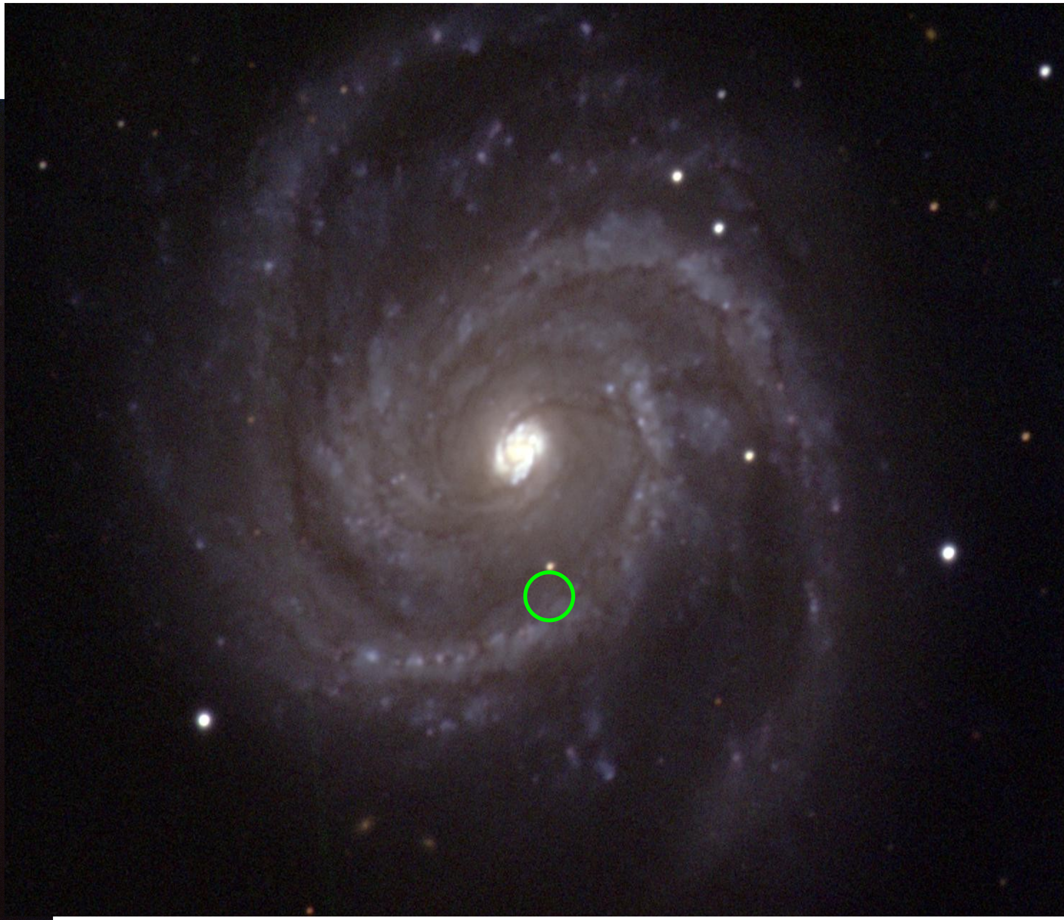
Joey Chatelain

Type Ia Supernovae

M100 in December 2002

M100 in Early 2006

FORS Team, 8.2-meter VLT, ESO



N.A.Sharp/NOAO/AURA/NSF

About 50 million ly away

Contents:

- Historical Supernovae
- Supernova Taxonomy
- Causes of Supernova
- Type Ia Sn as a Standard Candle
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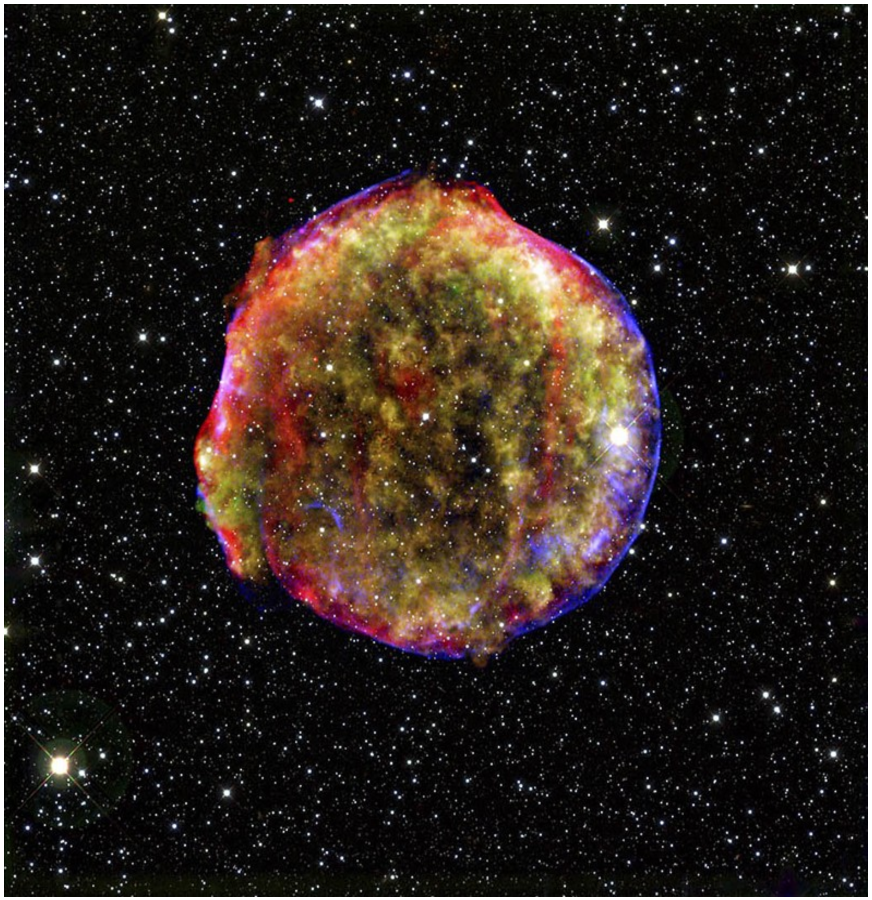
History of Sn

Tycho's Supernova remnant:
Type Ia Supernova recorded in 1572
Was said to be nearly the brightness of Venus in the night sky.



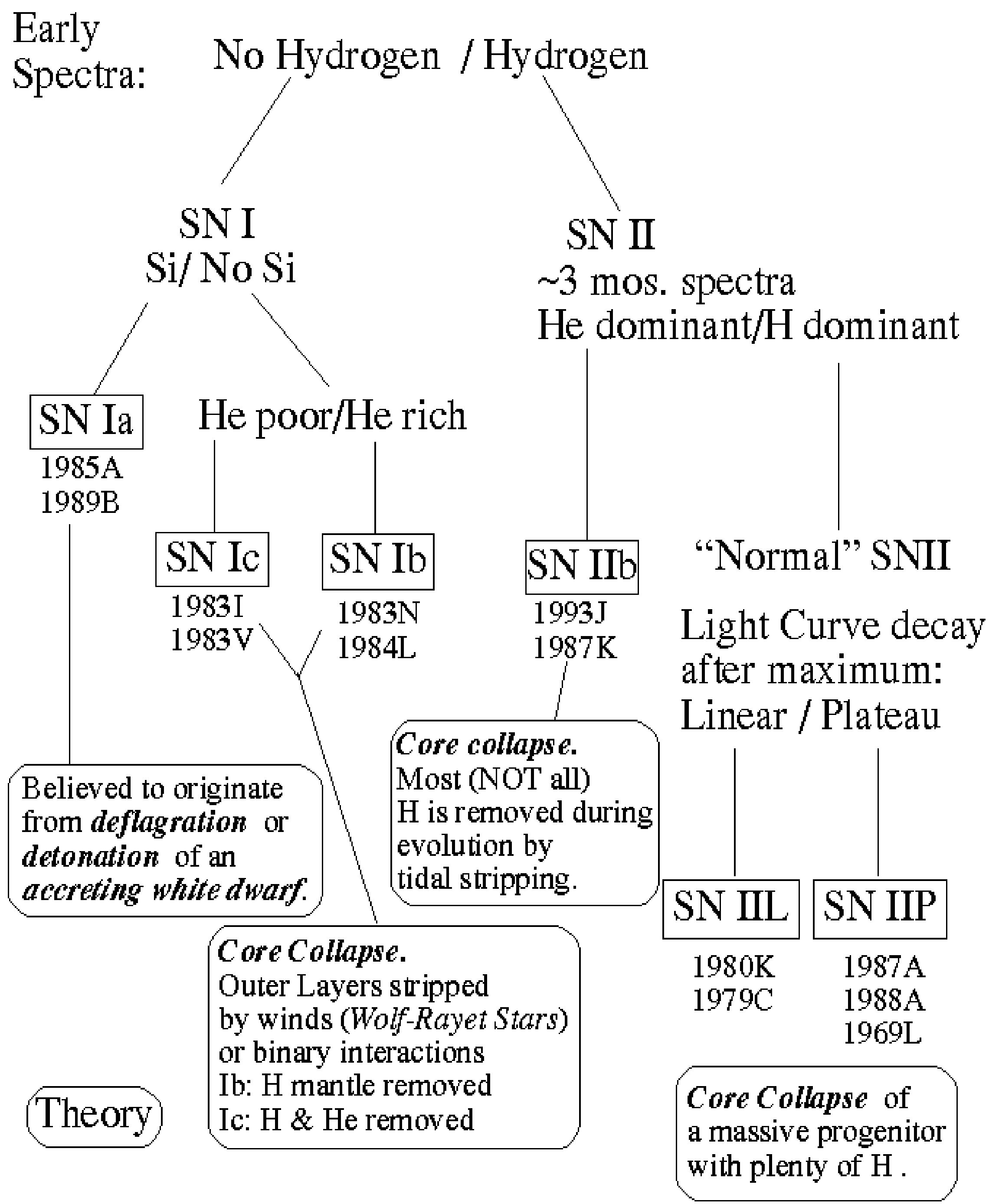
X-ray: NASA/CXC/SAO; Infrared: NASA/JPL-Caltech; Optical: MPIA, Calar Alto, O. Krause et al.

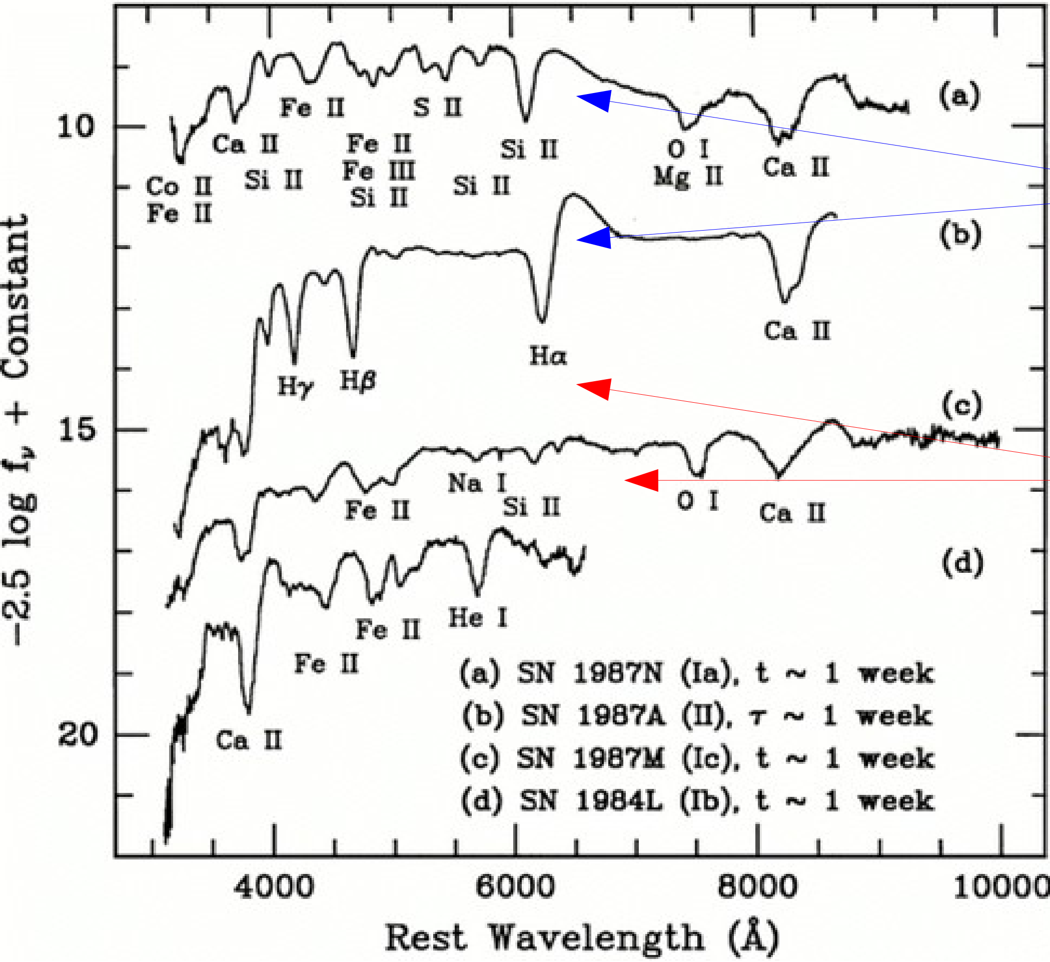
Supernova have been observed and recorded within the MW for thousands of years

Year	Date	Con	mag	Remnant	Observed/Comments
352 BC ?					Chinese
4 BC	spring	Aql			Chinese
185 AD		Cen	-2	G315.4-2.3	Chinese
369 ?					Chinese
386		Sgr		G11.2-0.3?	Chinese
393/396		Sco	-3	SNR 393	Chinese
437 ?		Gem			
827 ?		Sco/Oph	-10		
902 ?		Cas	0		
1006	Apr 30	Lup	-9+-1	SNR 1006	Arab,Chinese,Japan,Euro
1054	Jul 4	Tau	-6	M1	Chinese,also Arab, Japan
1181	Aug 6	Cas	-1	3C 58	Chinese and Japanese
1203 ?		Sco	0		
1230 ?		Aql			
1572	Nov 6	Cas	-4	Tycho SNR	Tycho Brahe's SN
1592 ?		Cet			Korean; probably Nova
1592 ?		Cas			Korean; probably Nova
1592 ?		Cas			Korean; probably Nova
1604	Oct 9	Oph	-3	Kepler SNR	Johannes Kepler's SN
1680?	1667?	Cas		Cas A	Flamsteed ? not seen ?

Michael Richmond, 2009

Supernova Taxonomy

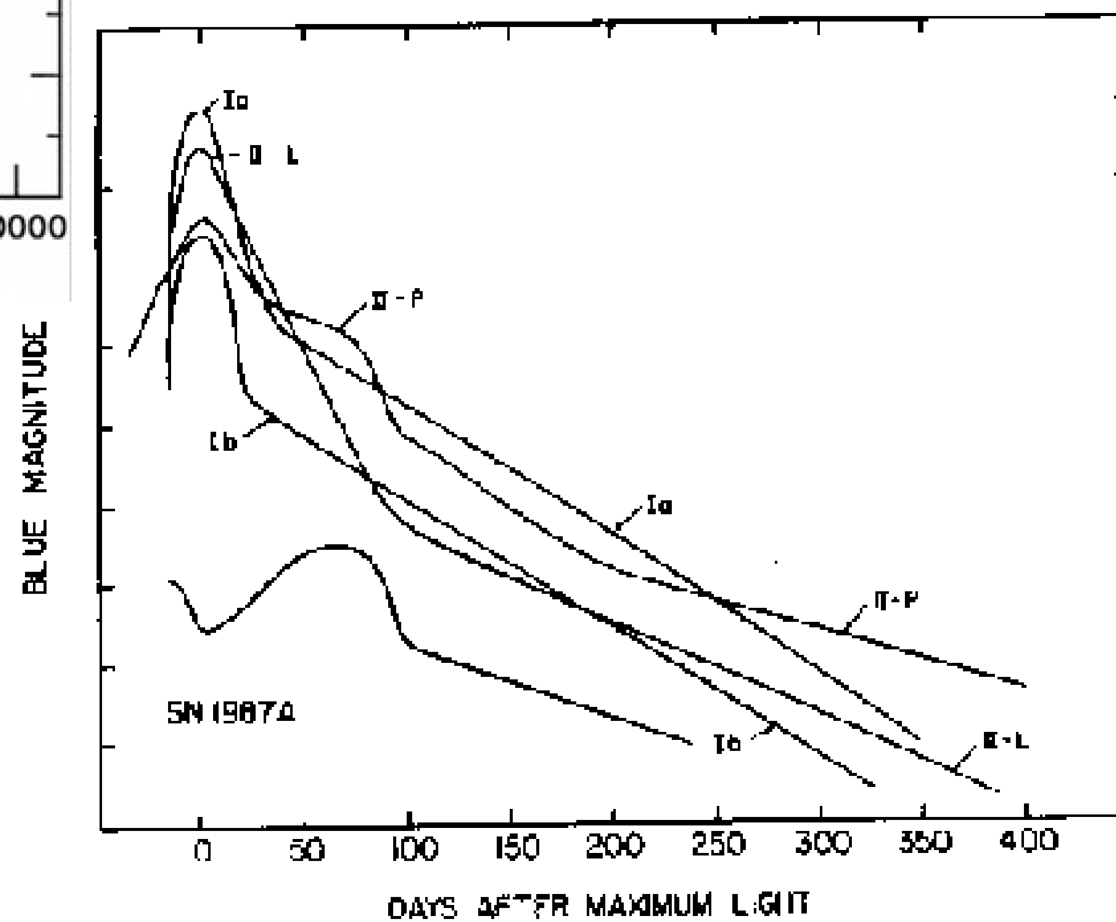




(Fillipenko 1997)

Spectra can form P Cygni Profiles due to expanding Shells

Note Hydrogen absorption



Note that Type Ia are conveniently the brightest of the Supernova allowing them to serve as our deepest probes.

What causes different types?

Type Ia

Exploding White Dwarf

Type Ib/c

Exploding WR Star

Type II

Exploding Massive Star

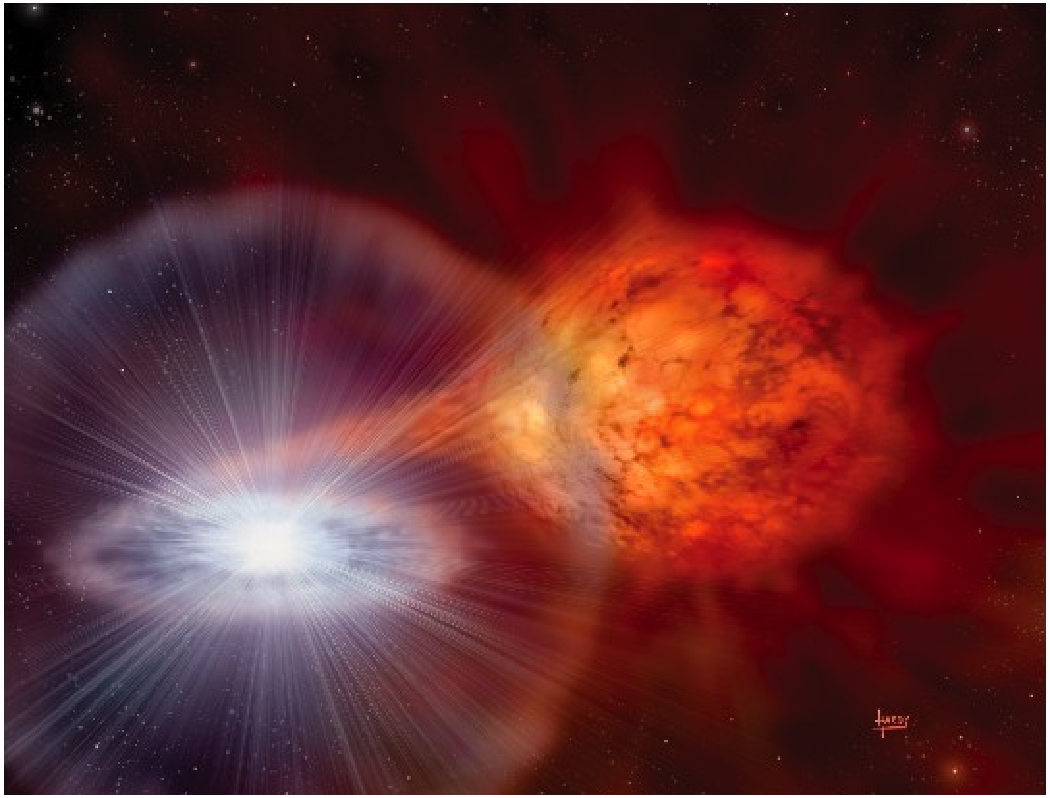
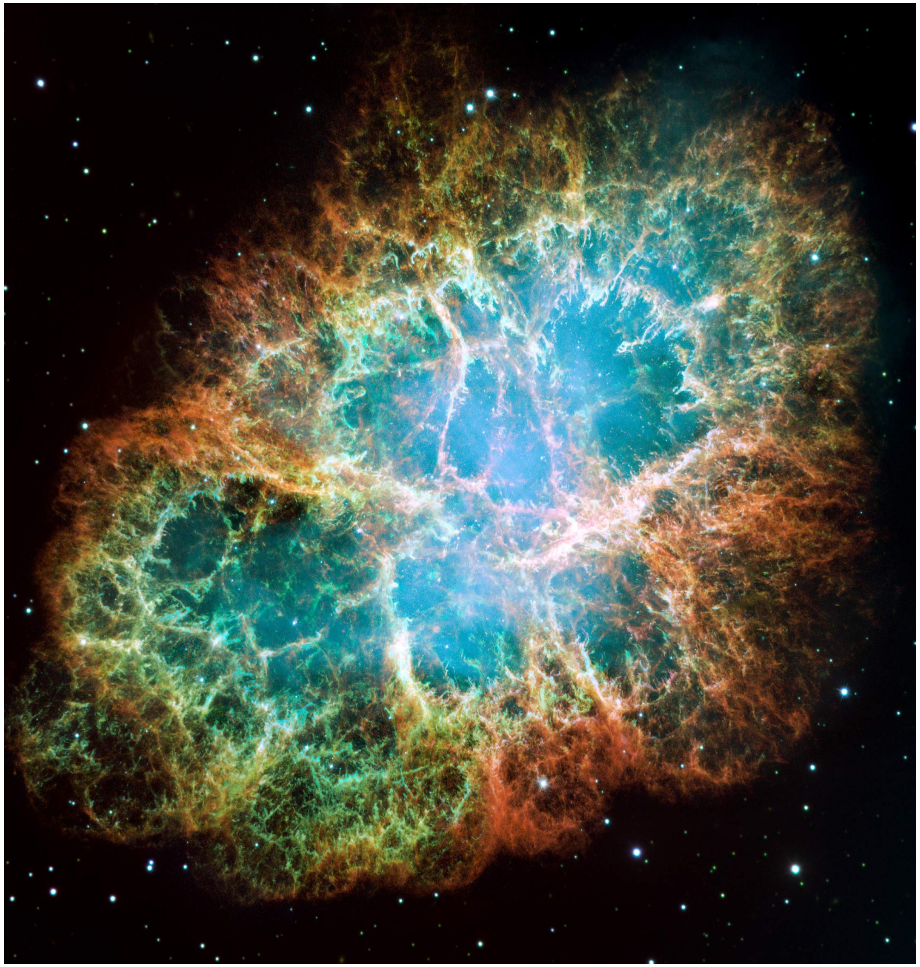
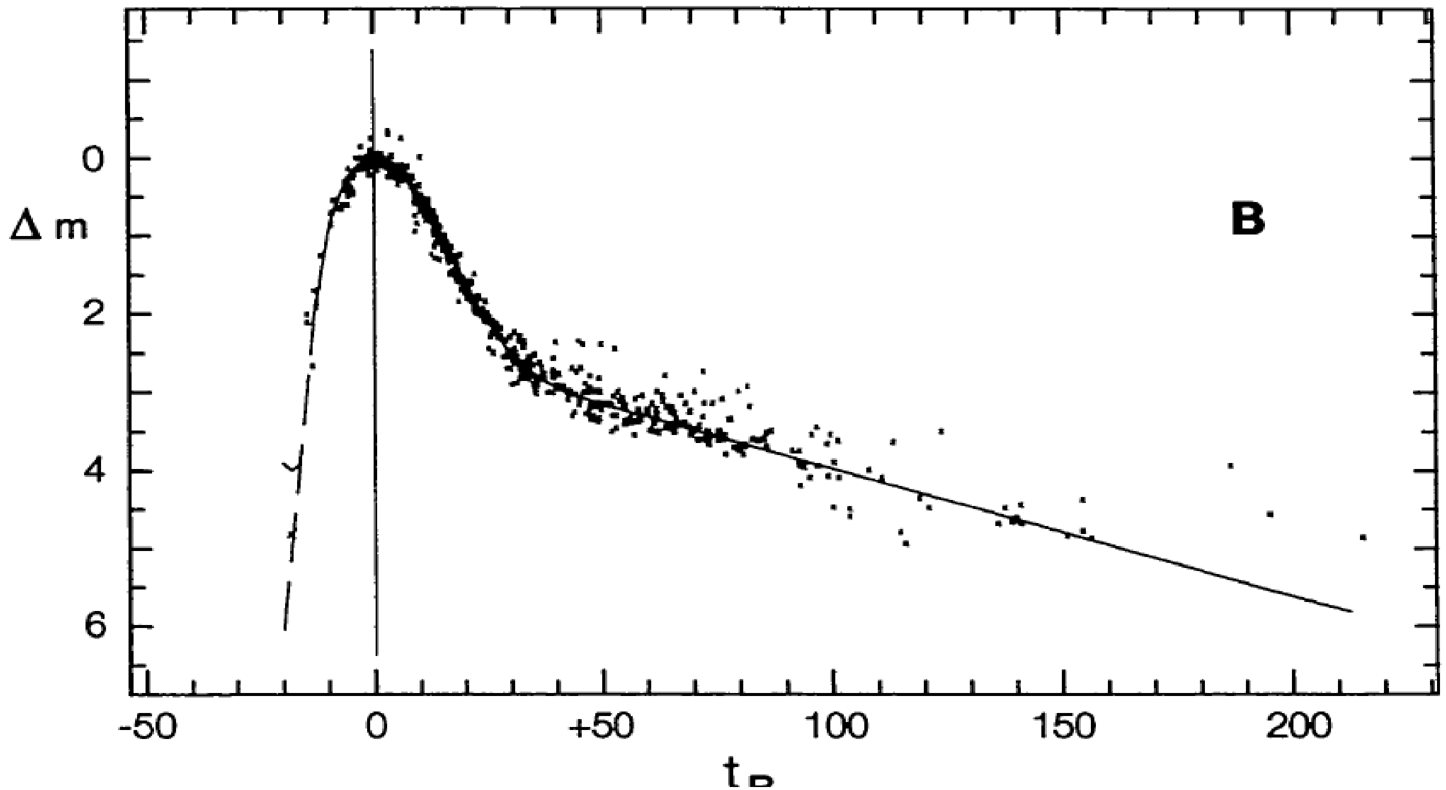


Image courtesy of David A. Hardy, © David A. Hardy/www.astroart.org.



NASA, ESA, J. Hester, A. Loll (ASU);

Type Ia as standard candles



Sandage found $M_V(max) = -19.92 +/- .13$

and $M_B(max) = -19.74 +/- .24$

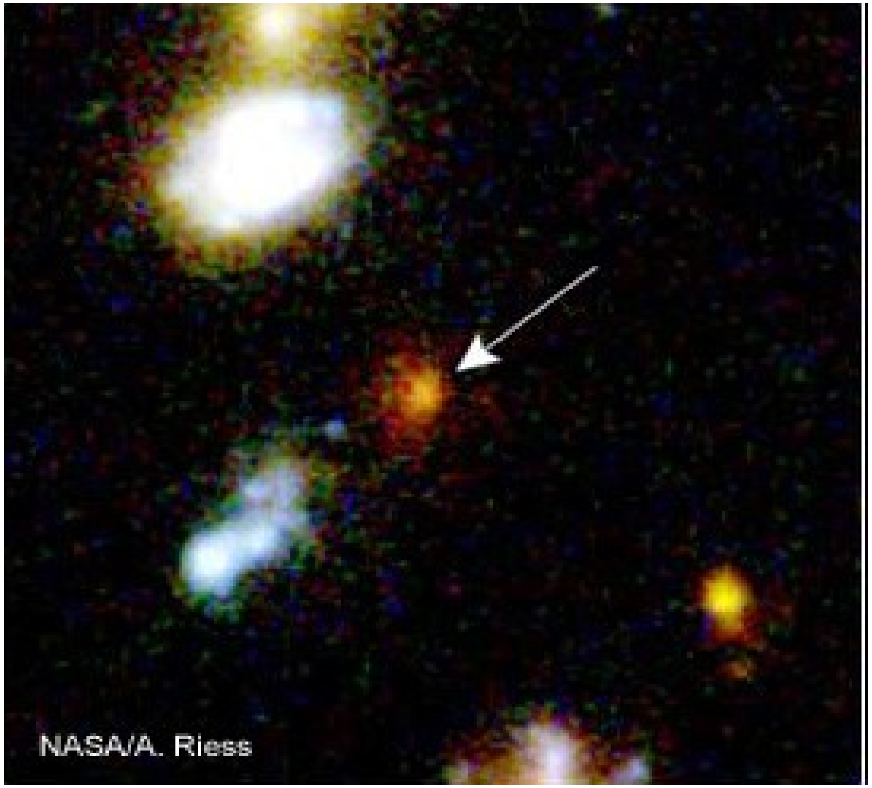
using Cepheid Calibration in 1992

Now use Distance modulus equation:

$$d = 10^{0.2(m - M + 5)}$$

Range of Type Ia Sn

Works out to 3000 Mpc w/ 8-10% accuracy



One of the most distant Sn ever detected, Sn1997ff was detected by the Hubble Deep Field in a galaxy nearly 3000 Mpc from Earth.

Overlap with cepheids

Sn1994D in NGC 4526.
NGC 4526 is only 17 Mpc away. Cepheid measurements have been made in NGC 4639 which is nearly 22Mpc distant.

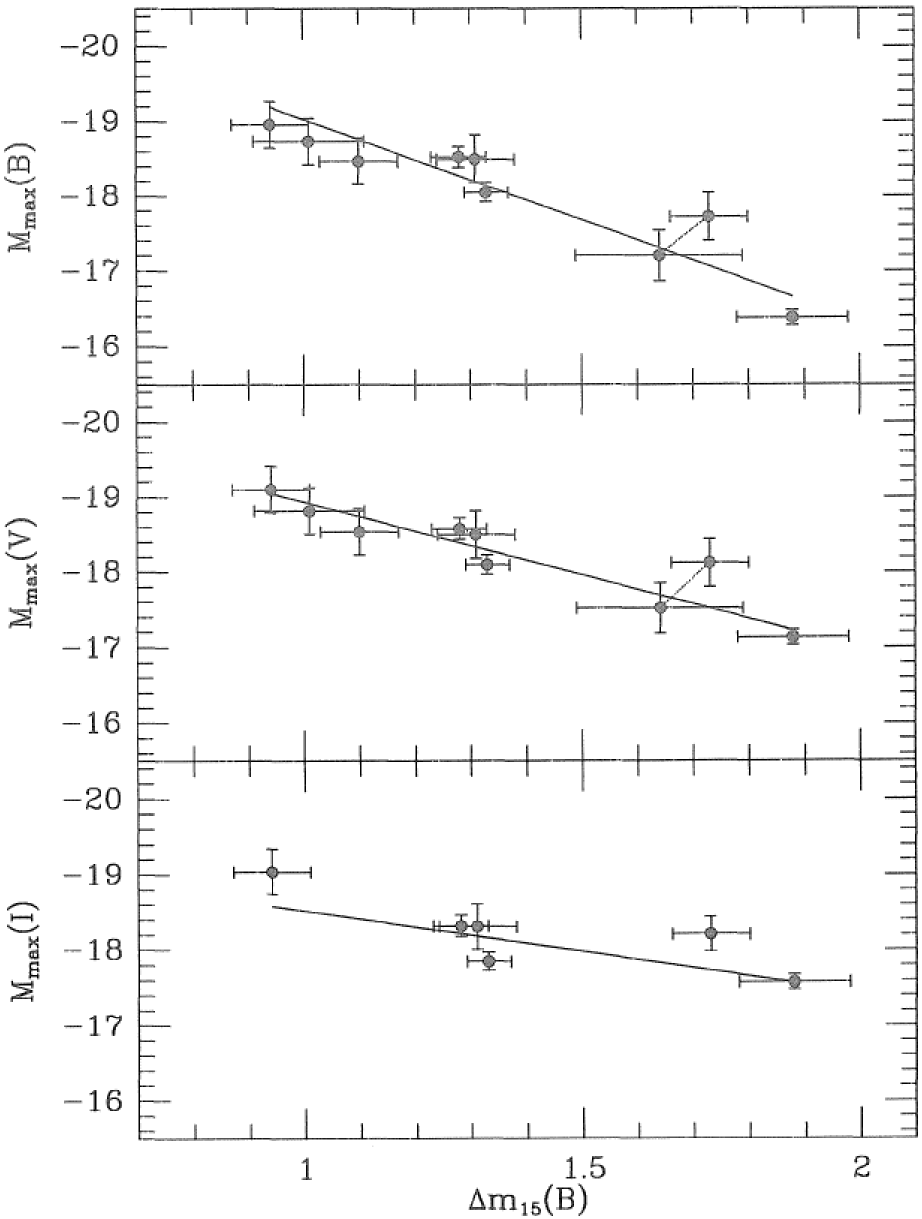
Problems with using Type Ia Sn as Standard Candles

Relative: Still based on some external calibration, Usually Faber-Jackson, Tully-Fisher, or Cepheids.

Unpredictable: We never know when or where a Super nova will occur, thus we can often miss peak brightness, which is the primary means of calibration.

Not actually all Identical: Both sub-Luminous and over-luminous Type Ia Sn have been seen. Varying by as much as .8 mag.

Overcoming these problems

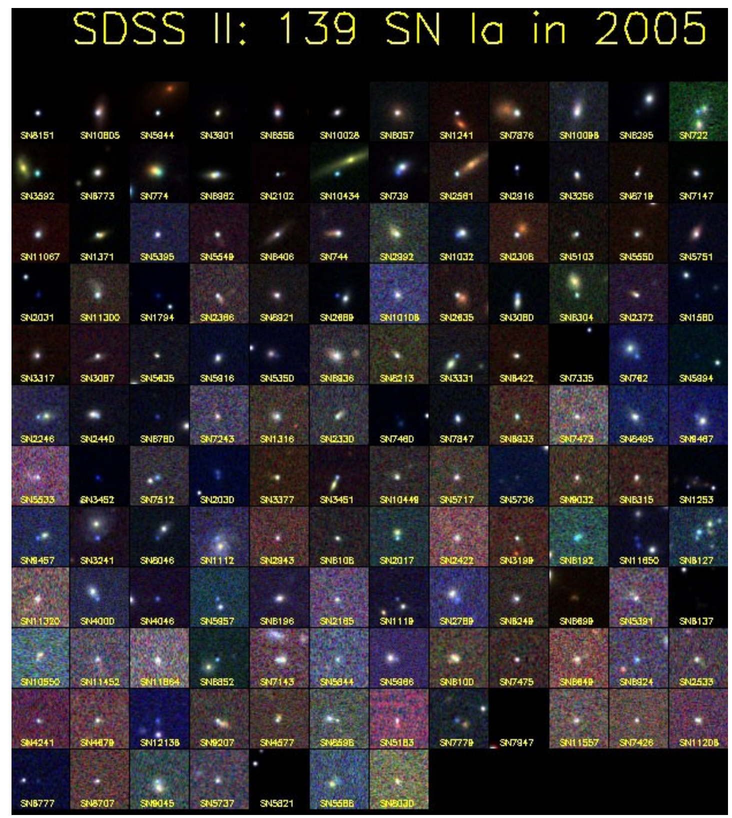


M.M.Philips

$$M_V^{max} = -9.96 - 2.31 \log(\dot{m})$$

During 1[st] 15 days

Supernova surveys



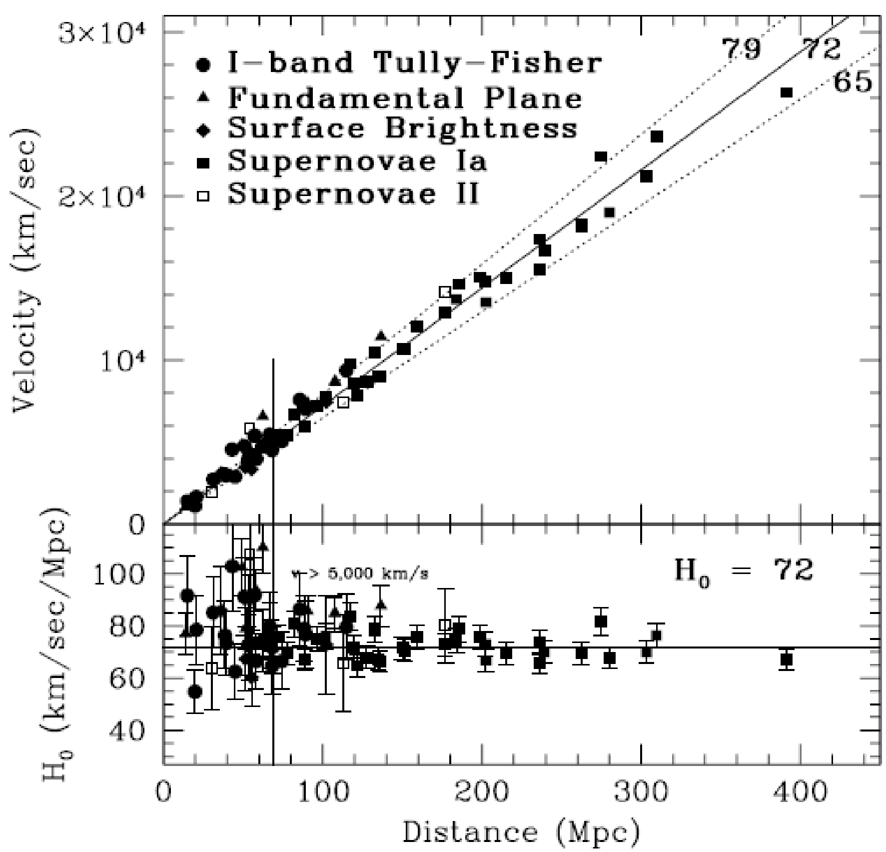
Joshua A. Frieman

Recent results

Final results from Hubble Space telescope Key Project to measure Hubble Constant

Freedman et al. 2000

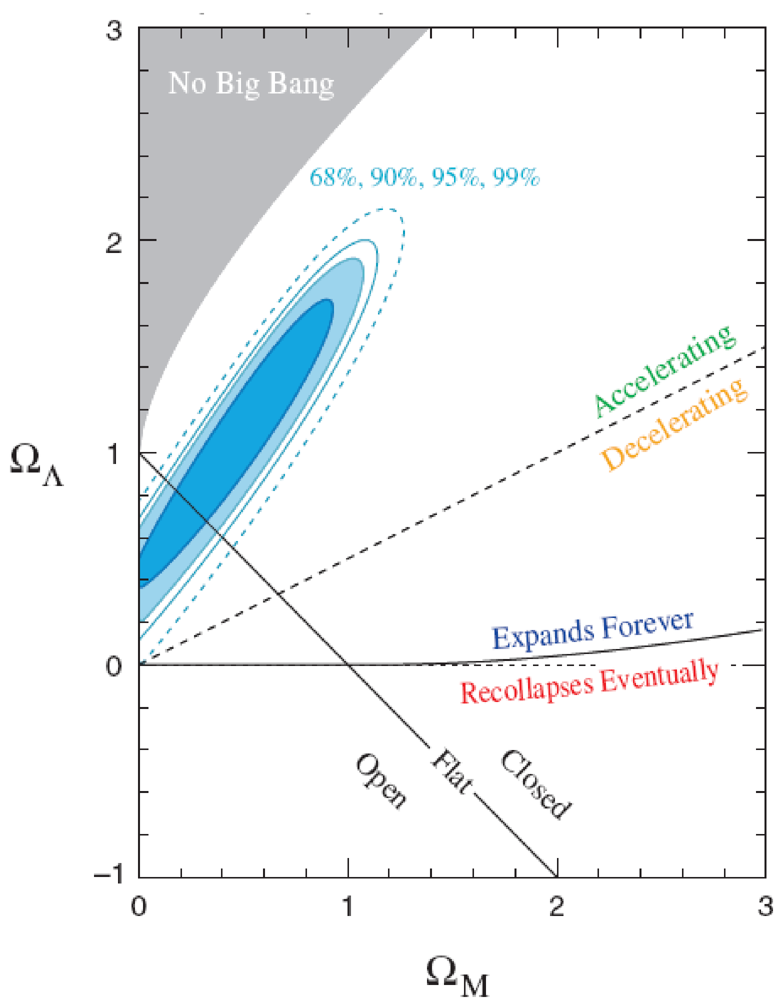
Found H_0=71 +/- 2_r +/- 6_s using Type Ia Sn



Supernova Cosmology Project

Knop et al. 2003

Used several high redshift Sn to constrain Quantities for Cosmological constants



Sources

Picture References

1.) http://rsd-www.nrl.navy.mil/7212/montes/snetax.html
2.) http://www.lbl.gov/Science-Articles/Archive/sabl/2005/October/04-supernovae.html
3.) http://www.pha.jhu.edu/~bfalck/SeminarPres.html
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5.) http://dujs.dartmouth.edu/wp-content/uploads/2008/05/picture-16.png
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8.) http://stupendous.rit.edu/richmond/answers/historical.html
9.) http://www.astrosurf.com/btatlas/n4639.htm

References

1.) Phillips, M. M. 1993
2.) Sandage et al. 1992
3.) Branch, D. 1992
4.) Freedman et al. 2000
5.) Binney and Merrifield 1998
6.) Carroll and Ostlie 1996

Wolf -Rayet Star is a star that has blown off outer shells of gas. This is a basic step in massive star evolution, and a star that has successfully blown off all Hydrogen will become a Type Ib supernova while a star that has blown off all of its He shells as well will explode as a type Ic.

P Cygni profile is a blueshifted Absorption line followed by a broad emission line with redshifted slope. This is characteristic of many massive stars that are sloughing off material (usually Hydrogen and Helium, but with Sn it can be a plethora of elements) due to radiation pressure. The feature is caused by an expanding mass shell that is mainly emitting, but is absorbing light from the central source (or inner mass shells) directly in the line of site, thus the blueshift.

What causes Sn Light curve Shapes? The initial shell is optically thick, so the initial outburst is not seen. However when the shell expands far enough The shell becomes optically thin, and the sharp rise is seen. After initial peak, radioactive nickel serves as the primary heat source, and the initial steepness of the downward slope is caused by the short half life of Ni(56) which is about 6 days. The Second more shallow slope is caused by Cobalt(56) decay into Iron which has a half life of about 77 day.