

Supernovae Ia

standard candles?

Sebastian Knop

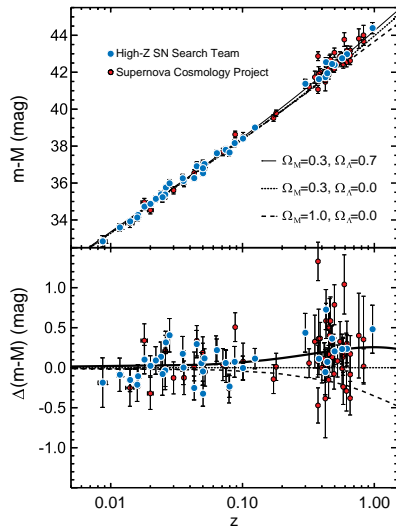
Hamburger Sternwarte

14. February 2008

Expansion of the universe

Standard candles

- calibratable absolute magnitude
- Observed apparent magnitude gives distance
- Redshift determined from SNe or better from host galaxy
- \Rightarrow distance - z relation is probed



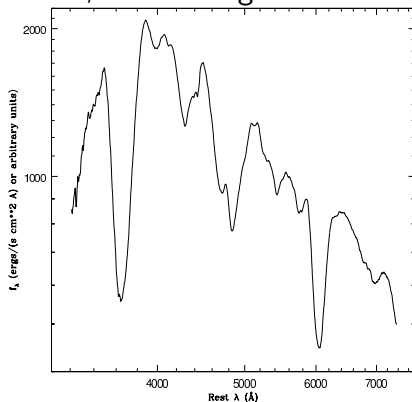
SN 1994D – type Ia

In NGC 4526:



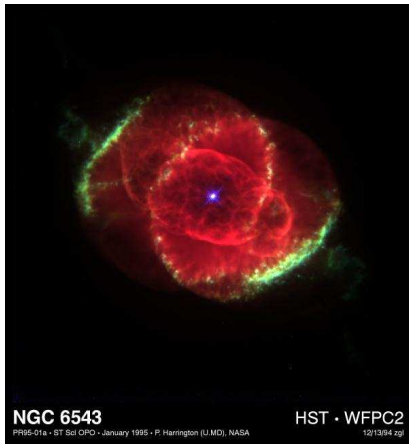
(Hubble gallery)

No H, but strong Si features



(SUSPEND database)

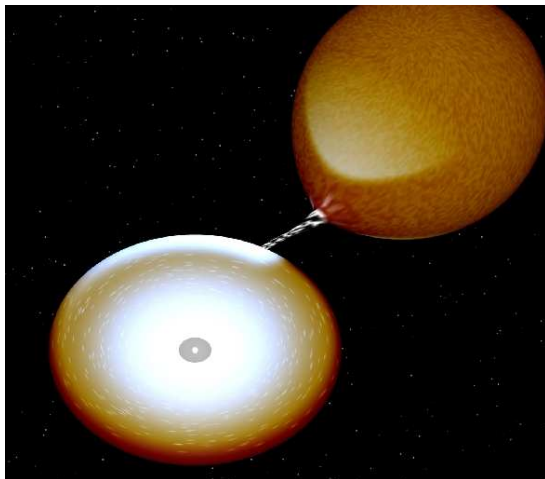
SN Ia originate from White Dwarfs



Cataclysmic Variables

Progenitors

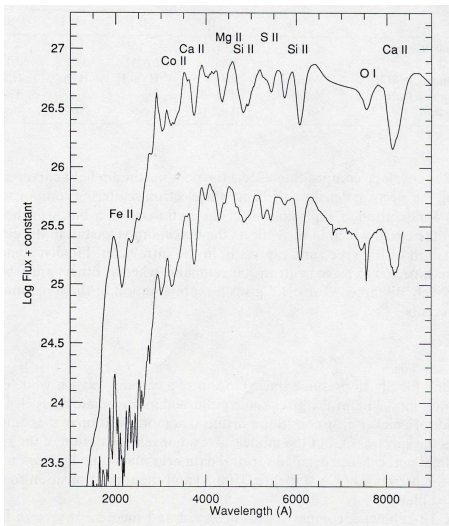
- They explode from white dwarfs
- Accretion in Cataclysmic variables is the trigger
- Super Soft Sources candidate for progenitor system



Cataclysmic Variables

Progenitors

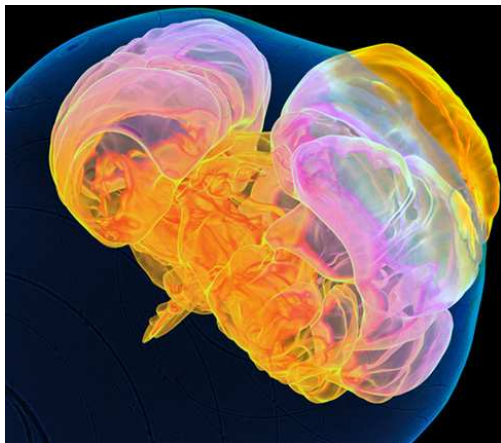
- They explode from white dwarfs
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SN Ia are thermonuclear nuclear explosions

Progenitors

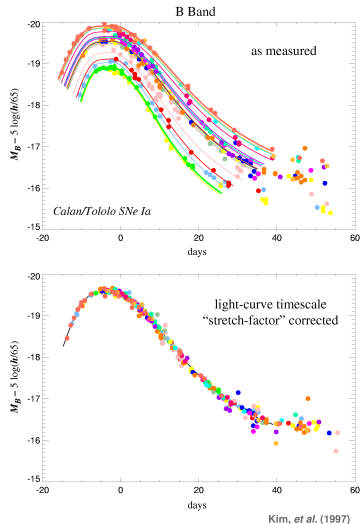
- Colossal H-bombs made out of C+O
- Trigger is the crossing of/nearing to the Chandrasekhar-mass $M_{\text{Cha.}}$
- $M_{\text{Cha.}}$ depends on chemical composition:
 $M_{\text{Cha.}}(\text{C}+\text{O}) = 1.4 M_{\odot}$
 \Rightarrow standard candle



(FLASH group Univ. of Chicago)
movie

SN Ia are powered by radioactive decay

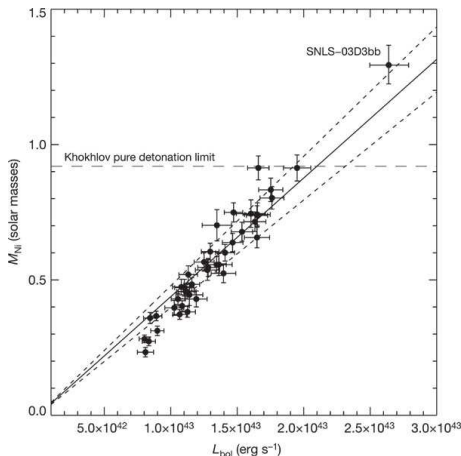
- lightcurve powered by radioactive decay
 $^{56}\text{Ni} \rightarrow ^{56}\text{Co} \rightarrow ^{56}\text{Fe}$
- variable absolute magnitude, hence no standard candle
- empirical stretch factor s renormalises the absolute magnitude



The champagne supernova

SN2003 fg

- redshift $z = 0.25$
- 0.87^{mag} larger absolute magnitude
- too bright for its „stretch”
- $M_{\text{Ni}} = 0.92 M_{\odot} \Rightarrow M \approx 2.1 M_{\odot}$
- More at higher redshift?

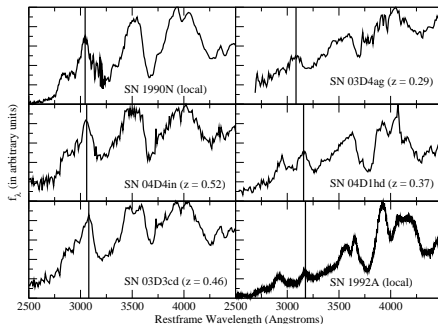


(Howell et. al 2006)

Further problems

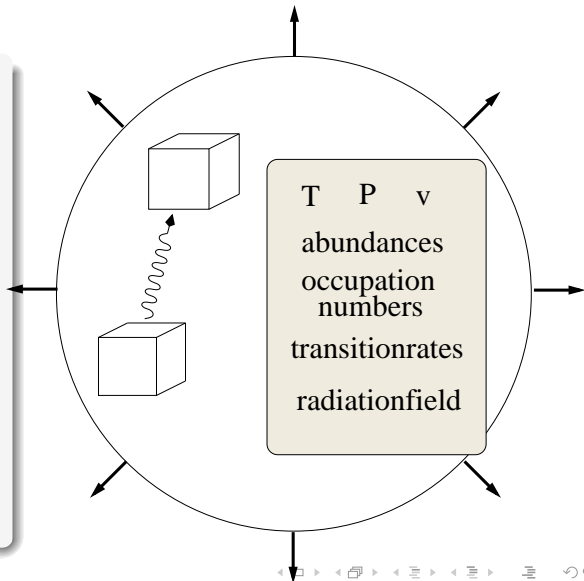
Inhomogeneous population?

- Spectral diversity
- Spectral evolution with z ?
- Asphericity due to secondary?
- Peculiar SNe



Spectrum synthesis

- Individual SNe must be analysed.
- Spectrum is the only source of information
- Difficult to synthesize (millions of blended spectral lines, $\nu \approx 0.1c$, scattering)
- Must do 4-D radiative transfer



Outlook for RT works

- Time dependent radiative transfer in spherical symmetry
 - calculate lightcurves
 - investigate spectral evolution with time
- Multidimensional radiative transfer
 - develop methods and code to do multidimensional RT
 - stationary 3D calculations of hydrodynamical atmospheres (FLASH)
 - must wait for faster/more hardware

Summary

- SN Ia explode from White Dwarfs, but the progenitors are still not known.
- Today's best model for explosion is a gravitational confined detonation.
- Intrinsic properties of SN Ia must be better understood in order to reliably use them as standard candles:
 - homogeneous population or several mechanisms?
 - asphericity and its effects on the spectra and lightcurves
 - spectral evolution with z ? (Especially in the UV)
- Radiative transfer modelling is the only method to extract information from the spectra.
- The radiation transport is computationally costly and suitable codes are still in development.