Wednesday, September 11, 2103

First exam Friday, first Skywatch due

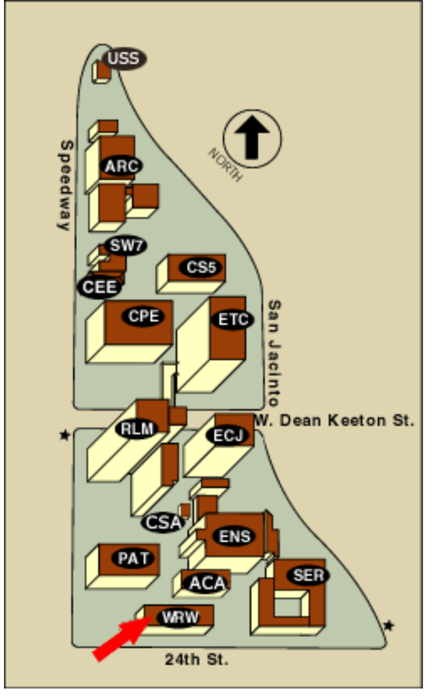
Review sheet posted.

Review session Tomorrow, 5 – 6 PM, WRW 102

Reading posted under “announcements” on web page, Chapter 6 - Sections 6.1, 6.2, 6.3 (also sections 1.2.4, 2.1-2.5, and 5.1)

Exam will draw on material presented in lecture. Use reading for back up, reinforcement.

Astronomy in the news?



Goal:

To understand what we have learned from the study of “live” supernova explosions in other galaxies.

Extra Galactic Supernovae: the basis for modern astronomy of supernovae.

Supernovae explode about once per second somewhere in the Universe, most unseen.

Cannot predict which galaxies will produce a supernova, so watch lots of galaxies.

We found two dozen per year prior to SN 1987A, but with new attention and use in cosmology, now find several hundred per year, about one per day, most at great distances, more difficult to study.

Nomenclature of Supernovae in other galaxies:
A-Z, aa-az, ba-bz, etc.

SN 1987A - 1st of 1987 (also most important, but that is not what the "A" means).

Currently discover roughly one per day. This year's latest officially named, SN 2013fg, discovered September 8 – How many so far in 2013?

New techniques will discover thousands of supernovae per year, new nomenclature, position: SUPERNOVA 2013fg = PSN (possible supernova) J08212244 -1318370

Before announced, search groups use internal names. We are currently using Nepali spirits.

Discussion Point:

How would you tell that an explosion was from a massive star or from a white dwarf star?

Goal:

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

Goal:

Certain elements show up in supernova:

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

Why those elements?

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

2 Helium -> unstable, no such element

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

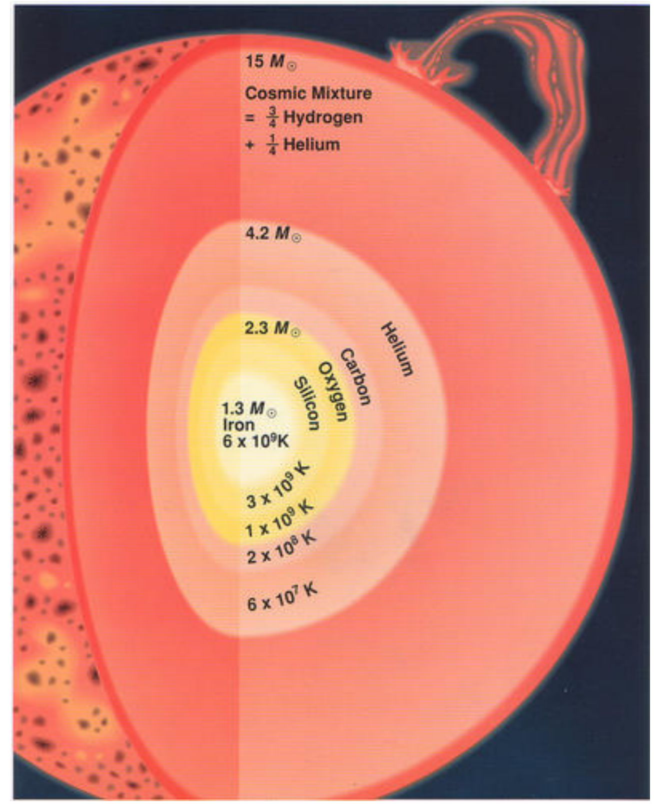
4 Helium -> Oxygen (8 protons, 8 neutrons)

5 Helium -> Neon (10 protons, 10 neutrons)

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

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

Then Sulfur, Calcium, Titanium.



Common “intermediate mass” elements forged in stars, and in their explosions, are built on building blocks of helium nuclei.

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,
$\Rightarrow$ always supported by thermal pressure
$\Rightarrow$ continues to evolve, finally explodes
The intermediate-mass elements are produced in the star before the explosion and then expelled into space.

In exploding white dwarfs (arising in stars with mass less than about 8 times the Sun), the core is composed of Carbon and Oxygen, and **the explosion creates the intermediate-mass elements, Magnesium, Silicon, Calcium, and also Iron.**

(between about 8 and about 12 solar masses, different story, maybe collapsing white dwarfs)

Stellar Physics:

There are many more low mass stars born than high mass stars.

High mass stars have more fuel to burn, but they burn much hotter and brighter. As a result they live a SHORTER time.

A short-lived star must be massive.

A long-lived star must be of relatively low mass.

Galaxy Physics:

Star are born in the spiral arms of spiral galaxies.

Elliptical galaxies have not formed any new stars in billions of years.

Categories of Supernovae

1st category discovered

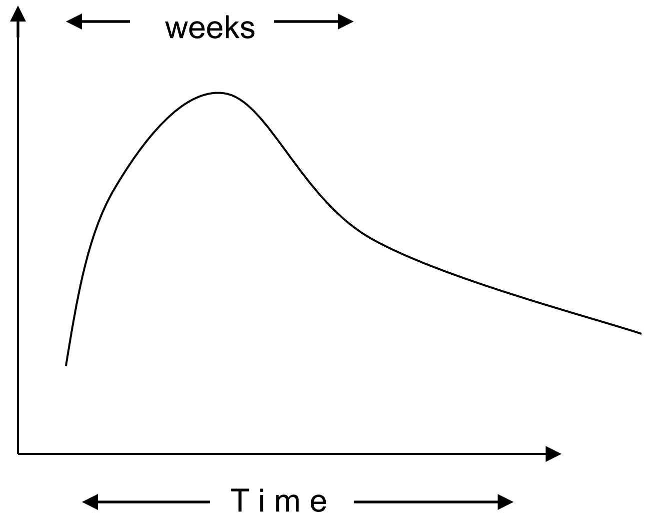
Type Ia - no detectable Hydrogen in the spectrum, rather "intermediate mass elements" such as oxygen, magnesium, silicon, sulfur, calcium. Iron appears later as the light fades.

These 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 **irregular galaxies**
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, intermediate mass elements early, iron later

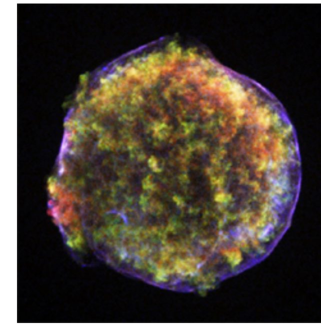
Light Curve - brightness vs. time consistent with an exploding C/O white dwarf
expect total disruption, ***no neutron star***



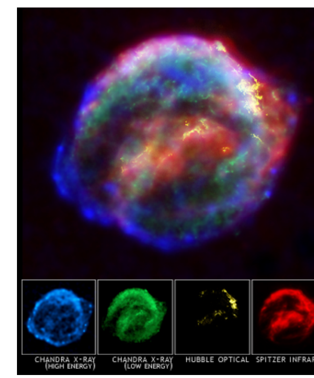
Type Ia occur in elliptical galaxies, tend to avoid spiral arms in spiral galaxies - old when explode, all evidence points to an exploding white dwarf.

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, 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

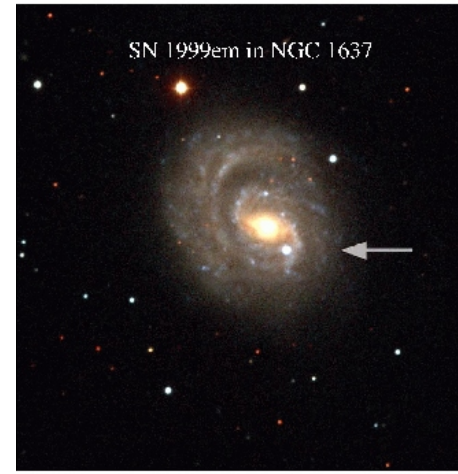
Type II Supernovae - "other" type discovered early in the study of supernovae, show Hydrogen in the spectrum early, Oxygen, Magnesium, Calcium, later

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



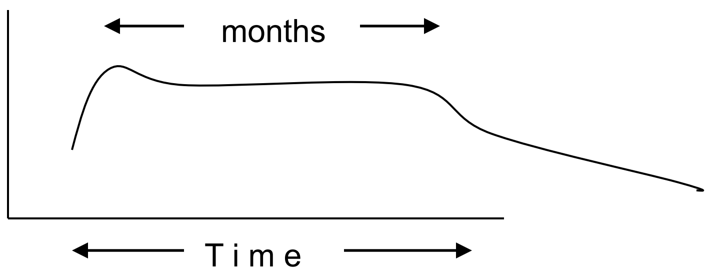
SN 1999em

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 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 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

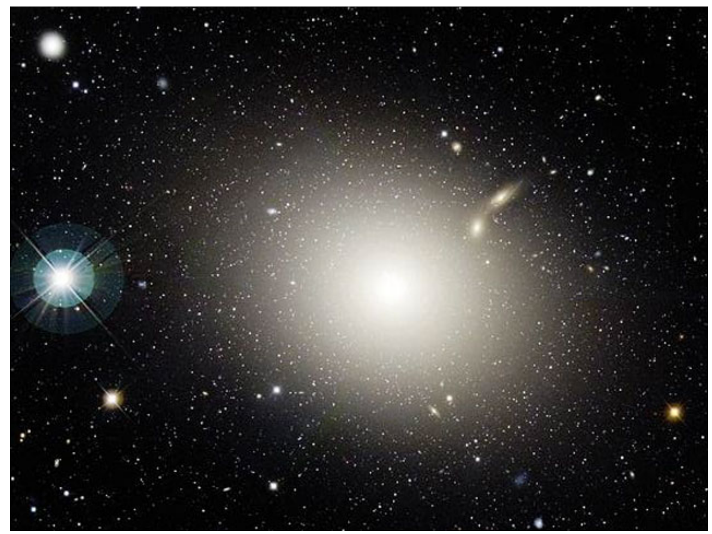
A supernova explodes in an elliptical galaxy. Near peak light what element do you expect to see in the spectrum?

➡ Hydrogen

⬅ Helium

⬆ Silicon

⬇ Iron



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