

September 8, 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

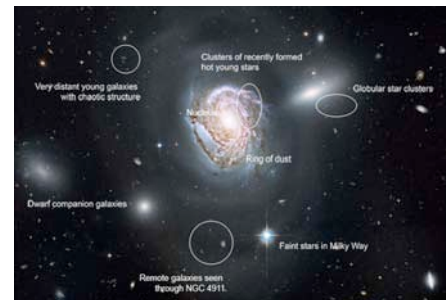
Review Session Thursday 5 PM, here, WEL 3.502.

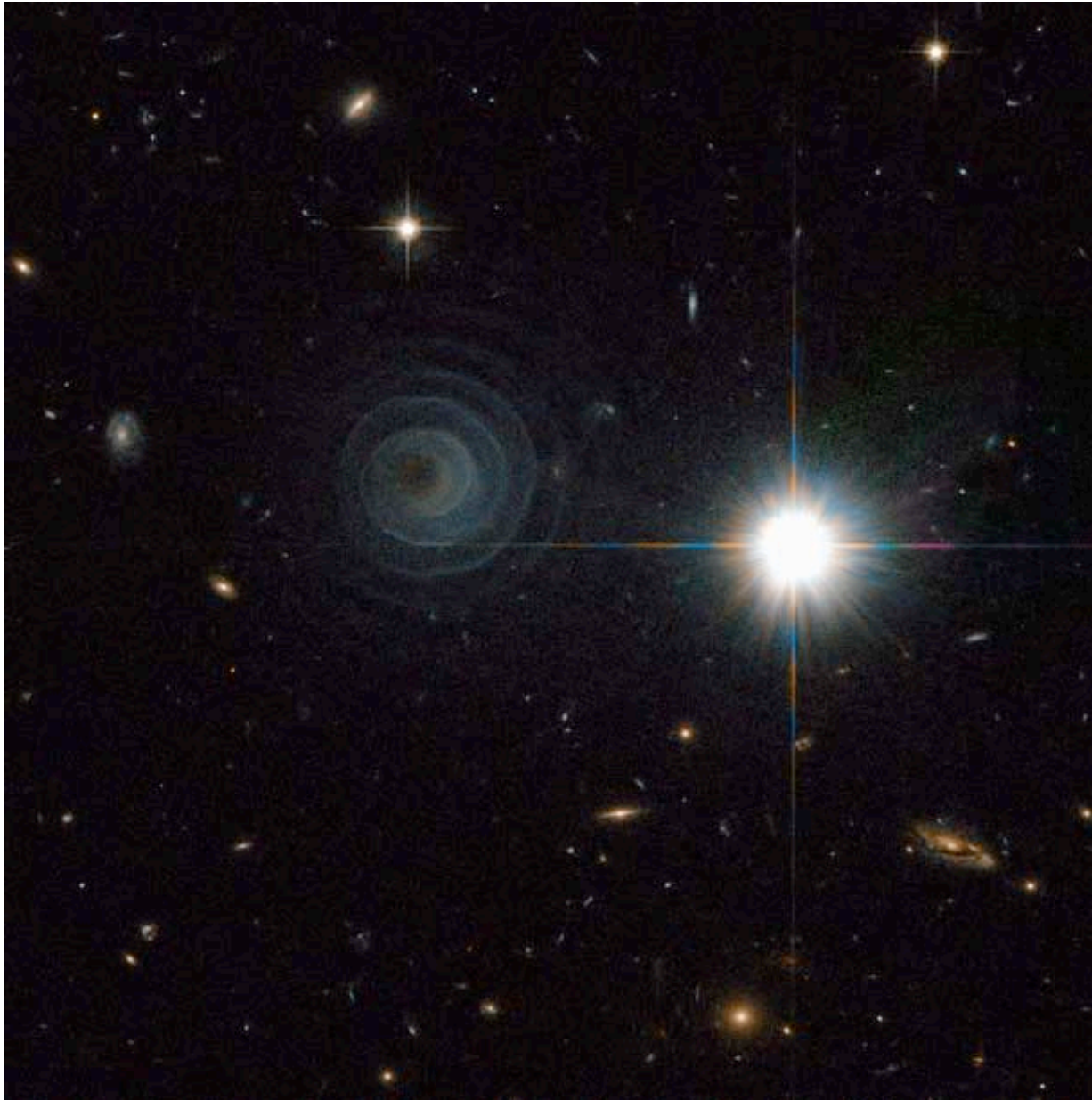
Astronomy in the News? 1976 Mars Lander might have found life after all. Chlorates in soil might have masked organic signal.

George Sudarshan, UT Physics, awarded Dirac Medal.

Inspiral of red giant in binary system (next page)

Pic of the Day –





Inspiral of carbon star red giant in binary system
(courtesy Phil Plait, Bad Astronomy, Franny Gaede)

Goal:

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

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

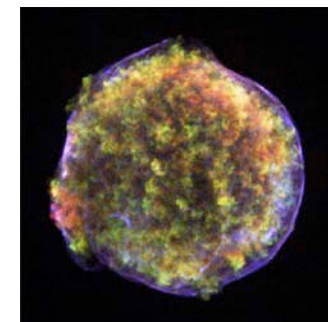
peaked light curve

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

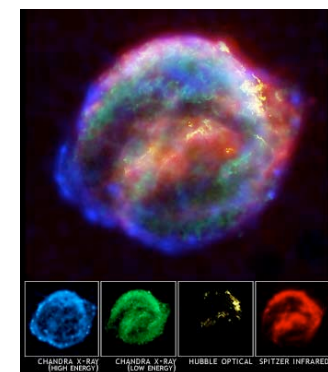
SN 1006, almost definitely Type Ia



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

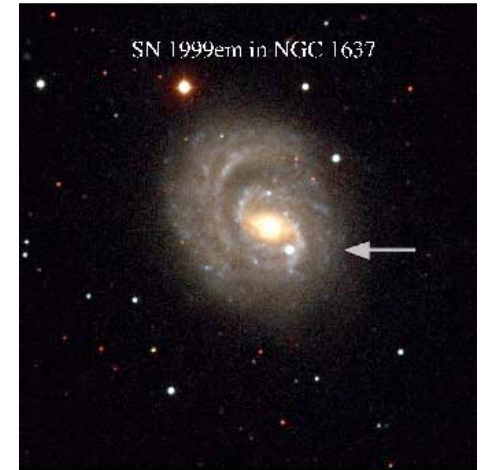
Type II Supernovae - “other” type discovered early in the study of supernovae, show Hydrogen in the spectrum early, Oxygen, Magnesium, Calcium, later

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 (no young stars)

Stars with more mass have more fuel, but they burn it at a prodigious 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)



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.

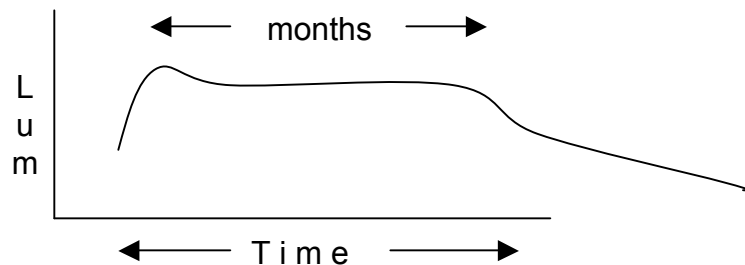
SN 386, 1181 records are sparse, might have been Type II

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

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



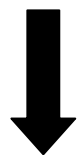
Hydrogen



Helium



Silicon



Iron



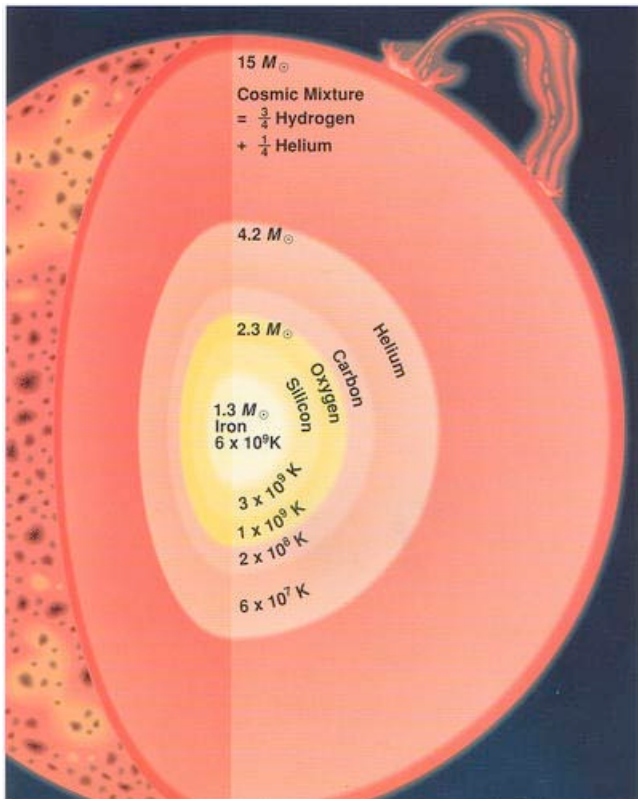
Goal:

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,
 \Rightarrow always supported by thermal pressure
 \Rightarrow continues to evolve, whether the Hydrogen envelope is there or not.



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

2 Helium \rightarrow unstable, no such element

3 Helium \rightarrow Carbon (6 protons, 6 neutrons)

4 Helium \rightarrow Oxygen (8 protons, 8 neutrons)

6 Helium \rightarrow Magnesium (12 protons, 12 neutrons)

7 Helium \rightarrow 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?



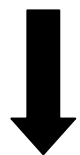
They are built up from the element iron



They are built up from the element hydrogen



They are built up from the element helium



They are built up from the element calcium

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

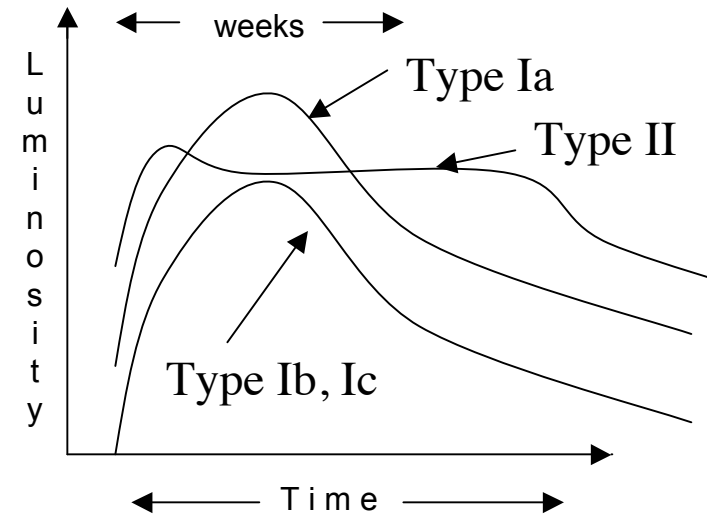
Type Ic: no Hydrogen no (or *very* little) Helium early, near maximum brightness; Oxygen, Magnesium, Calcium later on

Explode in the spiral arms of spiral galaxies	⇒ massive stars,
Never in elliptical galaxies	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

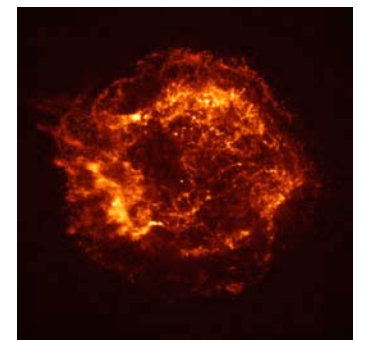
Similar to a Type Ia, usually, but not always, dimmer, consistent with a star that has lost its outer, Hydrogen envelope (or even Helium for a Type Ic) [will explain why dimmer later]



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