensional whole star simulations with the minimum resolutions 10^5-10^6 cm, not resolving the cellular structures of helium detonation. However, to assess the probability of ignition, propagation in the surface layer, and subsequent initiation of the core detonation, its cellular dynamics takes an important role as it does in the critical phenomena observed in terrestrial detonable systems.

In this study, 2D numerical simulation was conducted employing alpha-chain nuclear reaction networks (Fig. 1). In the conference, we will discuss the cell width and the irregularity of the cellular structure depending on the initial temperature/density, and the initial composition.

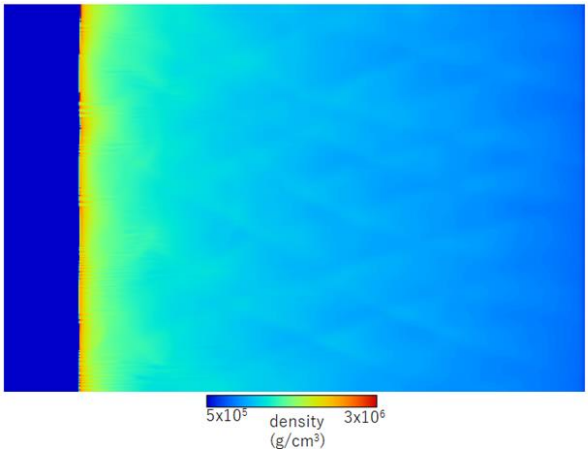

Fig. 1 Cellular structure of helium detonation

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