Tuesday, October 13, 2009

Reading: Chapter 7, SN 1987A

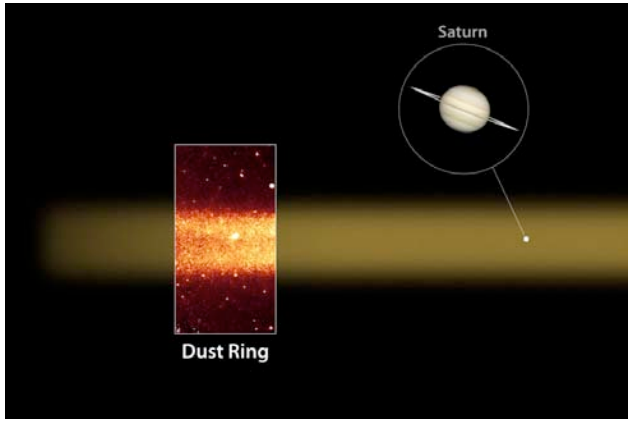
Movies posted on web site

Second exam Thursday, Review sheet posted, Review Wednesday
WEL 2.308, 5 - 6 PM

Turn in next Sky Watch at exam.

Astronomy in the News? No plume from Moon shot, may still be evidence of water.

Pic of the Day - huge new dust ring around Saturn



Detonations do not give the star time to react.

⇒For ***detonation alone***, the white dwarf would be turned essentially entirely to iron, ***Wrong!***

Deflagrations give the outer parts of the white dwarf time to expand, quench burning.

⇒For ***deflagration alone***, the outer parts are never burned, explosion would be relatively weak, substantial unburned carbon and oxygen must be expelled.

Careful observation in the ***infrared*** show no carbon survives the explosion, so ***Wrong!***

⇒For deflagration followed by detonation:

The detonation catches up with the expanding outer parts

Burns everything to intermediate mass elements, Mg, Si, S, Ca, but not to iron

Gives the right energy

Predicts essentially no unburned carbon and oxygen.

Matches wide variety of observations!

Physics problem - why does the deflagration change to detonation?

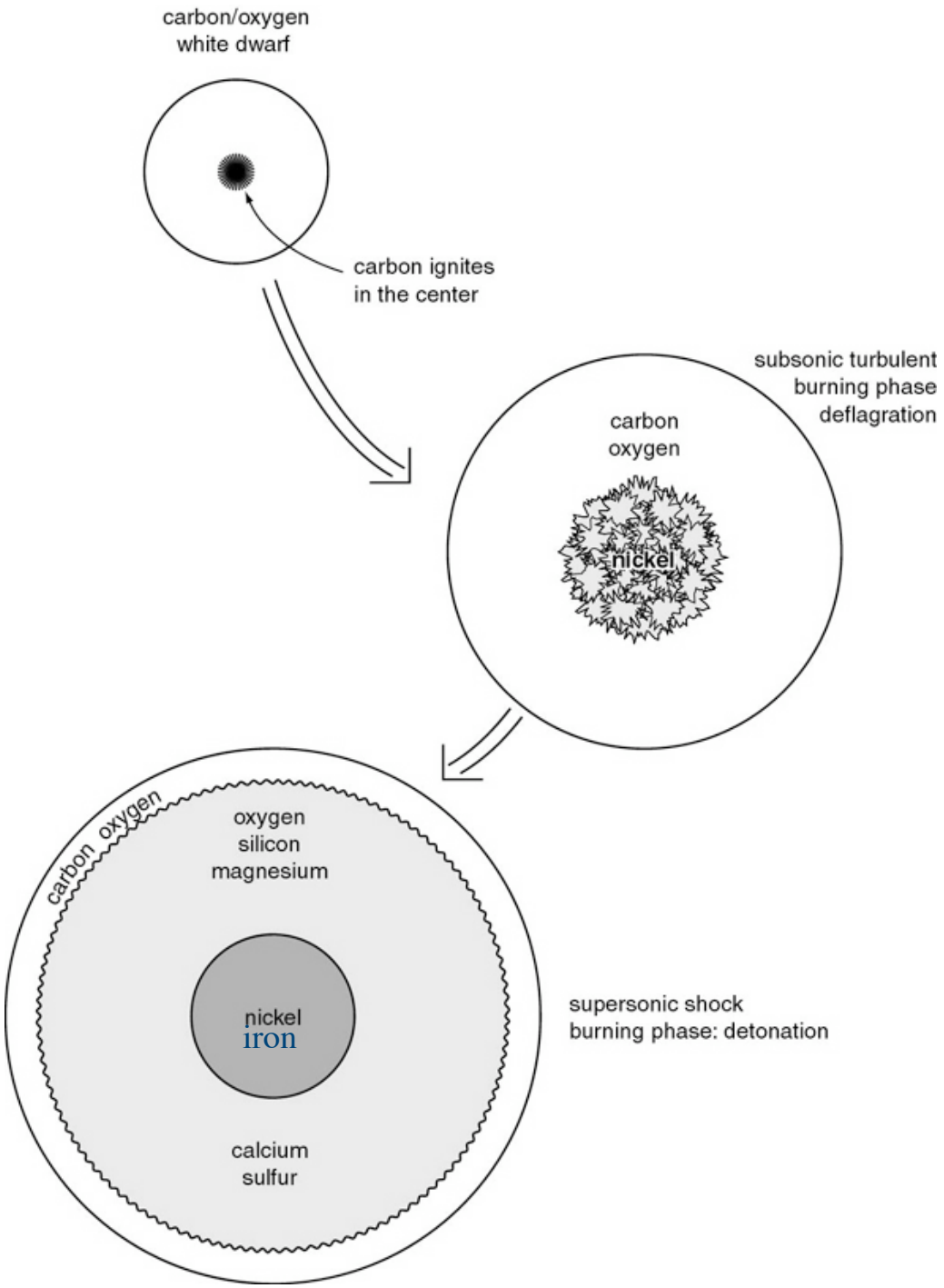
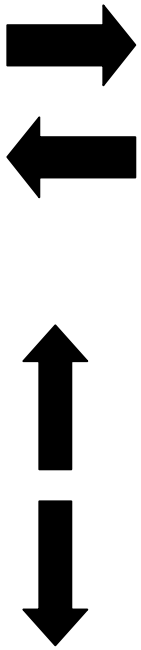

carbon/oxygen
white dwarf
carbon ignites
in the center
subsonic turbulent
burning phase
deflagration
carbon
oxygen
nickel
carbon oxygen
oxygen
silicon
magnesium
nickel
iron
calcium
sulfur
supersonic shock
burning phase: detonation

Figure 6.6

One Minute Exam

Astronomers detect Silicon when a Type Ia supernova is brightest and iron after it has faded. This means:



The exploded material is made of equal parts silicon and iron

The iron is in the inner portions of the ejected matter, the silicon in the outer portions

The white dwarf that exploded could not be made of carbon and oxygen

The supernovae was powered by the collapse of an iron core

Type Ia ***are*** Chandrasekhar mass carbon/oxygen white dwarfs

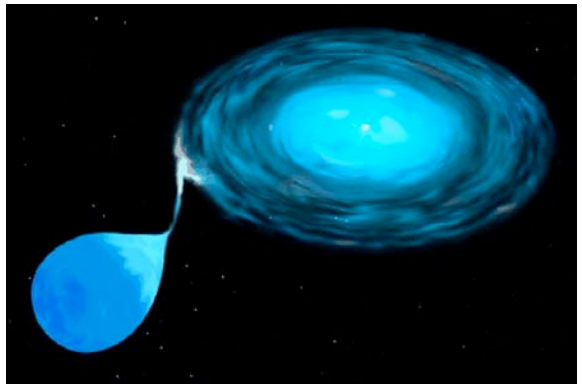
How does nature grow a white dwarf to 1.4 $M_{\odot}$?

Classical Novae: Problem with losing mass from white dwarf

Recurrent Novae: do seem to have large mass white dwarfs, encouraging.

Probably a binary, everyone assumes so.

No direct evidence, some recent indirect hints.

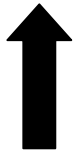


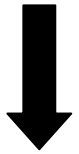
One Minute Exam

Why does a subsonic deflagration “flame” alone fail to account for the observations of a Type Ia supernova?


All the ejected matter would be iron.


A neutron star would be left behind.


The ejected matter would contain lots of carbon

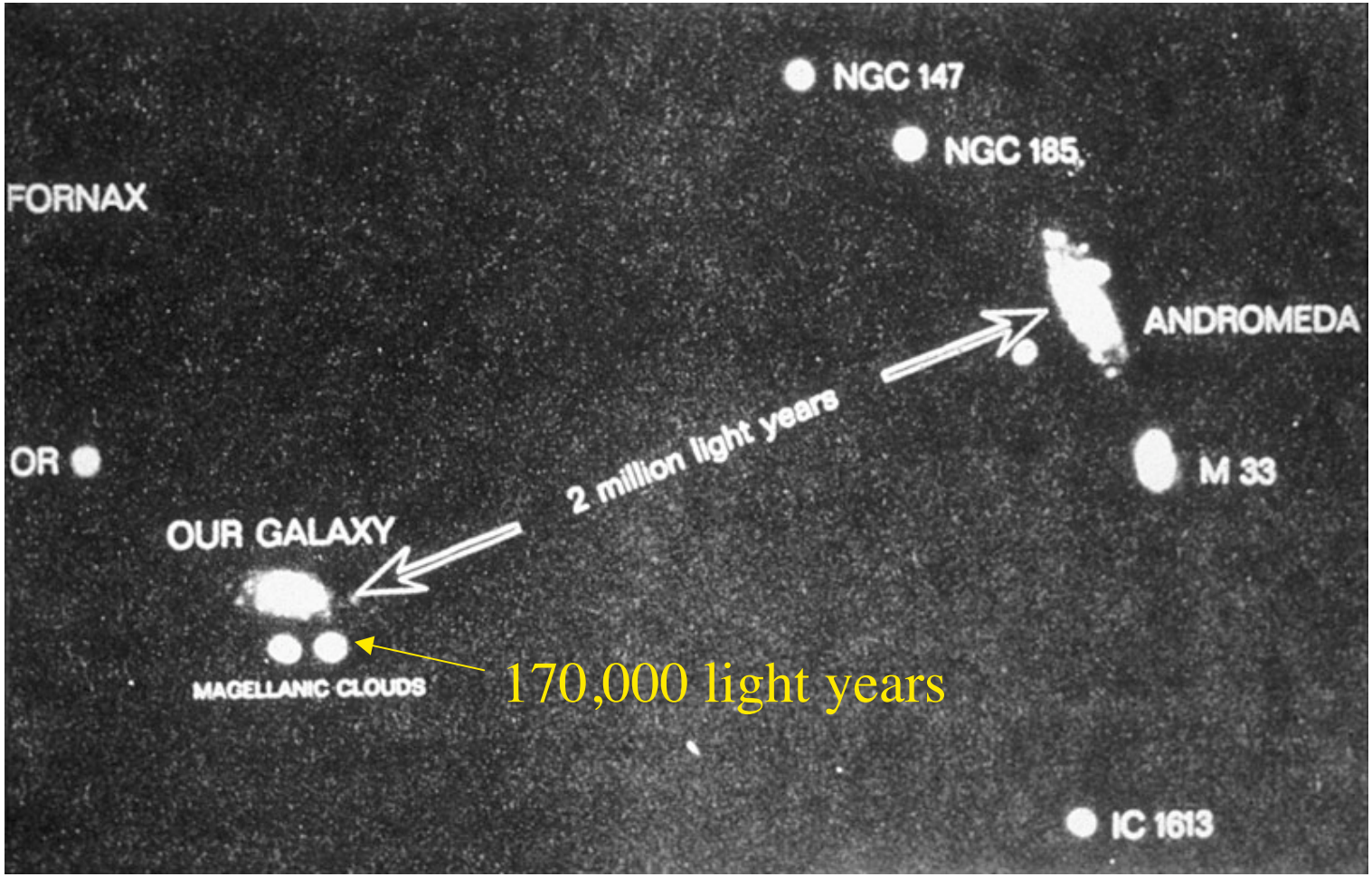

The ejected matter would have silicon on the outside and iron on the inside

Kepler

SN 1987A
first naked eye
supernova since
Kepler's in
1604

Tycho

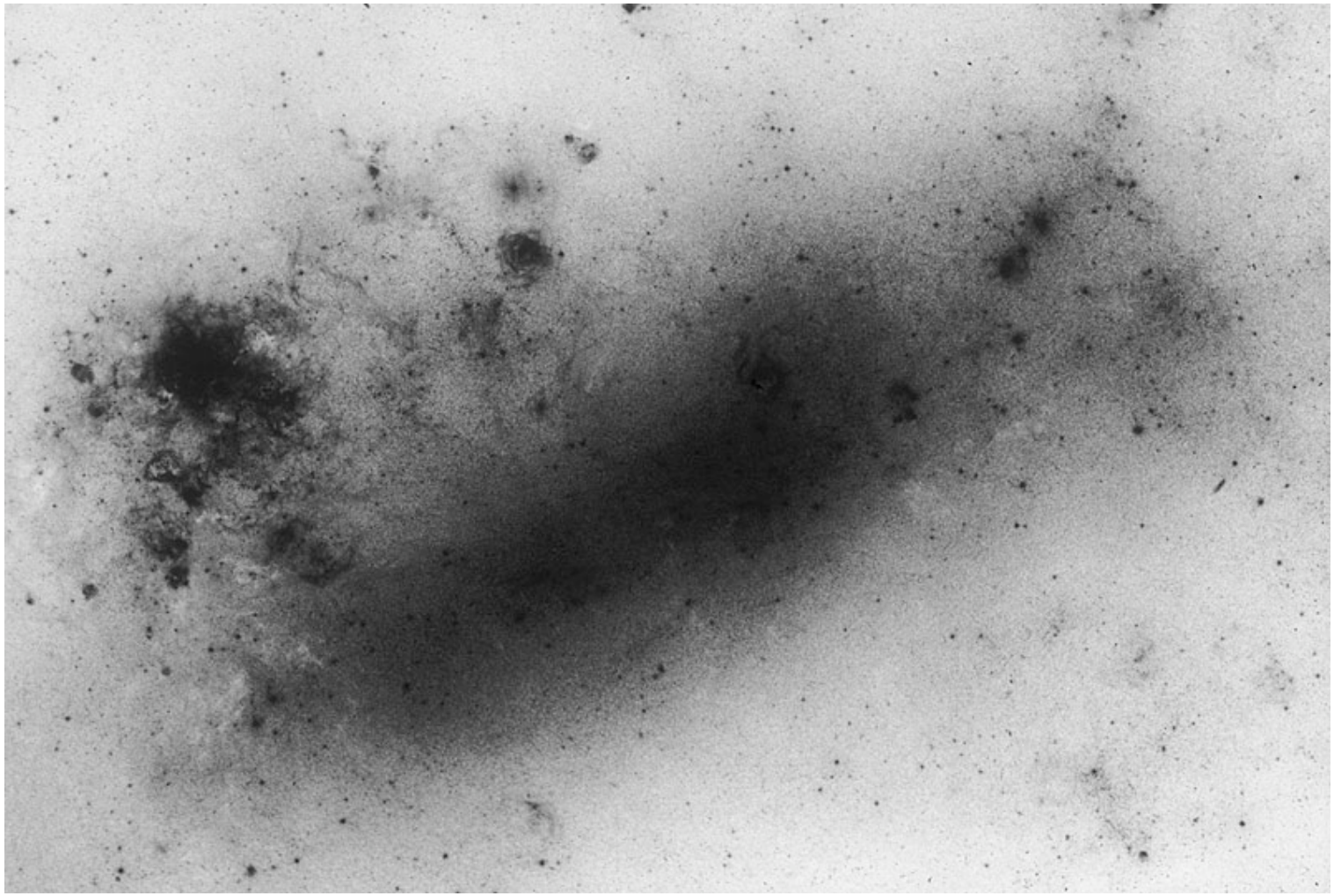
Local group


NGC 147
NGC 185
FORNAX
ANDROMEDA
OR
2 million light years
M 33
OUR GALAXY
MAGELLANIC CLOUDS
170,000 light years
IC 1613

Large Magellanic Cloud, irregular galaxy (color)

Large Magellanic Cloud, larger scale

LMC negative



Rob McNaught patrol photos - the day before

2-22-87

The first known photo of SN 1987A hours after shock breakout

2-23-87

One day later

2-24-87

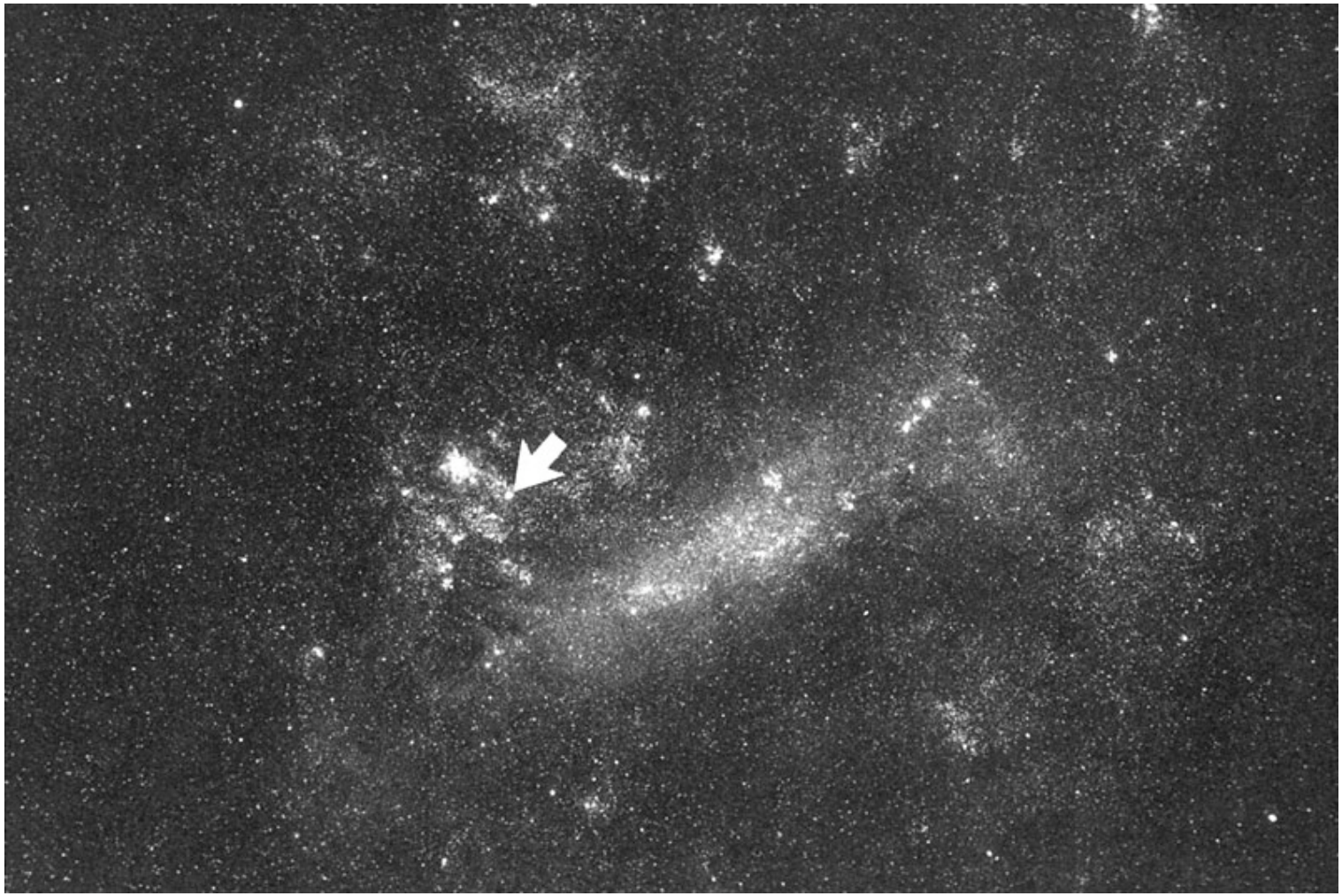
Near maximum light

5-20-87

About when I saw it

8-23-87

LMC w/arrow



One Minute Exam

When SN 1987A exploded, where would have been a good place to have seen it with your naked eye?

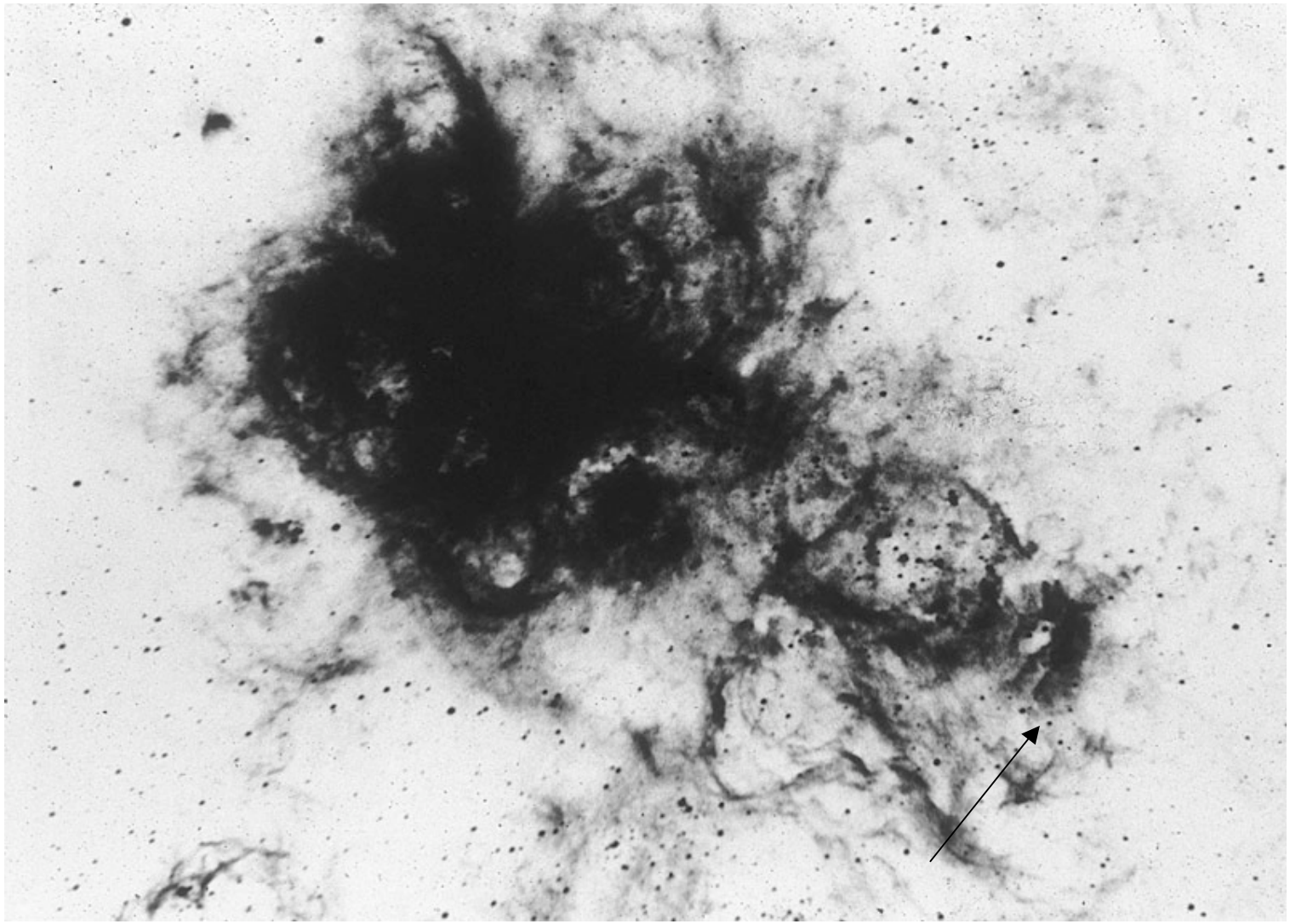
 Texas

 Japan

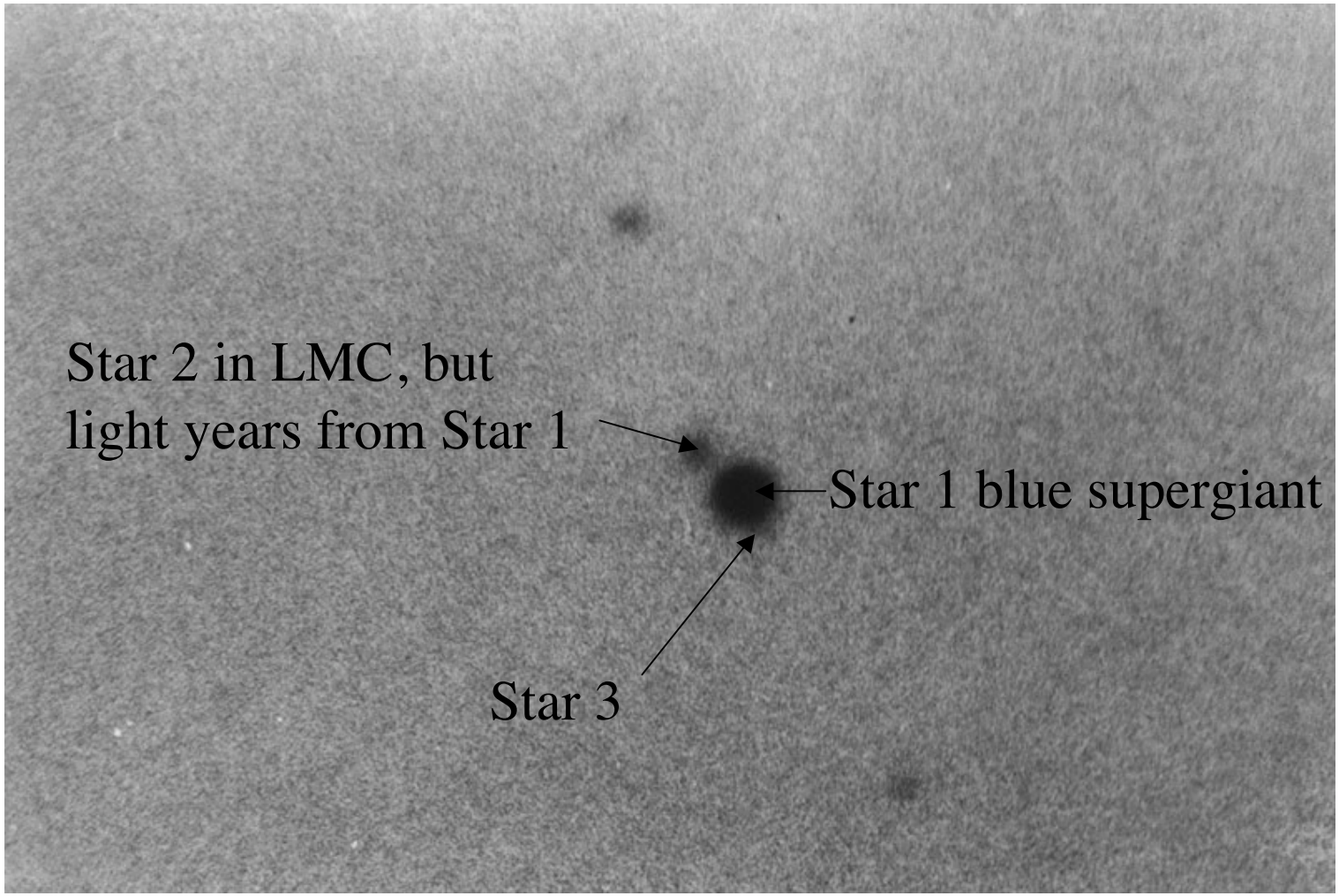
 Russia

 Argentina

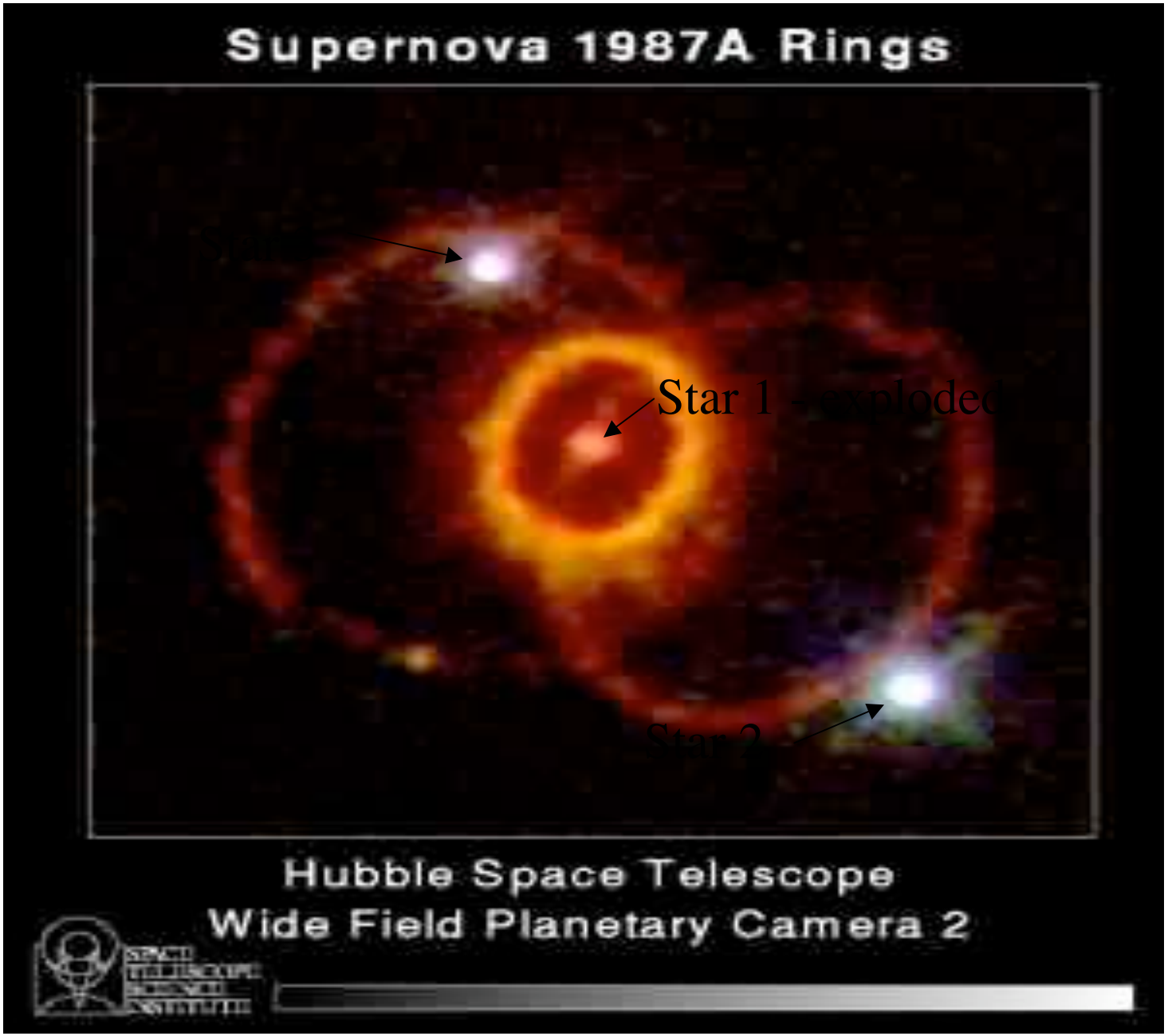
Photo of progenitor star (giraffe)

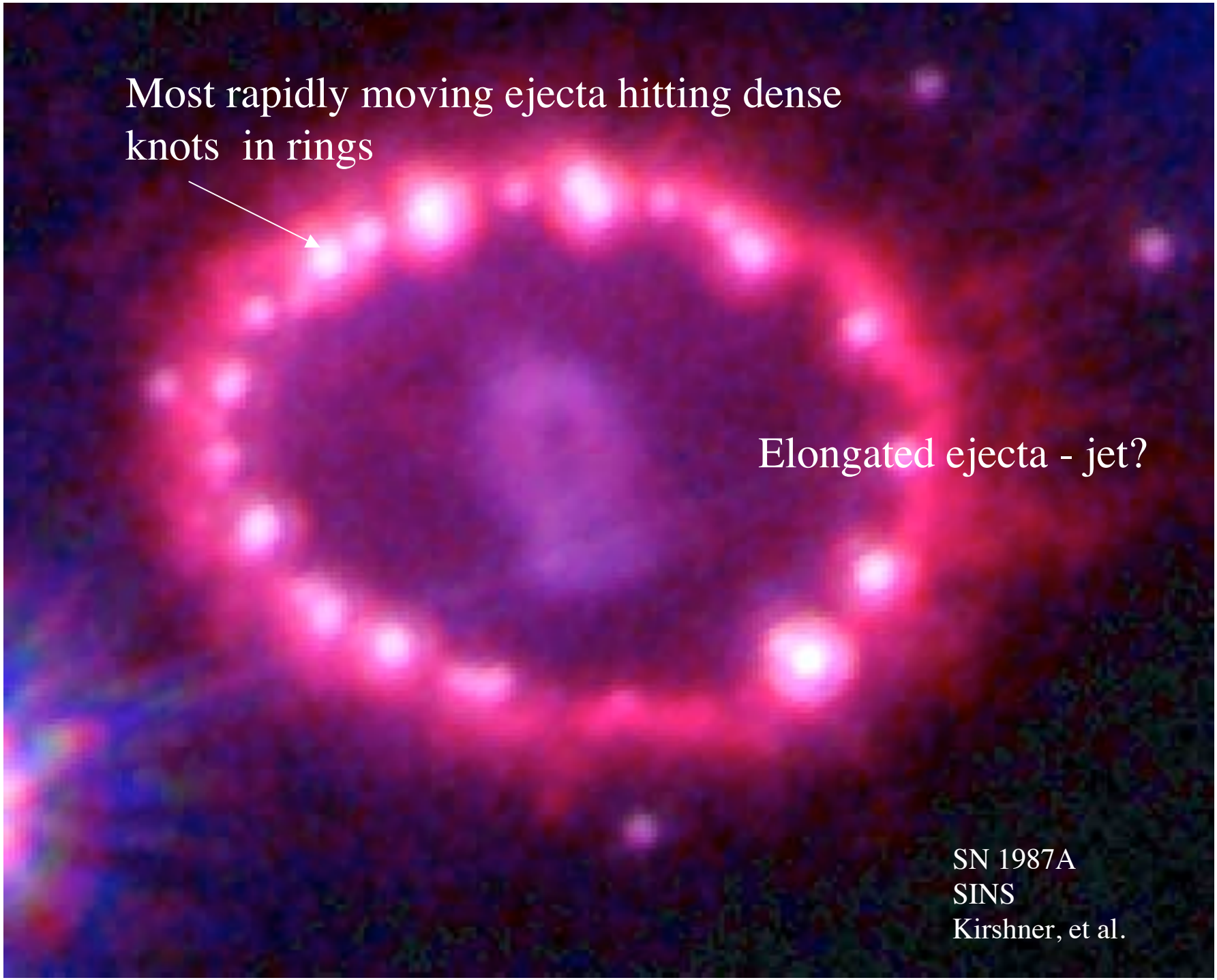


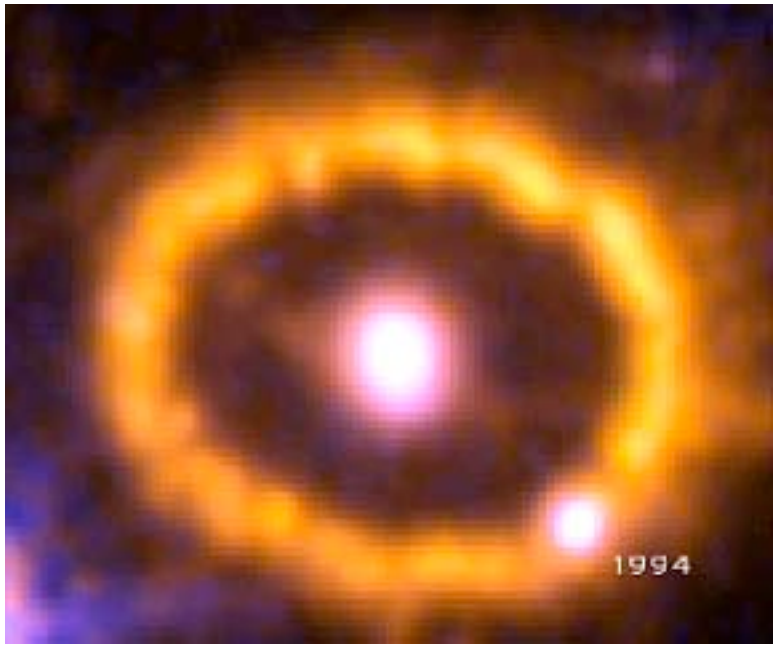
Stars 1, 2, 3

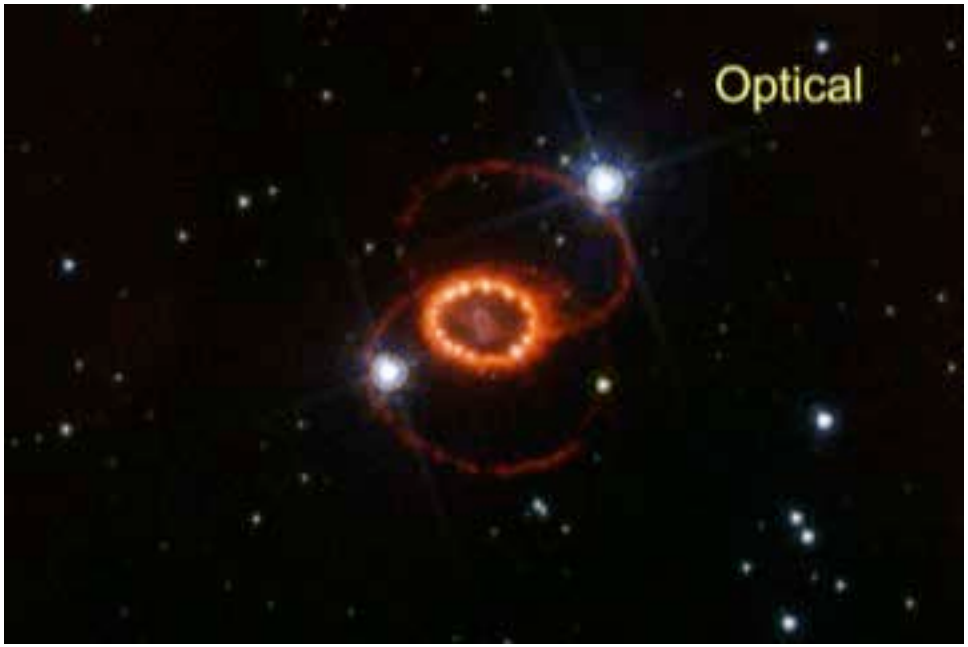


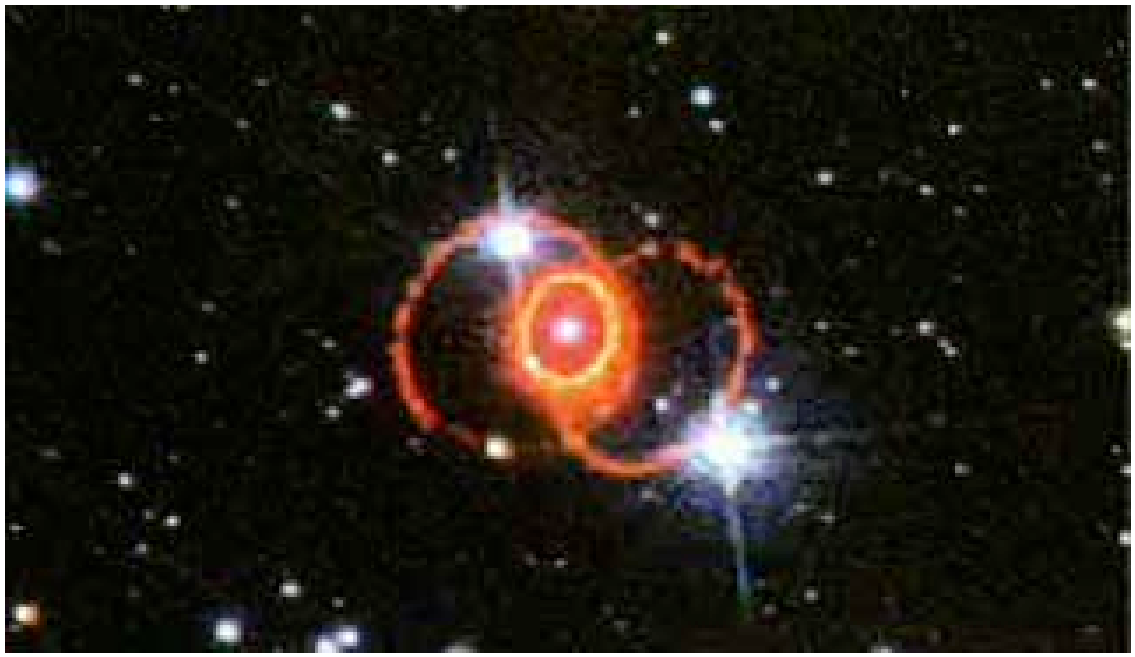
Close-up


Supernova 1987A Rings
Star 1 - exploded
Star 2
Hubble Space Telescope
Wide Field Planetary Camera 2


Most rapidly moving ejecta hitting dense knots in rings
Elongated ejecta - jet?
SN 1987A
SINS
Kirshner, et al.


1994


Optical



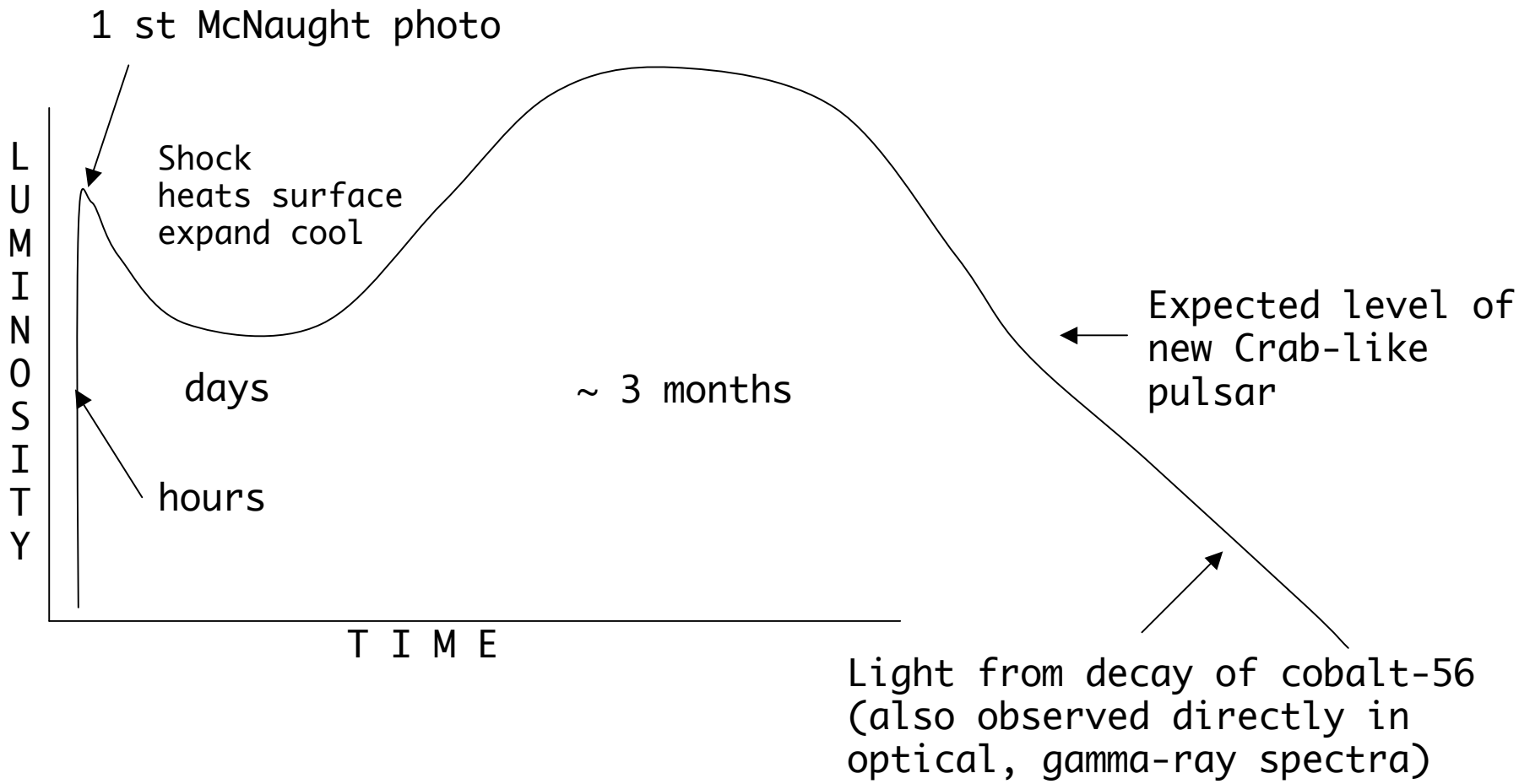
The single most important thing about SN 1987A is that we detected the neutrinos!

It was definitely a core-collapse event

10^{57} neutrinos emitted, most missed the Earth. Of those that hit the Earth, most passed though since neutrinos scarcely interact.

About 19 neutrinos were detected in a 10 second burst.

170,000 year history!



SN 1987A had a rather peculiar light curve because it was a relatively compact blue supergiant, not a red supergiant, brief shock heating, rapid cooling by expansion, no plateau, subsequent light all from radioactive decay

Neutrinos from SN 1987A proved a neutron star formed and lasted for at least 10 seconds while neutrinos were detected - where is it?

Expected to see it in ~ 1 year - still looking 22 years later

Any neutron star is dimmer by at least a factor of 10 than 1000 year-old Crab pulsar

If similar to object in Cas A, much too dim to detect
100 to 1000 × dimmer than Crab pulsar

Possibly black hole, not neutron star??
Don't know. Can't rule out.

Neutron star could be "hidden," or a slow rotator, or with a weak magnetic field, but counter to notion of jet - some evidence for jet, pr a very strong magnetic field that would radiate and slow it down quickly.

One Minute Exam

What was the most important thing about SN 1987A in terms of the basic physics of core collapse?

 It exploded in a blue, not a red supergiant

 It was surrounded by a ring

 It could be seen by the naked eye

 Neutrinos were detected from it

End of Material for Test 2

Story of how stars come to explode.

Two varieties, thermonuclear explosions of white dwarfs and core collapse.