Supernovae

OUTLINE
I. The Types of supernovae
II. An end stage of stellar evolution.
III. A way to make black holes and other exotic remnants.
IV. The source of heavy elements.
V. An important tool in cosmology.
VI. 2011 a flurry of supernovae activity.

II. What is a Supernova?

Supernova 1994D in NGC 4526

A supernova is the explosion of a star!

Type Ia – the explosion of a white dwarf. (~ 1.4 x mass of Sun)

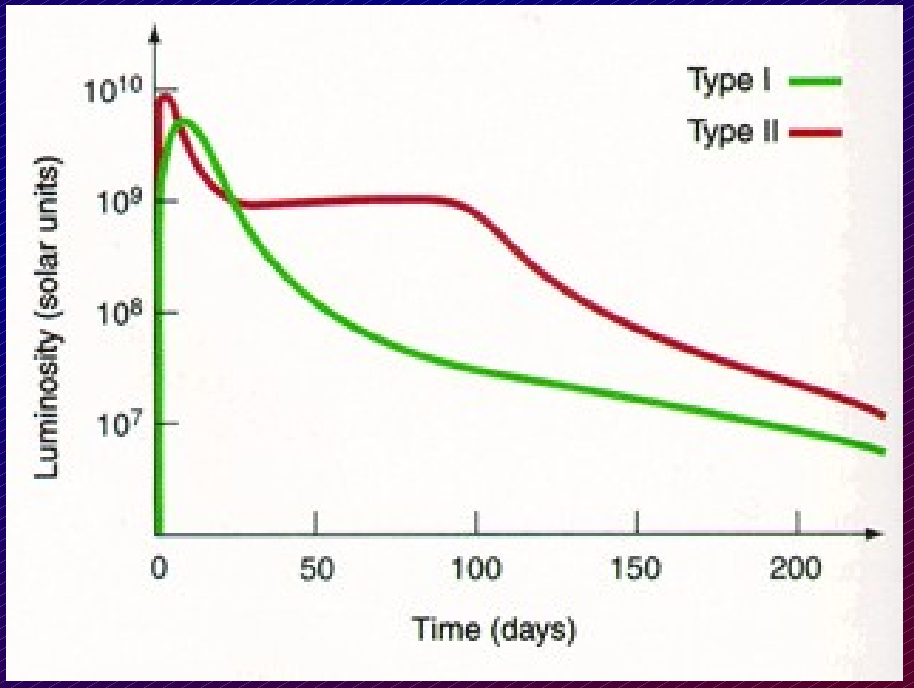
Type II – the explosion of a massive star. (over 12 x mass of Sun)

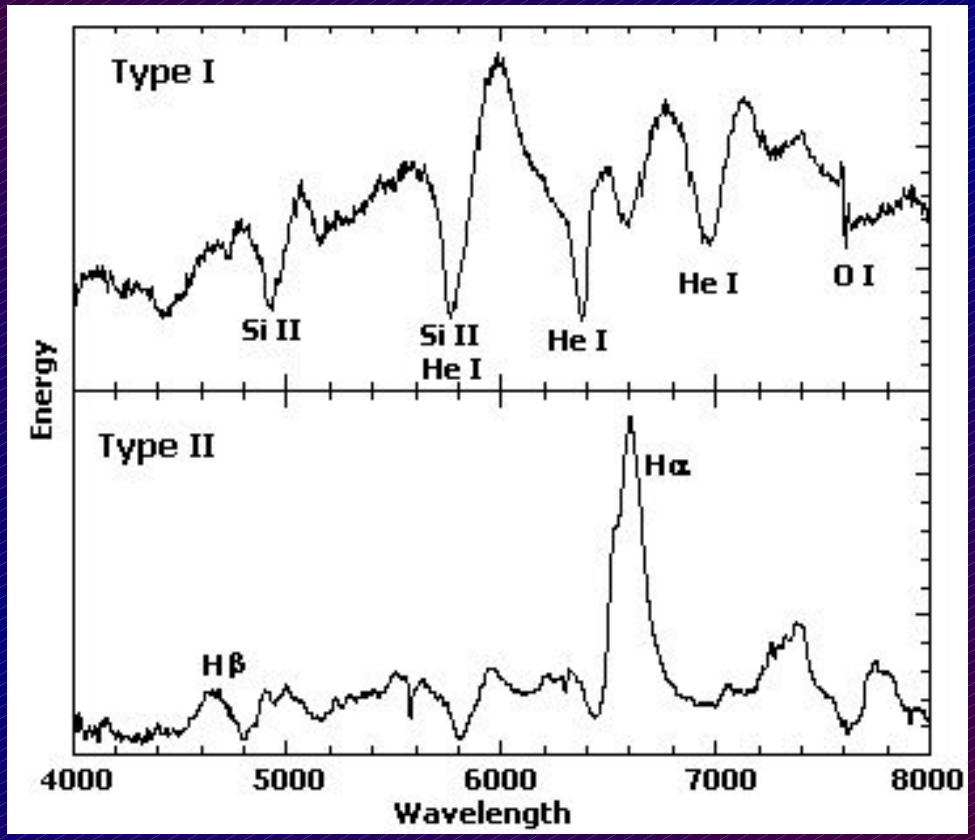
Supernova's briefly outshine their parent galaxy!

II The Types

How do you tell which type?

- The light curve (brightness vs time)
- The spectrum

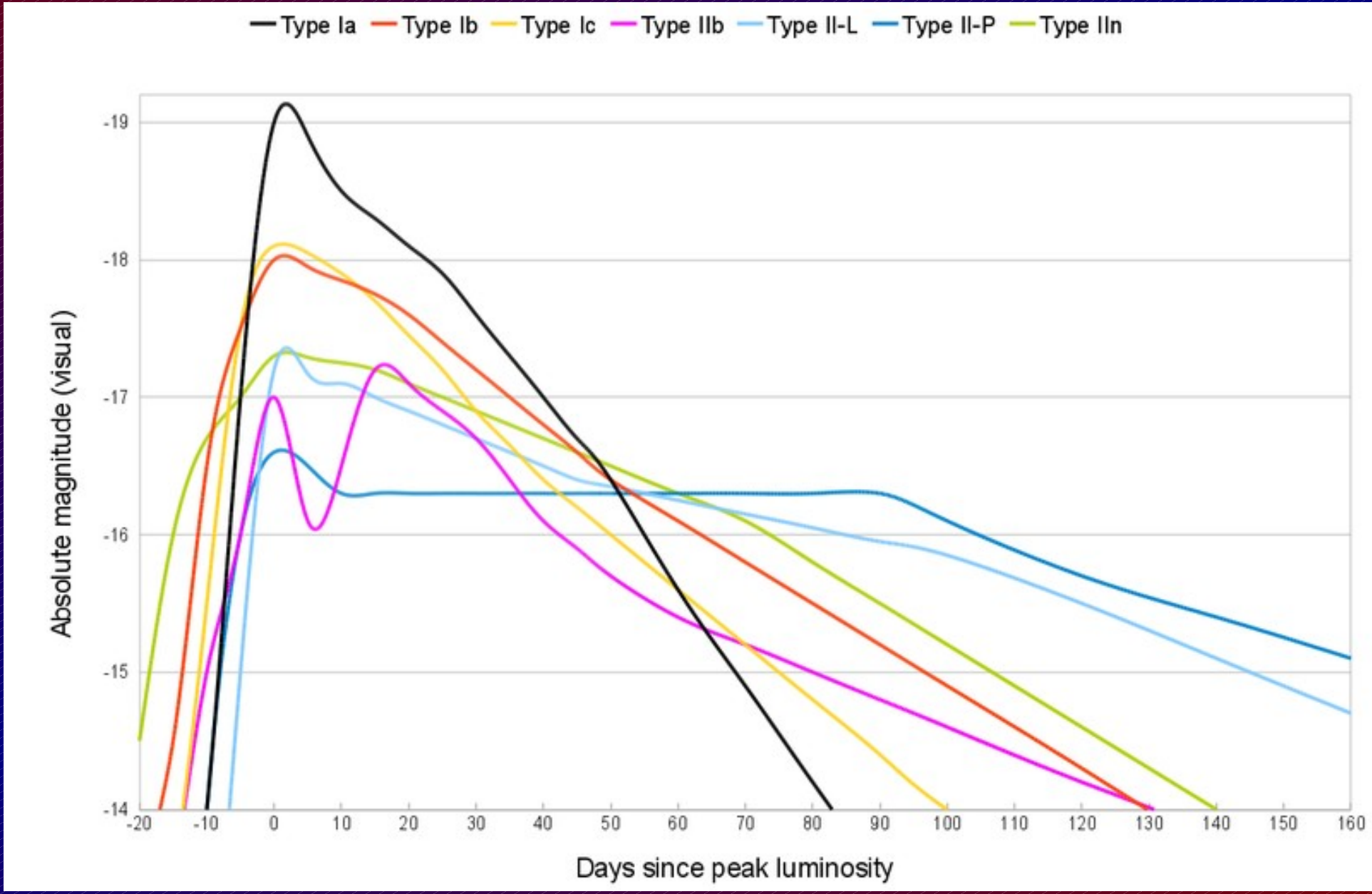




- The remnants

II The Types

More light curves (more accurate than previous slide.)



III. An end stage of stellar evolution

Stellar Evolution Basics

- Stars are born out of collapsing gas and dust.
- Stars tend to form in groups called clusters.
- Protostars tend to have gas/dust disks that blow away leaving planetary systems.
- Stars shine (give off energy) by nuclear fusion in their cores.
- The more mass they have, the shorter their lives.
- Stars spend most of their lives fusing H into He.

III. An end stage of stellar evolution

Stellar Evolution Basics (cont.)

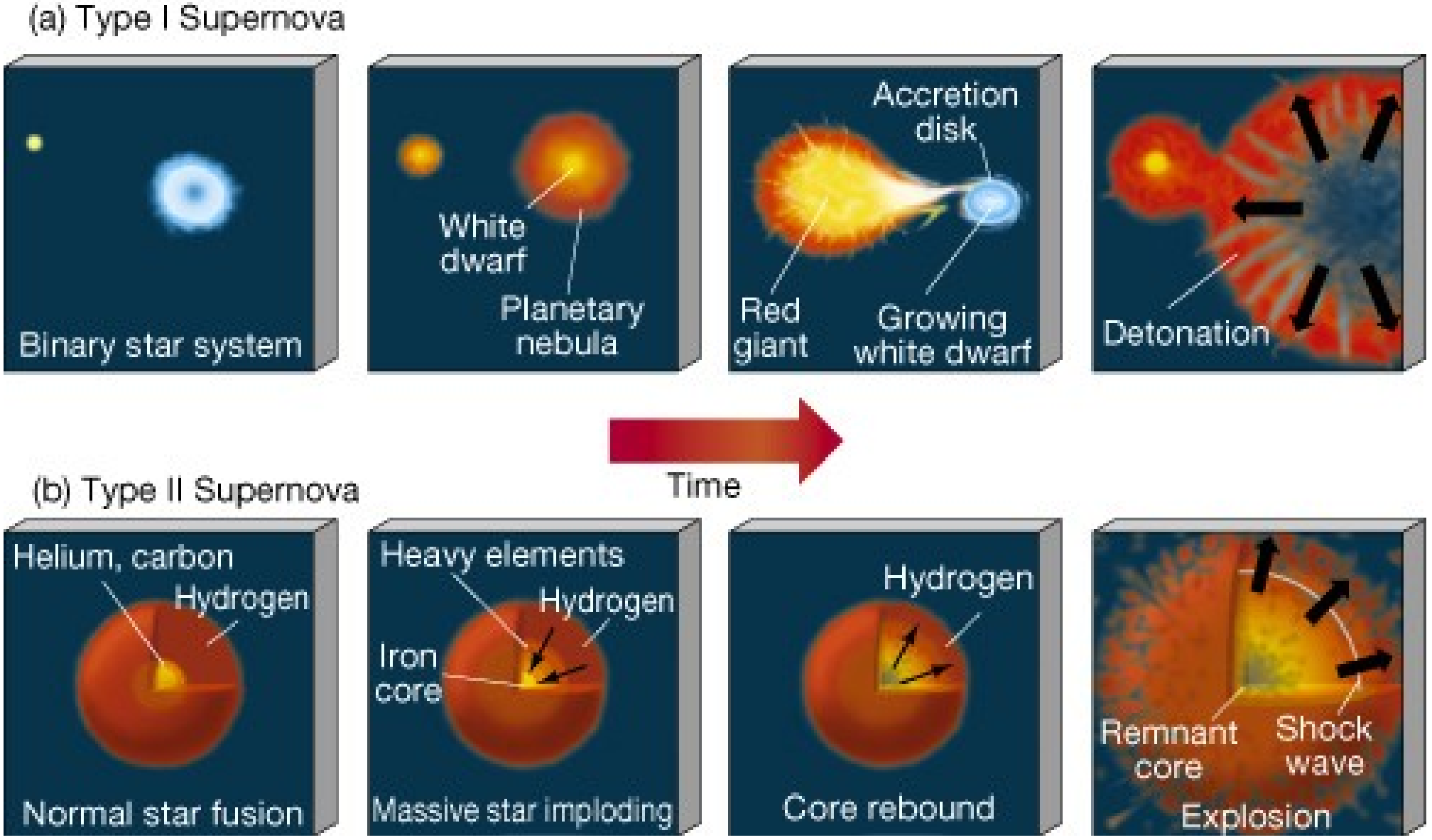
- The death of a star depends on its mass.
  - Low mass (0.08-0.5 M⊙) – He white dwarf (eventually)
  - Medium mass (0.5-8 M⊙) – Carbon – Oxygen white dwarf
  - Higher mass (8-12 M⊙) – Oxygen-Neon-Magnesium white dwarf
  - Very high mass (>12 M⊙) – Supernova
- Type I supernovae usually leave nothing behind
- Type II supernovae leave neutron stars, pulsars, black holes, or nothing

White dwarf: a compact stellar remnant (about the size of the Earth) made of d*egenerate* matter.

Degenerate matter: consists of atomic nuclei and electrons packed closely together. The pressure comes from the way two e- cannot occupy the same state.

Chandresekhar limit: the mass upper limit of a white dwarf, 1.4 M⊙. Any higher and runaway fusion will occur. Carbon detonation

III. An end stage of stellar evolution



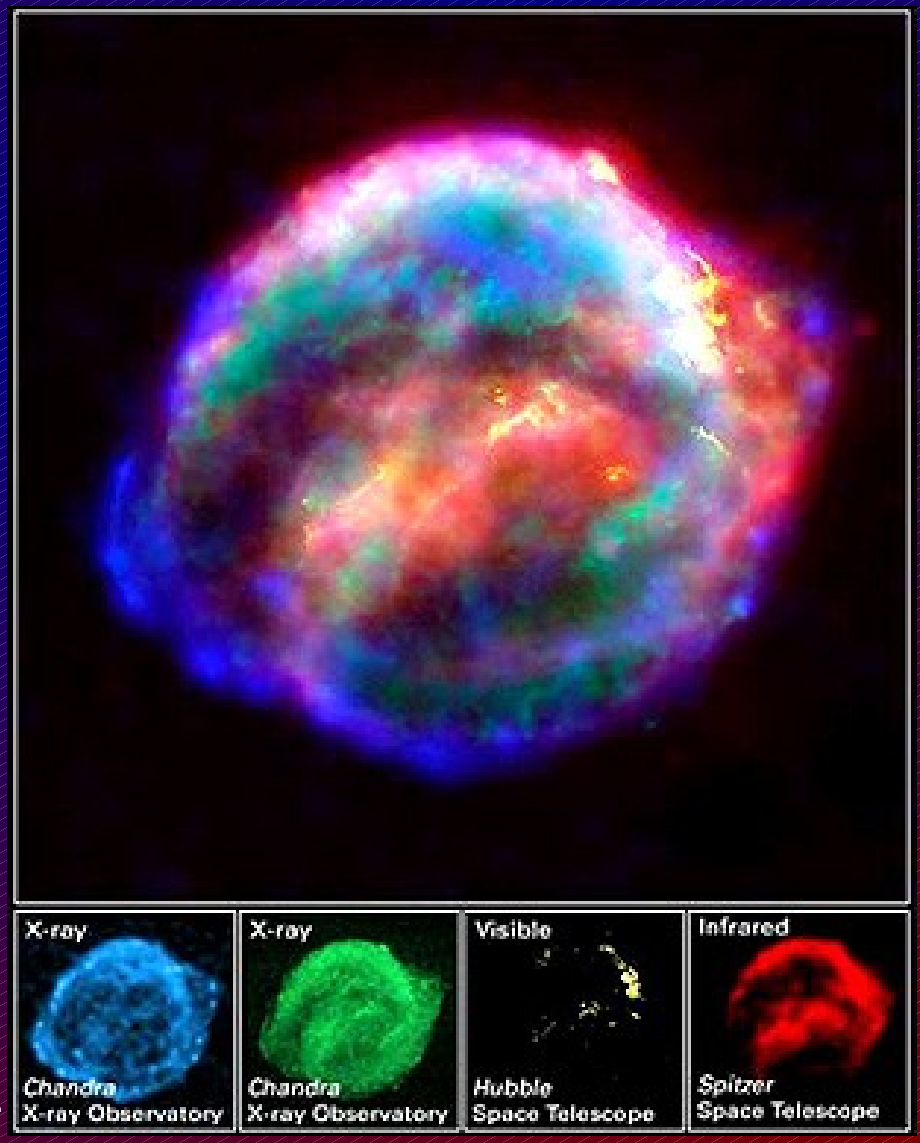
Demonstrate core collapse

IV. A way to create BH and other extreme remnants.

SNR = Supernova remnant
This can refer to a dense object leftover, or the expanding debris as it appears in the optical, radio, x-ray ...

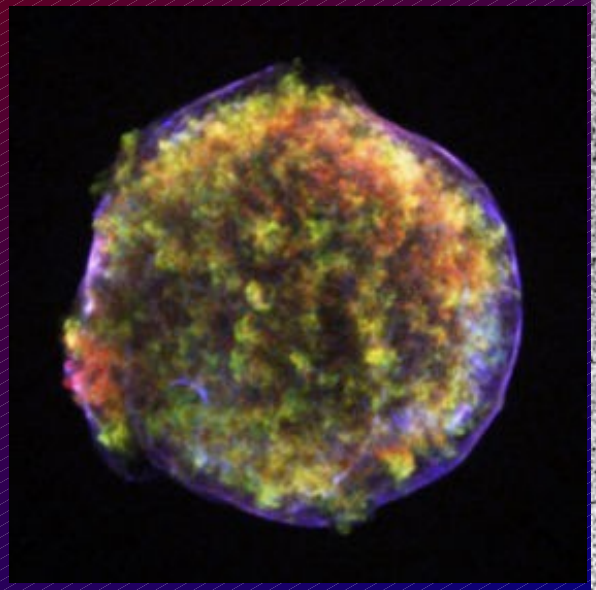
Neutron Stars
R=12 km, size of a city
Pulsar Rotation periods = .0014-30.0 s
Density = 5×10^{14} g/cm^3
Surface gravity = 10^{13} m/s^2

BH = Black Holes
Extreme gravity – general relativity
$R_S = 3.0\ M(M\odot)$ km

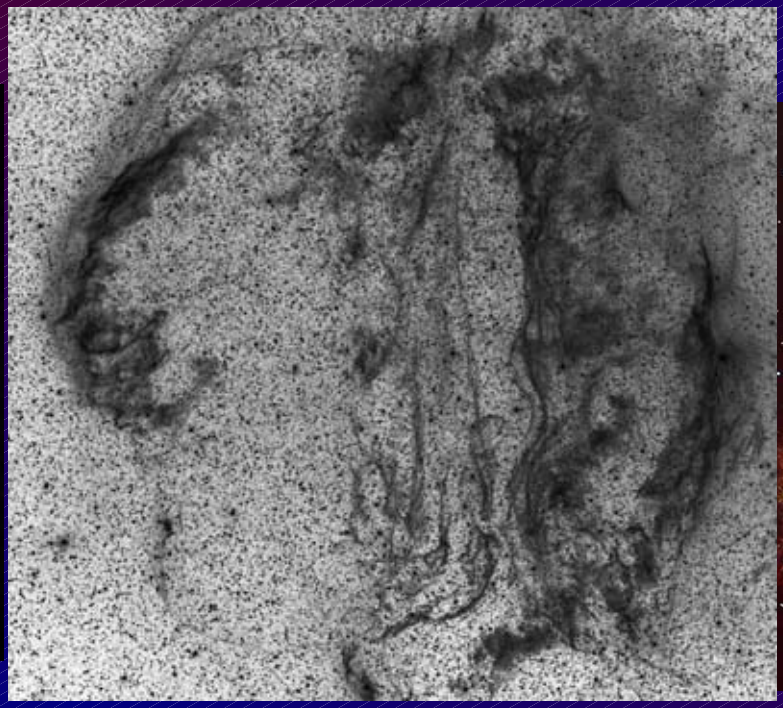


Kepler's Supernova of 1604.
In Ophiuchus. Type Ia. 6 kpc.

IV. Some cool supernova remnants.



SN 1572
Cas B, "Tycho's Nova"
Type Ia.
supernova.
In Cassiopeia.



Viel Nebula or "Cygnus Loop".
Light reached us ~5000 years ago.
1500 LY away.
In Cygnus, 3 degrees Across!

Crab Nebula.
"M1"
Type II.
Seen in 1054 A.D.
6500 LY away.
In Taurus (tiny).

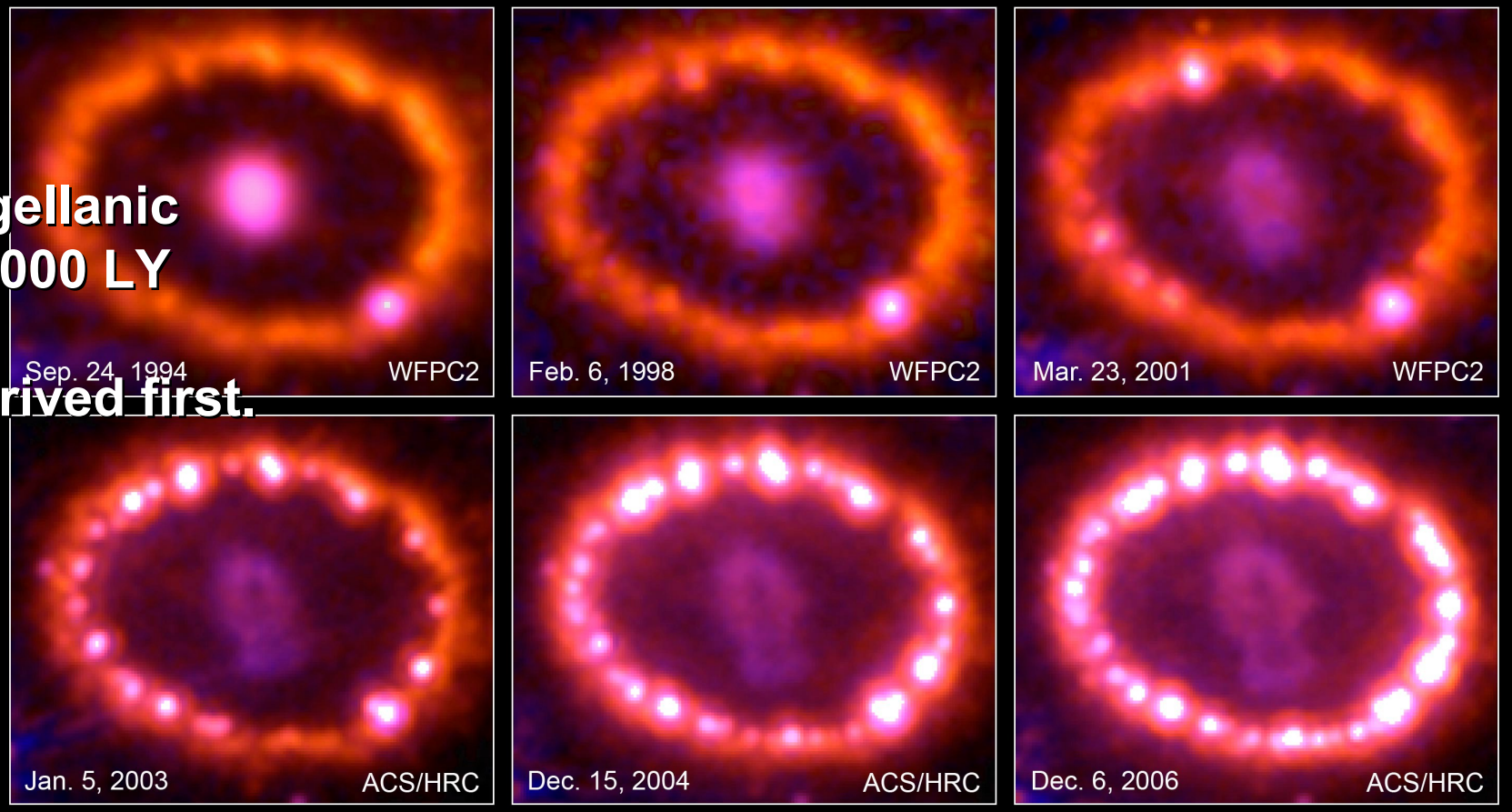
IV. The last important, nearby SN.

SN 1987A

Type II

In Large Magellanic Cloud – 180,000 LY

Neutrinos arrived first.



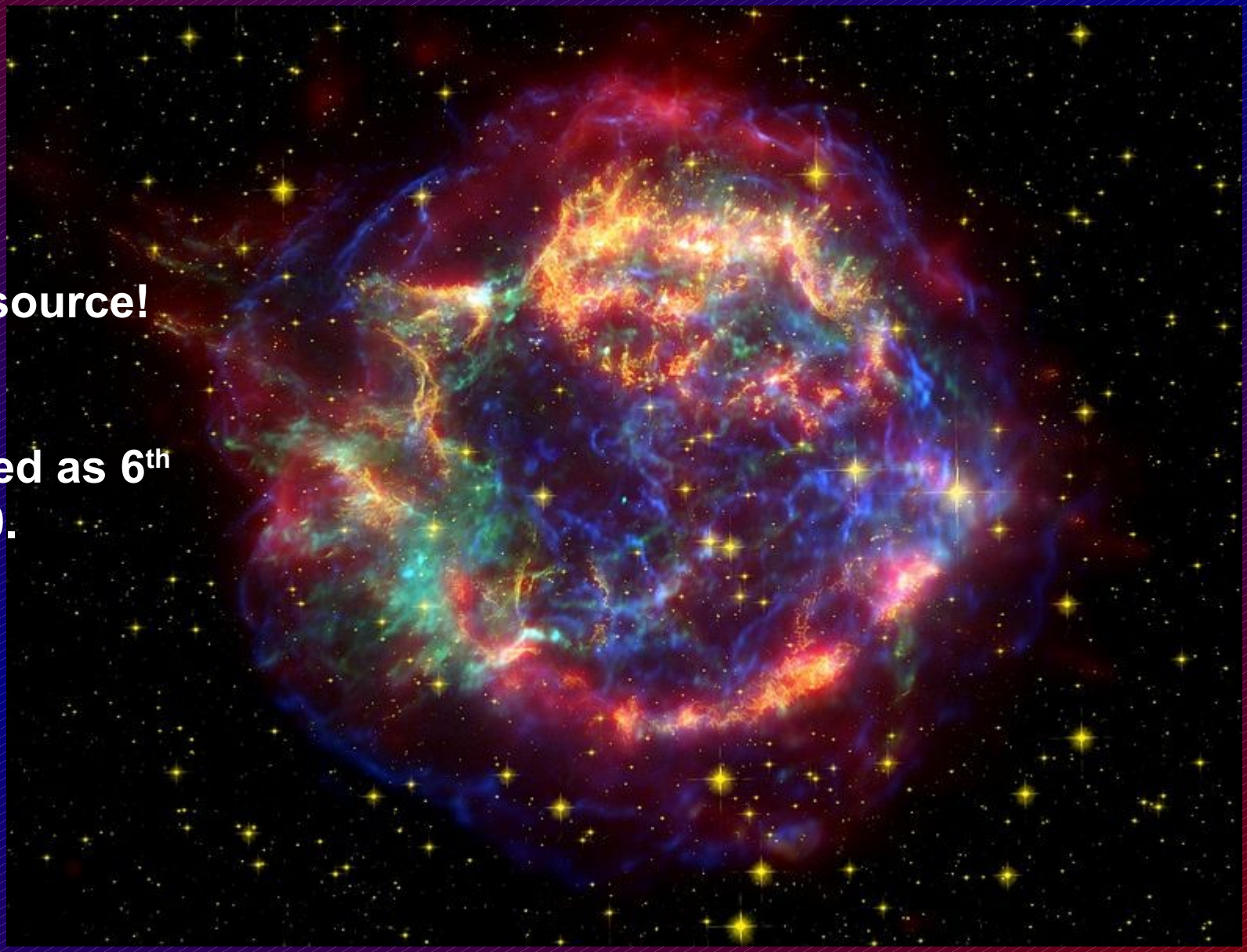
IV. Some cool supernova remnants.

Cas A

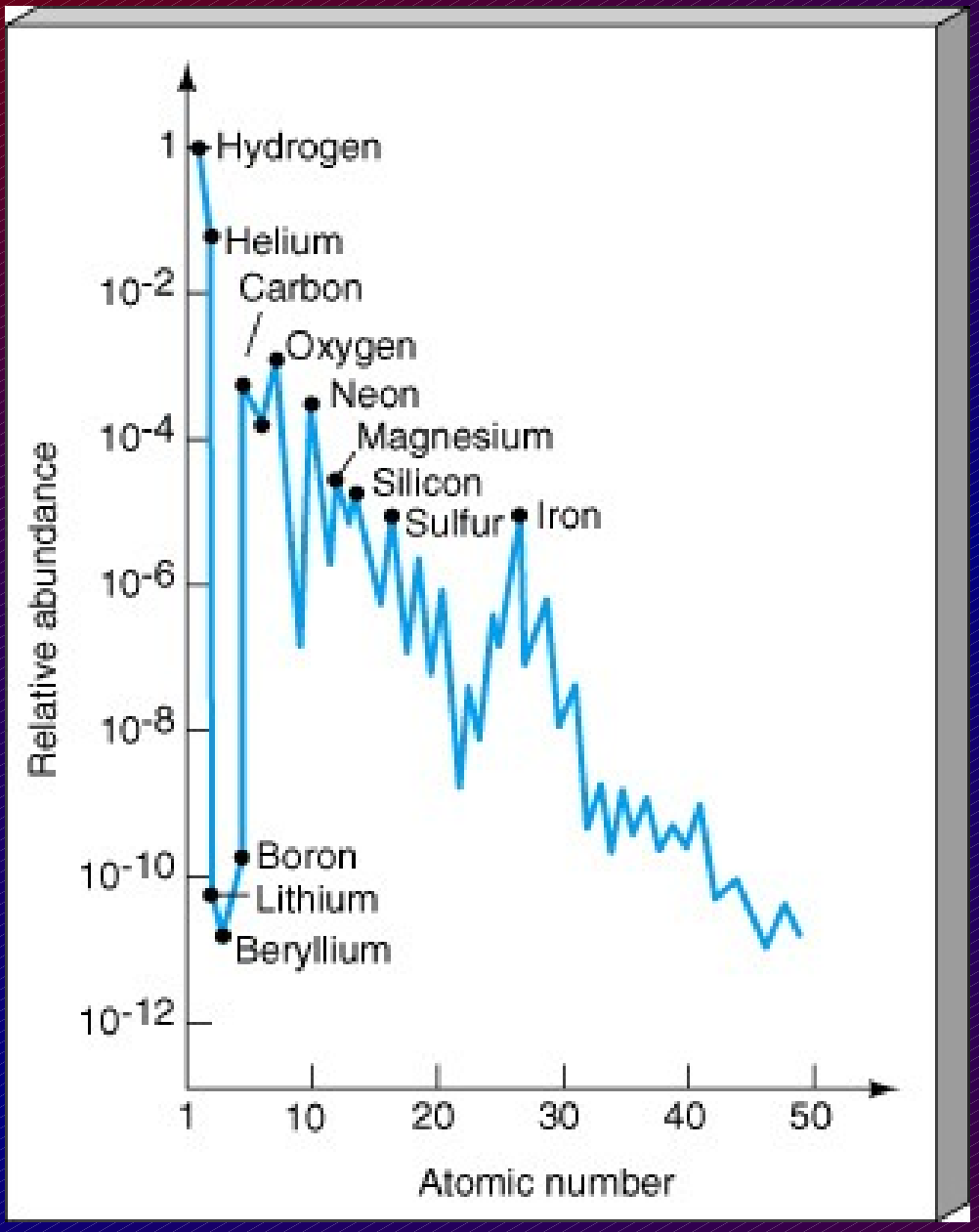
Type II

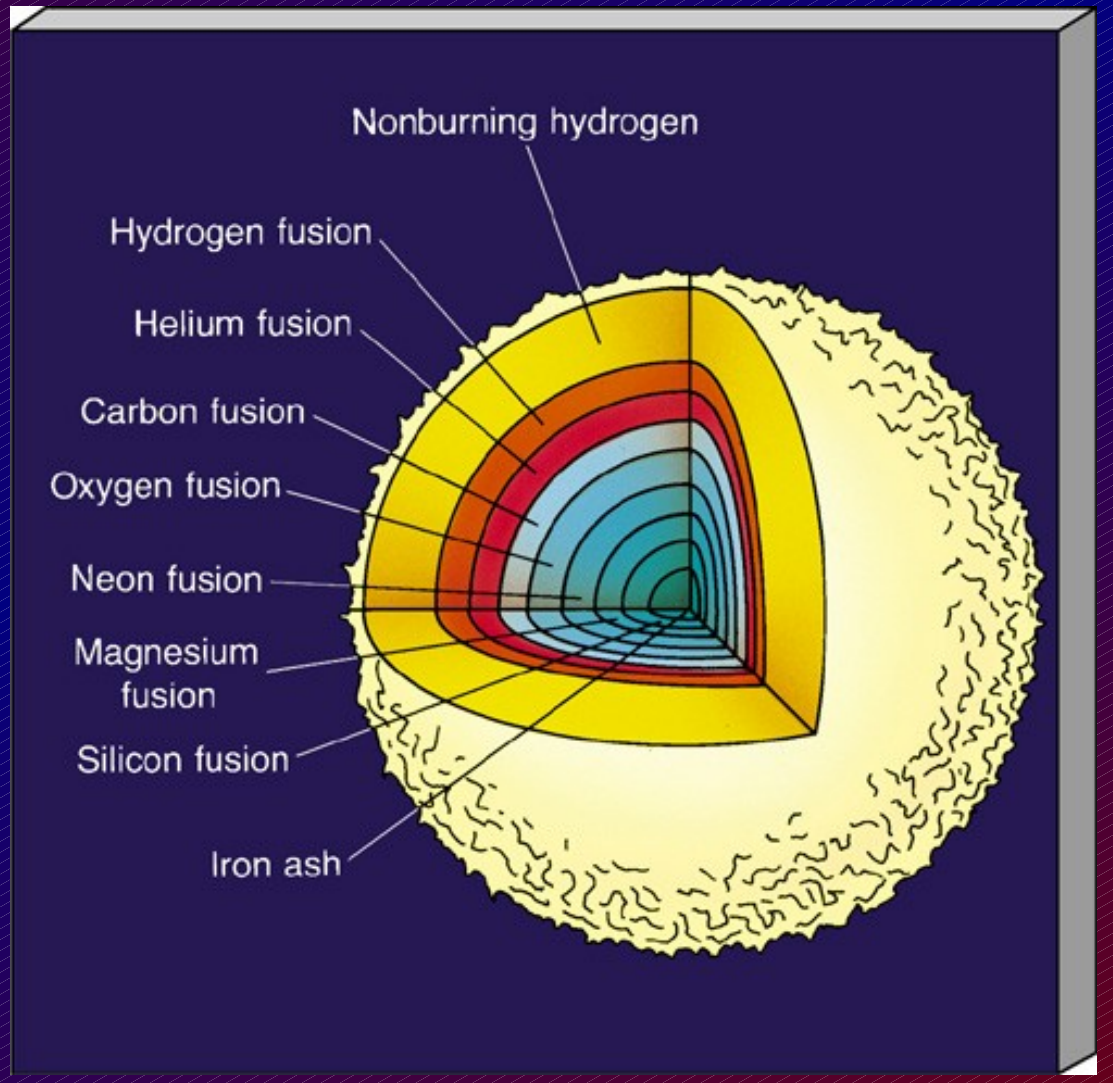
Brightest radio source!
~350 yrs old

Possibly recorded as 6th mag star in 1680.



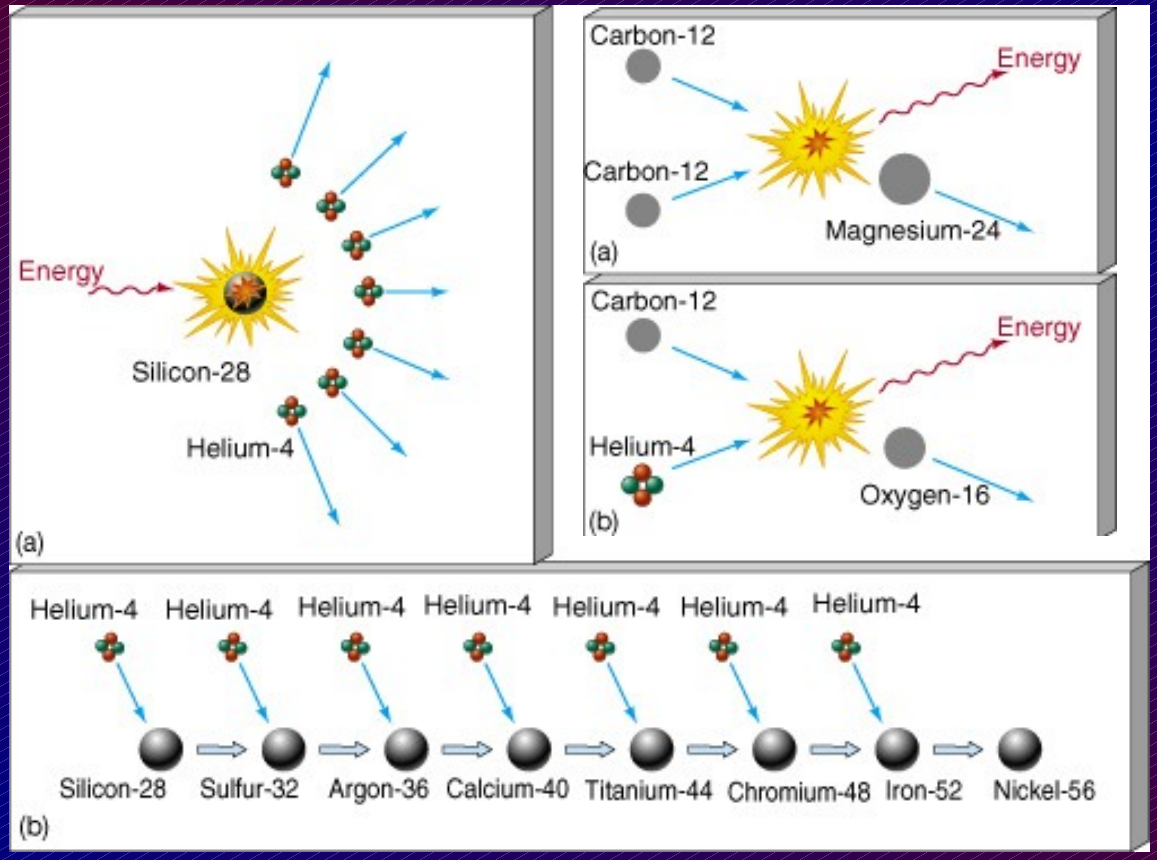
V. The source of the elements.

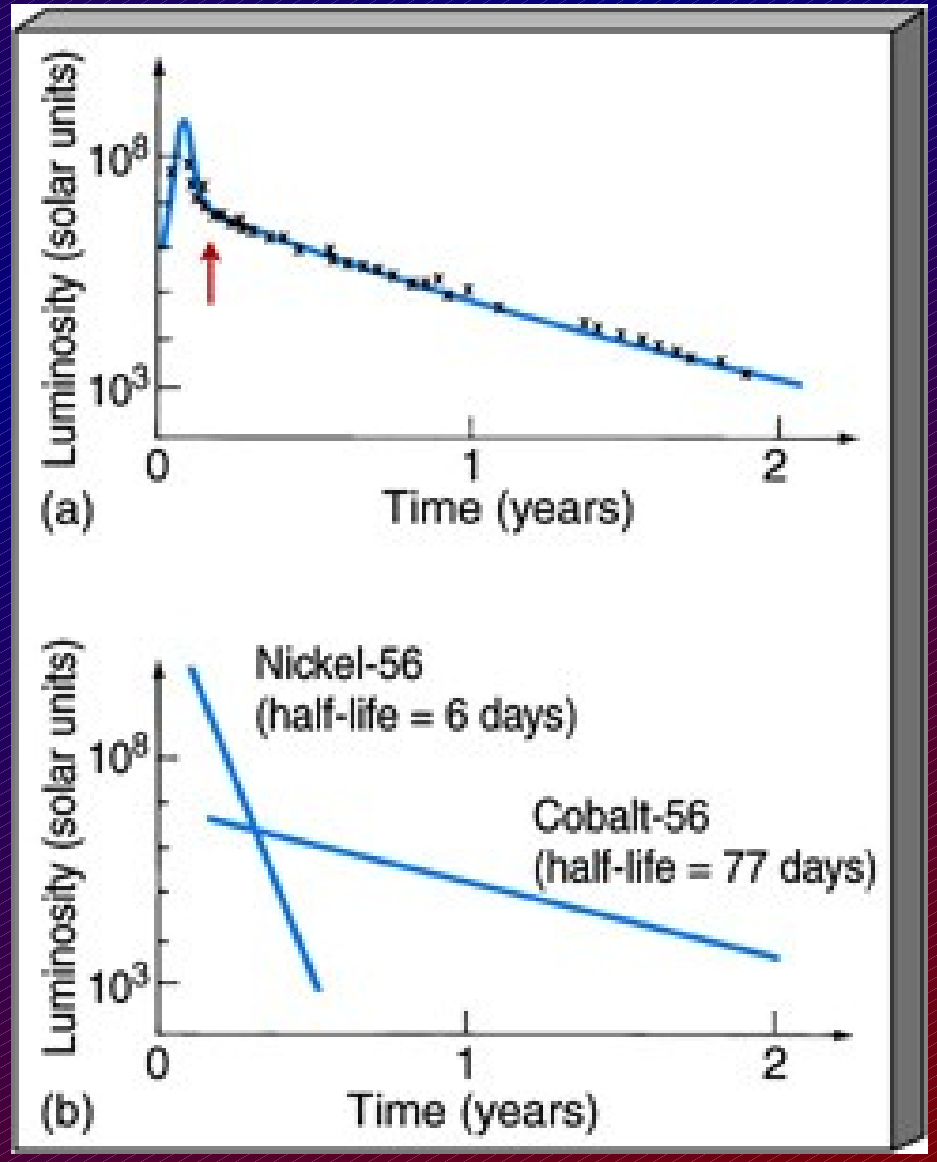




V. The source of the elements.

Alpha-process – elements w/even atomic numbers
S-process elements: Ca, Ti, Cr, ^{209}Bismuth
R-process elements: Thorium, Uranium, Plutonium



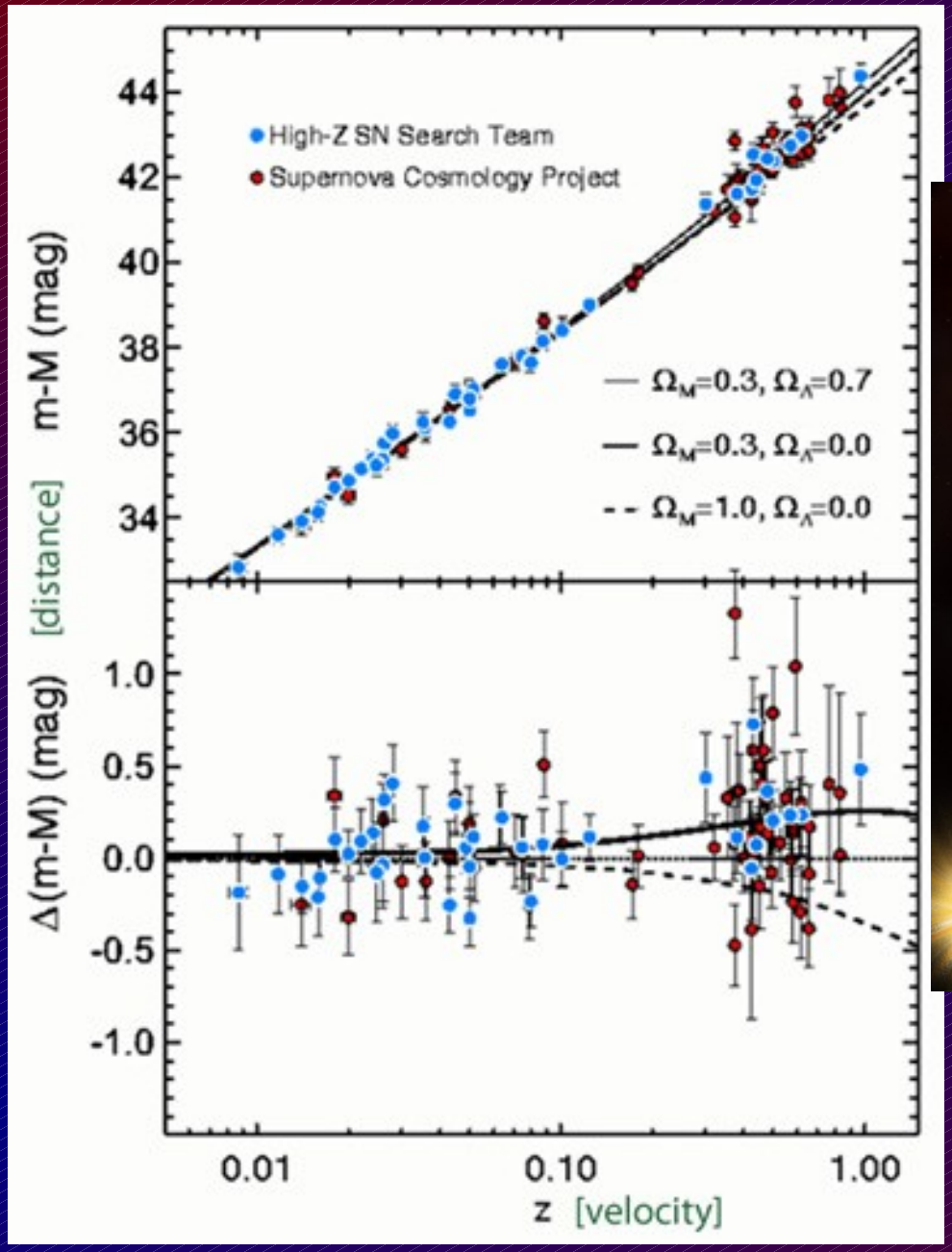


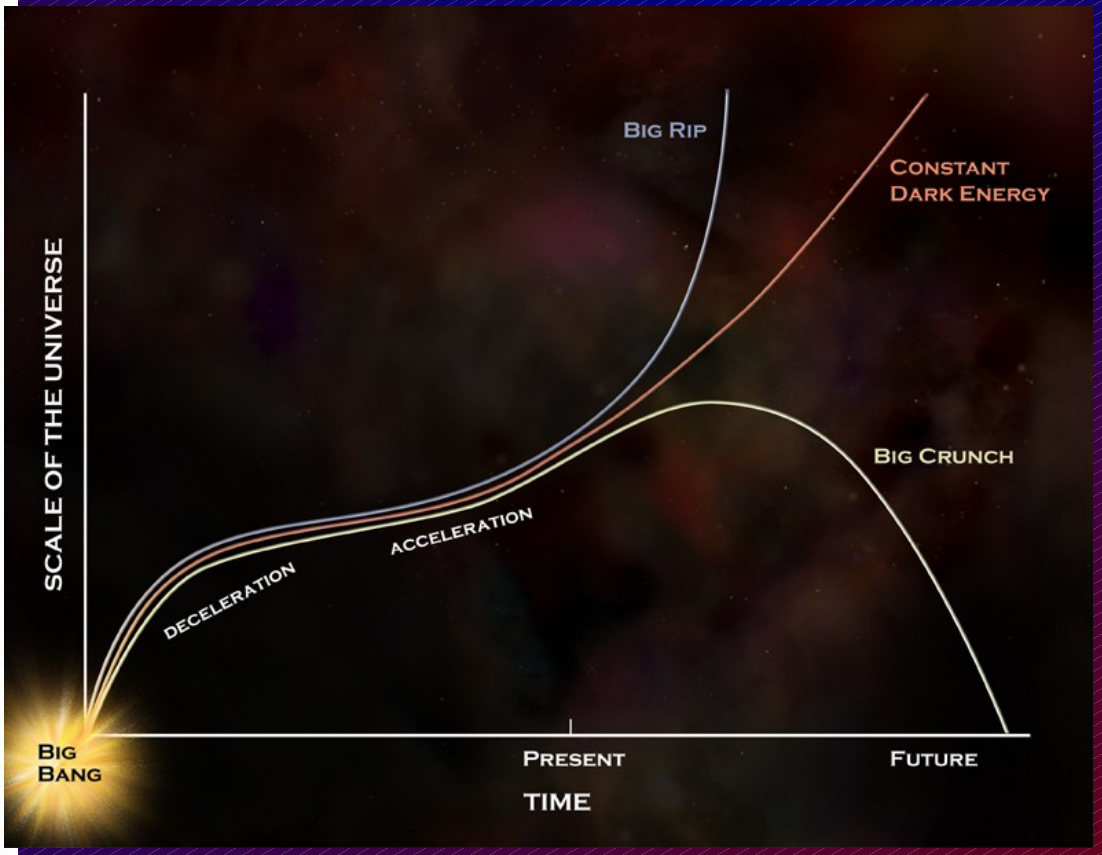
VI. Important tool for cosmology

Type Ia most useful
- Most luminous
- Same max luminosity every time
- Luminosity correlates with light curve

Click on the picture to see the full gallery shot of all 139 new Type Ia supernovae.

VI. Important tool for cosmology





New flurry of supernova excitement.

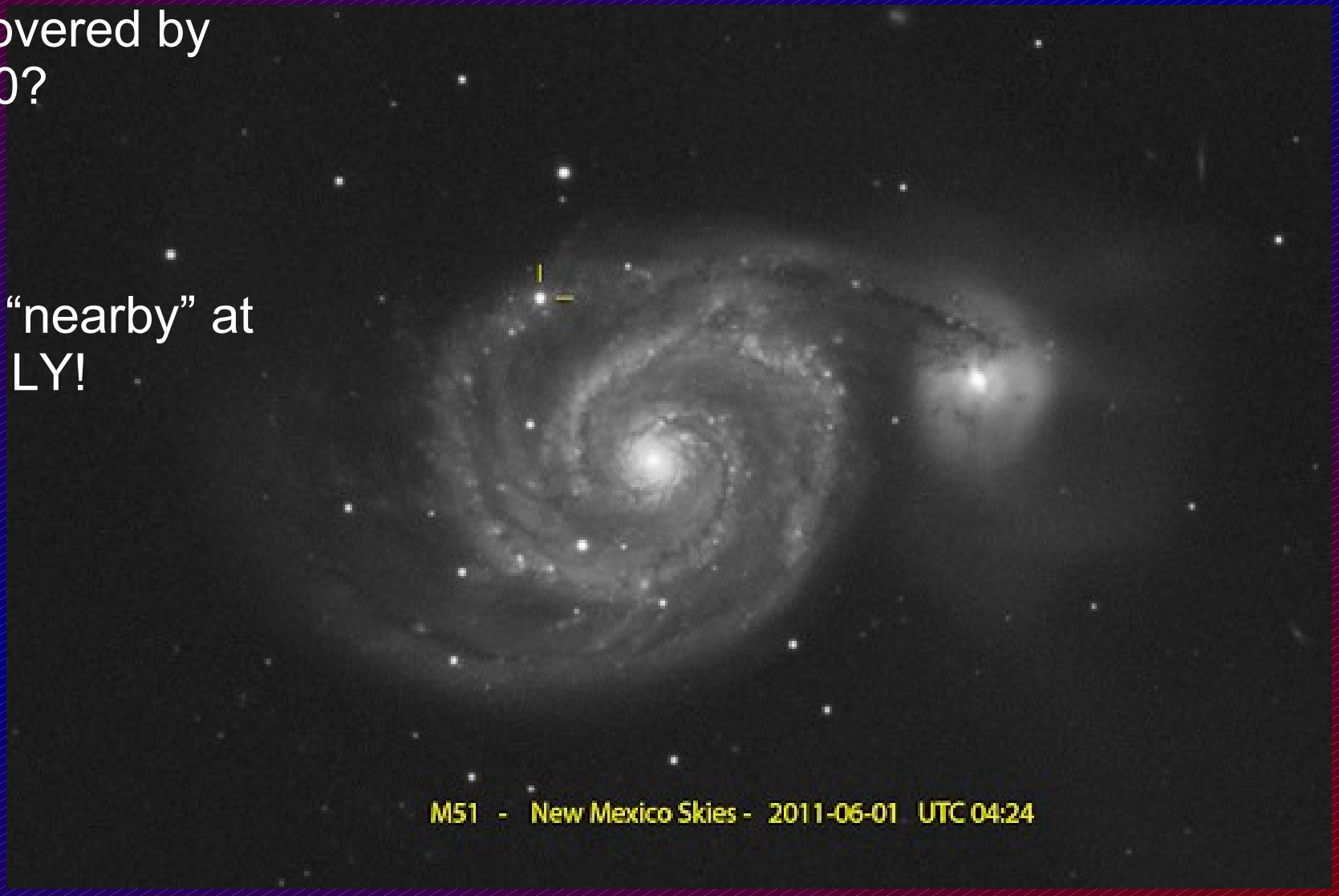
- A supernova is expected once every 50-100 yrs, but we haven't seen one since about 1680 (Cas A).
- Previous ones were visible during the daytime! Dangerous if too close!
- SN1987A was in the Large Magellanic Cloud
- M51 – 23 MLy
- M101 – 27 MLy

New Supernova in M51

First discovered by
on May 30?

Type Ia.

Galaxy is “nearby” at
23 million LY!



New Supernova in M51

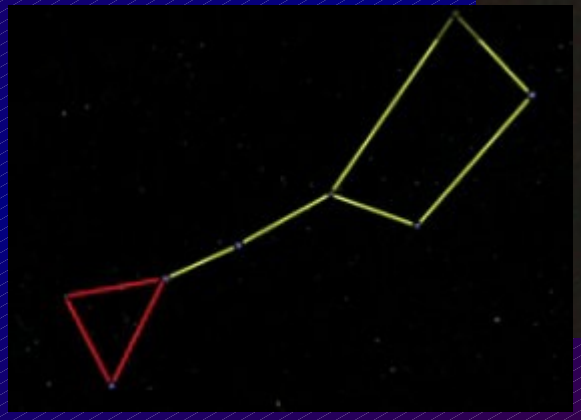
ONU picture with Mead DSI II on June 3, 2011.

New Supernova in M101

First discovered by PTF* survey on Aug 23.

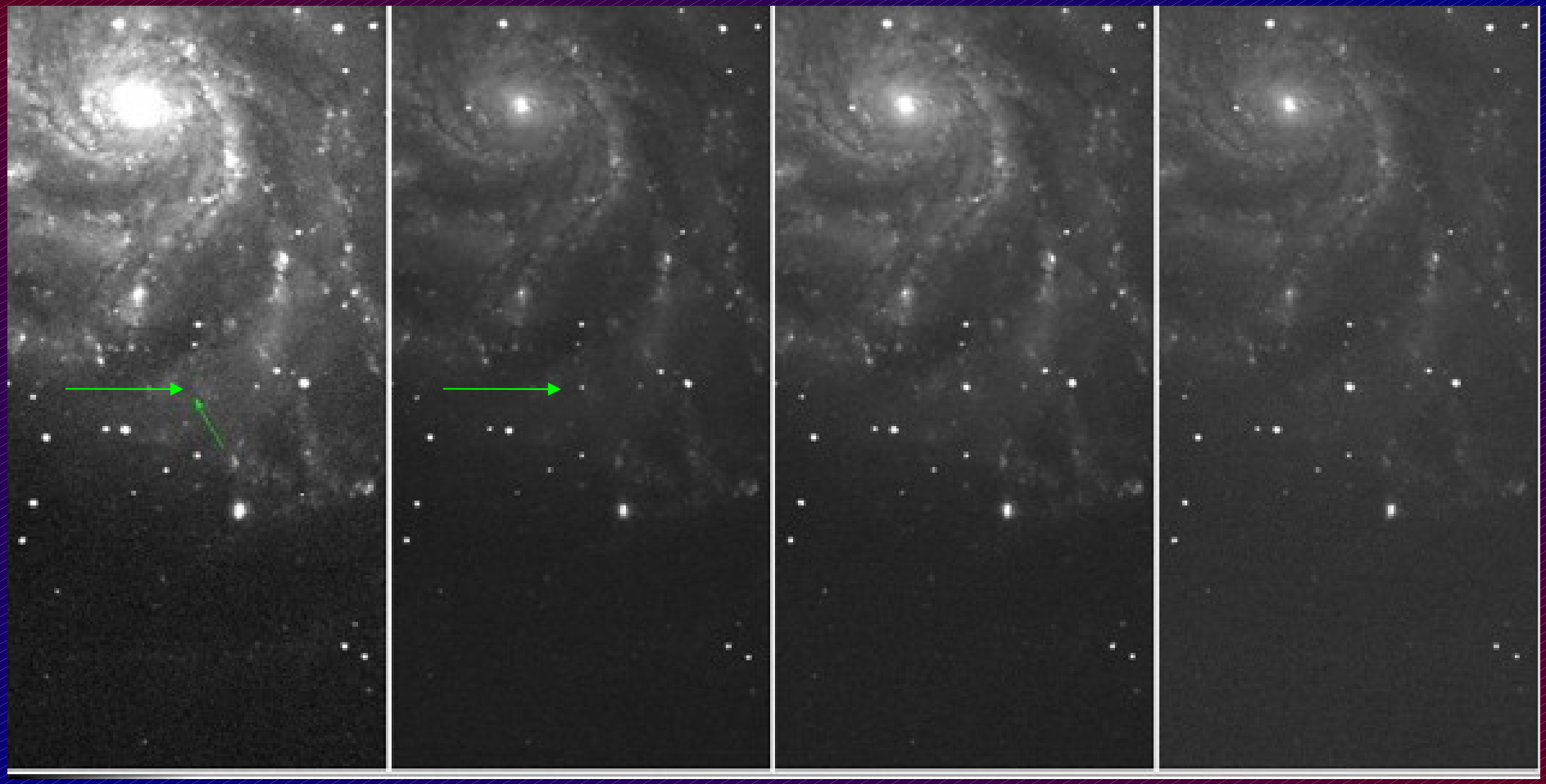
Type Ia.

Galaxy is “nearby” at 27 million LY!



*Palomar Transient Factory

Supernova in M101!



Aug 23 Aug 24 Aug 25 Aug 26

Dr. Jason Pinkney, 2011

New Supernova in M101

ONU picture with Mead DSI II on Aug 28, 2011.

Supernovae

SUMMARY

Types of supernovae based on light curve, spectra
An end stage of stellar evolution for a WD or massive star
The remnants (SNR) are dynamic and exotic
They create the heavy elements.
They are used in cosmology - revealed acceleration of universe
They recently happened in 2 nearby galaxies, not ours.

Which star is next to blow?

Eta Carina?

Betelgeuse?

Deneb?

Antares?

Garnet star?