Lecture 25 — Supernovae and Stellar Death Part II
Type Ia Spectrum

SN 2001ay (t= 1d)
SYNOW Fit

Krisiunas et al. Figure 19
SNe Ia are Thermonuclear Explosions I

- Explosion powered by nuclear fusion
  
  $C + O \rightarrow \text{Iron Group} + \text{Intermediate Mass}$

- Fusion makes it explode, Radioactivity makes it Shine

  \[ R_i = 10^8 \text{cm}, \quad R_{\text{break out}} \sim 10^{14} \text{cm} \]

  \[ V_{bo}/V_i \sim 10^{18} \]
SNe Ia are Thermonuclear Explosions II

- Shock Energy goes to $p \, dV$ work
- Light Curve Powered by Radioactive decay

$$^{56}Ni \xrightarrow{\frac{\tau}{2}=6.077 \, d} ^{56}Co \xrightarrow{\frac{\tau}{2}=77.27 \, d} ^{56}Fe$$
Type Ia Light Curve

B Band

as measured

Calan/Tololo SNe Ia

Kim, et al. (1997)

light-curve timescale
“stretch-factor” corrected

Kim, et al. (1997)
The death of Massive stars

Massive stars are stars with:

\[ M > 8M_\odot \]
Massive Star Evolution

- Ejected gas rings
- Ejected gas hidden behind dust
- Gas expanding away at 1.5 million miles per hour
- Expelled gas
- Visual image
- Infrared image
- Color enhanced
- AFGL2591
- The Pistol Star
- H fusion shell
- He fusion shell
- C fusion shell
- Ne fusion shell
- O fusion shell
- Ni fusion shell
- Iron core

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Energy in Thermonuclear SNe I

- Total energy released:
  - Fusion Energy Released in Explosion of Chandrasekhar Mass White Dwarf
    \[ = 10^{51} \text{ ergs} \]

\[ 1 \text{ Mton} = 10^{22} \text{ ergs} \]

\[ \text{SN} = 10^{29} \text{ Mton} \]

- Kinetic energy
  \[ = 10^{51} \text{ ergs} = 10^{29} \text{ Mton} \]
Energy in Thermonuclear SNe II

Light energy $= 10^{50}$ ergs $= 10^{28}$ Mton
Total energy released:

Gravitational Energy Released in Core Collapse

\[ = 10^{53} \text{ ergs} \]

1 Mton = \(10^{22}\) ergs

SN = \(10^{31}\) Mton
Energy in Core-Collapse SN II

Kinetic energy = $10^{51}$ ergs = $10^{29}$ Mton

Light energy = $10^{50}$ ergs = $10^{28}$ Mton
SN Types

- Distinction between Type I and Type II SNe
- Close Binary evolution
- Novae
- SNe Ia
Figure 2. The detailed classification of SNe requires not only the identification of specific features in the early spectra, but also the analysis of the line profiles, luminosity and spectral evolutions.
SNe Classification

Figure 1. Basic SN types spectra. A SN which near maximum (left panel) shows clear signature of Hα is defined as type II, if it shows a strong SiII absorption at about 6150 Å is a type Ia, otherwise it is of type Ib/c (in the figure we show a SNII characterized by strong He lines). Ten months later (right panel) SN Ia show strong emissions of [FeII] and [FeIII], SN Ib/c are dominated by [CaII] and [OI]. These same lines and strong Hα emission are typical of SNII.
SN Spectral Classification