9/27/06

Exams back, grades posted, key posted today

Extra credit back Friday

News?

Pic of the day - Earth from Saturn/Cassini spacecraft: pale blue dot

Type Ia
no Hydrogen or Helium
intermediate mass elements early on, iron later
avoid spiral arms, occur in elliptical galaxies
peaked light curve
all consistent with explosion in white dwarf, 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).

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

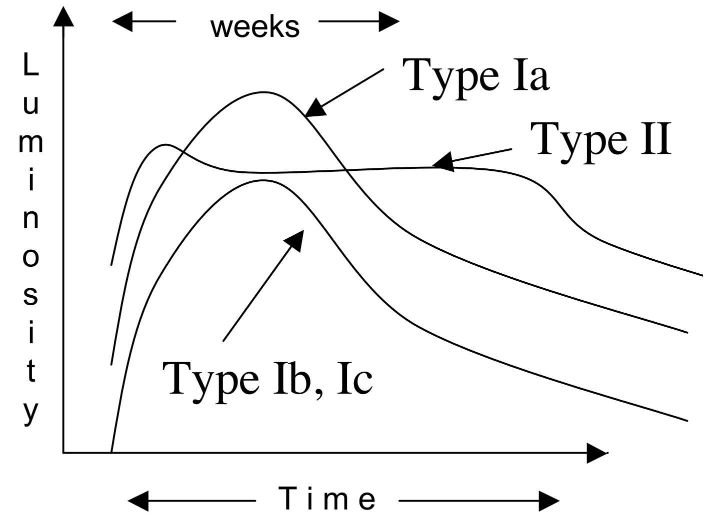
Explode in the spiral arms of spiral galaxies
Never in elliptical galaxies

⇒ 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

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, might have been a Type Ib, despite some evidence for a little Hydrogen in the remnant now

Kepler light curve not a “Type II,” could be consistent with Type Ia, b, c [Is there a compact object, or not??!!]

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

A Type II supernova

B Type Ia supernova

C Type Ic supernova

Type Ia: No Hydrogen, oxygen, magnesium, silicon, sulfur, calcium early, Iron later.

Not in spiral arms, do occur in elliptical galaxies -> old when blow -> white dwarfs, total disruption, no neutron star.
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, wind or binary transfer.***

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

Massive stars that give rise to Type II, Type Ib and Type Ic supernovae live a short time (millions, not billions of years) -> they die at the same rate at which they are born.

We have some idea of how rapidly massive stars of a given initial main sequence mass are born, the more massive the star, the rarer the birth.

We can count the rate at which massive stars die as Type II, Ib, or Ic supernovae (perhaps 3 Type II for every 1 Type Ib or Ic).

By comparing the birth rate and the death rate we can estimate that stars of about 8-20 $M_\odot$ make most of the Type II, and Type Ib, Ic supernovae.

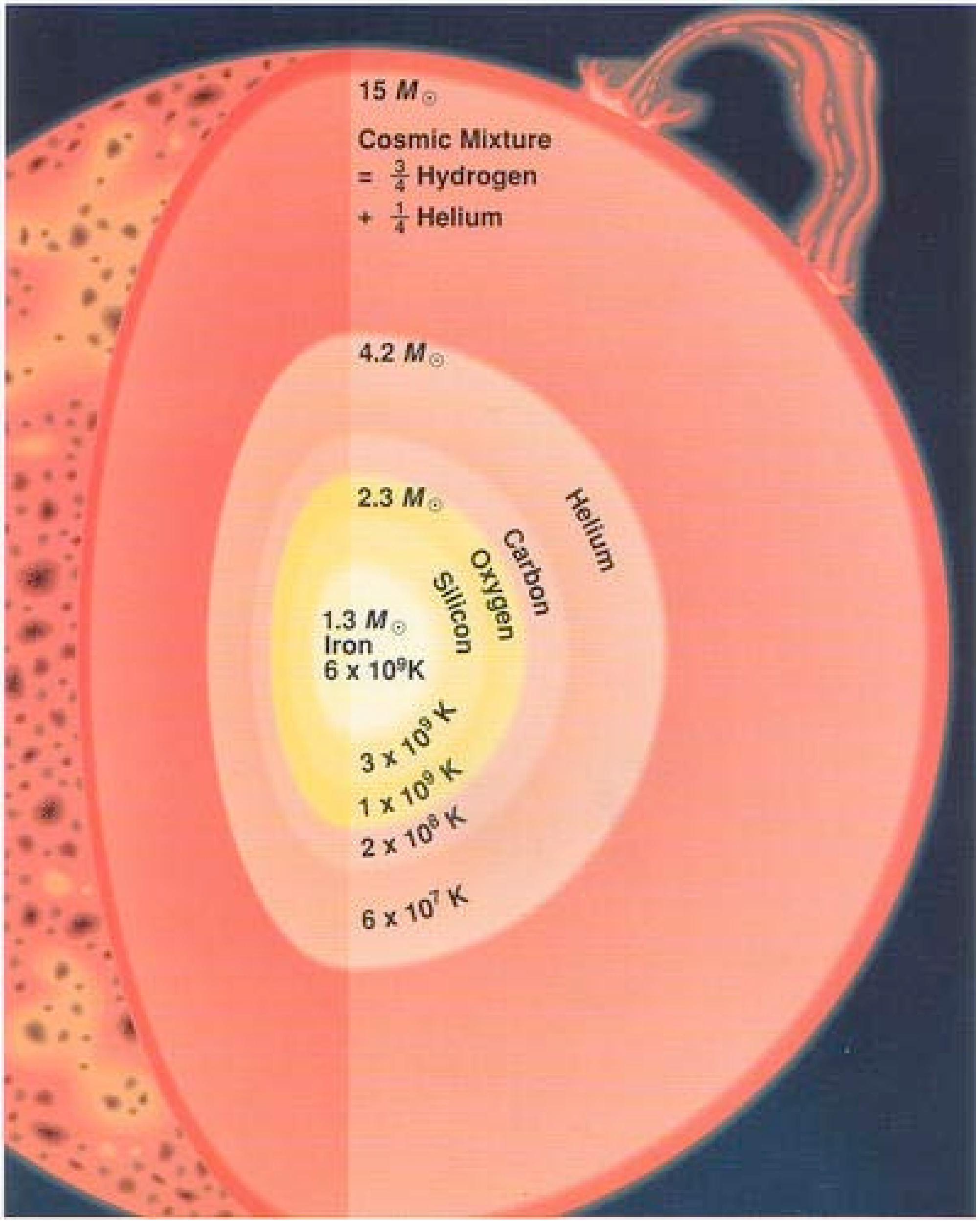
Stars with mass >20 $M_\odot$ are rare, hard to pin down. They could all explode or none explode (by making black holes) and the rate of supernovae would not be much different.

Even more recent (late 90's), possibility of "hypernovae."

For Types Ia, Ib, Ic, II the energy of explosion (motion energy, kinetic energy) is ~1% of the energy generated by collapse to form a neutron star.

Some explosions that otherwise resemble Type Ic (no Hydrogen, no Helium) have shown exceptionally high velocities. Some people have argued that this variation of Type Ic requires perhaps 10 × more explosion energy, thus coining the name "hypernovae" but ***asymmetries*** could play a role, brighter, faster in some directions than others. Nature, connection to "ordinary" Type Ic remains controversial.

These events represent a possible link to ***Gamma-Ray Bursts*** (Chapter 11), the formation of black holes (OR NOT).



Origin of Type II, Ib. Ic

How does a massive star get from hydrogen to iron, and why iron, and what then?