

SUPERNOVAE

These occur when a massive star explodes (or when two white dwarf stars merge)

For a short time, their brightness rivals that of their host galaxy

If we can use these as distance indicators, we can see out a significant fraction of the visible universe

SUPERNOVAE (type II)

Final stage of evolution of massive stars

* note mass loss can be large before this *

Burning of successively higher Z nuclei

Onion - like structure

Core contracts after each fuel exhausted,

heats up, next fuel ignites

until Fe is reached

Fusion reactions after Fe peak need energy *

& do not release it

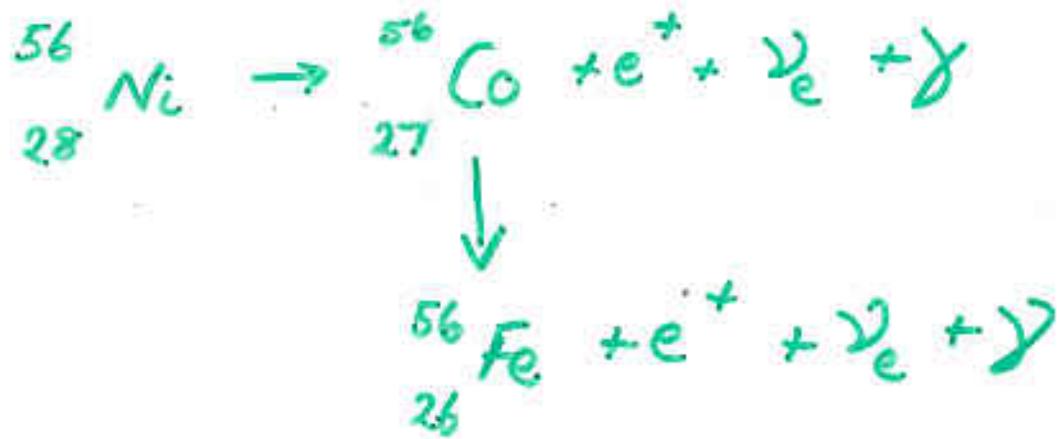
Fe core collapses

~~Chottenden~~

Supernovae (type II)

What causes the enormous light output?

Radioactive decay of ^{56}Ni formed in explosion



Q

What is a test you could make | ^{on the sky &} in the lab of this statement?

13.3 The Fate of Massive Stars

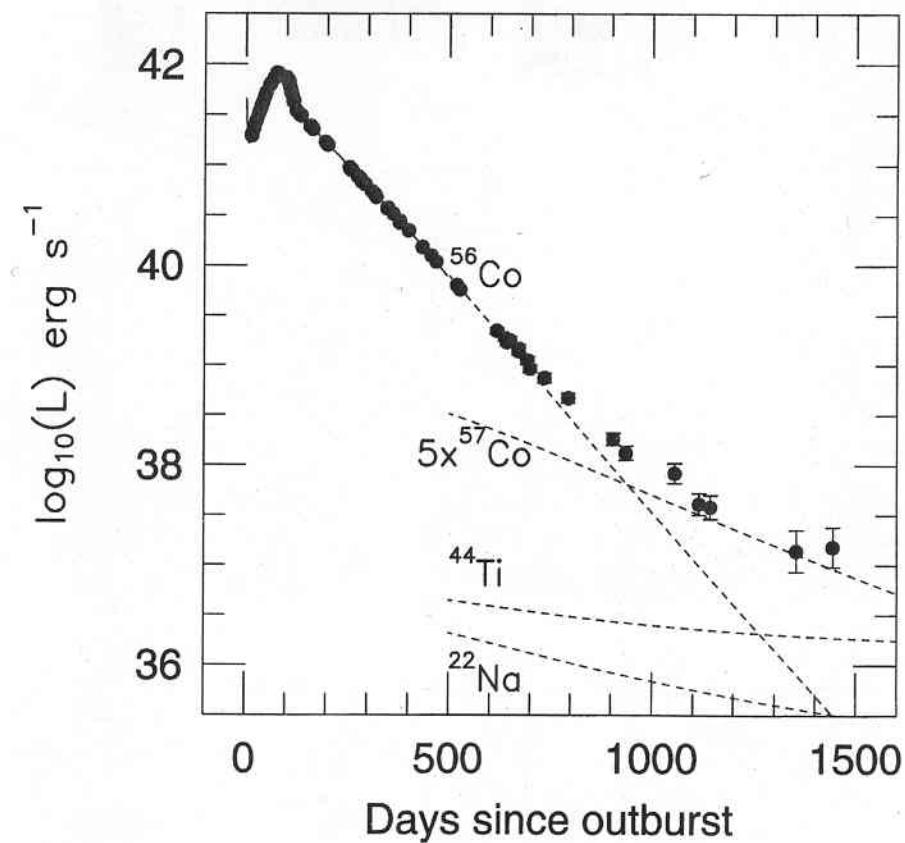


Figure 13.20 The bolometric light curve of SN 1987A through the first 1444 days after the explosion. The dashed lines show the contributions expected from the radioactive isotopes produced by the shock wave. The initial masses are estimated to be $^{56}_{28}\text{Ni}$ (and later $^{56}_{27}\text{Co}$), $0.075 M_{\odot}$; $^{57}_{27}\text{Co}$, $0.009 M_{\odot}$ (five times the solar abundance); $^{44}_{22}\text{Ti}$, $1 \times 10^{-4} M_{\odot}$; and $^{22}_{11}\text{Na}$, $2 \times 10^{-6} M_{\odot}$. (Figure from Suntzeff et al., *Ap. J. Lett.*, 384, L33, 1992.)

Take some ^{56}Ni and some ^{56}Co
and watch it decay : measure
its half life $t_{1/2}$

if no of nuclei of isotope reduce as

$$N(t) = N_0 e^{-\lambda t}$$

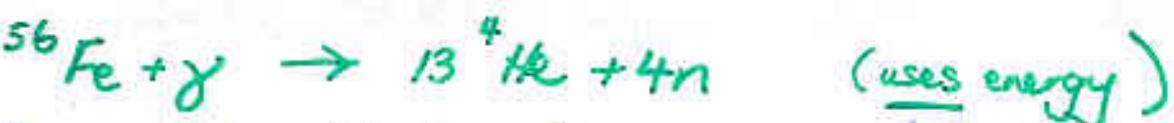
$t_{1/2}$ = amount of time for N_0 to
reduce by 2

$$= \frac{\ln 2}{\lambda}$$

half life of $^{56}\text{Ni} = 6$ days

$^{56}\text{Co} = 77.7$ days

SN 1987a light curve agrees



- Fe nuclei disintegrate to α particles & neutrons
(takes energy, further collapses)
- High densities allow reverse β decay
 - $e^- + p \rightarrow n + \nu$
(support from degenerate e^- removed)
(ν 's carry away lots of energy)
- Core implodes (what good is electron degeneracy without electrons?)
- Pressure is eventually so great that core 'bounces'
- Outer layers of star are pushed outward & lost to ISM (interstellar medium)
- Enormous energy output, can rival total luminosity of galaxy
 - mostly in neutrinos

Nucleosynthesis in supernovae

The disintegration of Fe nuclei during core collapse produces many neutrons

Many more are produced in reverse β decay

This large flux of neutrons is exactly what is needed to form elements heavier than Fe

(why?)