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New 3D White Dwarf Deflagration Models for Type Iax Supernovae

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Type Ia supernovae (SNe Ia) play a number of key roles in astrophysics. These include contributing substantially to cosmic nucleosynthesis, injecting kinetic energy in galaxy evolution and acting as cosmological distance indicators. Thanks to modern transient surveys it has become clear that type Ia supernovae are a diverse population with many different explosion scenarios proposed to explain normal SNe Ia as well as the various sub-classes. Nucleosynthesis constraints can help to understand the progenitors as different scenarios produce different elemental yields. In particular, explosion scenarios involving a deflagration phase produce relatively large amounts of neutron rich iron-group isotopes. Type Iax supernovae (SNe Iax), which are a sub-class of SNe Ia, are suggested to arise from pure deflagrations of Chandrasekhar mass CO white dwarfs. If this is the case SNe Iax are candidates for contributing to the enrichment of the Universe with neutron rich iron-group isotopes. Type Iax supernovae are estimated by Foley et al. (2013) to make up approximately 30% of the total SNe Ia rate. SNe Iax primarily occur in late-type host galaxies which implies they are a relatively young population and are spectroscopically similar to SNe Ia (although there are some differences) but generally have lower peak magnitudes. SNe Iax however have a much larger spread in their luminosity than normal SNe Ia: the faintest and brightest SNe Iax differ by more than 4 magnitudes at peak. Their infrared (IR) light curves don't show the secondary peak commonly seen in SNe Ia and the long-term evolution is different, potentially suggesting there is some form of luminous bound remnant left behind (in agreement with what is predicted by pure deflagration models). A key theoretical challenge is understanding the origin of this diversity across a wide range of wavelengths and epochs. One way to understand the diversity in the SNe Iax population is to explore how diversity in their initial conditions can impact the synthetic observables produced by models. To this end we present new 3-Dimensional, Carbon-Oxygen White Dwarf deflagrations (Lach, Callan et al. 2022) with varying geometric conditions including ignition radius of the deflagration and central density. We comment on the light curves and spectra produced from this series of models and compare the synthetic observables to the SNe Iax population. Finally, we discuss the possible causes of systematic differences between our model sequence and SNe Iax, the understanding of which are key to supporting or ruling out the pure deflagration scenario.

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