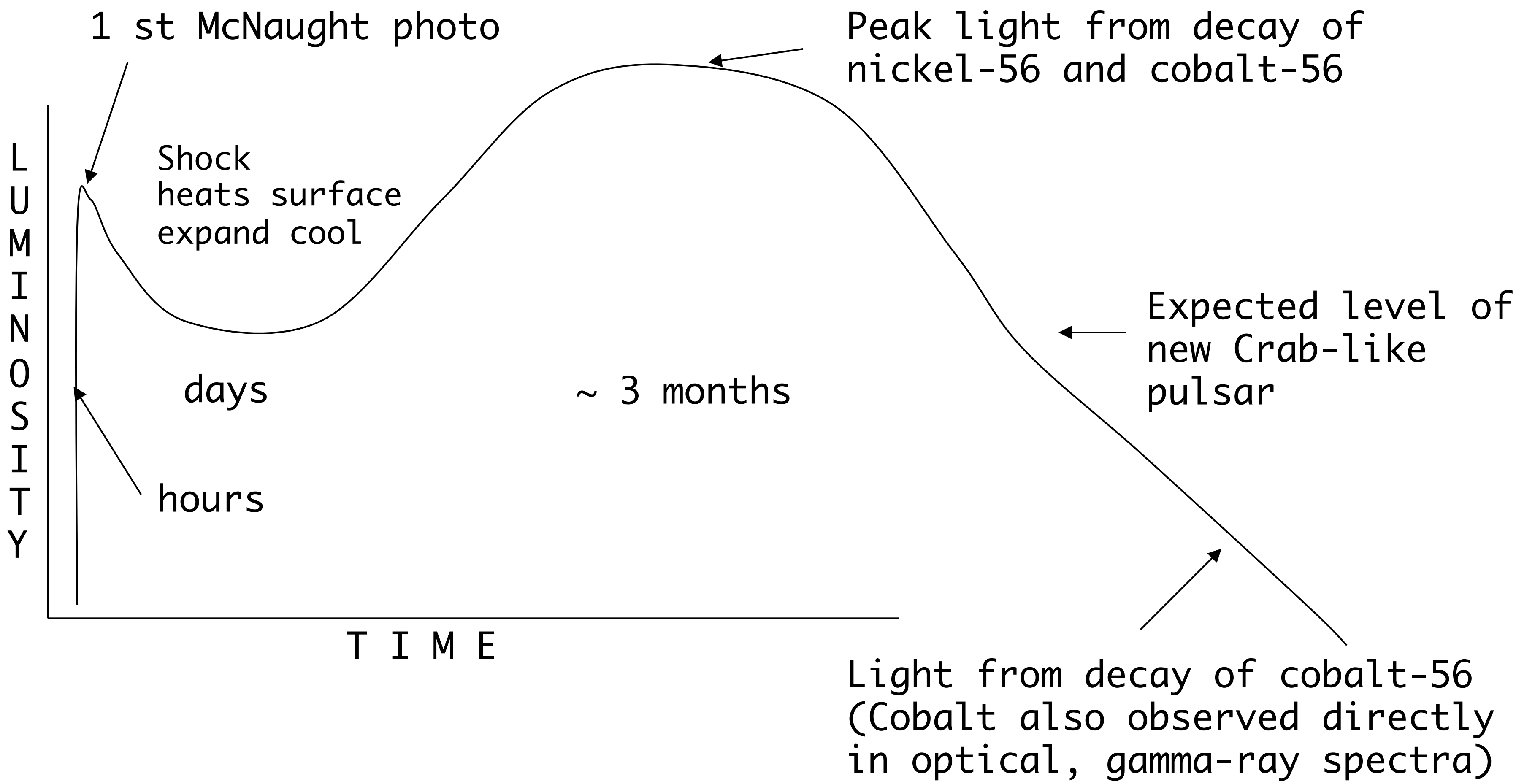
Monday, October 14, 2013

Reading: Chapter 8

Astronomy in the news?

Goal:

To understand the nature and importance of SN 1987A for our understanding of massive star evolution and iron core collapse.



SN 1987A had a rather peculiar light curve because it was a relatively compact blue supergiant, not a red supergiant (not sure why, maybe in binary system), brief shock heating, rapid cooling by expansion, no plateau, subsequent light all from radioactive decay.

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 produced radioactive nickel and cobalt

⬇ Neutrinos were detected from it

Saw neutrinos, neutron star must have formed and survived for at least 10 seconds.

If a black hole had formed in the first instants, neither light nor neutrinos could have been emitted.

No sign of neutron star since despite looking hard for 26 years.

Whatever is in the center of Cas A, most likely a neutron star, is too dim to be seen at the distance of the LMC, so SN 1987A might have made one of those.

Also possible that after explosion and formation of neutron star, some matter fell back in and crushed the neutron star to become a black hole.

Dim neutron star or black hole? Still do not know.

Another type of supernova

Ask me about its properties, vote about type of explosion.
Analogous to astronomers querying nature with their telescopes

Massive star, core collapse, neutron star

Exploding white dwarf

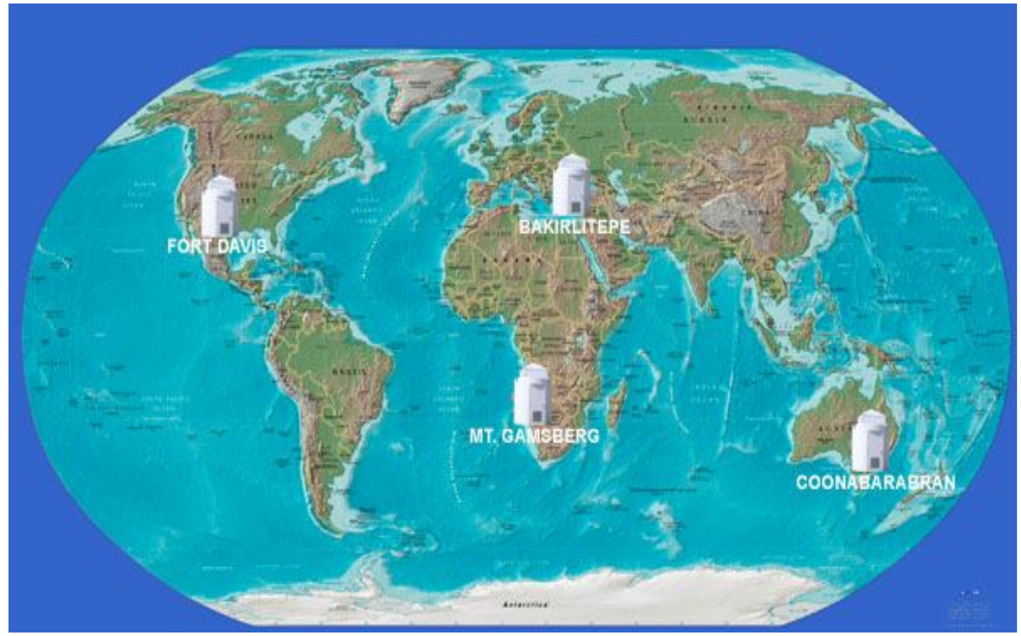
Goal – to understand the nature of a new class of super-luminous supernovae

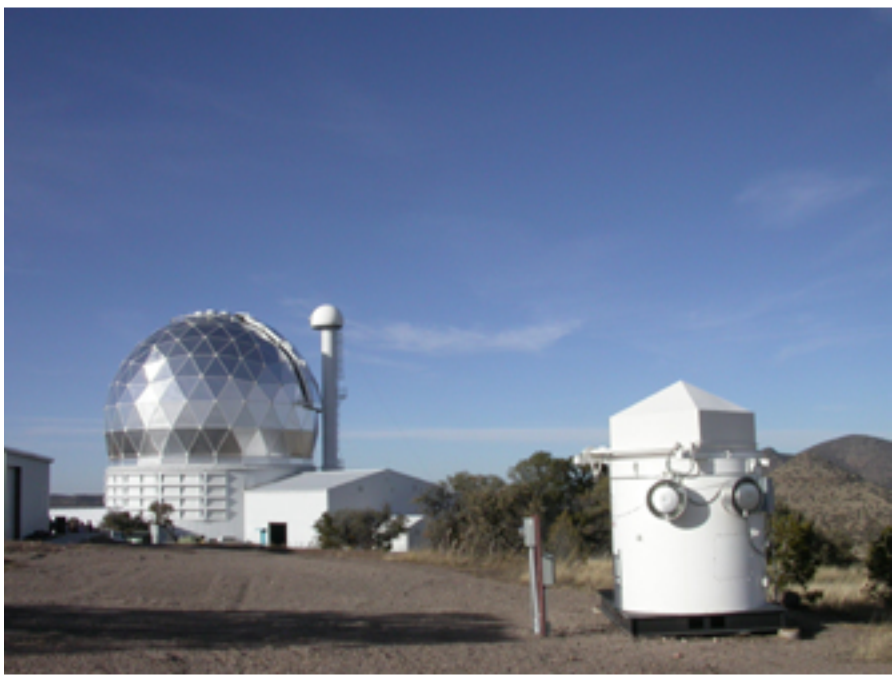
Goal – to understand how we found the superluminous supernovae

We participate in the U. of Michigan ROtic Transient Source Experiment (ROTSE) collaboration.

Four ROTSE telescopes around the world. Texas, Australia, Namibia andTurkey.

18 inch mirrors, 1.85 degree squared field of view. Moon is 0.5 degree

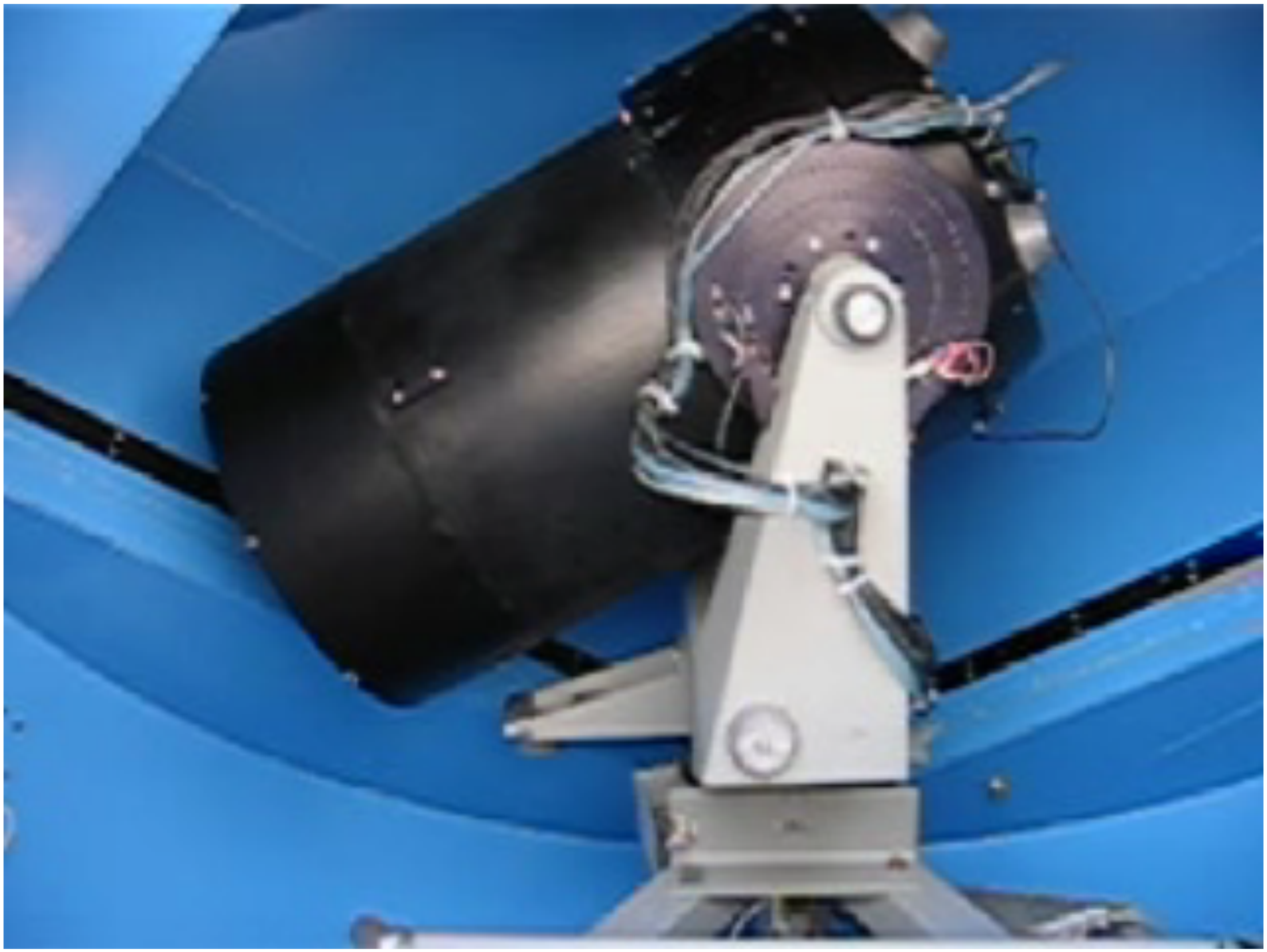




ROTSE can point and shoot within 6 secs of electronic satellite notification, take automatic snapshots every 1, 5, 20, 60 secs.

ROTSE has:
Discovered the optical transient ***during*** the 30 second gamma-ray burst;
Followed the light in unprecedented detail;
Relayed the discovery and coordinates to the HET for spectroscopic follow up.

ROTSE IIIb in action



ROTSE3B and Hobby-Eberly Telescopes

The Texas Supernova Search

2004 - Texas graduate student Robert Quimby used ROTSE to conduct the ***Texas Supernova Search***, covering unprecedentedly large volumes of space.

Original (and on-going) goal: search nearby rich clusters of galaxies, Virgo, Leo, Coma, Perseus, Ursa Major, for supernova very early, days, after outburst.

Possible with large field of view, rapid cadence of ROTSE, impossible with small field of view searches that target individual galaxies.

Unbiased search - large galaxies, small galaxies, AGN nuclei, centers as well as outskirts.

Included vast volume of space, a billion cubic light years behind target clusters in ~5 years.

For Sky Watch

Find Virgo, Leo, Coma, Perseus, Ursa Major clusters of galaxies.

A New Type of Supernova

By far the most dramatic discovery by Robert Quimby and the Texas Supernova Search was a whole new class of "super-luminous" supernovae, of order 10 to 100 times brighter than the classical types.

SN 2005ap: no H or He

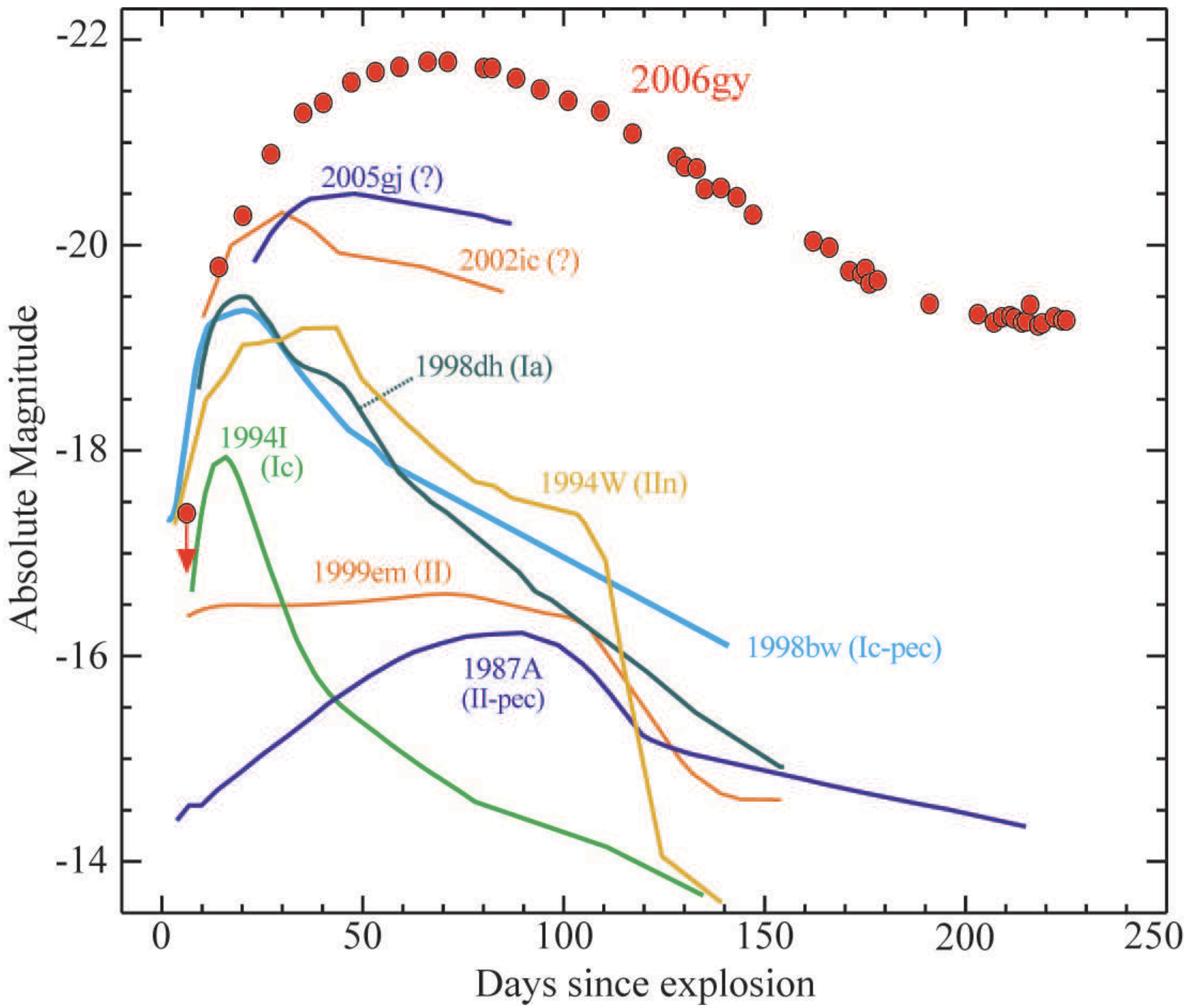
SN 2006gy: H

SN 2006tf: H

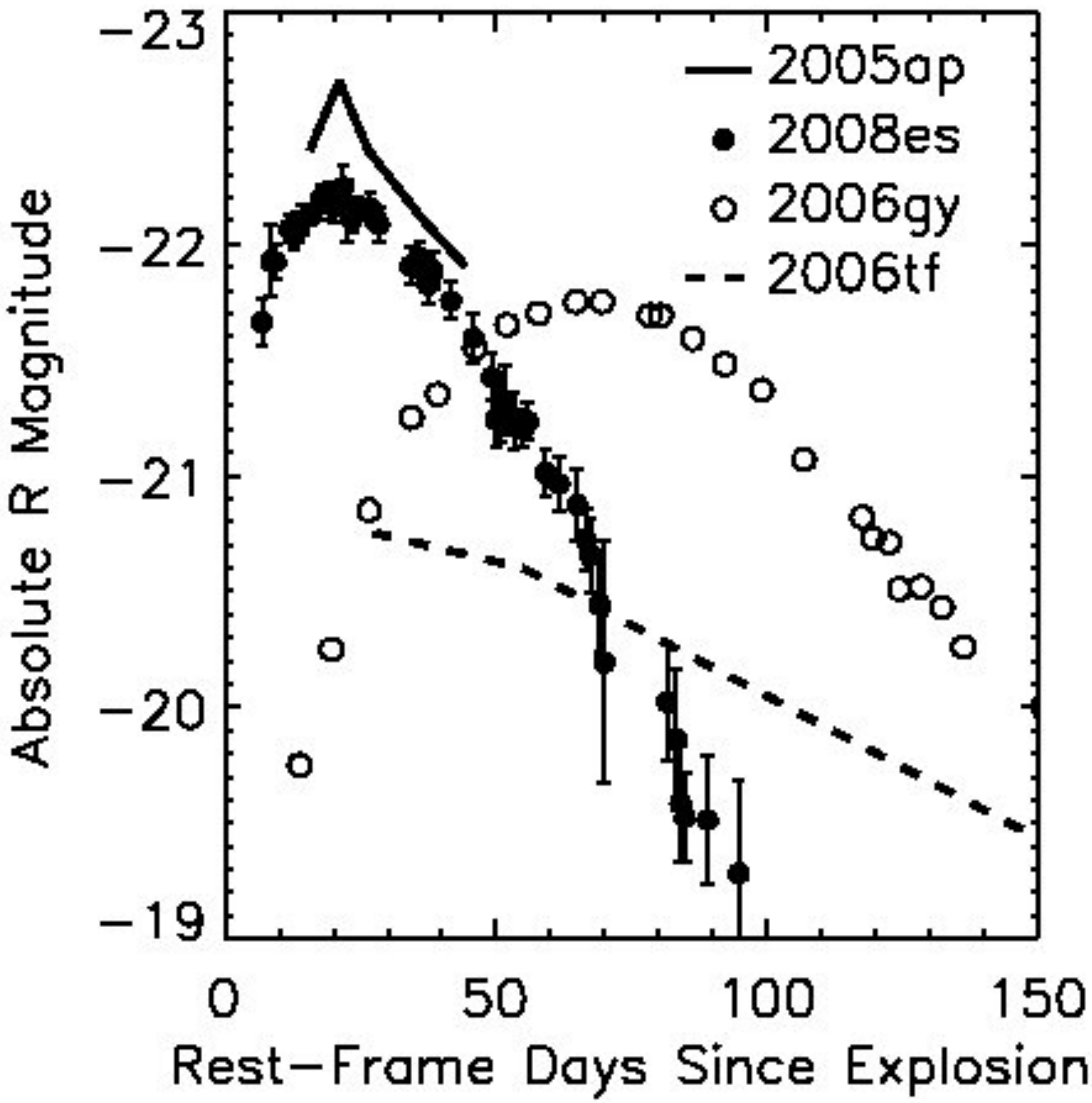
SN 2008es: very little H

SN 2008am: H

SN 2010kd: no H or He



SN 2006gy is much brighter than the normal Type II, SN 1999em



SN 2005ap and SN 2008es are even brighter yet.

SN 2006gy

The first to get major press was SN 2006gy

Rose to maximum in 70 days (1 to 2 weeks is typical) => large mass involved

~100 times brighter than normal

Slower decline

Rich spectrum, characterized by broad, intermediate, and narrow lines of Hydrogen, a Type II, but of a sort never seen before

Detailed analysis showed that SN 2006gy had to arise from a very massive star, ~100 solar masses

SN 2006gy

NASA publicity machine engaged (Chandra X-ray observations)

#3 on Time Magazine's list of top 10 science discoveries of 2007

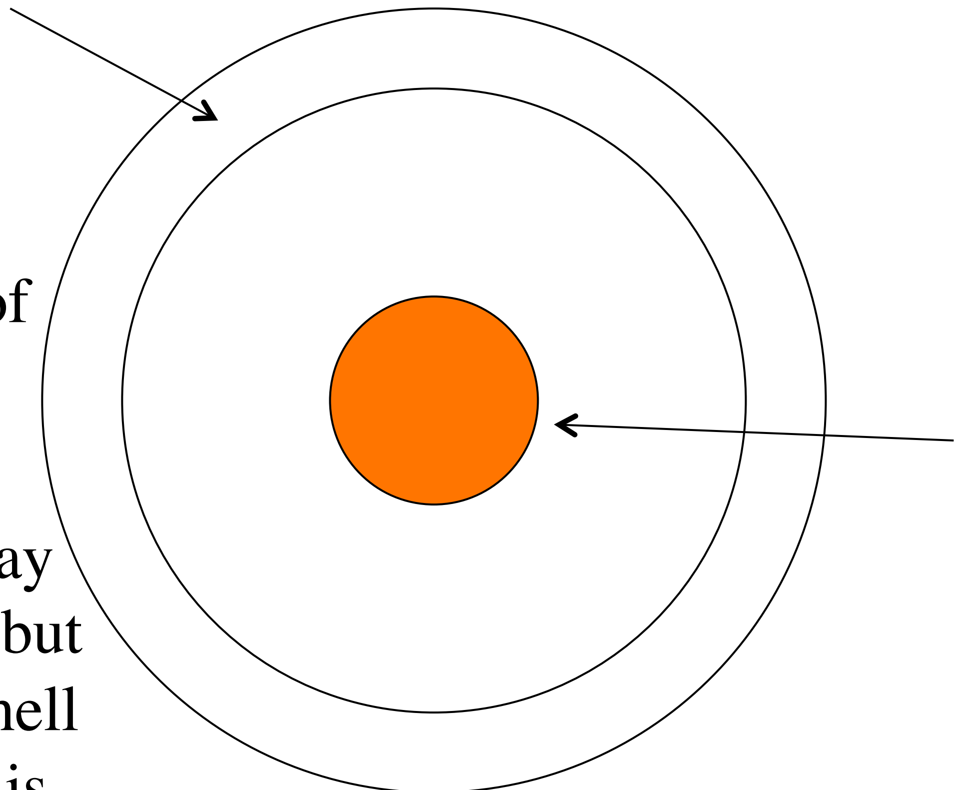
(after decoding of human genome and before 700 new species including carnivorous sponges and giant sea spiders; #1 was stem cells)

Robert Quimby won the 2010 Robert J. Trumpler Award of the Astronomical Society of the Pacific for Best PhD Dissertation in Astronomy

Goal – to understand why the super-luminous supernovae are so bright

Simple Version of Shell-Shock Model

Shell of matter previously expelled by progenitor star with size about 100 times that of Earth's orbit



Supernova from massive star, but nature otherwise obscured by shell, so unknown

The supernova may expand and cool, but when it hits the shell its kinetic energy is converted to heat that is radiated efficiently

Shell-Shock Model

Need a massive shell of circumstellar matter expelled by the progenitor star months to years prior to its explosion.

Shell sitting at a radius of about 100 times the size of the Earth's orbit, so does not need to expand at all to radiate.

Supernova then collides with that shell, efficiently radiates kinetic energy as radiant energy, no loss to expansion and cooling.

Candidate progenitor stars - Luminous Blue Variables such as Eta Carinae, known to eject shells of matter in a burst, mechanism unknown

The shell-shock model works for SN 2006gy and related hydrogen-rich events, SN 2008es, SN 2008am