KAVLI IPMU INSTITUTE FOR THE PHYSICS AND MATHEMATICS OF THE UNIVERSE

THE UNIVERSITY OF TOKYO

Accretion induced collapse of white dwarfs: multicolor light curve simulations

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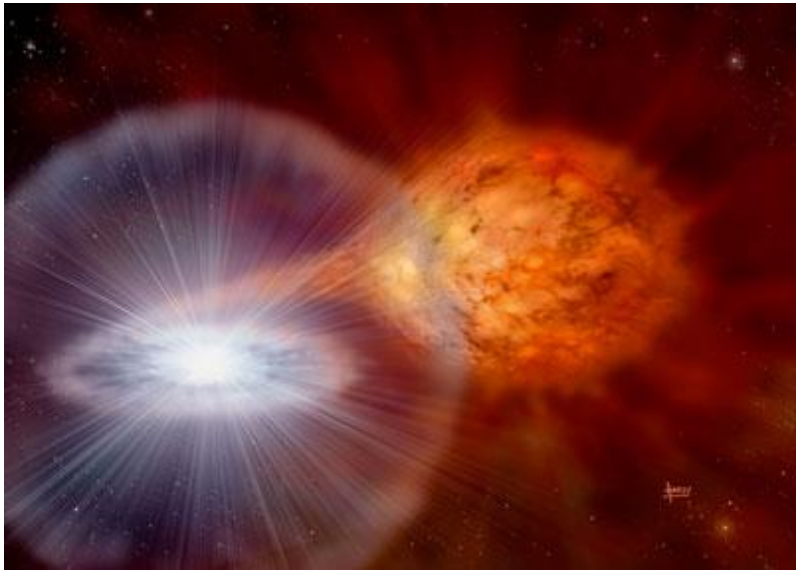


White dwarf inside the outer atmosphere of a red giant
Credit: STFC/David Hardy

Accreting white dwarfs (WDs)

- Collapse to form a neutron star (NS)
- Explosion as a Type Ia supernova (SN)

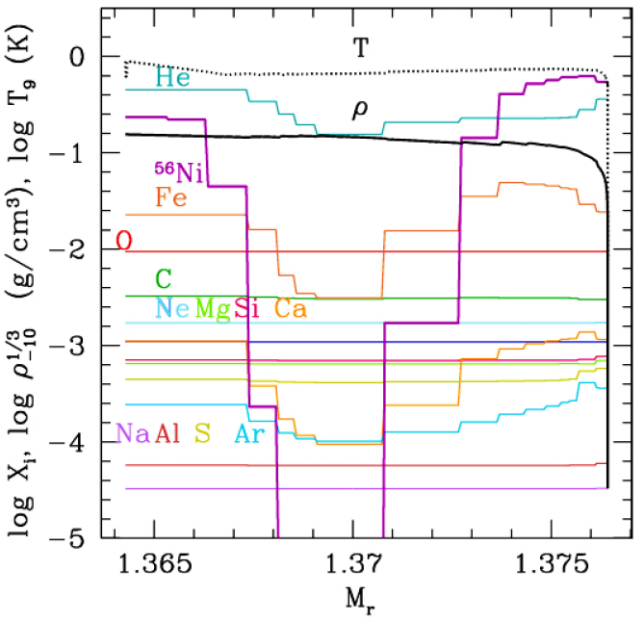
O–Ne WDs, rather than C–O white dwards, undergo AIC (Miyaji et al. 1980; Nomoto 1984)

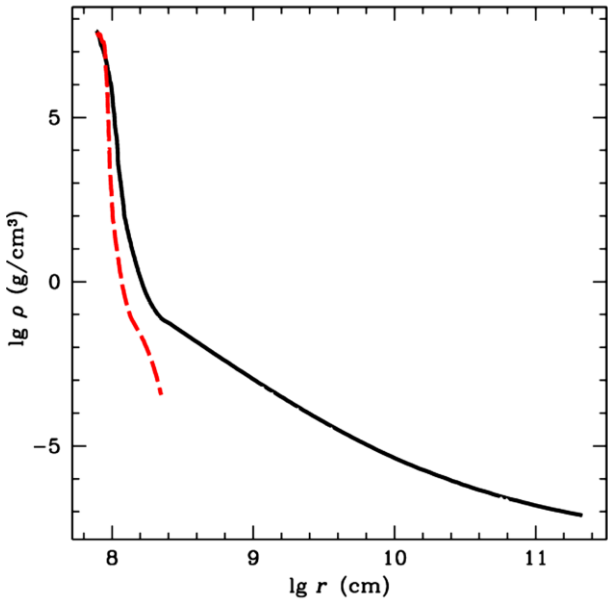
No direct observations of AIC have yet been made!

- Models of the collapse produce a weak explosion and $\sim 10^{-3}\,M_{\odot}$ of ^{56}Ni-rich ejecta: Woosley & Baron (1992); Dessart et al. (2006); Abdikamalov et al. 2010)
- Radio, optical, and X-ray signatures have been predicted: Piro & Kulkarni (2013); Metzger & Bower (2014)

Our goal: find AIC signatures using detailed radiation hydro simulations

Model and methods: radiation hydrodynamics simulations





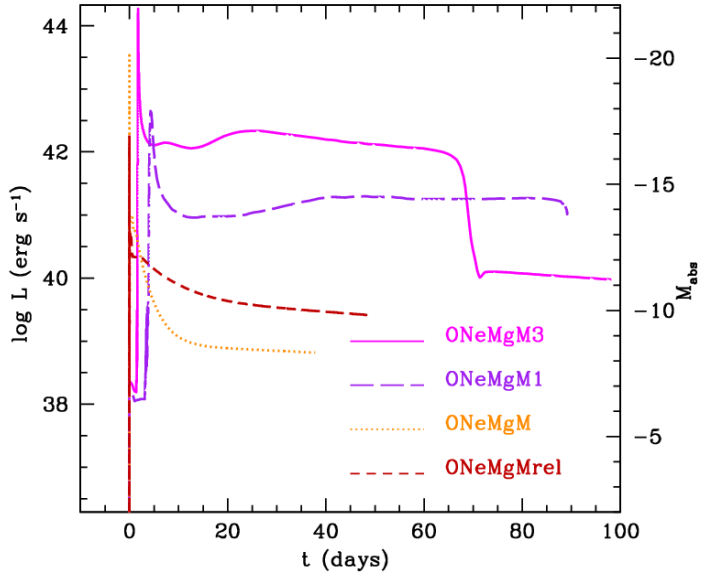
O+Ne+Mg core model + envelope

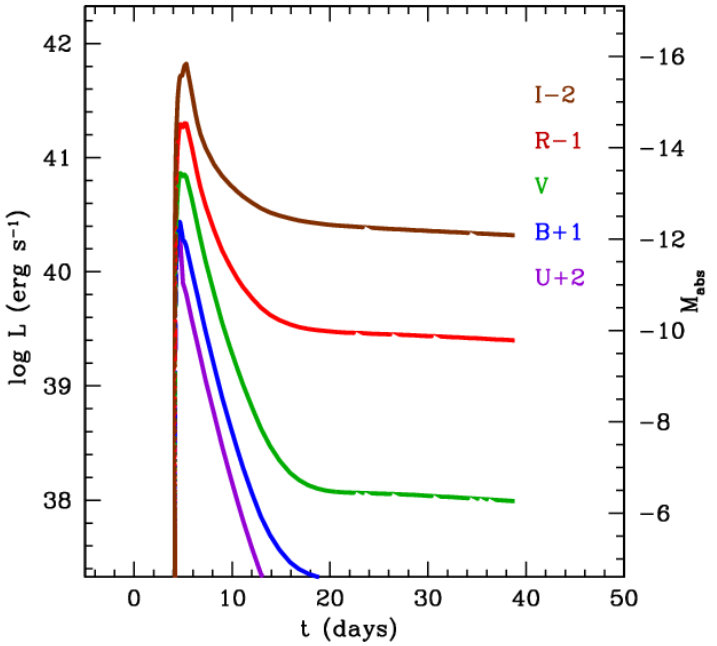
- O+Ne+Mg core model with 1.377M ⊙ at a presupernova stage (Nomoto 1984, Nomoto 1987).
- M_{ej} = 0.011 $M_{\odot}$, E_{51}= 0.13, M(^{56}Ni) = 0.002 $M_{\odot}$.
- Compact models leads to relativistic velocities (> 0.9 c).
- We consider several models with more massive hydrogen envelope (M_{env} up to 3 $M_{\odot}$).

Radiation hydrodynamics

- Calculation of the light curves: multigroup radiation hydrodynamic code STELLA (Blinnikov et al. 2000) modified by hydro relativistic corrections (Misner & Sharp, 1969).
- STELLA solves implicitly time-dependent equations for the angular moments of intensity averaged over fixed frequency bands and computes variable Eddington factors that fully take into account scattering and redshifts.

Results of radiation hydrodynamics simulations





- **Short X-ray flash**: from 0.1 s (T_{color} ~ 10^7 K, M_{bol} = -16) in ONeMgMrel model to 100 s (T_{color} ~ 10^6 K, M_{bol} = -18) in ONeMgM model.
- In 2-5 hours after the X-ray flash, the **faint optical emission** M_{bol}=-12…-13 can be seen during several days.
- Current and upcoming transient surveys such as the Palomar Transient Factory should detect **a few AIC per year** for an AIC rate of $\sim 10^{-2}$ of the Type Ia rate (Metzger 2010) .
- The duration and peak luminosity of AIC transients increase with the ejecta mass.
- More luminous AIC transients are more likely to be accompanied by detectable gravitational waves: AIC - promising electromagnetic counterpart to events detected with ground-based interferometers.