Type II Supernova Cosmology

Thomas de Jaeger

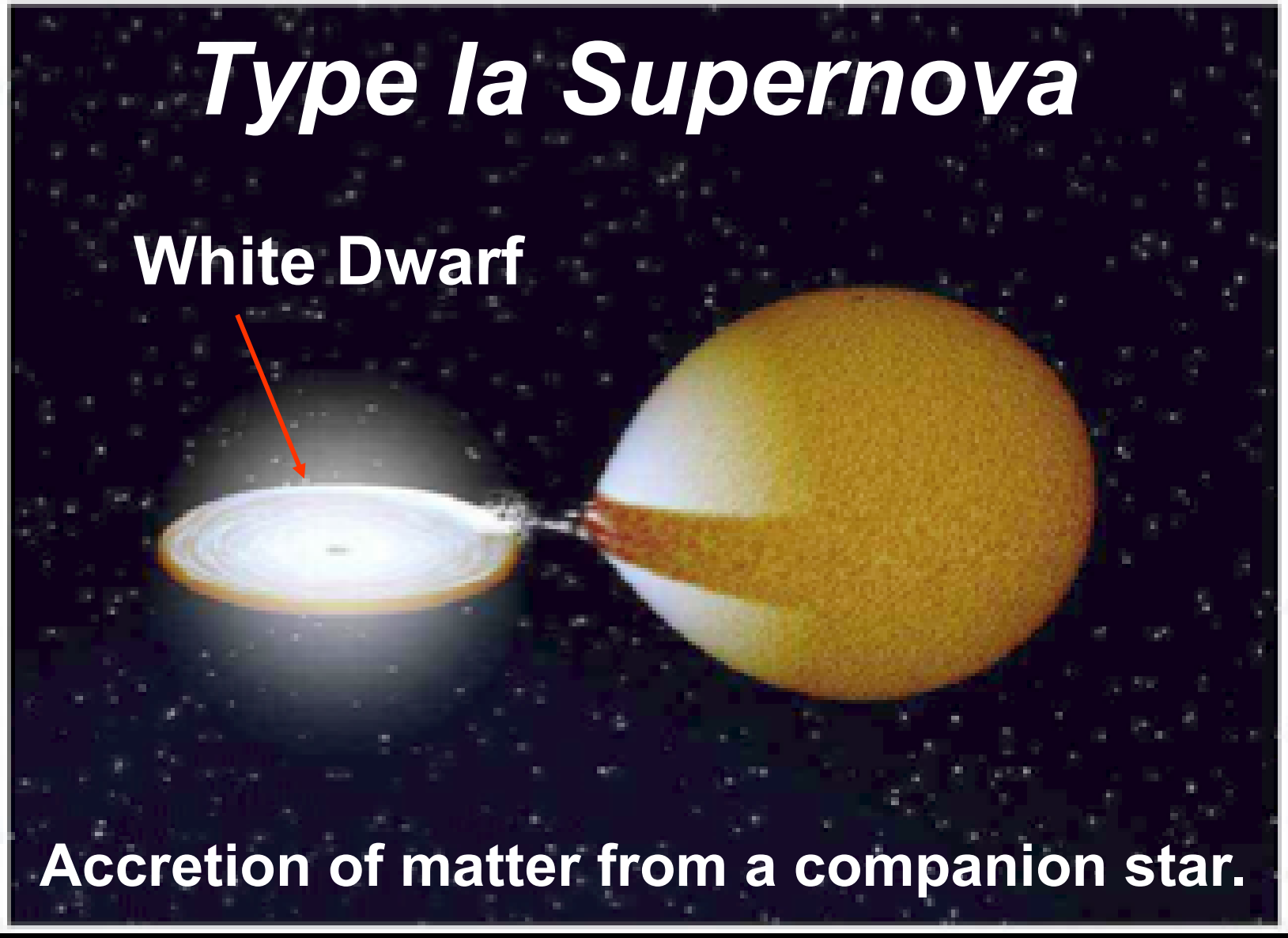
(Bengier and Google/Lick Postdoctoral Fellow, UCB)

04/18/2019
UC Berkeley

Type Ia Supernovae (Alex, Ben)

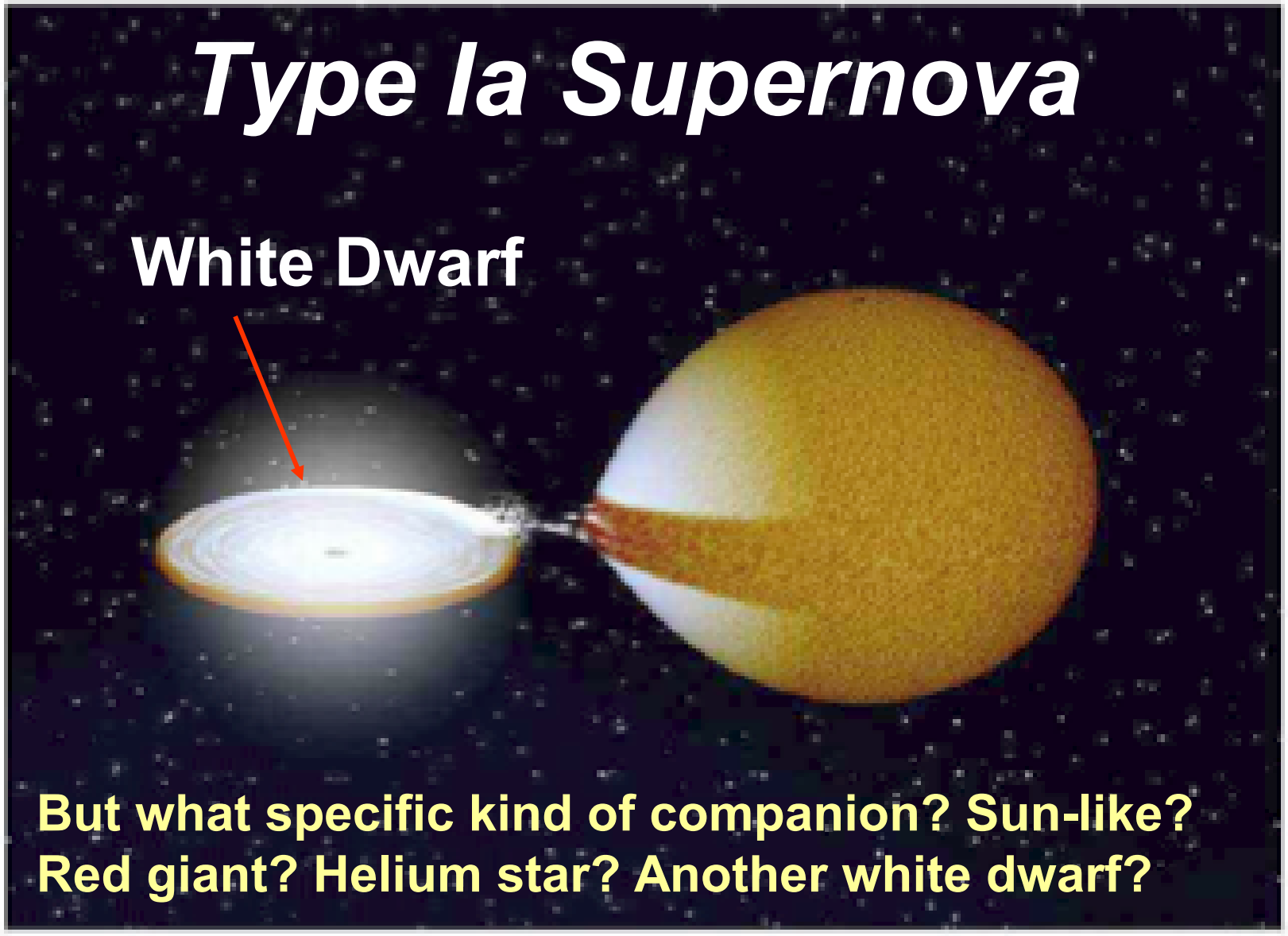
- SNe Ia are the most mature and well-exploited objects for galaxy distance measurements and the present-day Hubble constant.
- But we also need independent methods to verify the apparent discrepancy in the value of H_0.
- Ideally, use supernovae with better understood *progenitor stars*.

Type Ia Supernova



An explosion resulting from the thermonuclear runaway of a white dwarf near its maximum mass

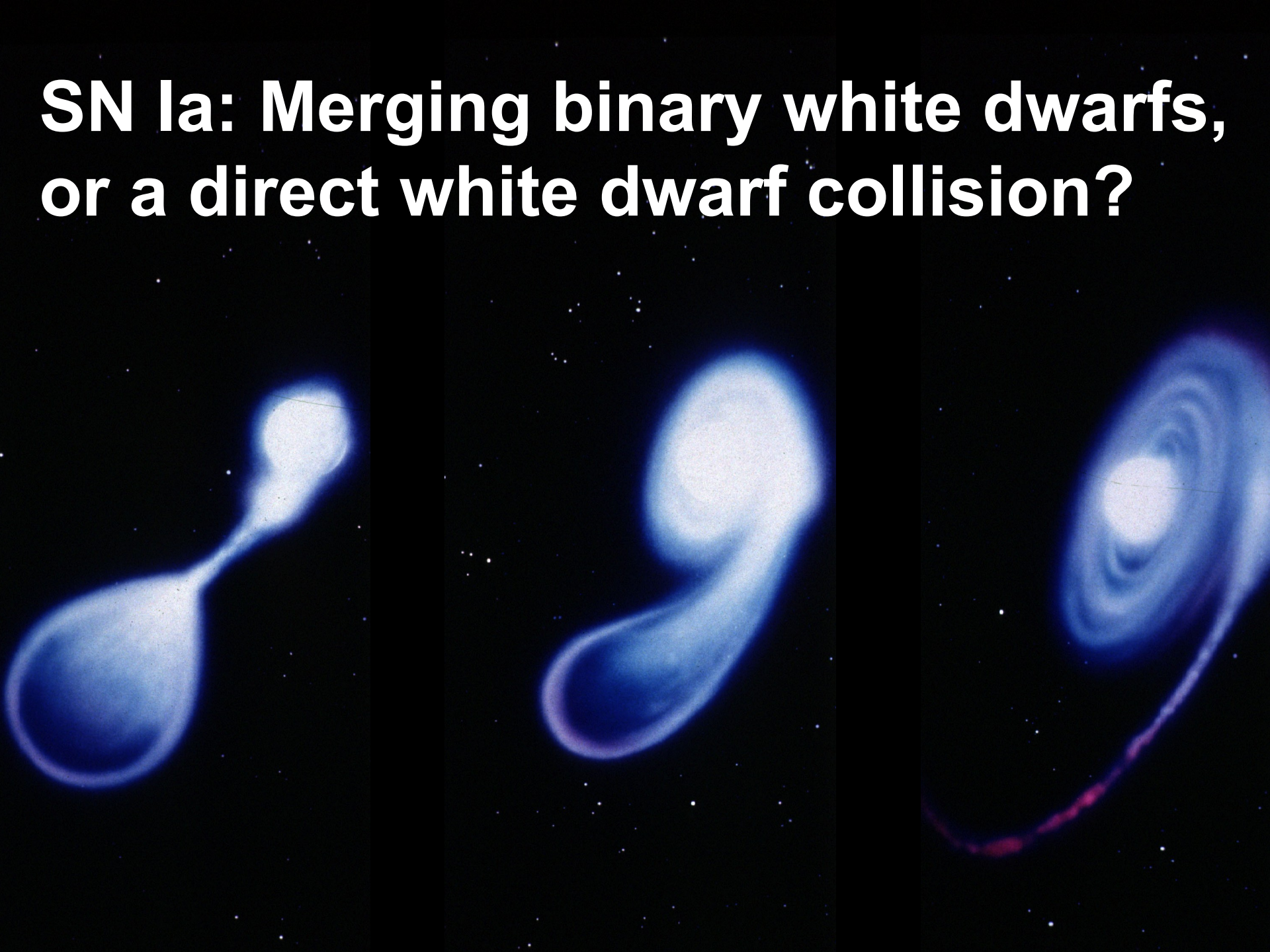
Type Ia Supernova



But what specific kind of companion? Sun-like? Red giant? Helium star? Another white dwarf?

And does the white dwarf need to have close to its maximum possible mass? Could be less massive.

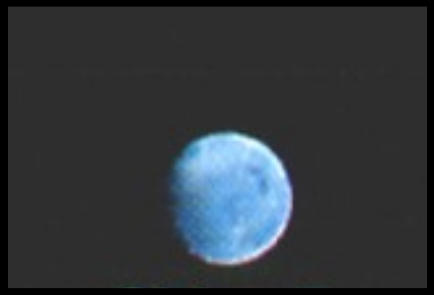
SN Ia: Merging binary white dwarfs, or a direct white dwarf collision?



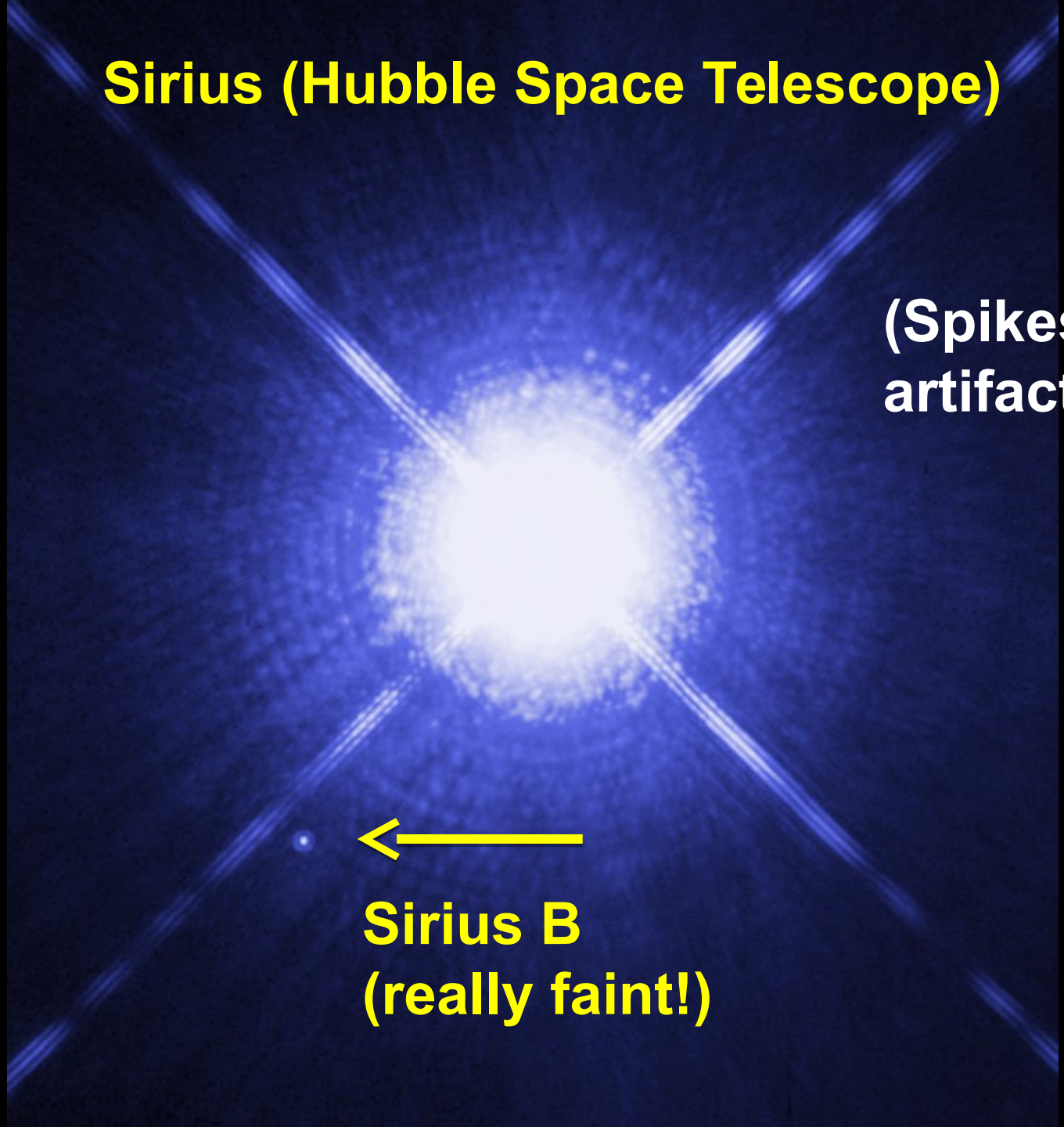
SUN

Earth

white dwarf

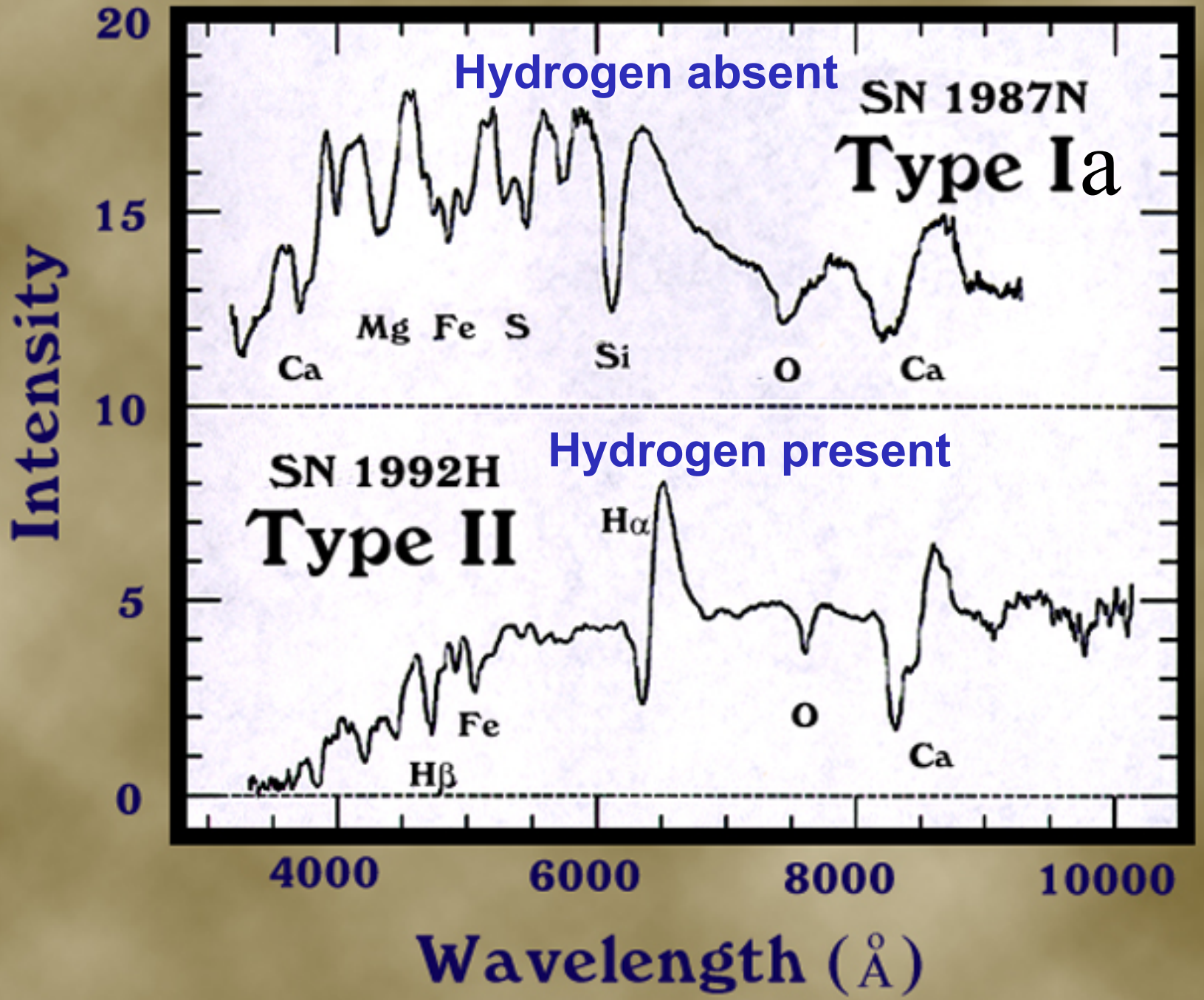


White dwarfs are very small, dim, and hard to see.


Sirius (Hubble Space Telescope)
(Spikes:
artifacts)
Sirius B
(really faint!)

Type II Supernovae

- Progenitors of Type Ia supernovae not well understood.
- There *might* be some kind of error we have not taken into account.
- Use Type II supernovae to check – completely independent of SNe Ia.


Hydrogen absent
SN 1987N
Type Ia
Ca
Mg Fe S
Si
O
Ca
Hydrogen present
SN 1992H
Type II
Hα
Fe
Hβ
O
Ca
Intensity
20
15
10
5
0
4000
6000
8000
10000
Wavelength (Å)

SN II Progenitors: Red Supergiants!

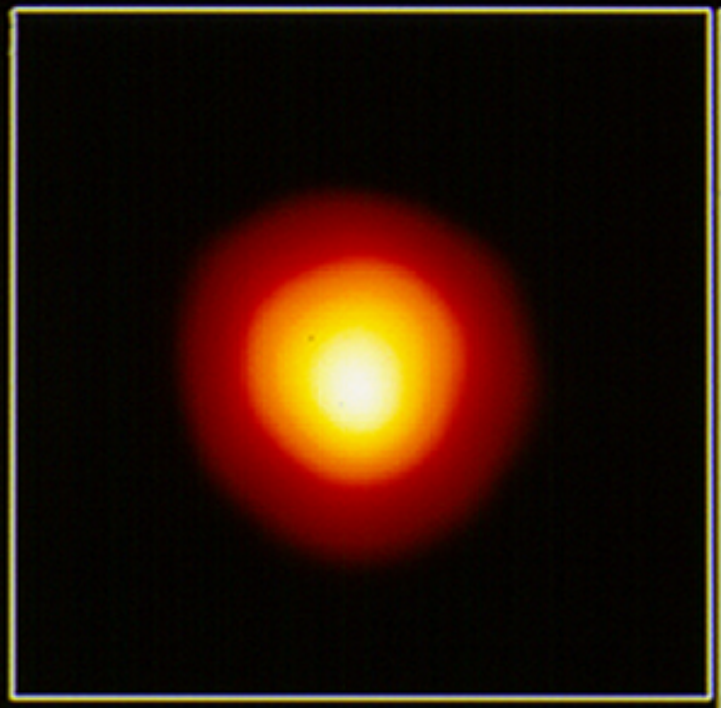
Pre-explosion star
(Matilla et al. 2010)

SN 2008bk

About 1000 days later

Red supergiant progenitors have been found for about 20 SNe II – no exceptions! Well understood.

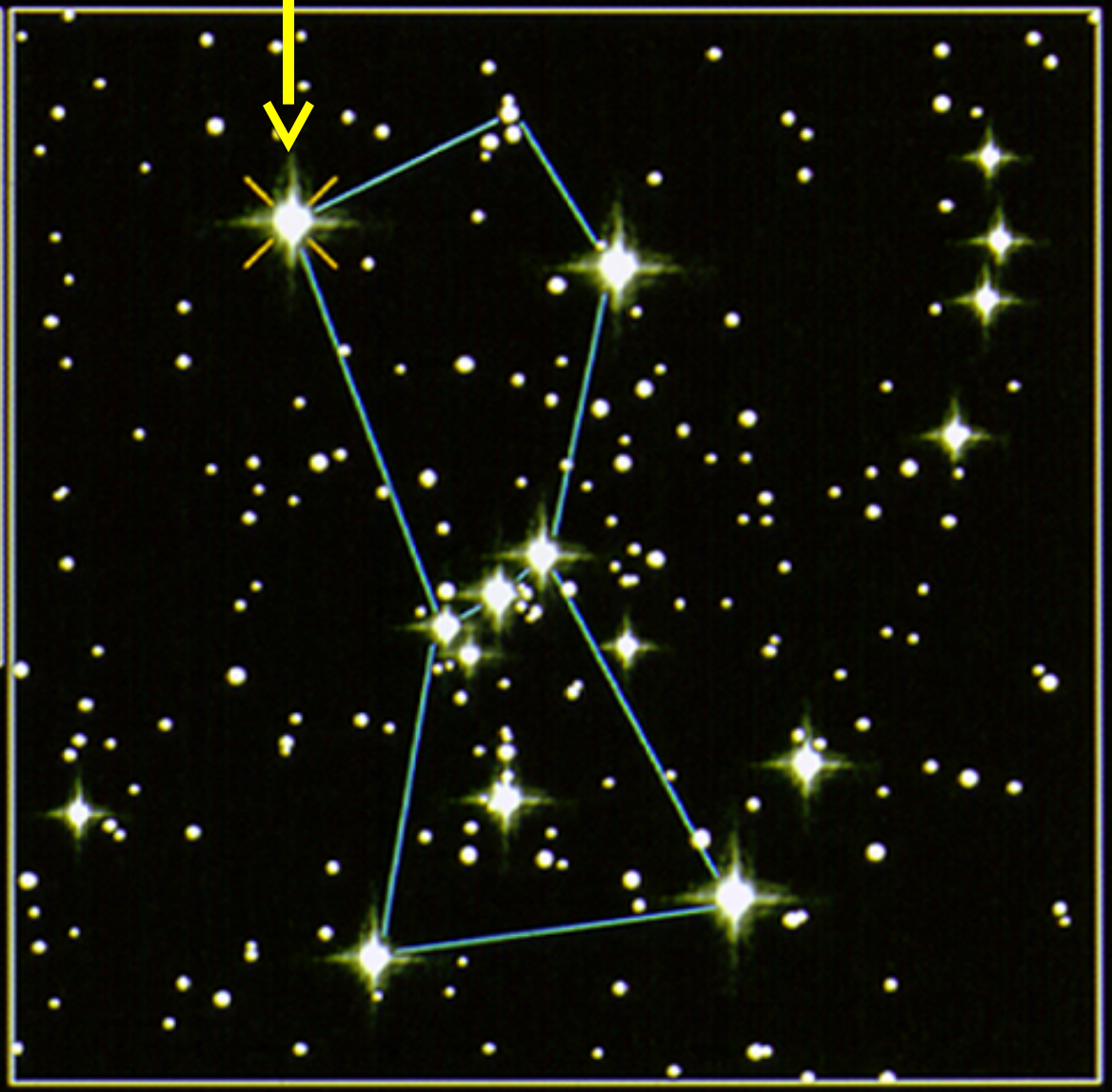
Betelgeuse

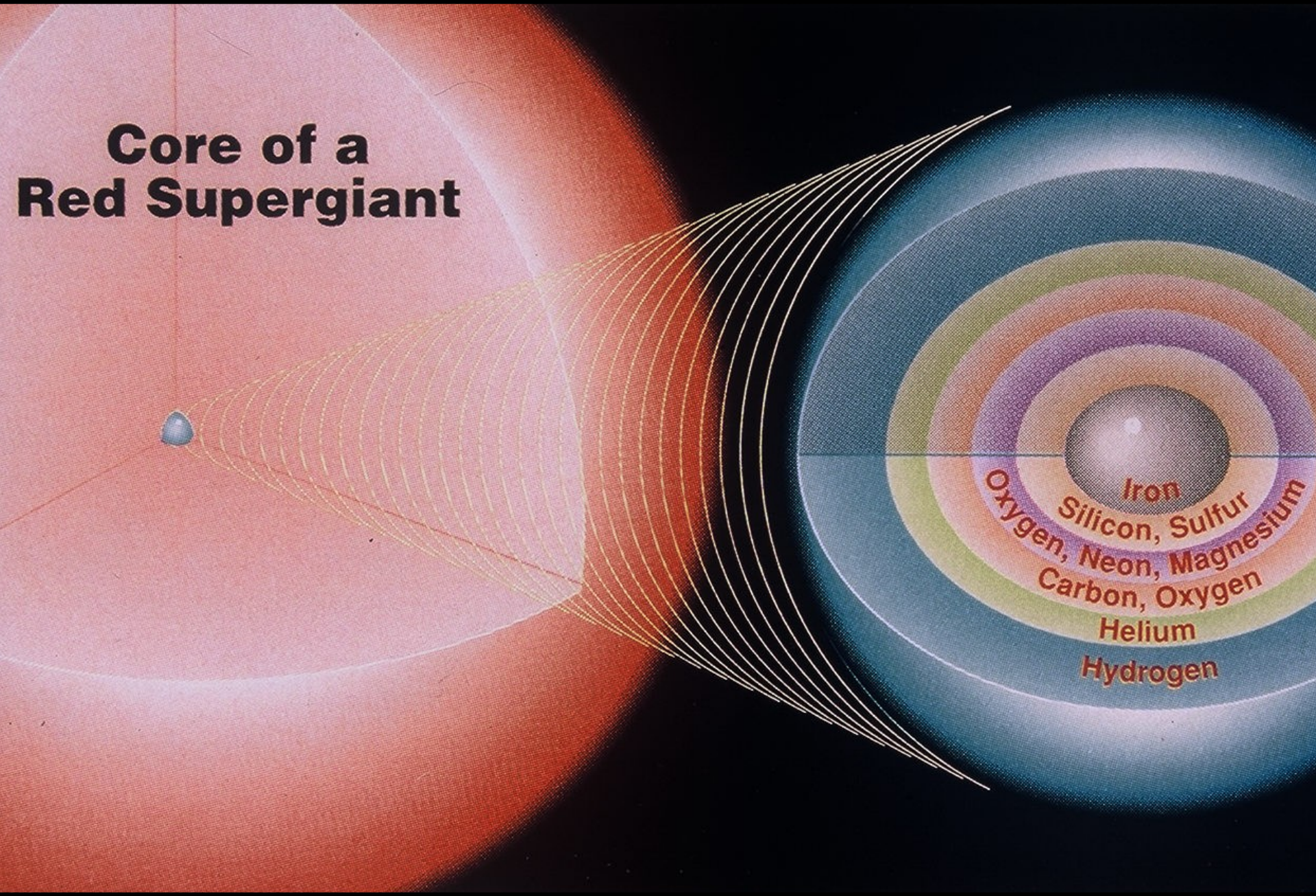


Size of Star

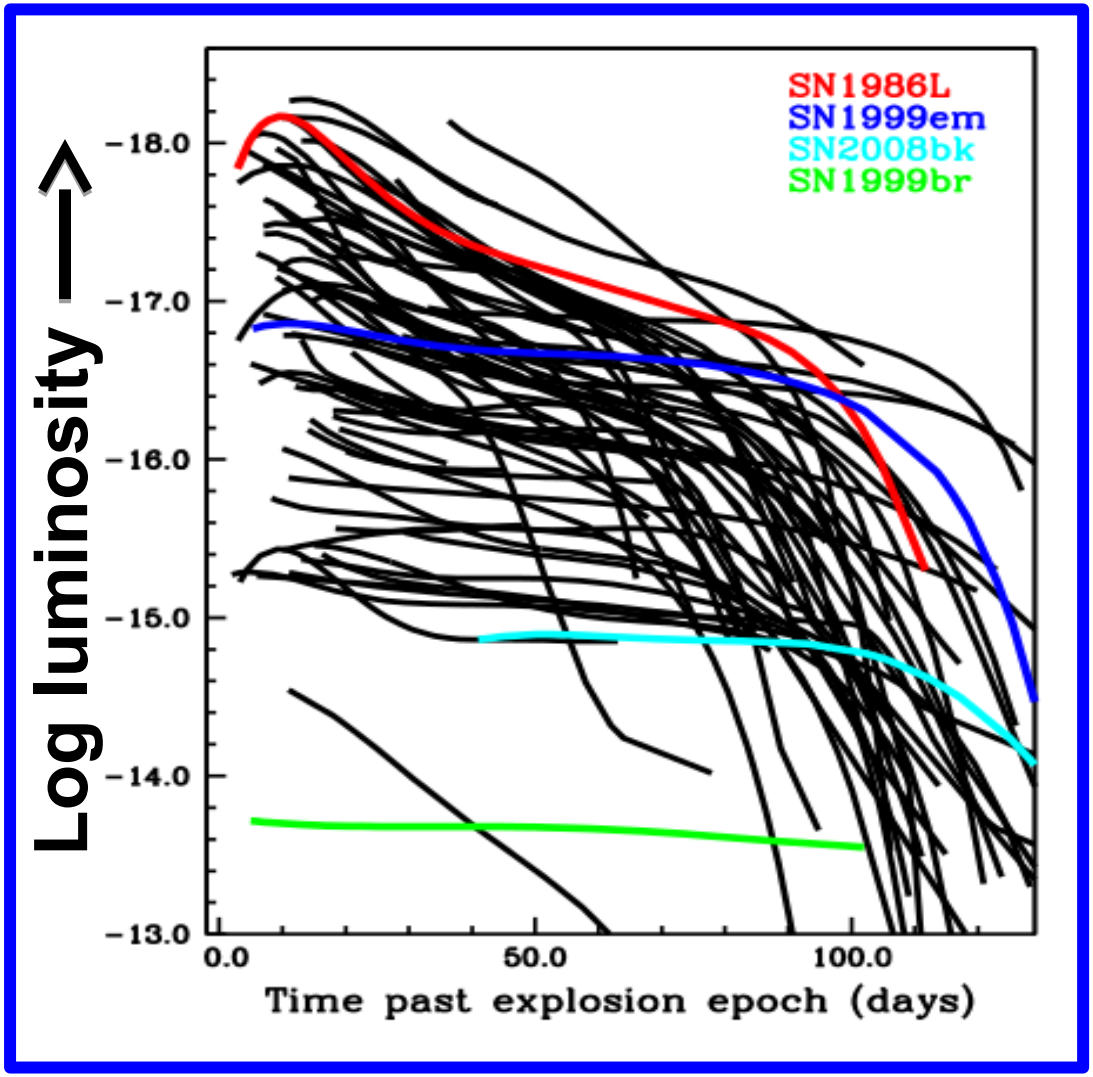
Size of Earth's Orbit

Size of Jupiter's Orbit




Core of a
Red Supergiant
Iron
Silicon, Sulfur
Oxygen, Neon, Magnesium
Carbon, Oxygen
Helium
Hydrogen

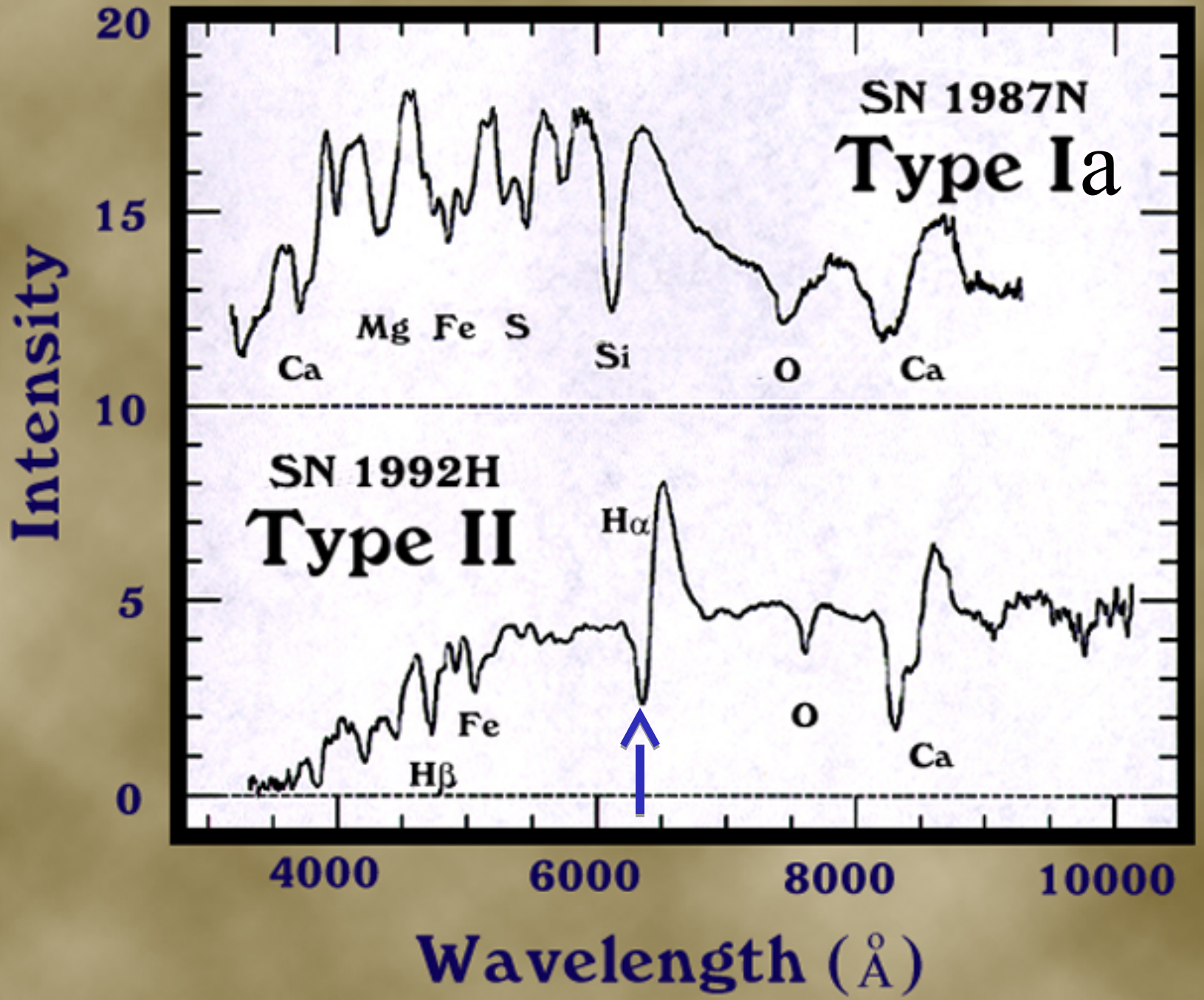
SNe II are NOT standard candles: wide range of luminosities



(Anderson et al. 2014)

But SNe II *are* standardizable!!

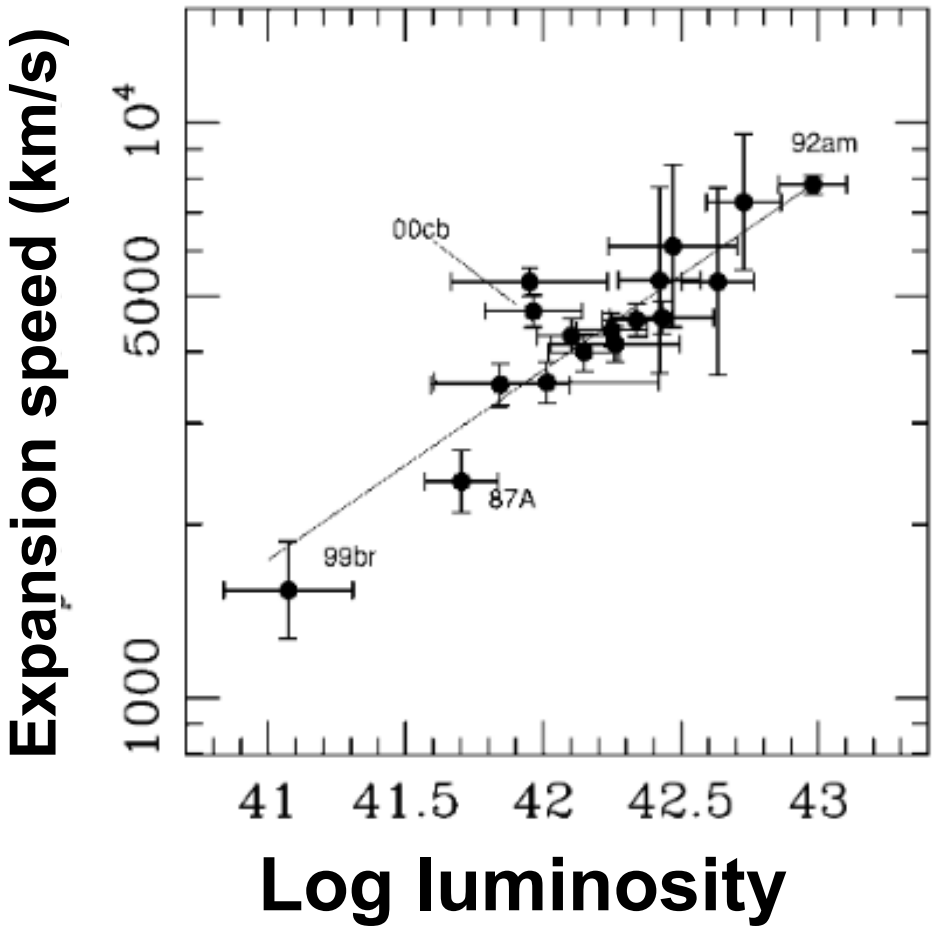
Measure the expansion velocity of the ejected gases from the spectrum.


20
15
10
5
0
Intensity
SN 1987N
Type Ia
Ca
Mg Fe S
Si
O
Ca
SN 1992H
Type II
Hα
Fe
Hβ
O
Ca
4000
6000
8000
10000
Wavelength (Å)

But SNe II are standardizable!!

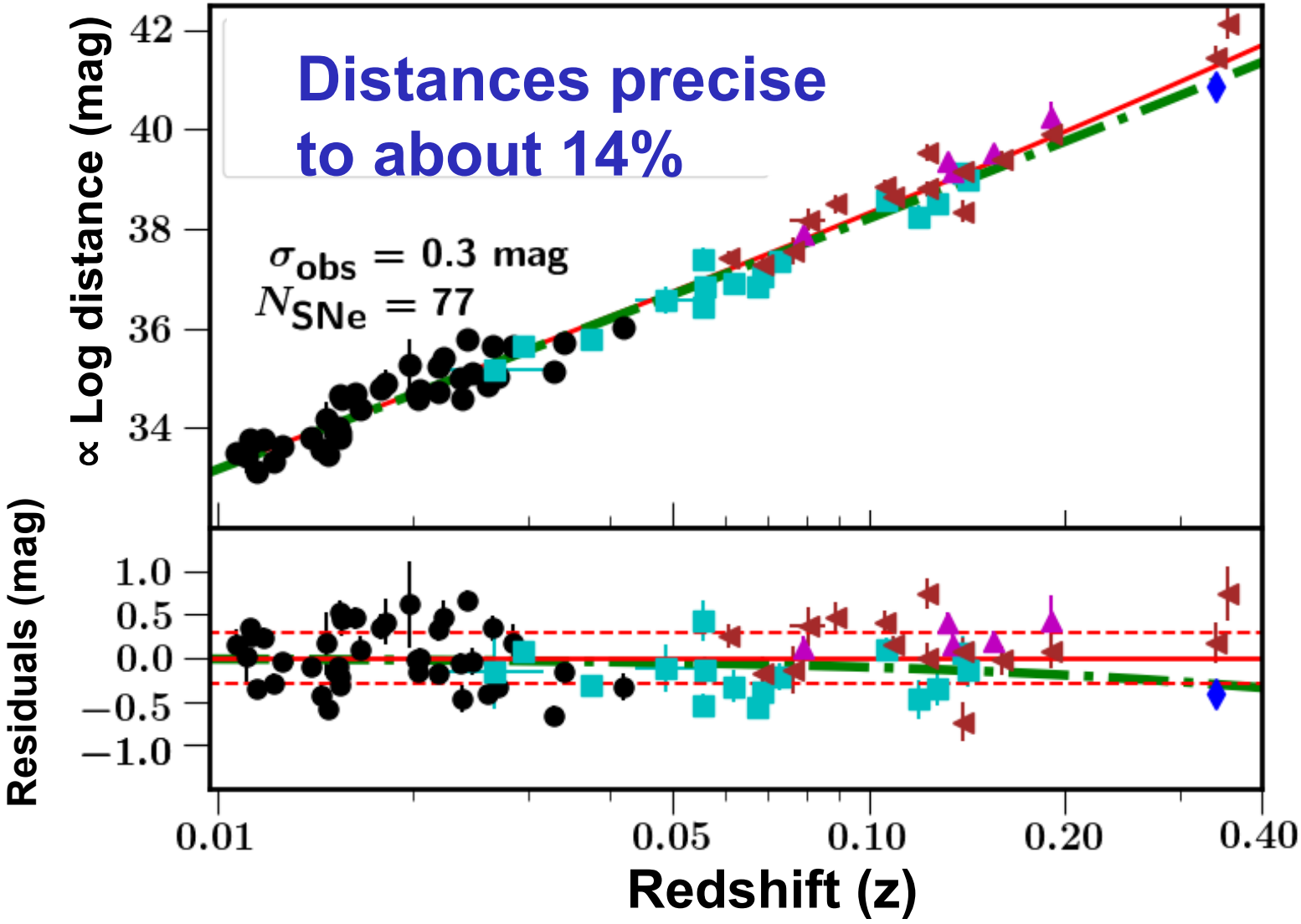
Expansion velocities of the ejected gases:

Luminous SNe II expand faster than less-luminous SNe II.



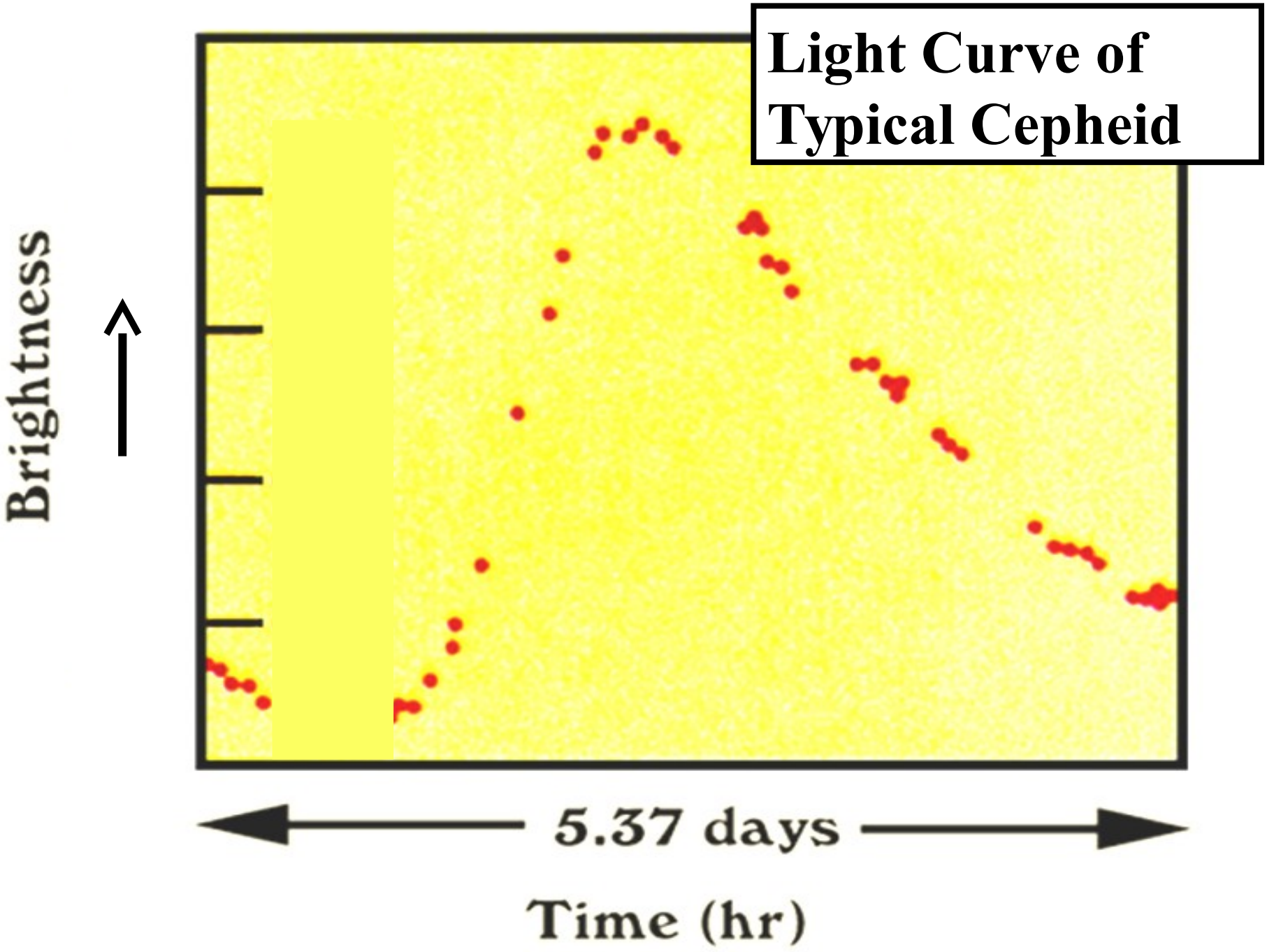
(Hamuy & Pinto 2002)

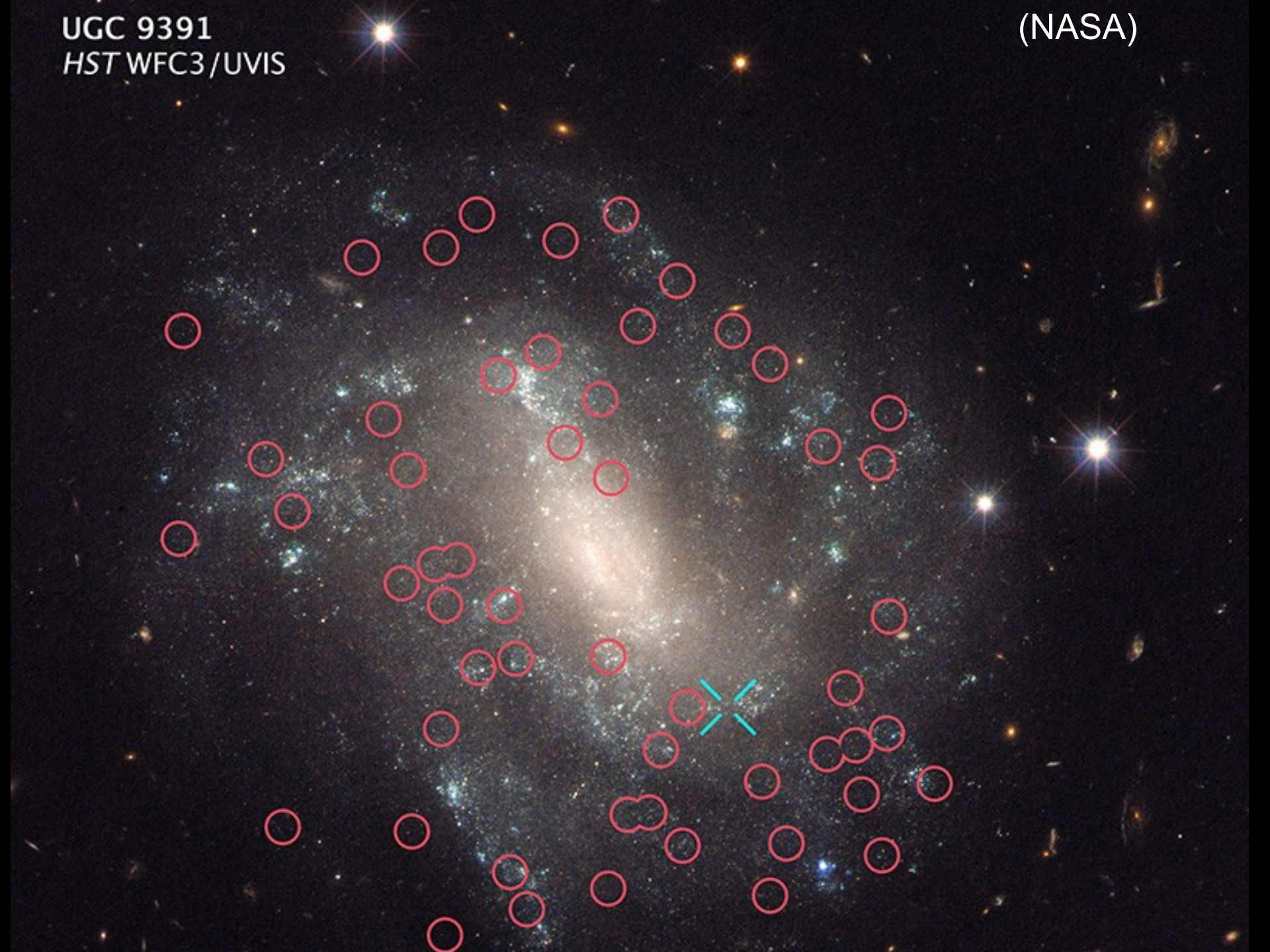
Standardizable Candle Method (SCM)



Work in Progress

- Dozens of SNe II: KAIT/Nickel light curves, Lick/Keck spectra to get expansion speeds of gases.
- Use SCM to construct new Hubble diagram; measure H_0 and compare with that derived from SNe Ia.
- Also: Cepheid measurements of distances of nearby galaxies that hosted SNe II, to improve luminosity calibration of SNe II (as with SNe Ia).


Light Curve of Typical Cepheid
Brightness
5.37 days
Time (hr)


UGC 9391
HST WFC3/UVIS
(NASA)

What H_0 Value Will We Find?

- Close to $H_0 = 74.03 \pm 1.42$ km/s/Mpc, as with SNe Ia?
- Close to the Planck prediction, $H_0 = 67.4 \pm 0.5$?
- Some value in between these?
- The result should indicate whether the tension is real!
- Stay tuned!