2/13/06

Exam grades, answer key will be posted tomorrow, exams returned Wednesday

Absence/Failing notices for first exam - formality

Wheeler absent Friday “How to be a President” workshop, San Diego

Film - SN 1987A

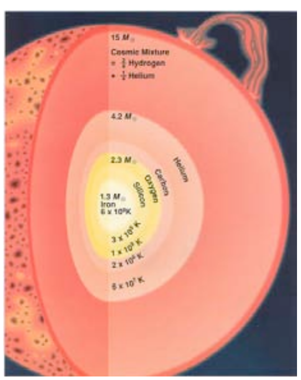
News?

Pic of the day - N44 nebula in the Large Magellanic Cloud

SN 2006X, discovered February 7, is proving to be very interesting. In relatively nearby galaxy M100 in the Virgo Cluster, about 11 Million parsecs, 35 million light years away. Discovered only a few days after explosion, 2 weeks before maximum brightness, still perhaps a week from now. Near spiral arm, but shows Silicon, Sulfur, Oxygen, Calcium in the spectrum - Type Ia. Enveloped in dust, asymmetric.

Most recent SN - 2006ad discovered Feb 9

Physics: in massive stars (more than about 12 - 15 times the Sun) the core of Helium or heavier elements, Carbon, Oxygen, Magnesium, Silicon, Calcium, finally Iron, continues to be hot even as it gets dense,
⇒ always supported by thermal pressure
⇒ continues to evolve, whether the Hydrogen envelope is there or not.



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)

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

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

Common elements forged in stars are built on building blocks of helium nuclei

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

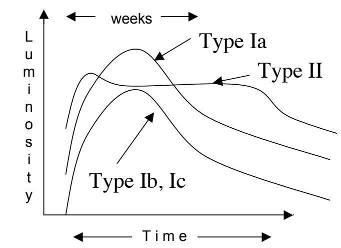
Explode in the spiral arms of spiral galaxies
Never in elliptical galaxies

$\Rightarrow$ 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

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

Name an element seen in SN 2006X that proves that it is a Type Ia supernova

Oxygen, Silicon, Sulfur, Calcium

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.

Type Ic: no Hydrogen no (or *very* little) Helium early, Oxygen, Magnesium, Calcium later.

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.