Recent results on (a) metallicity dependencies and (b) double degenerate collisions

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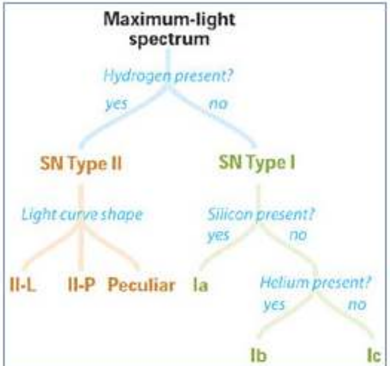
Outline

1. Systematic dependencies from ^{22}Ne: simple counting, simmering, & dynamics
2. Double-degenerate mergers: collision cases

A Field Guide to Supernova Spectra

by Leif J. Robinson

The only sure way to know that you've got a supernova in your sights, especially shortly after an explosion, is to capture a diagnostic spectrum. Basically, supernovae come in two flavors: those that have hydrogen (Type II, from a very massive star that blows up) and those that don't (Type I, due to thermonuclear runaways in a less massive star).



Supernova types are characterized by their chemistry and light curves.

S&T illustration; source: Astronomy and Astrophysics Encyclopedia (1994).

Both types exhibit a wide variety of subclasses. Type Ia is of no interest because these stars don't emit neutrinos. Types Ib and Ic are thought to undergo core collapse like Type II supernovae and, therefore, should emit neutrinos.

SKY & TELESCOPE

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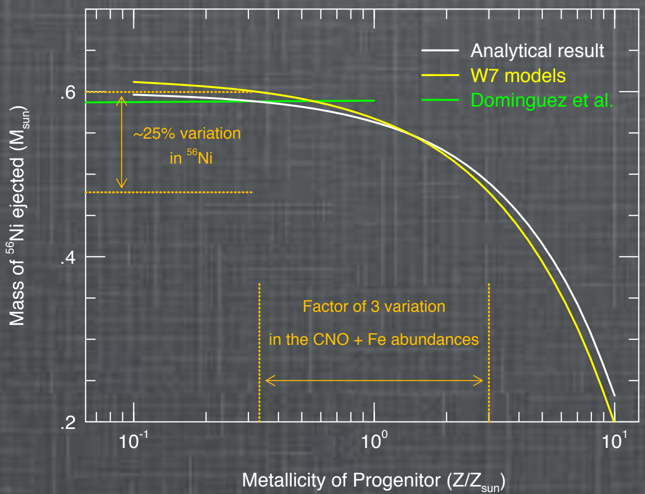
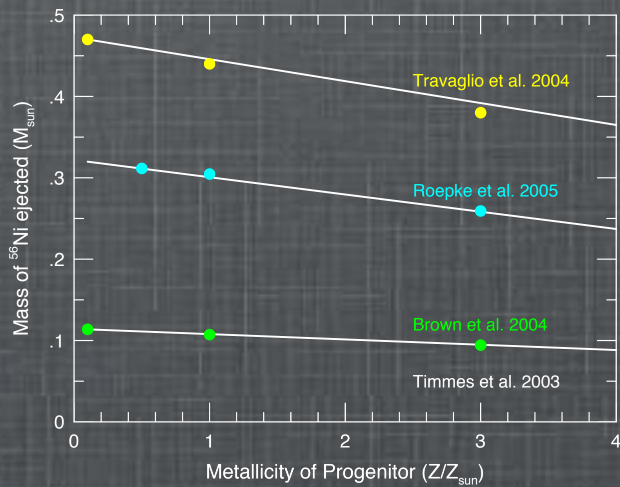
August, 1999

A higher metallicity can reduce ^{56}Ni, yielding a dimmer Ia.

$$M(^{56}\mathrm{Ni}) = M(^{56}\mathrm{Ni})_{Z=0} \left[1 - 0.057 \frac{Z}{Z_\odot}\right]$$

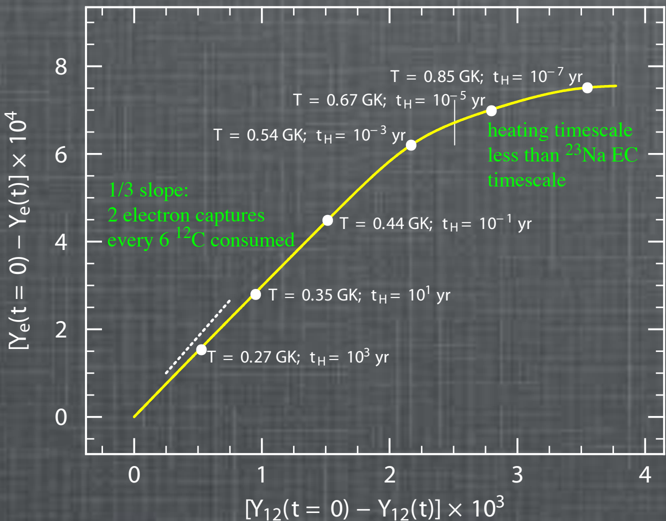
TBT03

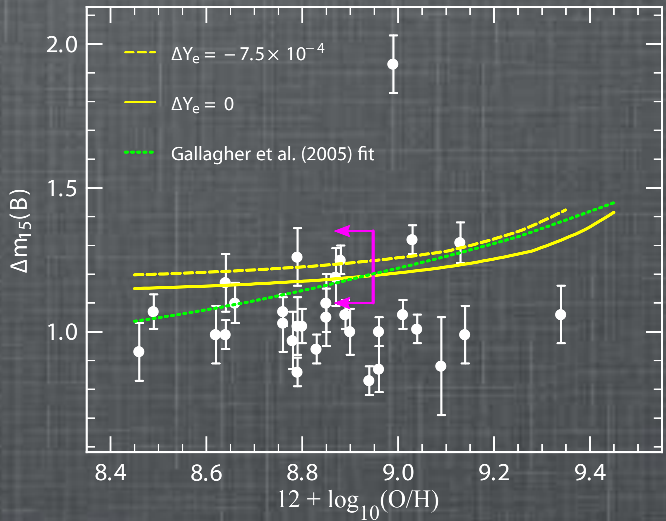




Neutronization during "simmering" sets a floor that could wash out the TBT03 metallicity effect for individual SNIa with $Z/Z_{sol} < 1/2$.

Piro & Bildsten 2008
Chamulak et al 2008

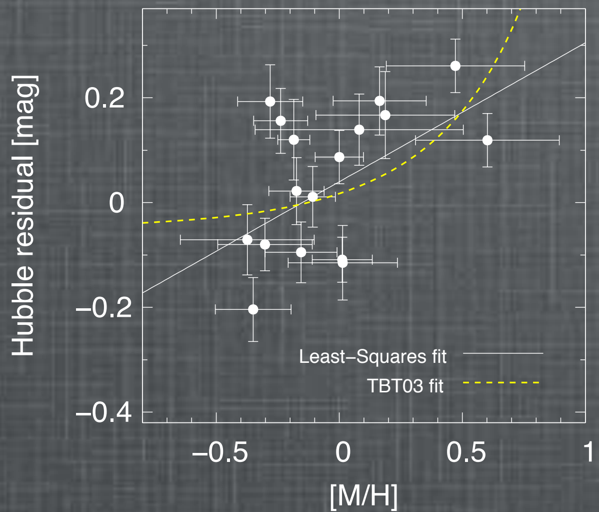




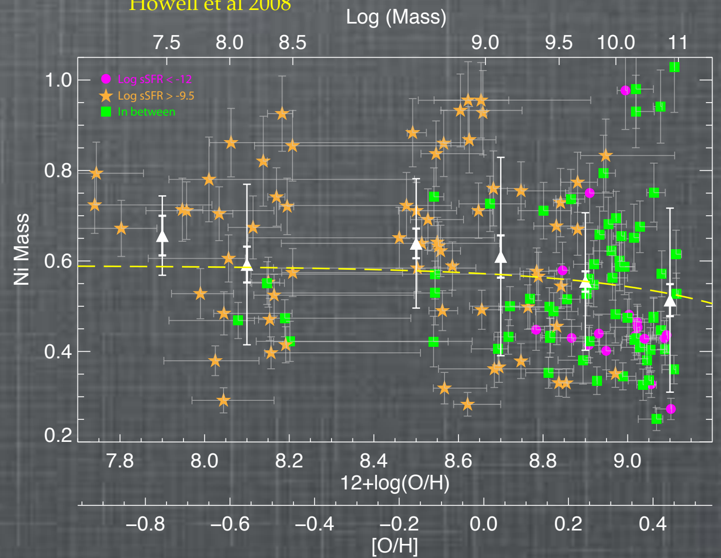
Correlations between O/H and Δm_{15}(B) may be masked.

Recent observations leave the situation somewhat murky.

Gallagher et al 2008



Howell et al 2008



Constraining a Z dependence is challenging in part because there appears to be a stronger dependence on mean stellar age.

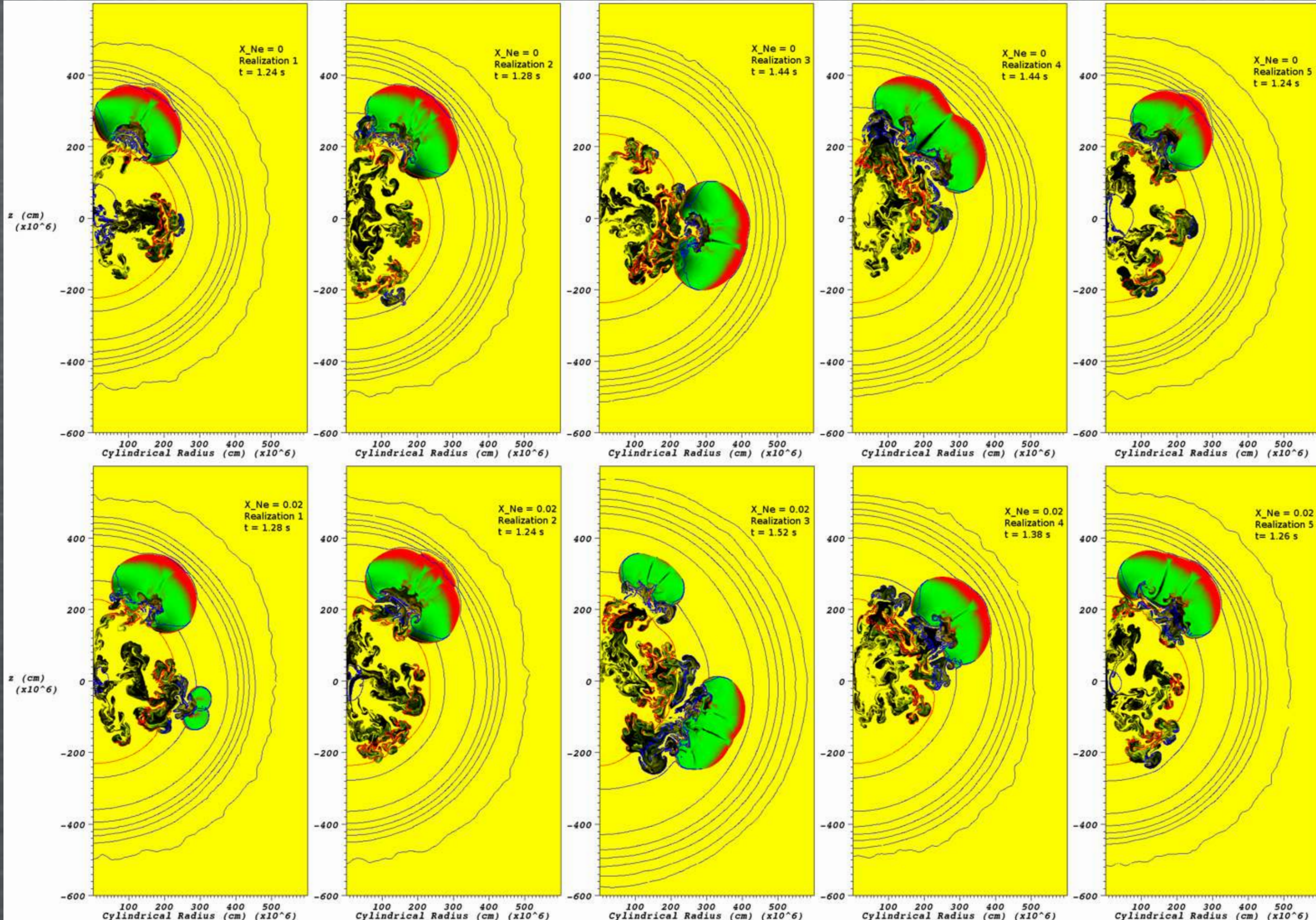
Given the uncertainty, we continue to look for new metallicity effects.

Townsley et al. 2009

We've now examined how ^{22}Ne influences rising of burning material and expansion of the star.

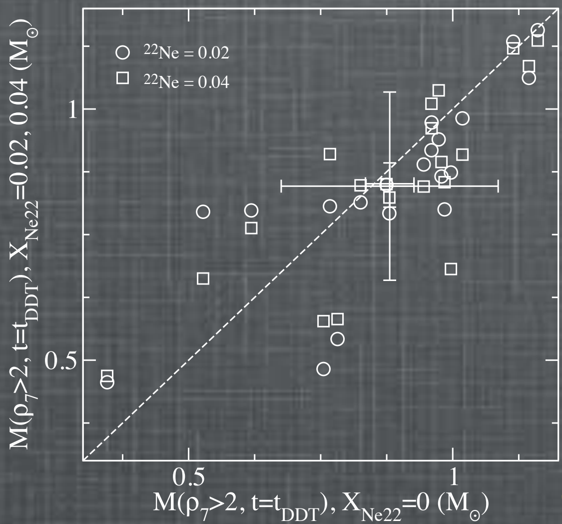
We use a suite of randomized initial conditions in 2d DDT models, whose ^{56}Ni masses and Si-group velocities have averages and ranges similar to those observed.

yellow CONe
red OSi
green Si-group
black Fe-group

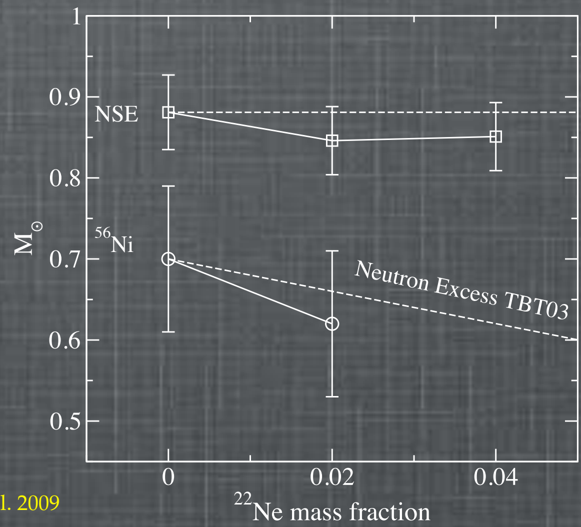


Townsley et al. 2009

From 20 ignition conditions, systematic changes from expansion prior to detonation are too small to alter the TBT03 effect.



Townsley et al. 2009



This points to ignition morphology as being the dominant driver of the ^{56}Ni yield of the explosion for a fixed DDT density.

Interlude

"To the extent that it's possible, it is the isotopes that keep the theorists honest."

David Arnett
2009 Hans A. Bethe Prize

We've started an NSF funded effort to examine double-degenerate mergers with Lagrangian and Eulerian toolkits.

$$b = R\sqrt{1 + \left(\frac{v_{\rm esc}}{v}\right)^2} \qquad\qquad t_{\rm coll} = \frac{1}{\pi b^2\ v\ n}$$

Following Pfhal et al. (2009), for typical WD & globular parameters we find 1 WD-WD collision in globulars per year within 100 Mpc .

If there are blue stragglers, there are going to be grazing WD-WD collisions ...

... and Chomiuk et al. 2008 identify a SNIa remnant in a globular orbiting NGC 7457.

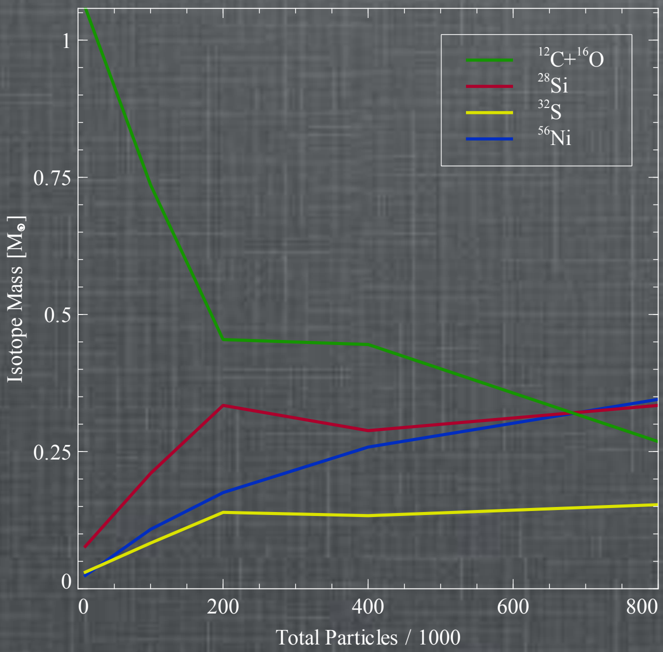
0.6 + 0.6 Msun, zero impact parameter, SNSPH

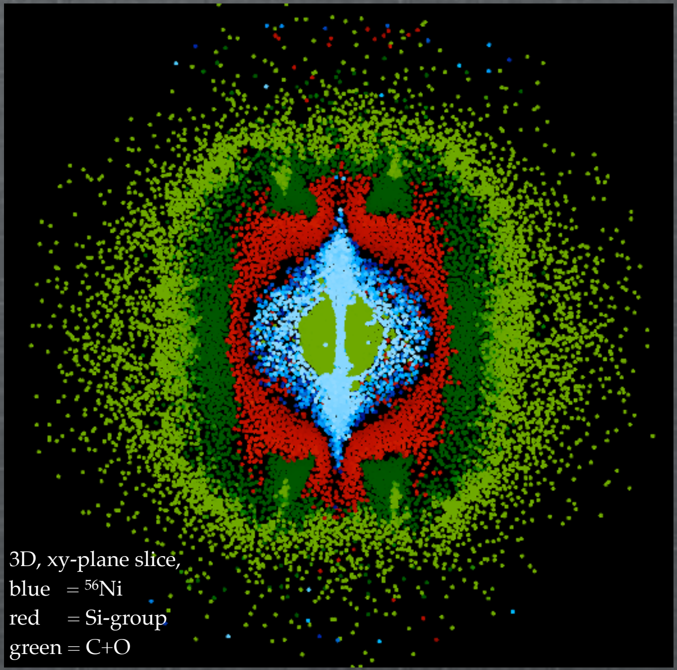
3D, all particle projection onto xy-plane, color shows speed in x-direction.

Raskin et al. 2009

Head-on collisions of 0.6 + 0.6 Msun WD produce dim SNIa with a somewhat unusual element distribution.

Raskin et al. 2009





0.6 + 0.6 Msun,
1 WD radii
impact parameter,
fails to yield an
initial explosion.

3D, xy-plane slice,
color shows
temperature

Raskin et al. 2009

Questions and Discussion