Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Multidimensional Simulations of Type Ia Supernovae and Classical Novae

By

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Explosive astrophysical phenomena have historically played a significant role in understanding the universe and our place within it. Stellar explosions are important distance indicators, allowing exploration of the structure and evolution of the universe. They also form and disperse heavy elements. The progenitors and mechanisms of stellar explosions vary tremendously. I used multidimensional simulations to study two distinct types of explosions that are believed to result from similar progenitor systems: compact white dwarf stars that accrete matter from stellar companions. The two types of explosions I studied are type Ia supernovae and classical novae.

Type Ia supernovae are thought to arise from a thermonuclear explosion originating in the core of an accreting white dwarf and leave no remnant. These events are the premier distance indicators in cosmological studies, but questions remain about systematic biases and intrinsic scatter. My investigation centered on the systematic impact of the central density of the progenitor on the brightness of the supernova. Relating the progenitor's central density to its age provided a theoretical explanation of the observed trend that type Ia supernovae from older stars are dimmer. I also demonstrated the importance of a statistical study of such problems, due to the strongly nonlinear effects involved.

Classical novae are important for the study of circumstellar dust formation and are significant contributors of specific isotopes found in our galaxy. They result from a thermonuclear runaway occurring in the accreted envelope on a white dwarf. Only the envelope is consumed, so the white dwarf remains and the event may recur on time scales of 10^4 to 10^5 years. My study made use of a new simulation code specialized for low-Mach-number flows, such as convection just prior to the explosion. I developed hydrostatic initial models and physics modules necessary for simulations of classical novae. This problem provided unexpected challenges, but preliminary simulations are underway. Future results will explore the effects of convection, particularly the quantity and mechanisms of mixing.

My research into stellar explosions provided important insight into their mechanisms and required considerable development work, which improved our models and will allow more realistic simulations in the future.

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