February 3, 2010

First Exam Friday

Reading assignment, Chapter 6 Sections 6.1 - 6.3, plus Section 1.2.4, Sections 2.1 - 2.5, Section 5.1, Betelgeuse pg 115ff.

Review Sheet posted,

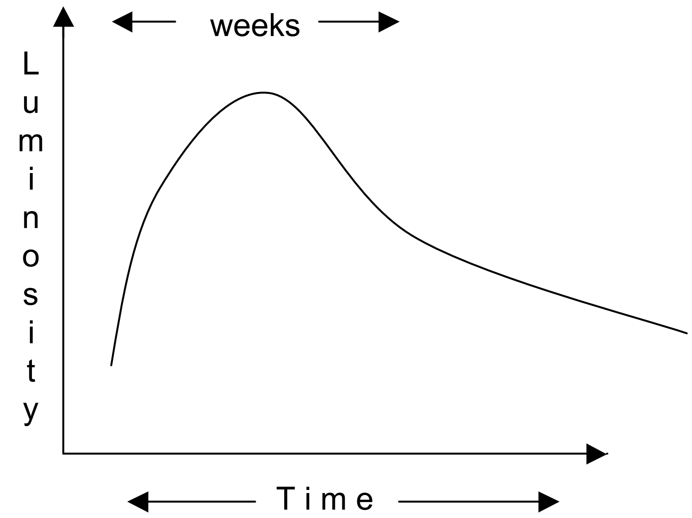
Review Session Tomorrow, Thursday 5 PM, RLM 15.216B.

Astronomy in the News? Previous plan to return humans to the Moon is cancelled. NASA to focus on new technologies to get into space.

Karl Gebhardt Great Lecture on Black Holes, Dark Matter, Dark Energy, Saturday, 1:00 PM, Room 2.302 ACES Building.

Pic of the Day - debris of asteroid collision.

Type Ia - no hydrogen, intermediate mass elements early, iron later

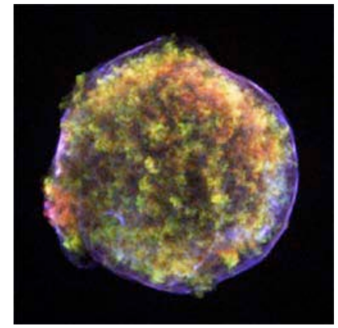


Light Curve - brightness vs. time consistent with an
exploding C/O white dwarf
expect total disruption, ***no neutron star***

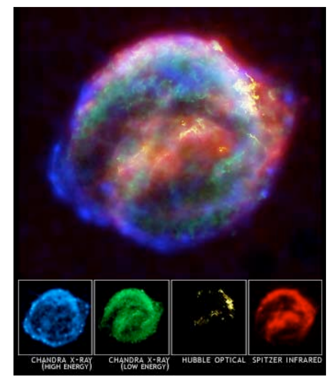
Type Ia occur in elliptical galaxies, tend to avoid spiral arms in spiral galaxies - old when explode, all evidence points to an exploding white dwarf.

SN 1006, almost definitely Type Ia

Tycho, SN 1572 definitely Type Ia - recent discovery, spectrum from peak light reflected from surrounding dust, arriving only “now.”



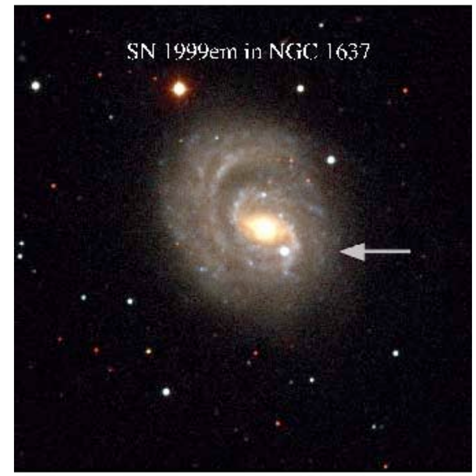
Kepler, 1604, probably Type Ia (no sign of neutron star, same ejected composition as SN 1006, Tycho), but some ambiguities.



If recurrent nova U Sco with a white dwarf of more than 1.3 solar masses becomes a supernova, it will probably be a Type Ia

Type II Supernovae - "other" type discovered early in the study of supernovae, show Hydrogen in the spectrum early, Oxygen, Magnesium, Calcium, later

Most occur in spiral galaxies, *in the spiral arms*, ***they have no time to drift from the birth site***
sometimes in irregular galaxies
never in elliptical galaxies



SN 1999em

Stars with more mass have more fuel, but they burn it at a prodigous rate, live a shorter time!

→The progenitor stars are young, short-lived massive stars

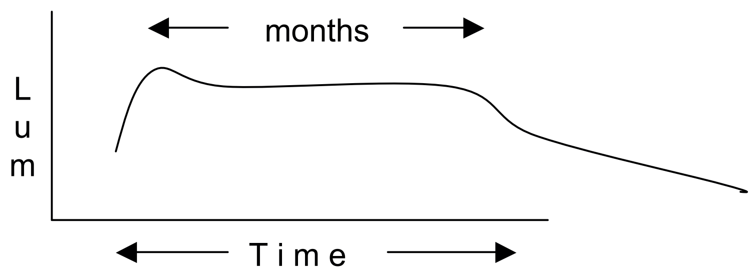
We expect such stars to evolve to form iron cores and collapse to a neutron star or black hole (physics to come)

Light curves of Type II supernovae are consistent with explosion in a Red Giant

Betelgeuse is a massive red giant, 15 solar masses: we expect it to become a Type II supernova. ***Maybe tonight!*** Rigel probably burning He to C/O, explode later.

SN 386, 1181 records are sparse, might have been Type II
Crab was a “peculiar” Type II (high helium abundance, slow explosion)
Cas A was probably something else (next topic),
SN1987A was a “peculiar” Type II.

Not obvious that any of the historical supernovae were a “normal” Type II, although Type II are common in other galaxies



Discussion Point:

We have talked about certain elements showing up in supernova:

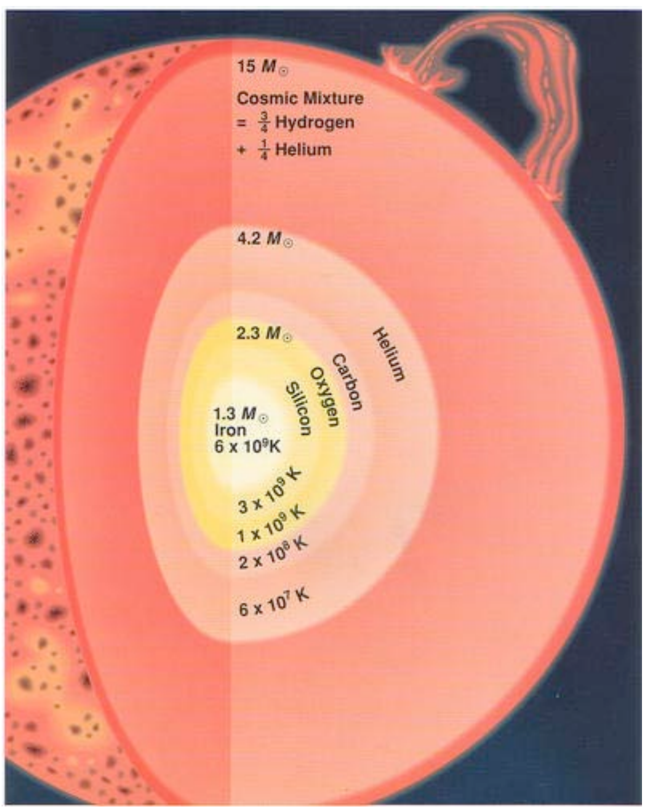
Oxygen, Magnesium, Silicon, Sulfur, Calcium, Iron.

Why those elements?

Physics: in massive stars (more than about 12 - 15 times the Sun) the core is composed of Helium or heavier elements, Carbon, Oxygen, Magnesium, Silicon, Calcium, finally Iron. The core continues to be hot even as it gets dense,

⇒ always supported by thermal pressure

⇒ continues to evolve, whether the Hydrogen envelope is there or not.



H -> He (2 protons, 2 neutrons - Chapter 1, figure 1.6)

2 Helium -> unstable, no such element

3 Helium -> Carbon (6 protons, 6 neutrons)

4 Helium -> Oxygen (8 protons, 8 neutrons)

6 Helium -> Magnesium (12 protons, 12 neutrons)

7 Helium -> Silicon (14 protons, 14 neutrons)

Common elements forged in stars, and in their explosions, are built on building blocks of helium nuclei

Type Ia

no Hydrogen or Helium

intermediate mass elements (oxygen, magnesium, silicon, sulfur, calcium) early on, iron later

avoid spiral arms, occur in elliptical galaxies

peaked light curve

all consistent with thermonuclear explosion in white dwarf that has waited for a long time to explode, total disruption

Type II

Hydrogen early on, Oxygen, Magnesium, Calcium later

explode in spiral arms, never in elliptical galaxies

“plateau” light curve

consistent with massive, short-lived star that has an explosion deep within a Hydrogen Red Giant envelope by core collapse to leave behind a neutron star (or maybe a black hole).

One minute exam

Why do the elements carbon, oxygen, magnesium, and silicon frequently appear in the matter ejected from supernovae?

➡ They are built up from the element iron

⬅ They are built up from the element hydrogen

⬆ They are built up from the element helium

⬇ They are built up from the element calcium

One minute exam

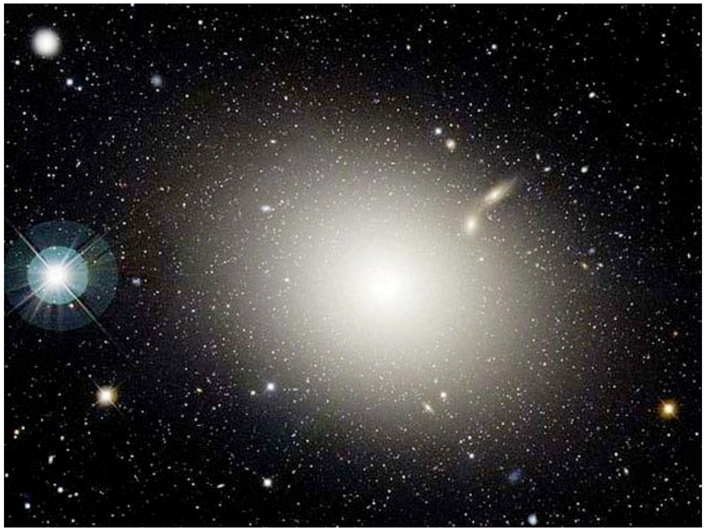
A supernova explodes in an elliptical galaxy. Near peak light what element do you expect to see in the spectrum?

➡ Hydrogen

⬅ Helium

⬆ Silicon

⬇ Iron



New Types, blurring the old categories, identified in the 1980's, defined by elements observed in the ***spectrum***.

Type Ib: no Hydrogen, but Helium early, near maximum brightness; Oxygen, Magnesium, Calcium later on

Type Ic: no Hydrogen no (or *very* little) Helium early, near maximum brightness;
Oxygen, Magnesium, Calcium later on

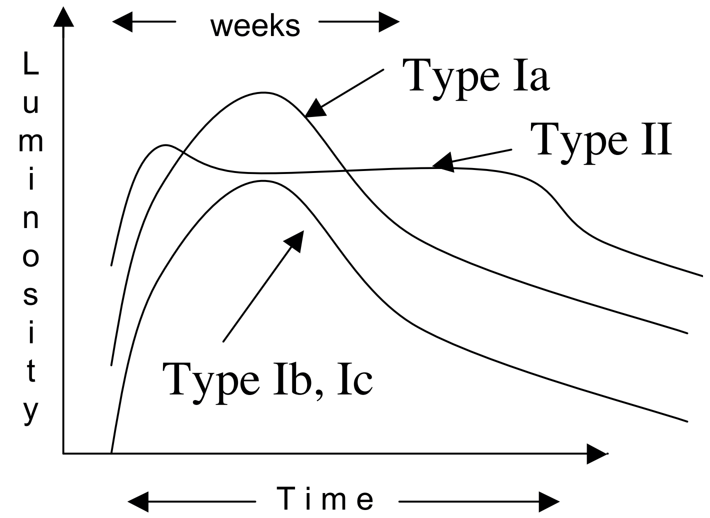
Explode in the spiral arms of spiral galaxies
Never in elliptical galaxies

⇒ massive stars, expect neutron star or black hole

Like Type II, but have somehow lost their outer layers of Hydrogen or even Helium ⇒ wind (§2.2) or binary mass transfer (Chapter 3).

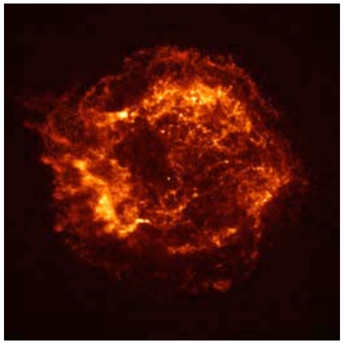
Type Ib, Type Ic Light Curve

Similar to a Type Ia, usually, but not always, dimmer, consistent with a star that has lost its outer, Hydrogen envelope (or even Helium for a Type Ic) [will explain why dimmer later]



Crab might have had a light curve like this, but probably too much Hydrogen to qualify as a Type Ib

Cas A seems to have been dim at explosion, some evidence for a little Hydrogen in the remnant now. Recent spectrum of light from peak reflected from dust, arriving "now" shows it was closely related to a Type Ib.



One Minute Exam

A supernova that explodes within the spiral arm of a spiral galaxy and shows no evidence for hydrogen or helium in its spectrum is probably a

→ Type II supernova

← Type Ia supernova

↑ Type Ib supernova

↓ Type Ic supernova

Type Ia:

No Hydrogen or helium, intermediate mass elements (oxygen, magnesium, silicon, sulfur, calcium) early on, Iron later.

Not in spiral arms, do occur in elliptical galaxies -> old when blow

Peaked light curve

All consistent with explosion in Chandrasekhar mass carbon/oxygen white dwarf in binary system, total disruption

Original mass on the main sequence M < 8 solar masses

Type II: Hydrogen early, Oxygen, Magnesium, Calcium, later.

Type Ib: no Hydrogen, but Helium early, Oxygen, Magnesium, Calcium later. ***H envelope lost, by stellar wind or binary star transfer.***

Type Ic: no Hydrogen no (or *very* little) Helium early, Oxygen, Magnesium, Calcium later. ***Even more mass loss, by stellar wind or binary star transfer.***

In spiral arms, never in elliptical galaxies -> short lived -> massive star -> expect core collapse, neutron star or black hole.

Original mass on the main sequence M > 8 solar masses

End of Material for Test 1