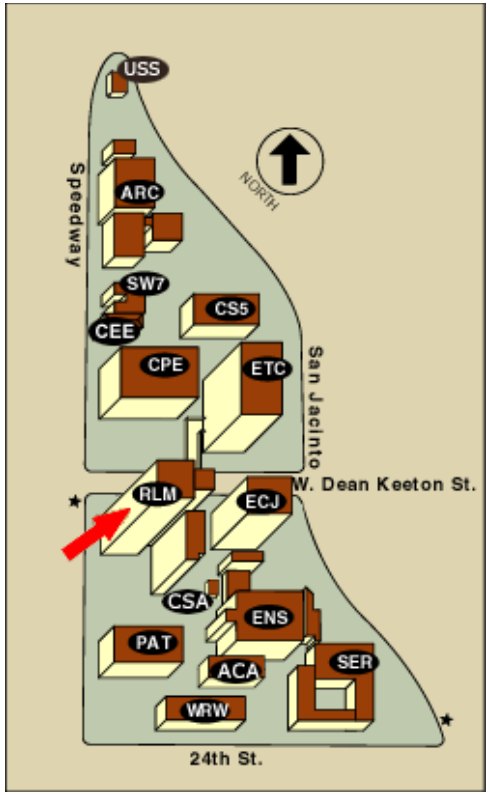
Monday, February 3, 2014

First Exam, Skywatch, Friday February 7.

Review sheet posted today.

Review session Thursday, 5 – 6 PM, RLM 7.104

Reading: Section 5.1 (white dwarfs), 1.2.4 (quantum theory), Section 2.3 (quantum deregulation), Section 6.1 (supernovae; *not* Type Ib, Type Ic, next exam).



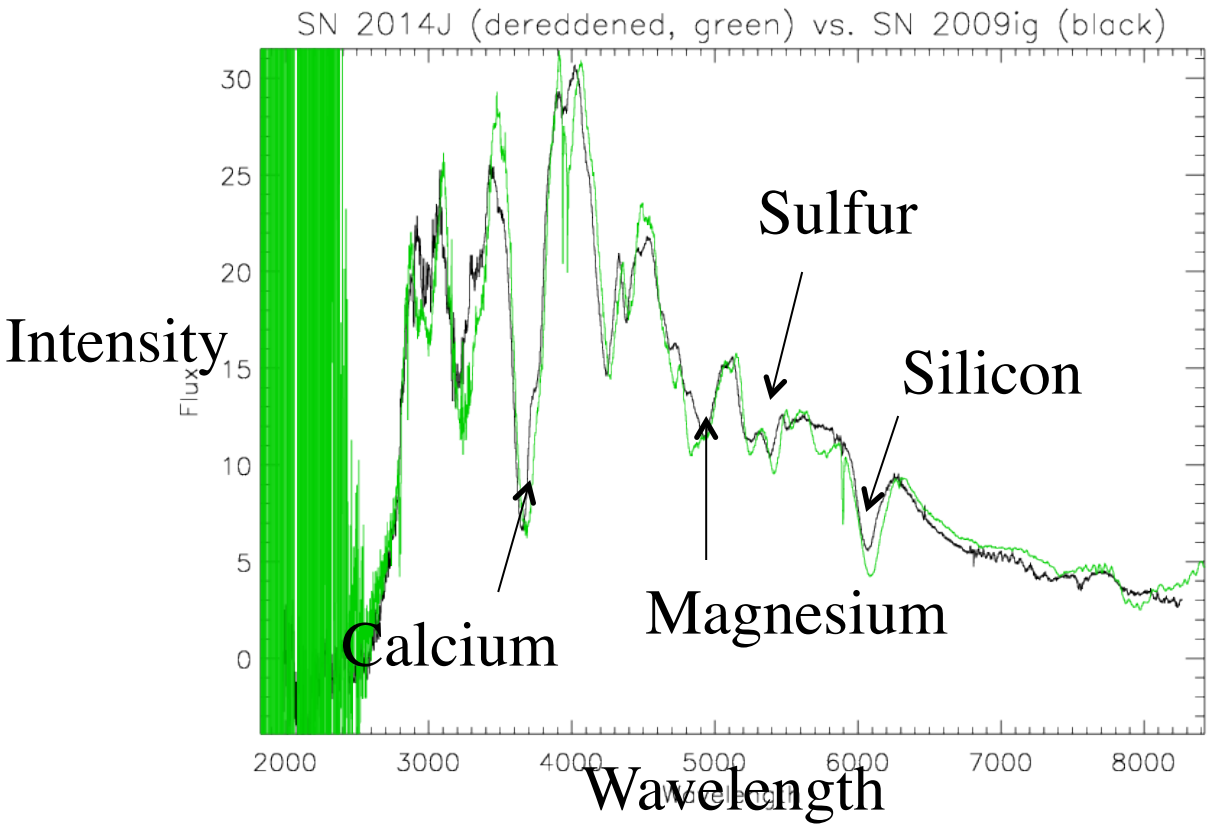
Astronomy in the news?

Update on new “nearby” supernova SN 2014J in M82

Our second attempt to measure the shape of the explosion with a telescope at Calar Alto, Spain, was messed up by weather.

We are attempting to schedule time on MONET, a newly-robotocized telescope at McDonald Observatory, operated by collaborators in Germany.

First spectrum from Hubble Space Telescope



Goal:

To understand the observed nature of supernovae and determine whether they came from white dwarfs or massive stars that undergo core collapse.

Categories of Supernovae

1st category discovered

Type Ia – near peak light, no detectable Hydrogen or Helium in the spectrum, rather "intermediate mass elements" such as oxygen, magnesium, silicon, sulfur, calcium. Iron appears later as the light fades.

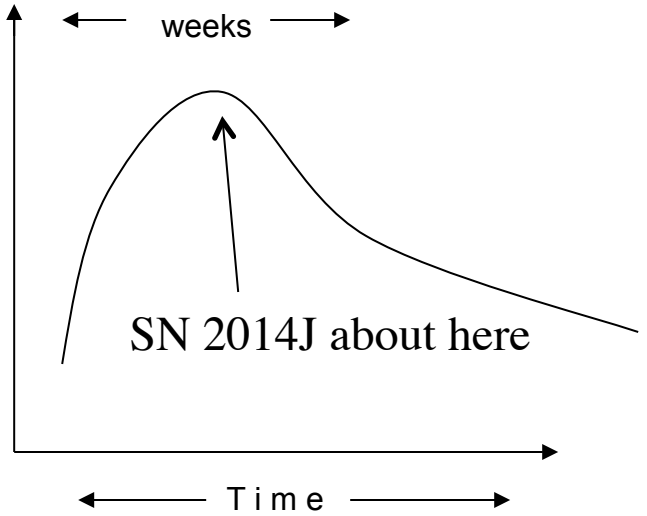
Type Ia occur in all galaxy types:
In **spiral galaxies** they tend to avoid the spiral arms, they have had time to drift away from the birth site → ***the star that explodes is old***

In **elliptical galaxies** where star formation is thought to have ceased long ago → ***the star that explodes is old, billions of years***

⇨***the progenitor that explodes must be long-lived, not very massive, suggesting a white dwarf.*** Sun is long-lived, but won't explode

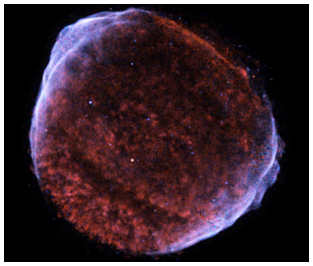
Type Ia - no hydrogen or helium, intermediate mass elements early, iron later

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



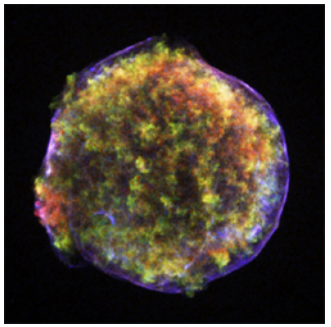
Type Ia occur in elliptical galaxies, tend to avoid spiral arms in spiral galaxies - old when explode, all evidence points to an exploding white dwarf.

SN 1006, almost definitely Type Ia

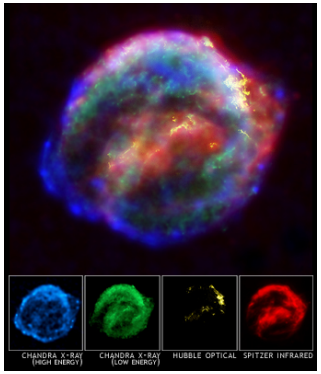


Tycho, SN 1572 definitely Type Ia

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.



Type Ia
no Hydrogen or Helium
intermediate mass elements (oxygen, magnesium, silicon, sulfur, calcium) early on, near maximum, iron later
avoid spiral arms, occur in elliptical galaxies
peaked light curve
no neutron star

all consistent with thermonuclear explosion in white dwarf that has waited for a long time (hundreds of millons to billions of years) to explode, total disruption

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

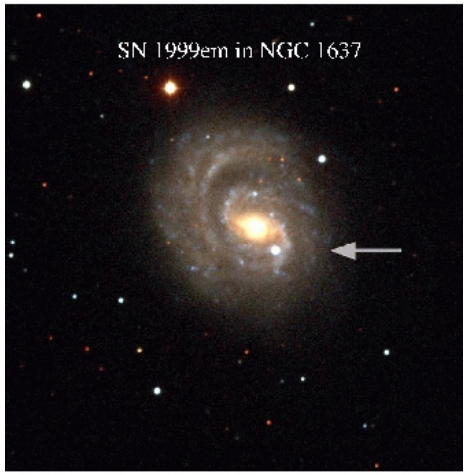
Most occur in spiral galaxies, *in the spiral arms*, ***they have no time to drift from the birth site***

never in elliptical galaxies (no young stars)

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 (millions to tens of millions of years) massive stars

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



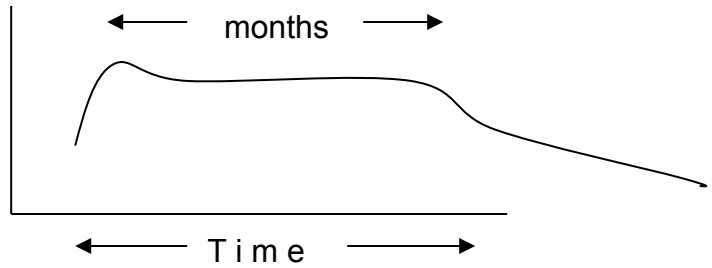
SN 1999em

“Plateau” light curves of Type II 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.

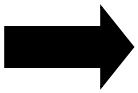
SN 386, 1181 records are sparse, might have been Type II
Crab was a “peculiar” Type II (high helium abundance, slow explosion)
Cas A was probably something else with a very thin layer of Hydrogen (next topic),
SN1987A was a “peculiar” Type II.

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



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 hydrogen

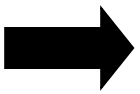
 They are built up from the element helium

 They are built up from the element calcium

 They are built up from the element iron

One minute exam

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

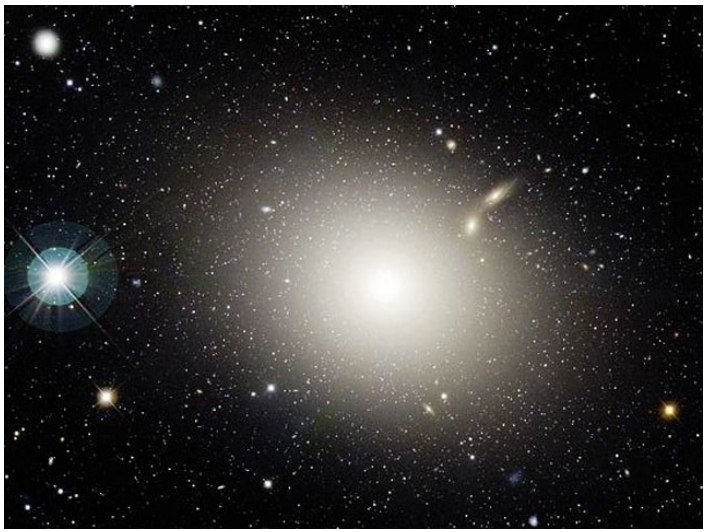


Hydrogen

Helium

Silicon

Iron



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-rich Red Giant envelope by core collapse to leave behind a neutron star (or maybe a black hole).

End of Material for Test 1

Another type of supernova

Ask me about its properties, vote about type of explosion.
Analogous to astronomers querying nature with their telescopes

➡ Massive star, core collapse, neutron star

⬅ Exploding white dwarf

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

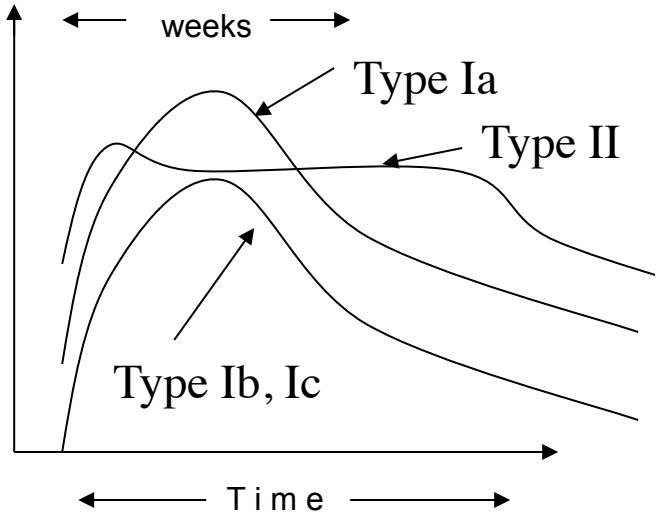
Explode in the spiral arms of spiral galaxies
Never in elliptical galaxies

$\Rightarrow$ massive stars, expect neutron star or black hole

Like Type II, but have somehow lost their outer layers of Hydrogen or even Helium $\Rightarrow$ 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.