Monday, January 30, 2017

First exam Friday. First Sky Watch Due.

Review sheet posted Today.

Review session Thursday, 5:00 – 6:00 PM **WEL 2.308**

Reading:

Chapter 6 Supernovae, Sections § 6.1, 6.2, 6.3
Chapter 1 Introduction, §1.1, 1.2.1, 1.3.1, 1.3.2
Chapter 2, §2.1, Chapter 5 White Dwarfs, § 5.1

Questions? Raise your hand high

Astronomy in the news?

Astrophysicists have long thought that hydrogen must be crushed into a metallic form in the high pressure at the center of Jupiter. Now Harvard physicists claim they have made metallic hydrogen in the lab. Others are skeptical.

Goal:

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

Goal:

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

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

2 Helium -> unstable, no such element

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

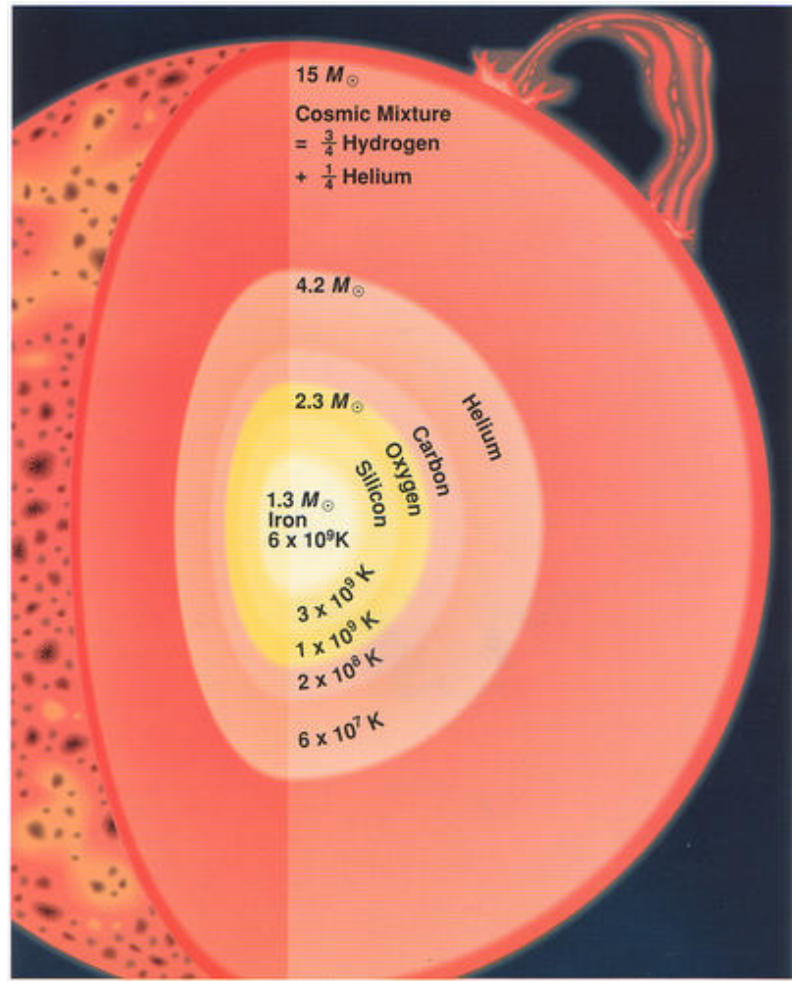
4 Helium -> Oxygen (8 protons, 8 neutrons)

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 (heavier than hydrogen and helium, lighter than iron) that are forged in stars, and in their explosions, are built on **building blocks of helium nuclei**.

Production of the Elements:

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 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 white dwarf is composed of Carbon and Oxygen, and **the explosion creates the intermediate-mass elements, Magnesium, Silicon, Calcium, and also Iron.**

Similar elements, but different systematics.

(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:

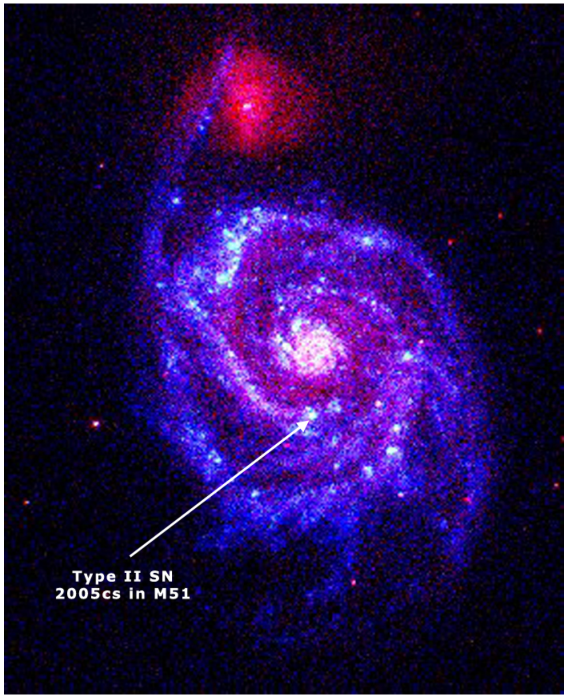
Star are born in the spiral arms of spiral galaxies.

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

Implications:

A star that dies in a spiral arm has not had time to drift far from its birth site. It is probably short lived, so the product of a massive star.

A star that dies far from a spiral arm has drifted far from its birth site. It is probably long lived, so the product of a white dwarf explosion.



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

If a supernova explodes in the spiral arm of a spiral galaxy

→ It was probably an exploding white dwarf

← It was probably an exploding massive star

↑ It probably ejected silicon

↓ It probably ejected helium

One minute exam

If a supernova explodes far away from any spiral arm of a spiral galaxy

➡ It was probably an exploding white dwarf

⬅ It was probably an exploding massive star

⬆ It probably left a neutron star

⬇ It probably exploded in an elliptical galaxy

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.

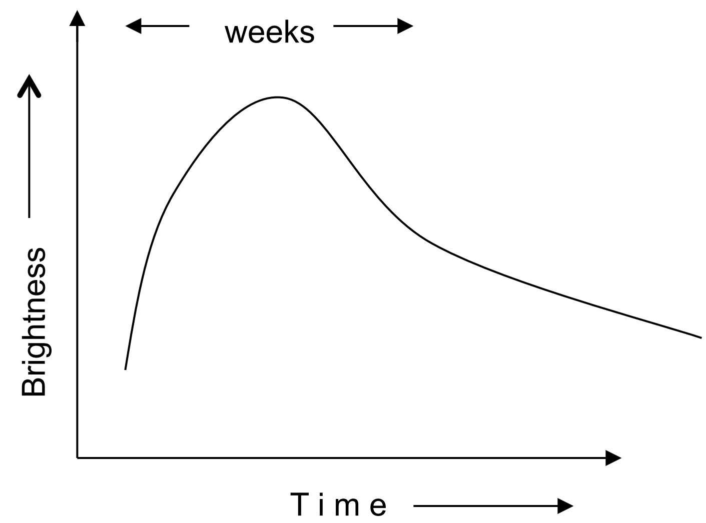
Type Ia occur in all galaxy types:
In **spiral galaxies** they tend to avoid the spiral arms, they have had time to drift away from the birth site → ***the star that explodes is old***

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

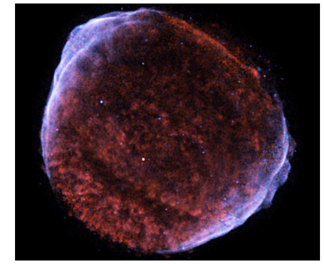
Type Ia - no hydrogen or helium, intermediate mass elements early, iron later

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



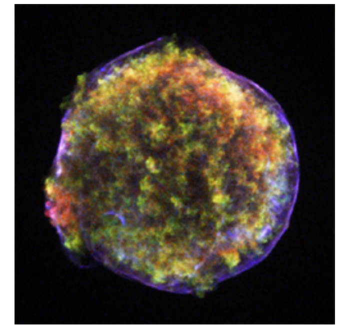
Type Ia occur in elliptical galaxies, tend to avoid spiral arms in spiral galaxies - old when explode, all evidence points to an exploding white dwarf.

SN 1006, almost definitely Type Ia

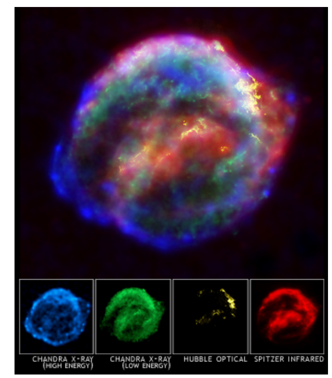


Tycho, SN 1572 definitely Type Ia

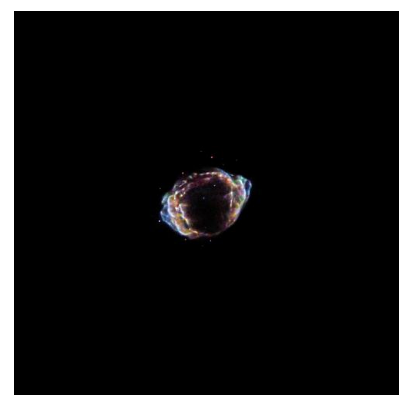
Recent discovery: spectrum from peak light reflected from surrounding dust, arriving only "now."



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



G1.9+0.3 probably a Type Ia.

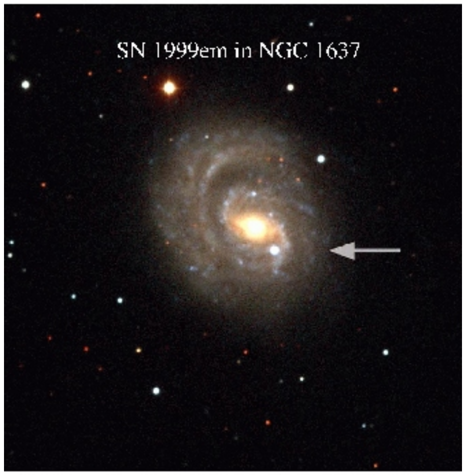


Type Ia

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



SN 1999em

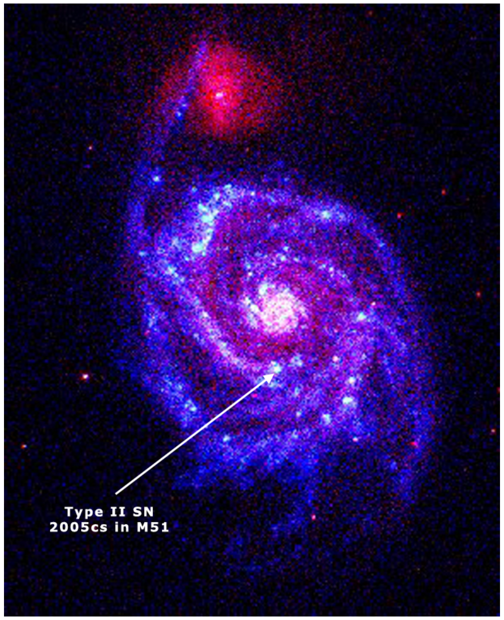
Most occur in spiral galaxies, *in the spiral arms*, ***they have no time to drift from the birth site***

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)



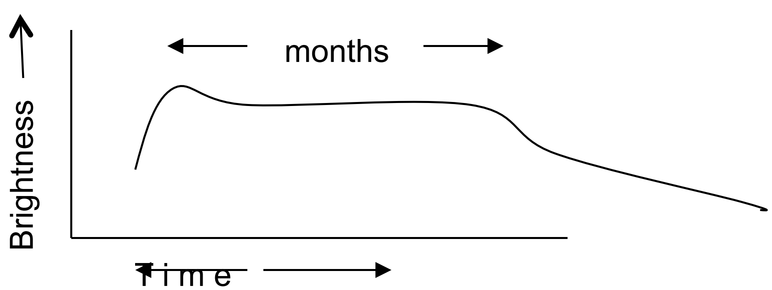
"Plateau" light curves of Type II are consistent with explosion in a **Red Giant**

Betelgeuse is a massive red giant, 15- 20 solar masses: we expect it to become a Type II supernova. ***Maybe tonight!*** Rigel in Orion probably burning He to C/O, explode later.

SN 386, 1181 records are sparse, might have been Type II

Crab was "peculiar" (high helium abundance, slow explosion), but probably a Type II. Expelled outer hydrogen envelope has been difficult to detect directly, but is inferred.

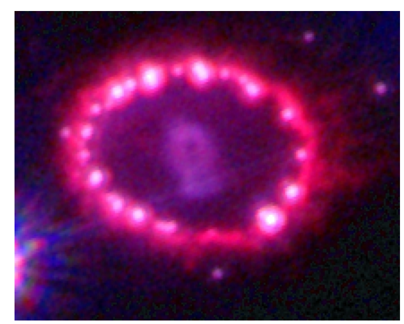
Cas A was probably something else with a very thin layer of Hydrogen (next topic),



Type II are common in other galaxies, more frequent than Type Ia.

Crab nebula

SN1987A was a "peculiar" Type II



One minute exam

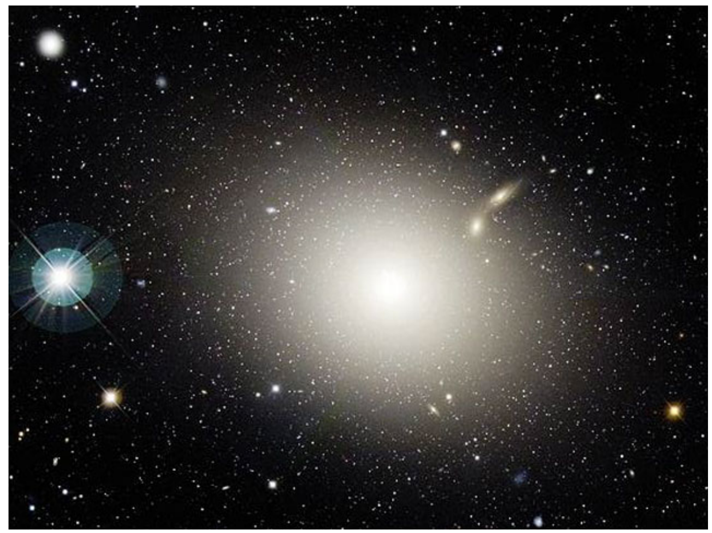
A supernova explodes in an elliptical galaxy. Near peak light what element do you expect to see in the spectrum?

➡ 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).

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