

9/24/07

Exam 1: multiple choice scores posted today, exams returned, answer key posted Wednesday

Hand in Sky Watch TODAY, returned Friday

Astronomy in the news? Equinox last Sunday, Harvest Moon this coming Wednesday

Pic of the Day - false color Infrared image of star-forming region in our Galaxy



*Sky Watch Extra Credit - location of supernovae*

*SN 1006 - Lupus/Centaurus (not this time of year)*

*SN 1054 Crab Nebula - Taurus*

*SN 1572 Tycho - Cassiopeia*

*SN 1604 Kepler - Ophiuchus*

*Cassiopeia A - Cassiopeia*

*Vela supernova - Vela (not this time of year)*

*Betelgeuse - Orion, Red Supergiant due to explode “soon” 15 solar masses*

*Antares - Bright Red Supergiant in Scorpius, 15 to 18 solar masses  
(+companion)*

*Rigel - Orion, Blue Supergiant due to explode later, 17 solar masses*

*Aldebaran - Bright Red Supergiant in Taurus, 2.5 solar masses (WD not SN)*

*Can only count each objects once for credit, but can do any objects missed earlier in later reports. Add relevant objects I don't specifically mention in class.*

All SN since 1680, since invention of telescope, modern astronomy, have been discovered in other galaxies.

Our Galaxy is overdue for another!

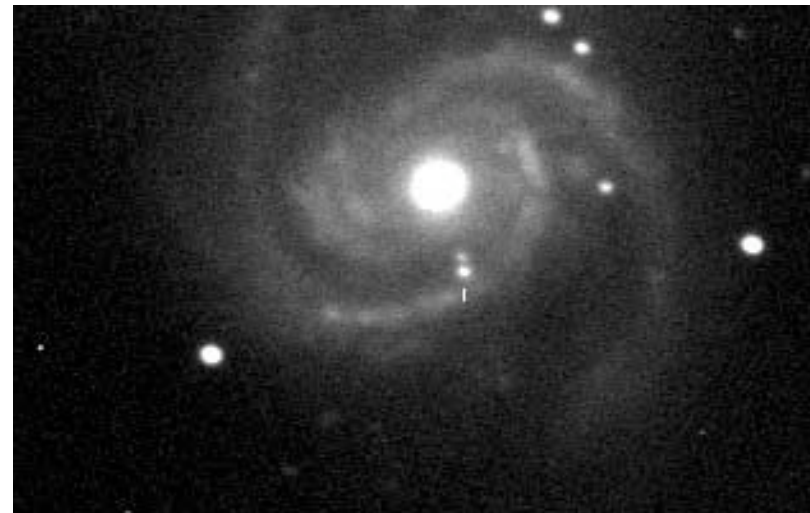
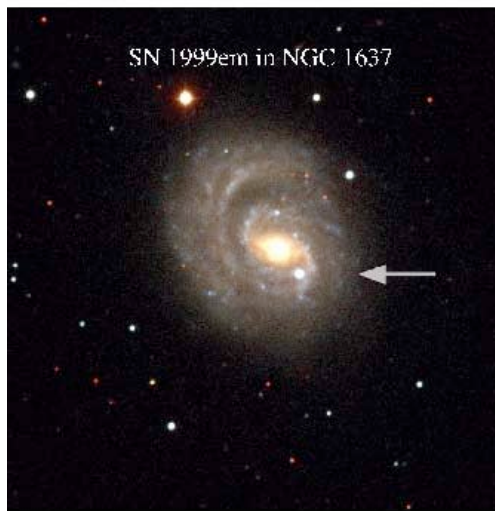
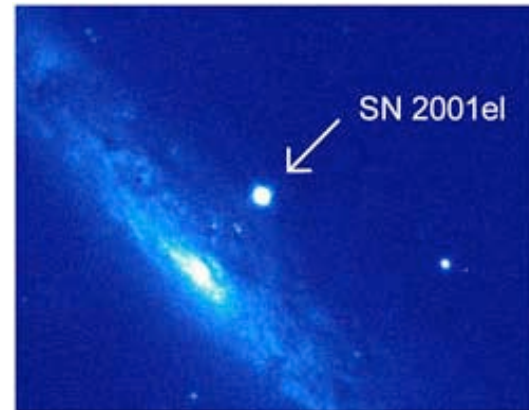
Recognition (early in the 20th century) that some “novae” were in distant galaxies and hence were 10,000 to 100,000 times brighter than classical novae in the Milky Way.

Led to the recognition and naming of “super” novae.

Web site of recent bright supernovae:

<http://www.rochesterastronomy.org/snimages/>

## Sample of extragalactic supernovae



SN 2006X

Extra Galactic Supernovae: the basis for modern astronomy of supernovae

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 over 100 per year, most at great distances, more difficult to study.

Nomenclature: A-Z, aa-az, ba-bz, etc.

SN1987A - 1st of '87 (also most important, but that is not what the "A" means).

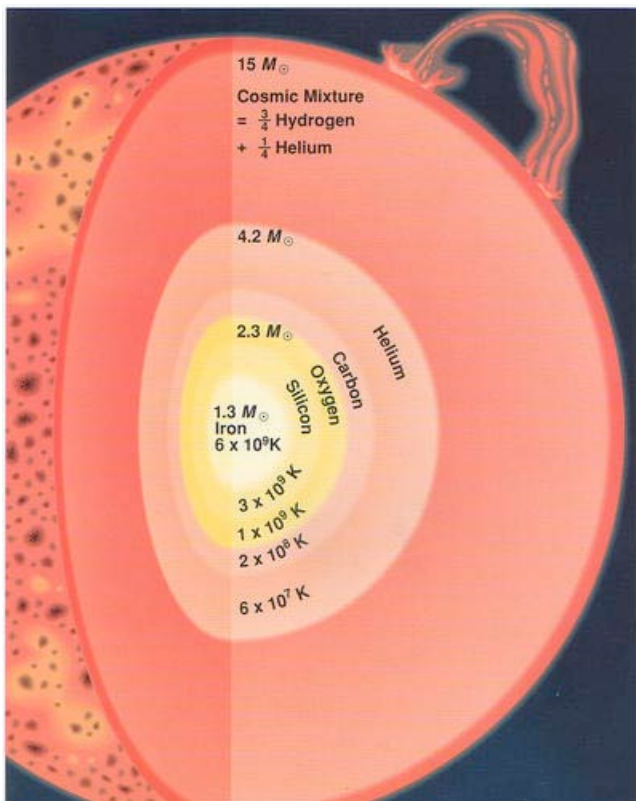
This year latest, SN 2007kd, discovered Sunday - #290

## One Minute Exam

Tycho's supernova of 1572 shows no sign of a compact object left over in its center. This suggests that:

- A) It made a jet
- B) It was formed by the collapse of a massive star
- C) It was formed by an exploding white dwarf
- D) It actually exploded much earlier than 1572

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,  
⇒ 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

# Categories of Supernovae

1st category discovered

Type Ia - no detectable Hydrogen in the spectrum, rather “intermediate mass elements” like 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**

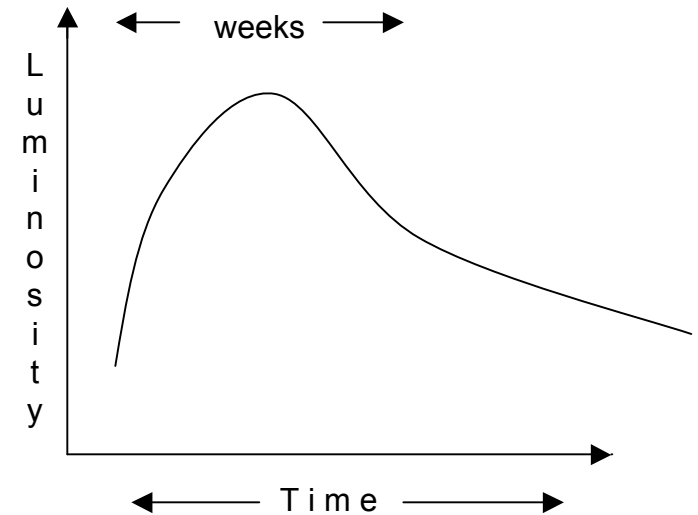
In **elliptical galaxies** where star formation is thought to have ceased long ago → *the star that explodes is old*

[*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, probably a white dwarf.

SN 1006, almost definitely Type Ia

Tycho, SN 1572 almost definitely Type Ia

Kepler, 1604, some argue yes (no sign of neutron star, same ejected composition as SN 1006, Tycho), but some ambiguities suggesting a massive star progenitor.

If U Sco becomes a supernova it will probably be a Type Ia

## One minute exam

Why do the elements carbon, oxygen, magnesium, and silicon frequently appear in the matter ejected from supernovae?

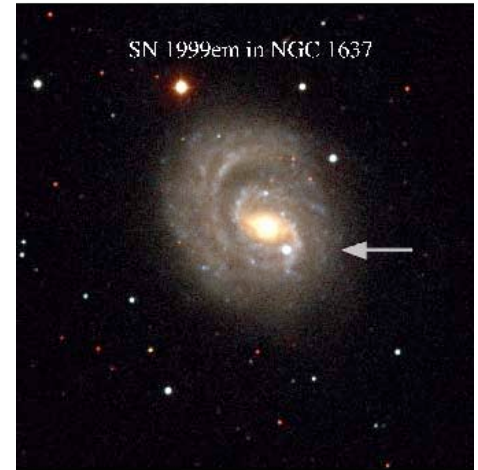
- A) They are built up from the element iron
- B) They are built up from the element hydrogen
- C) They are built up from the element helium
- D) They are built up from the element calcium

***Type II Supernovae*** - “other” type discovered early, 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*

→ *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.

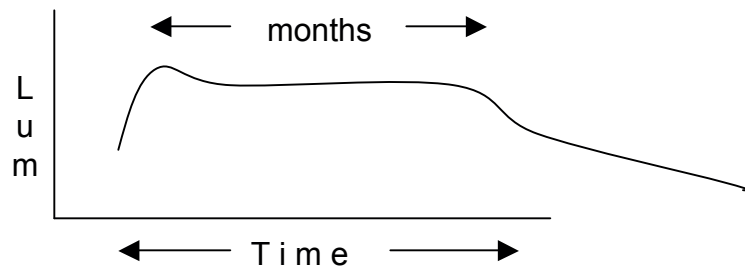
SN 386, 1181 records are sparse, might have been Type II

Crab was a “peculiar” Type II (high helium abundance, slow explosion)

Cas A was probably something else (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

SN 2006X showed evidence for the elements oxygen, magnesium, silicon, sulfur, calcium near its peak of light output. What type of supernova was it?

- A) Type Ia
- B) Type II
- C) Insufficient information