

ASTR 5590 - Supernovae

★ Cartoon Slide

Baade + Zwicky suggested new class of novae, or that it was 2 distinct ones

Zwicky began systematic search w/
3.25" camera on Caltech roof, then
18" → 48" Schmidt telescopes @ Palomar
↳ 20 SNe per year

→ few week outburst (rise, peak)
exponential decline, half-life ~60d

★ what does decline suggest?

Classified into 2 Types, w/ various subtypes

Types slide

- I** broad emission bands (Fe⁺ + Fe⁺⁺ lines) hundreds/blends
 - no H lines
 - spectral + L evolution identical
 - found in all types of galaxies (Ia)
- II** Balmer series of H lines soon after max
 - wider range of properties

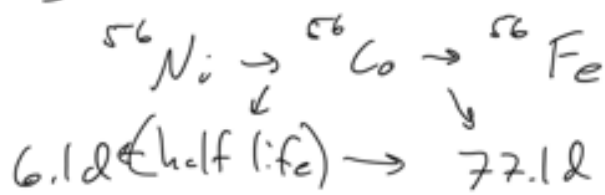
- spirals, usually arms

SN rate per $L(B) = 10^{10} L_0(B)$ [MW size]

Ia $\rightarrow 0.2$ / century (but these brighter)

II $\rightarrow 0.6$ / century

Ia C-O core (from remnant of low mass star: WD) burns explosively, everything burns to natural endpoint



per decay: 1.72 MeV 3.5 MeV

@ max, ${}^{56}\text{Ni}$ decay E deposited into expanding envelope, heated so glass
exp. decay of light curve from ${}^{56}\text{Co}$

${}^{56}\text{Ni} \rightarrow 0.1 - 1 M_{\odot}$ produced, ends up as Fe

\rightarrow most important source is ISM

Explosion not well understood, odd so uniform

Acc. from MS or giant companion?

Double degenerate (WD-WD) merger?

No object left

C-O burning sensitive: $\dot{S} \propto T^{12}$
n r i . \rightarrow sens. to instabilities
perfect burning?

- subsonic detonation
- supersonic shock compression (detonation?)
↳ get Fe, no good

LCs all very similar, empirically scalable
↳ can use as distance indicators
for cosmology

Tycho → light echoes star spectrum of Ia
1572, observed by Tycho Brahe
in Cassiopeia

★ Show slides + video

II likely source of γ -ray bursts

After He burning, core hot enough
to produce e^-, e^+ pairs

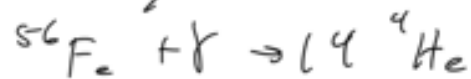
↳ annihilations produce $\nu_e, \bar{\nu}_e$ pairs
that escape easily, so P support
lost faster w/ each new element

★ 15 M_{\odot} star burning stages

Produce Fe core $\sim 1.5 M_{\odot}$:

- $p + e^- \rightarrow n + \nu_e$ (inverse β decay)

- thermal γ -rays disintegrate Fe



10% of rest mass is converted to ν

$$\sim 3 \times 10^{53} \text{ erg}$$

w/ $\sim 10^{51}$ erg going into ejecta

Classic bounce of outer stellar layers on

newly formed NS likely not right

\rightarrow shock forms before hitting that stalls,
produced by rad., e^- , e^+ bubble

Explosion may create heavier elements

r -process (rapid)

\rightarrow need to make things before they can
 β decay

- in ~ 10 s, produce elements thru

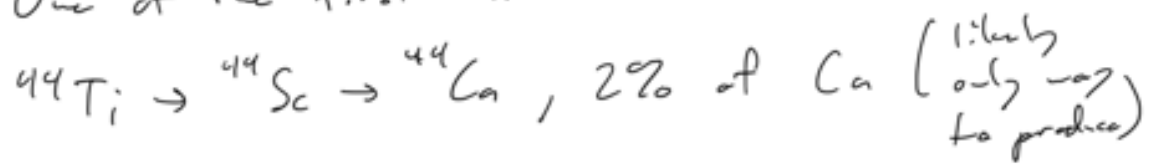
$\text{Fe} + n \rightarrow \uparrow \text{element} + n \rightarrow \dots$

Cas A light echoes consistent w/ II b

- seemingly unobserved historically, although
may have been recorded by Flamsteed
on Aug 16th, 1680 (~ 300 yr ago)

\hookrightarrow if ejected outer shells before explosion,
much of emission could have been
absorbed

One of the first discrete radio sources



- Ti & Fe clumpy, not coincident
evidence for turb. ^{or asymmetry} explosion, bipolar?
