THE FASCINATING UNIVERSE OF VARIABLE STARS

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AAVSO Speakers Bureau
ALCON 2009

Historical Perspective – Mira

- David Fabricius discovered "omicron ceti" in 1596
  - Brightened from 3rd to 2nd magnitude, then disappeared – thought to be nova. (Actually disappears from view varying from 2nd to 9th magnitude)
  - Re-observed in 1609 by Fabricius, and re-discovered in 1631 by Johann Fokkens Holwarda who determined 11 month period
  - Johannes Hevelius observed in 1639 and 1642, and named the star "Mira" – *The Wonderful*
- Earlier ancient discovery records unclear. Hipparchus may have discovered Mira in 134 BC
- As an aside - Fabricius and his son Johannes discovered sunspots before Galileo (1611)!

Historical Perspective – Algol

- Geminiano Montanari discovered "beta Perseii" in 1667
  - Brightness varies from 2.1 to 3.4 magnitude in 2.87 days
  - Period of less than 3 days credited to John Goodricke in 1782-83
  - In 1881 Edward Pickering theorized (correctly) that it was an eclipsing binary star system
- European, Arab, and Chinese cultures knew its variability and considered it evil
  - "Demon's Head" – Arab
  - "Mischief-maker" – Arab
  - "Satan's Head" – Hebrew
  - "Lilith" – Adam's legendary demonic first wife – Babylon/Hebrew
  - "The Spectre's Head" - Europe
  - "Piled-up Corpses" - Chinese

Historical Perspective – Supernova

- Chinese astronomers have the first recorded histories of supernova
  - Over 20 candidates identified over the past 2000 years.
  - Confirmed dates include 185, 393, 1006 (brightest and also recorded in Egypt, Iraq, Italy, Japan and Switzerland), 1054 (Crab nebula remnant shown above)
- In 1572 Tycho Brahe observed SN 1572 and argued it was very far from earth – contradicting the Aristotelian idea the world beyond the Moon and planets was immutable

Film and CCD's have lead to discovery of most Variables

Year	Number of Variable Stars Identified	
1596	1	Mira
1696	3	Mira, Algol, c Cygni
1796	11	Includes first Cephei discovery in 1784
1896	430	75 by photography
1996	31,187	Most by photography

Today's Categorization of Variable Stars

- Pulsating Variables

  Periodic expansion and contraction of surface
  Includes Cepheids, RR Lyrae, RV Tauri, Long Period, Semi-regular

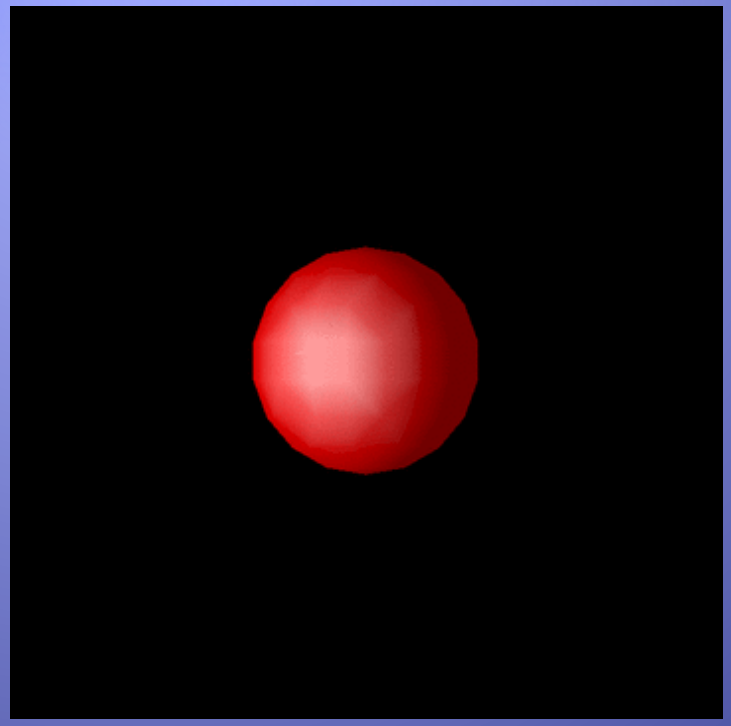
- Eclipsing Variables

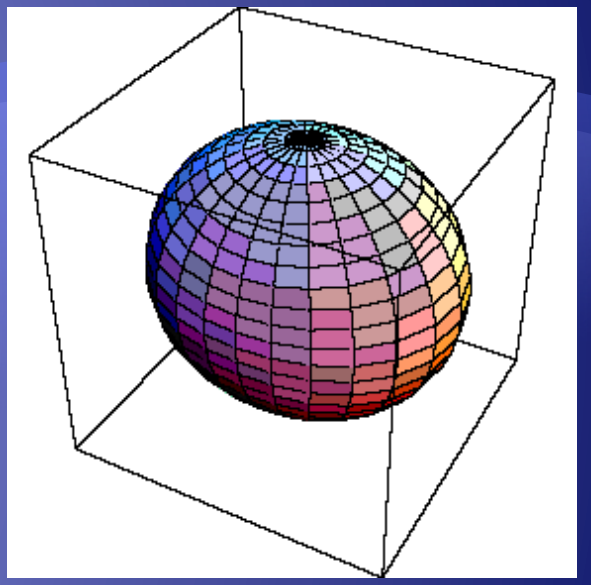
- Eruptive Variables –

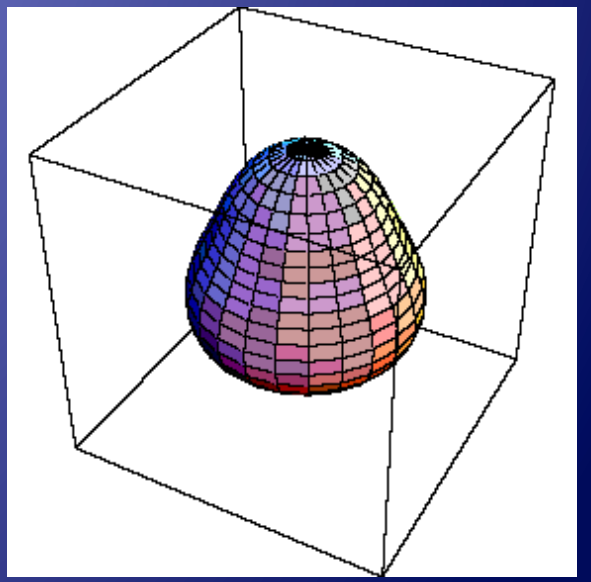
  Supernovae, novae, dwarf novae, cataclysmic variables

Pulsating Variables

Radial and non-radial motion







http://www.physics.usyd.edu.au/~bedding/animations/visual.html

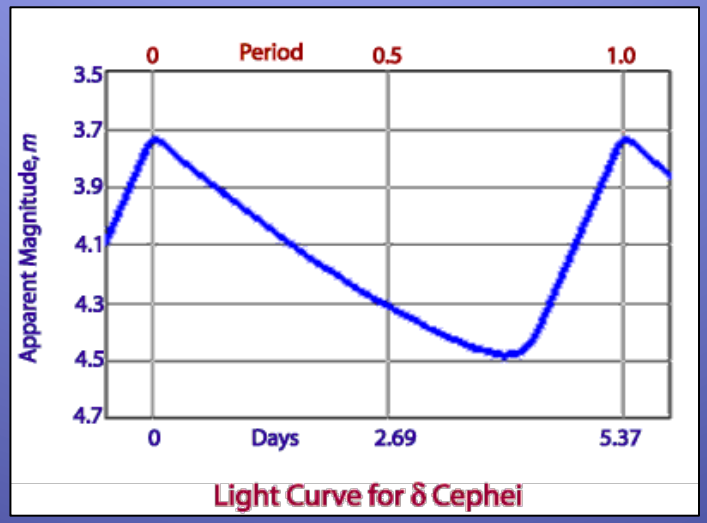
Examples of Different Types of Pulsating Variables


Henrietta Leavitt

Cepheids –

Period 1-70 days

Magnitude variation - .1 – 2.0 mag

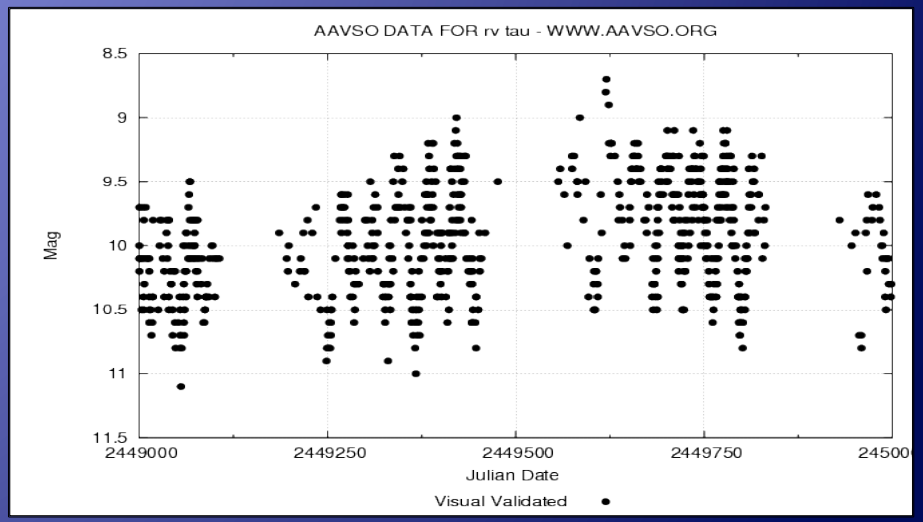


RV Tauri –

Period up to 100 days

Magnitude variation up to 3.0 mag

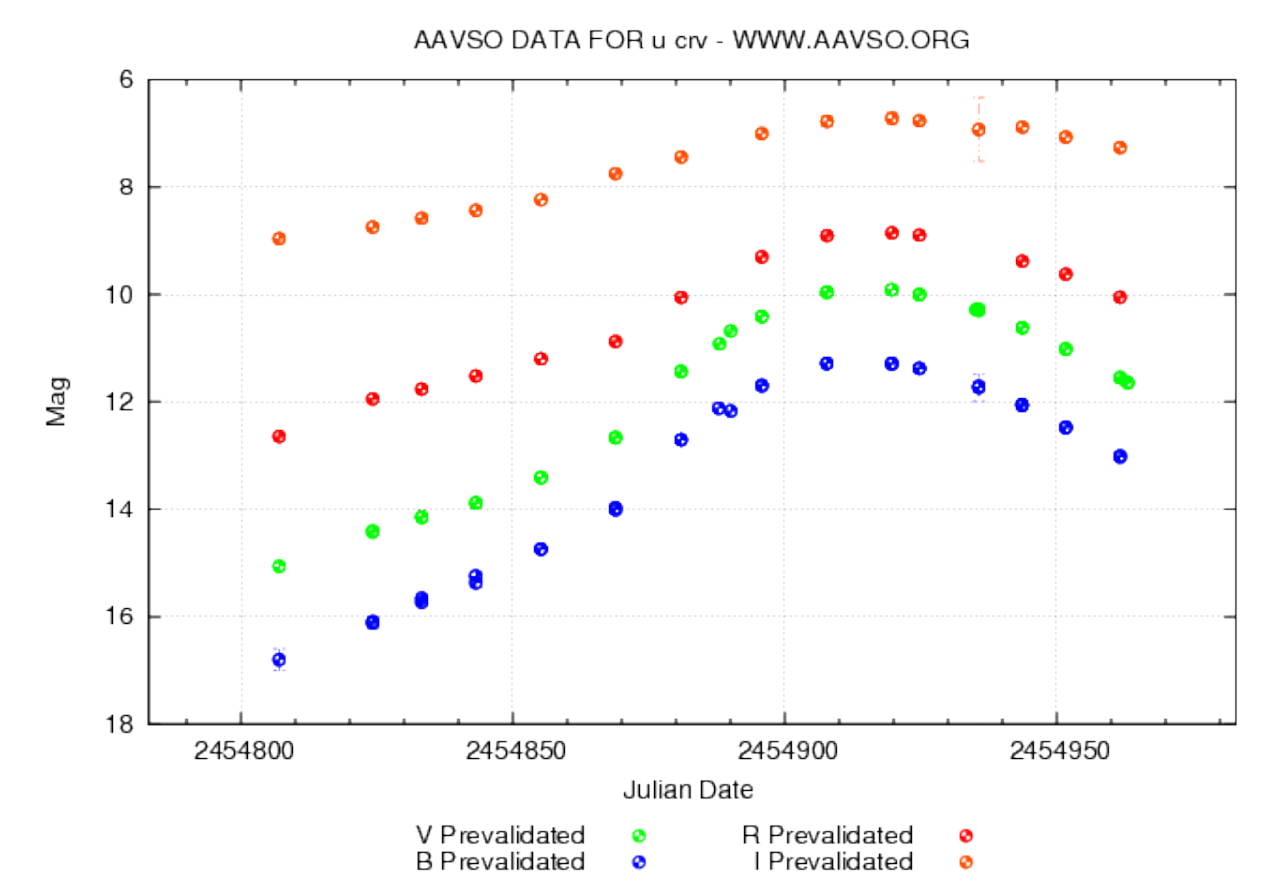
1000 days



Long Period Variables (LPV)

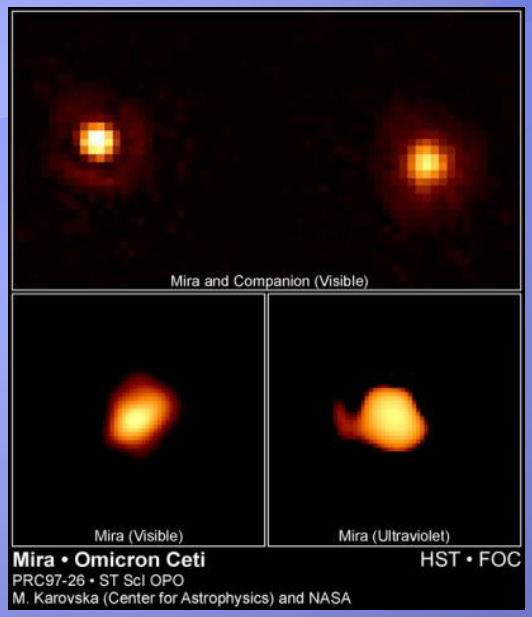
Multi-filter Amateur Observations of U Crv

(Periods 80-1000 days, Magnitude variation 2.5 – 5.0 mag)

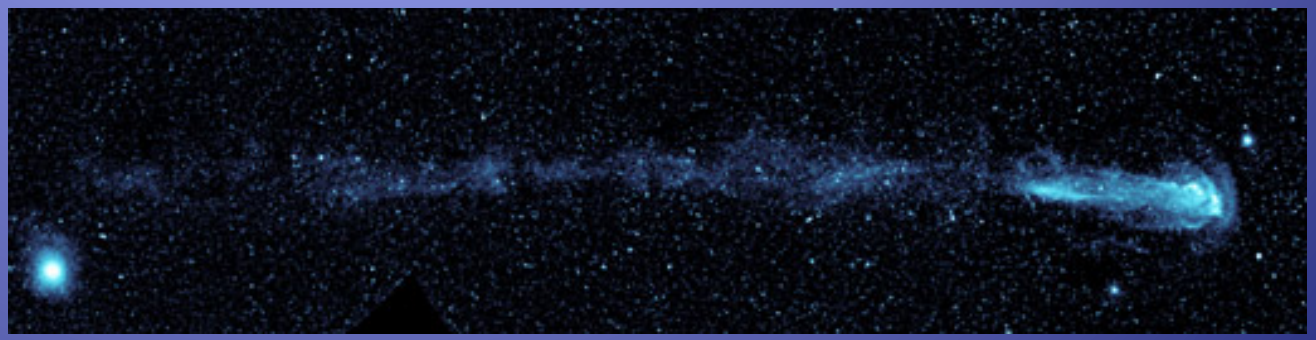


Observations by G. Myers using GRAS G4 & G15 10" scopes – www.global-rent-a-scope.com

Mira, the "First" LPV, Continues to Amaze



In 1997 Hubble Space Telescope resolved the binary star in Mira, and detected matter either being swept from its surface by its companion or having its atmosphere heated by the companion

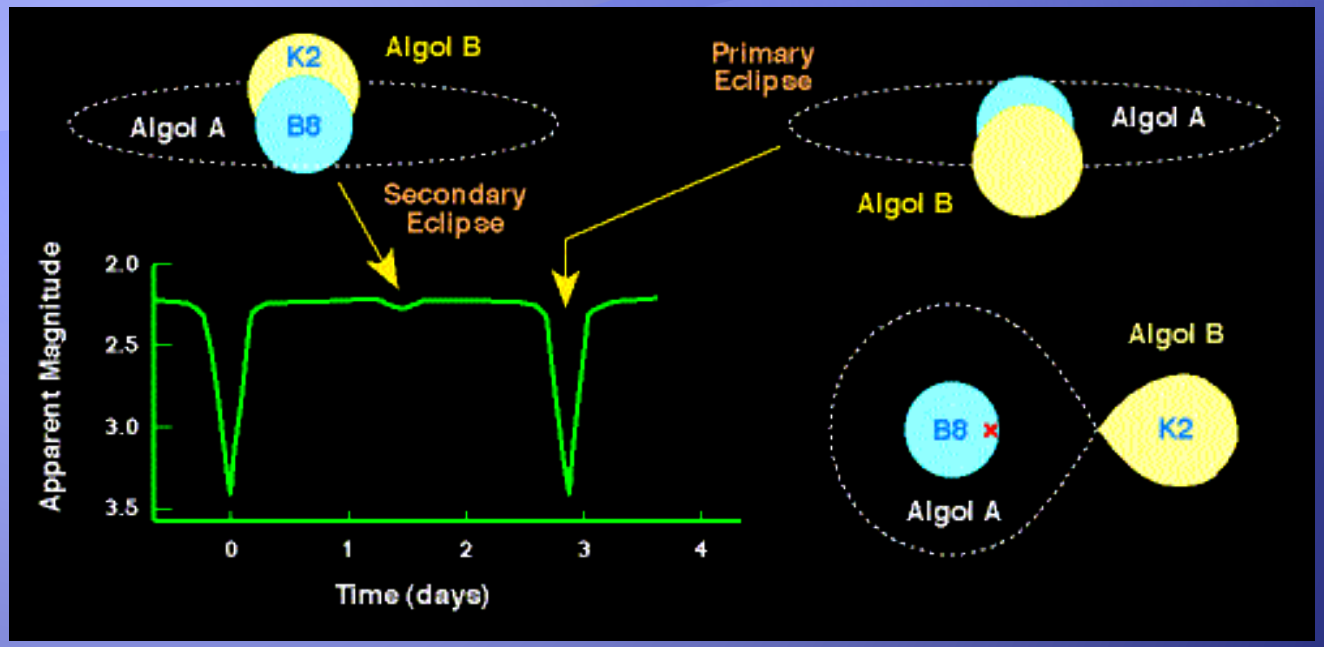


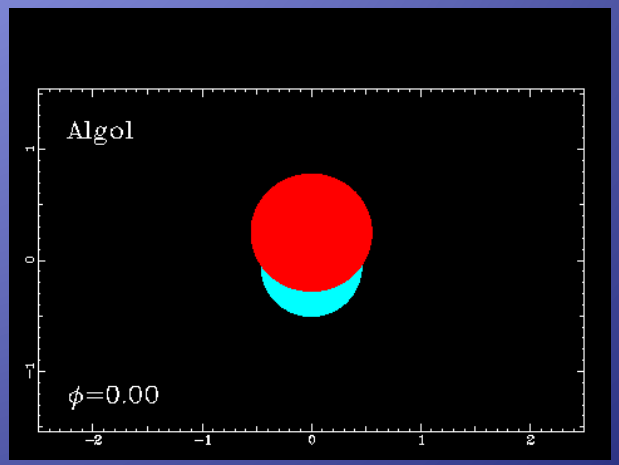
GALEX Ultraviolet Images detected a 13 light-year long "tail" in 2006

http://hubblesite.org/newscenter/archive/releases/1997/26/text/

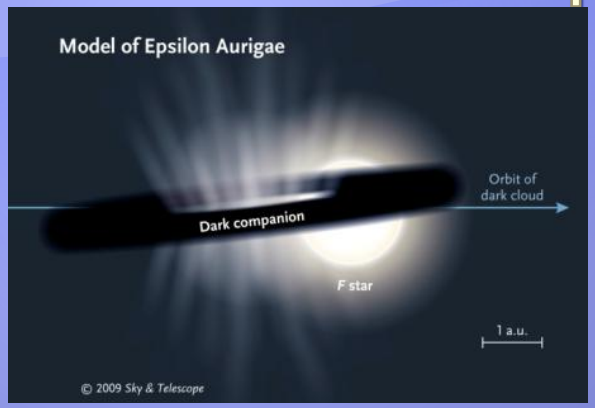
http://www.nasa.gov/mission_pages/galex/20070815/a.html

Eclipsing Binaries

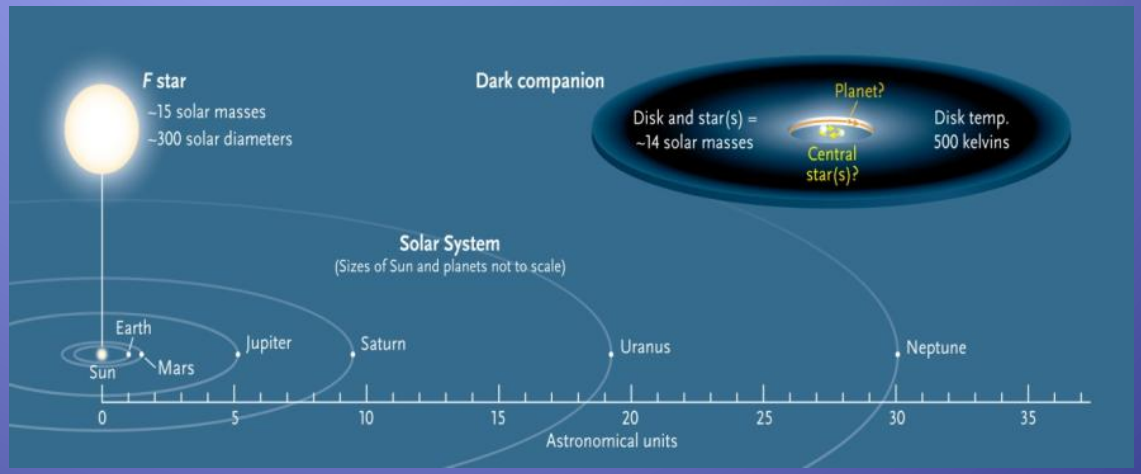


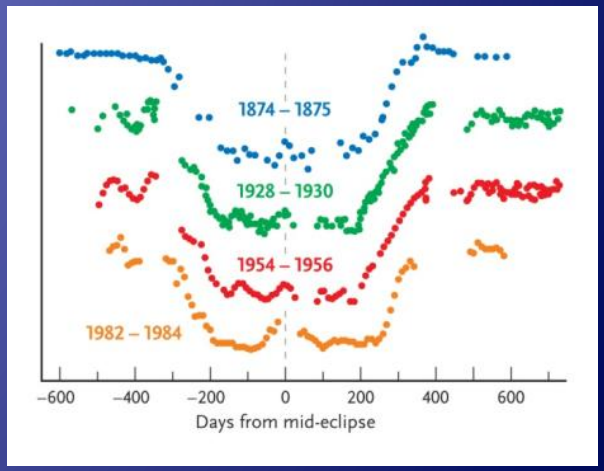


An Unusual Bright Eclipsing Binary is the Center of a Major Astronomy Outreach Campaign – Epsilon Aurigae



- Eclipse begins Aug. 11, 2009
- Minimum light begins Dec. 19, 2009
- Mid-eclipse Aug. 4, 2010
- Minimum light ends Mar.19, 2011
- Eclipse ends May 13, 2011





To Learn More and Get Involved, go to www.citizensky.org

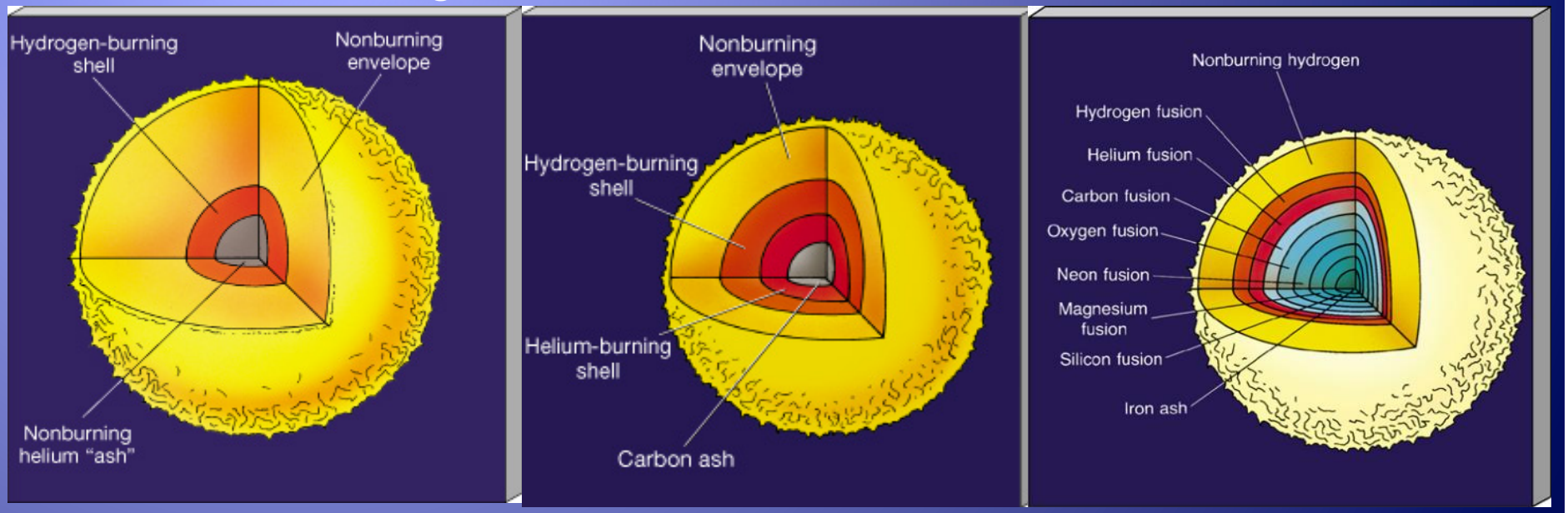
Erupting Variables

- Erupting variables are - *stars that have occasional violent outbursts caused by thermonuclear processes either in their surface layers or deep within their interiors*

- Major Types
  - Supernovae
  - Recurrent Novae
  - Cataclysmic Variables

Supernova Evolution –
Large Stars Evolve to Neutron Stars and Black Holes

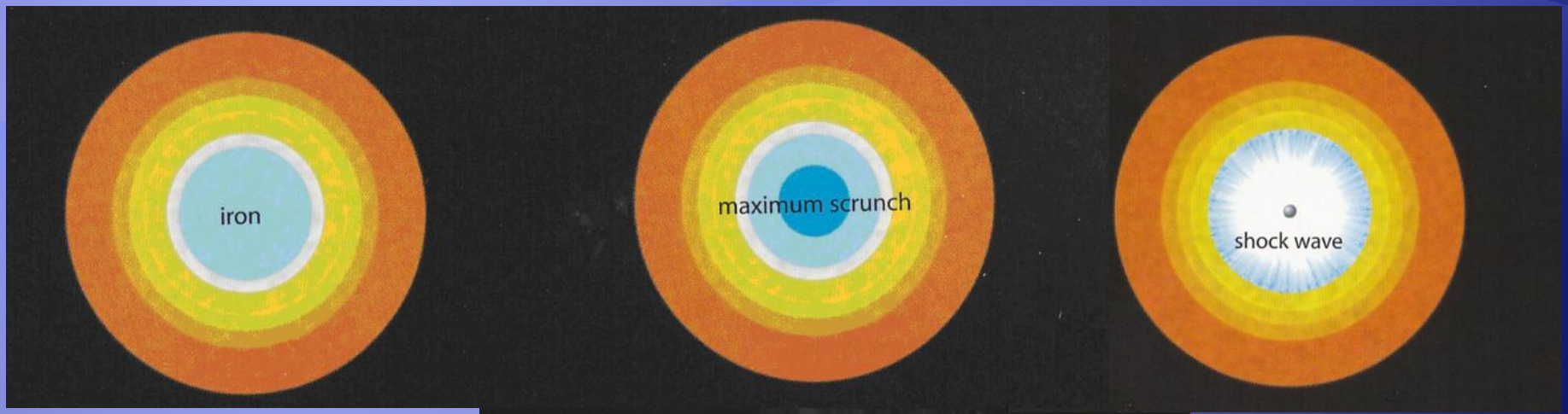
At the end of their lives, Stars Evolve Through Stages of Shell Burning With massive stars burning Heavier Elements

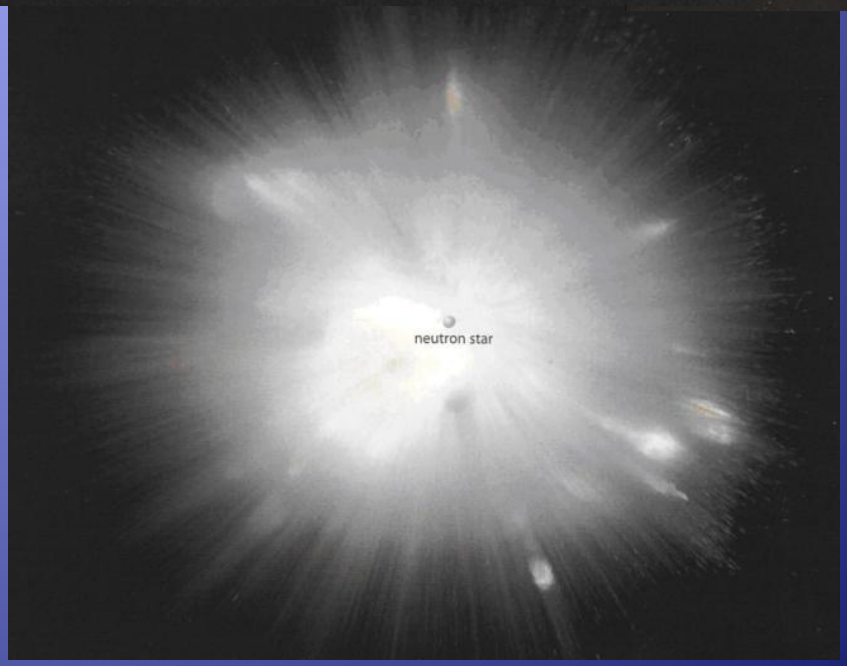


Time (post main sequence) →

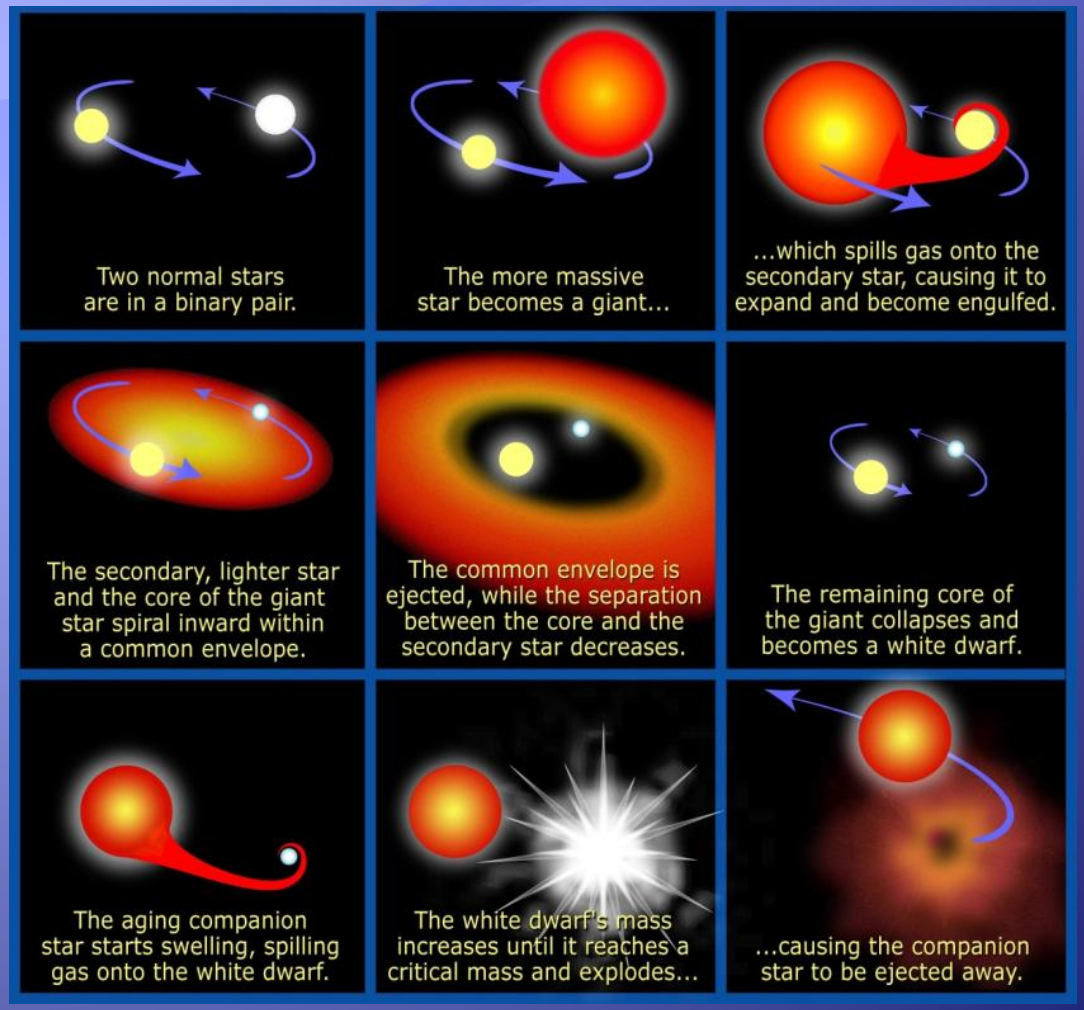
All Stars > .8 M⊙ | Heavier Stars | Heaviest Stars

Supernova Death!

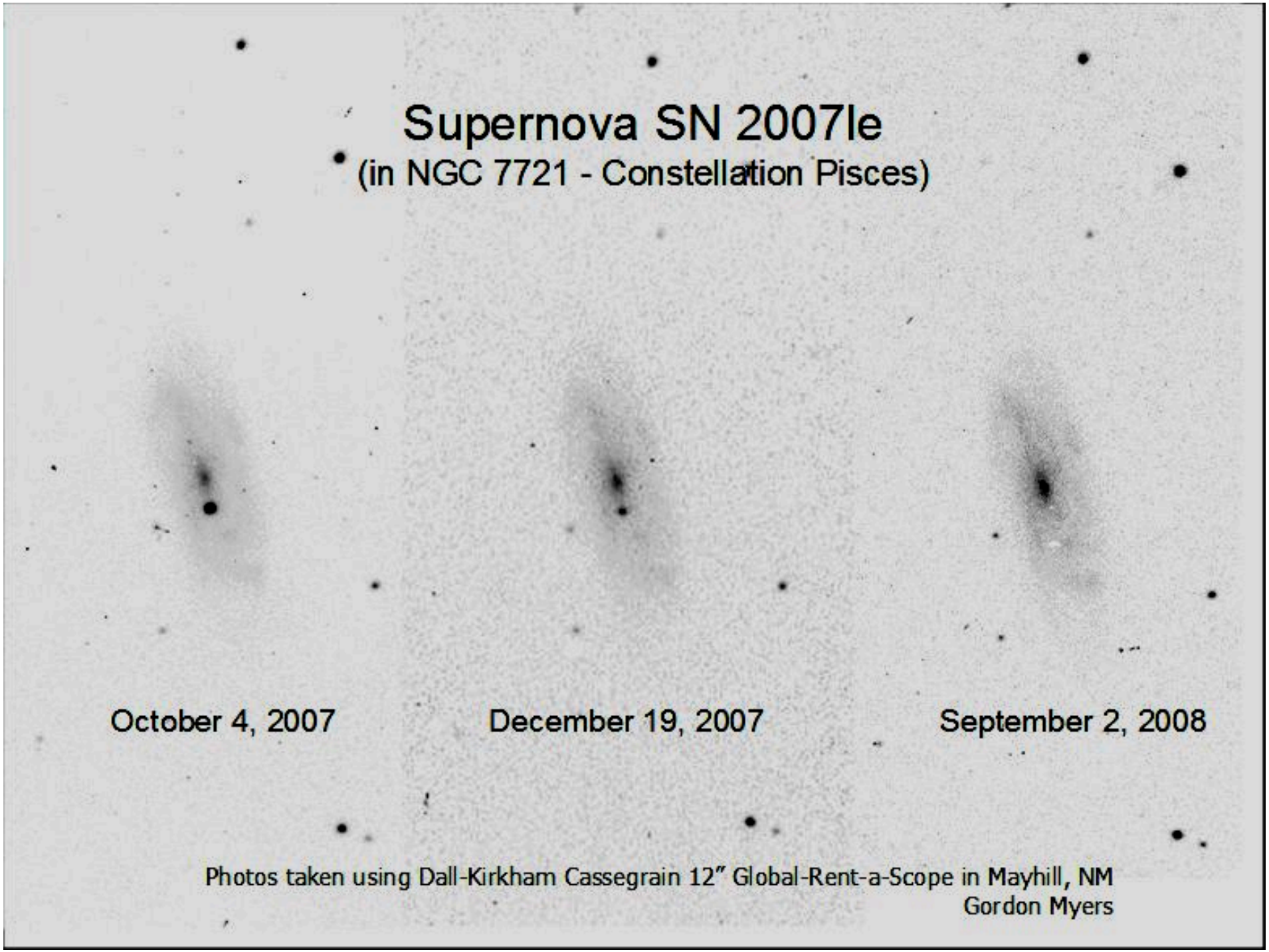




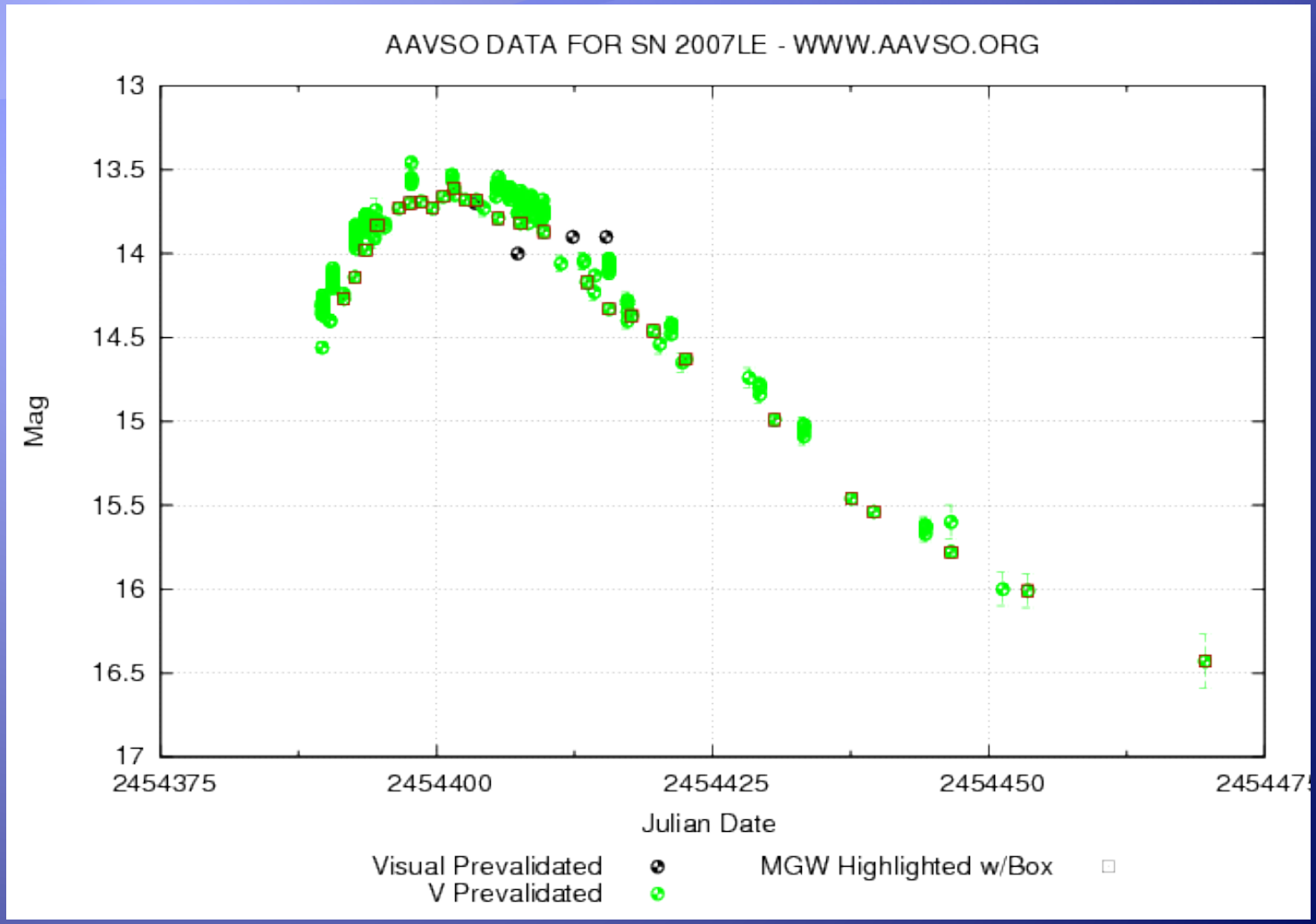
A Different Type of Supernova – Type Ia
A "Standard Candle"



http://www.pha.jhu.edu/~bfalck/Iaprogenitor.jpg


Supernova SN 2007le
(in NGC 7721 - Constellation Pisces)
October 4, 2007
December 19, 2007
September 2, 2008
Photos taken using Dall-Kirkham Cassegrain 12″ Global-Rent-a-Scope in Mayhill, NM
Gordon Myers

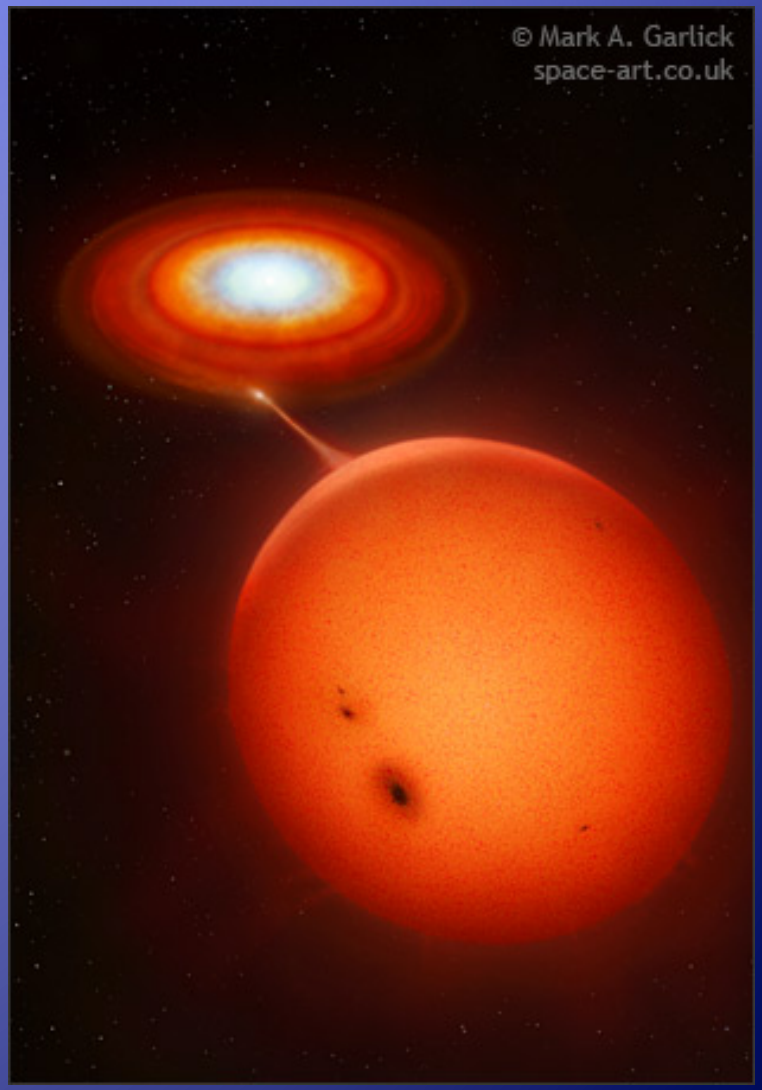
AAVSO Measurements of SN 2007le



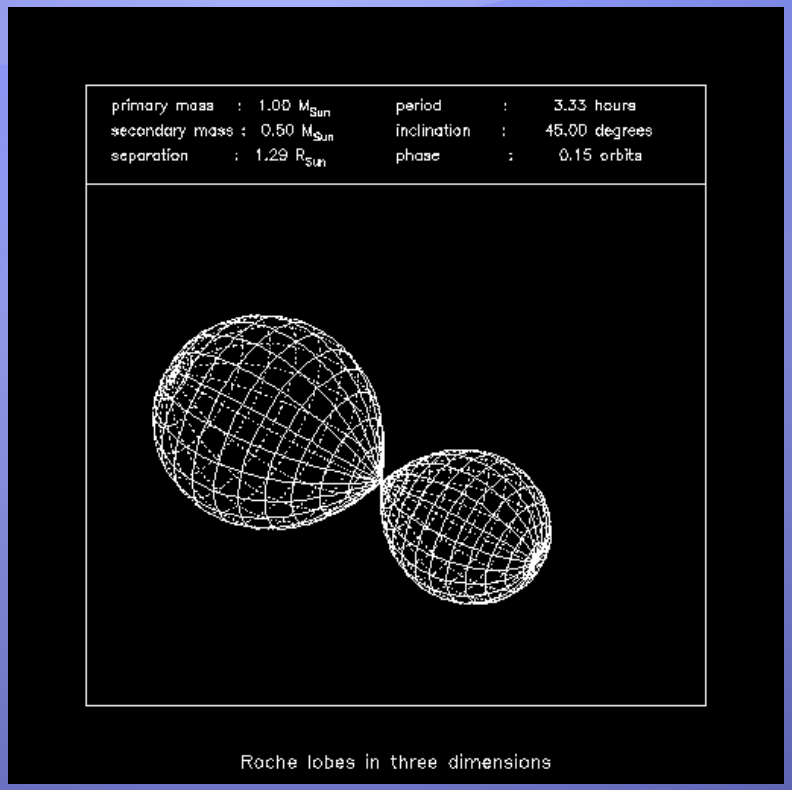
Cataclysmic Variables

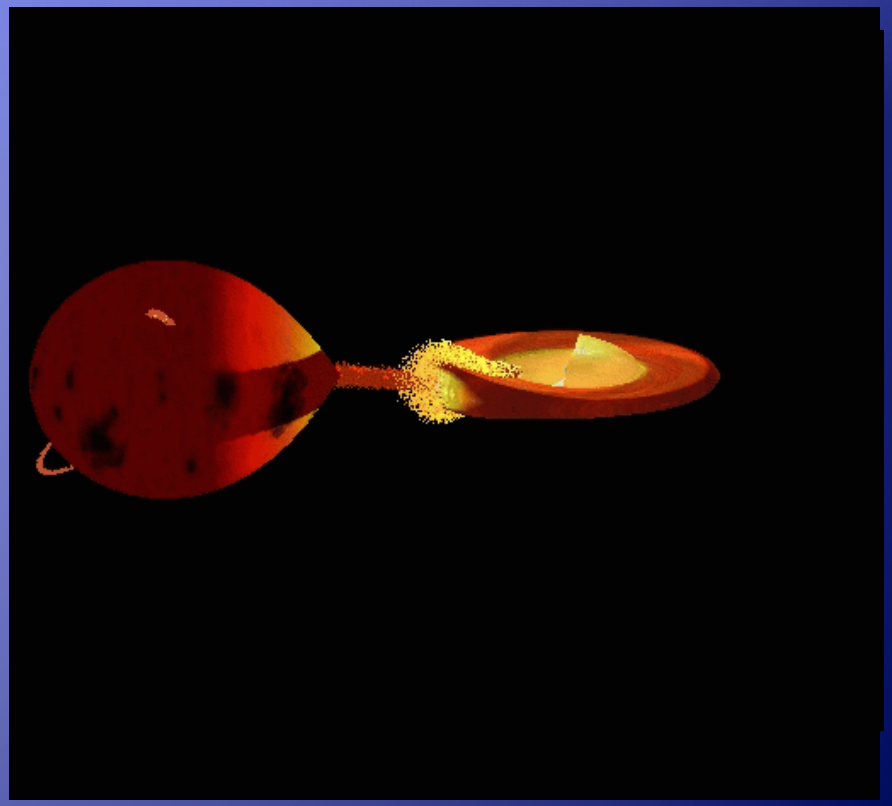
Key Properties –

- Binary Star System
- Stellar Material Flows from red dwarf star onto accretion disk surrounding white dwarf companion
- Flow stops and starts
- Orbital period 78 minutes up to around 10 hours
- "Hot spot" where stream hits accretion disk is often hotter and brighter than either star



Cataclysmic Variable Mass Flow

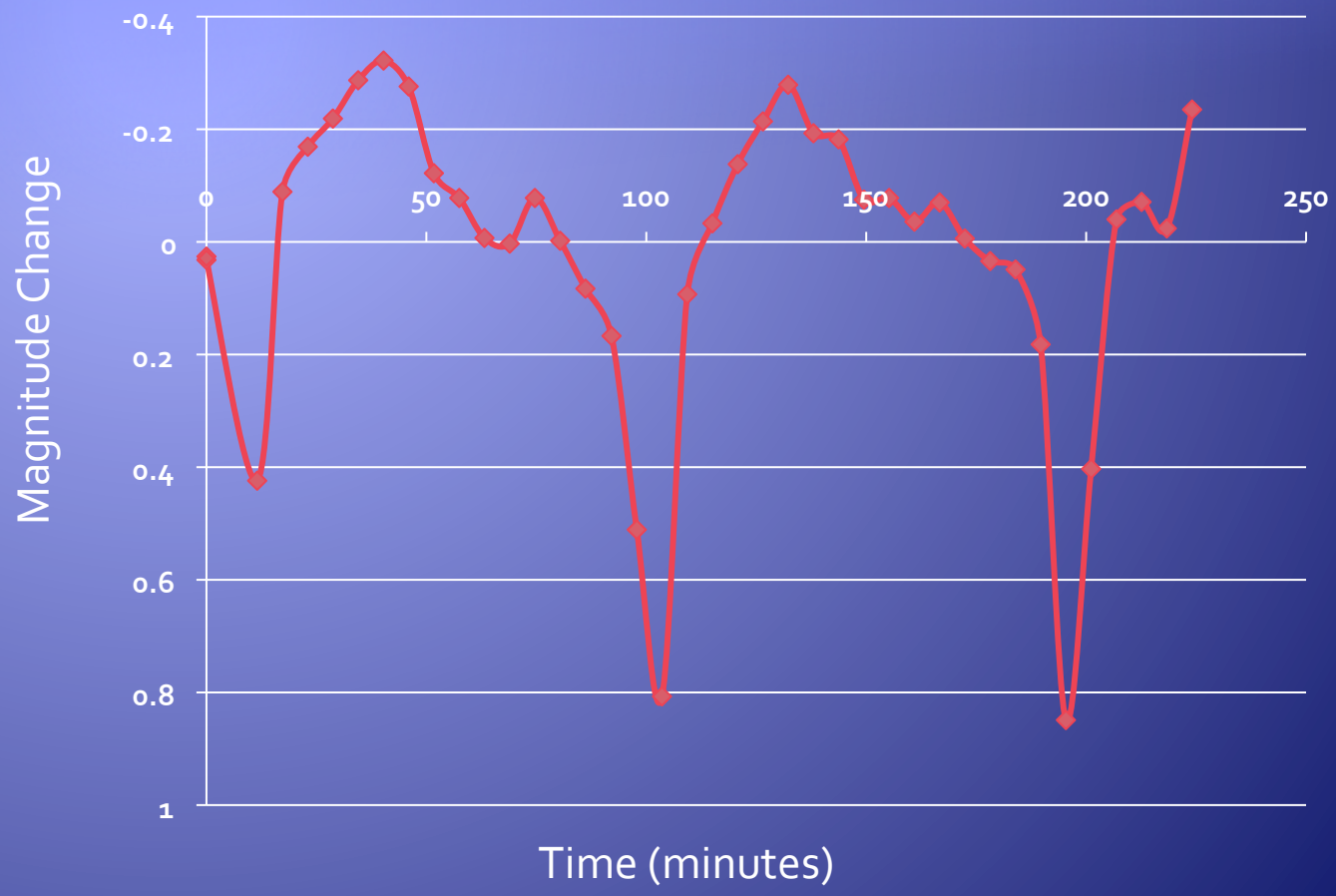




http://www.vikdhillon.staff.shef.ac.uk/seminars/lives_of_binary_stars/

CV Amateur Measurements

(First attempt measuring SDSS1524+22 Using 12" GRAS Scope in New Mexico with 3 minute exposures)



AAVSO

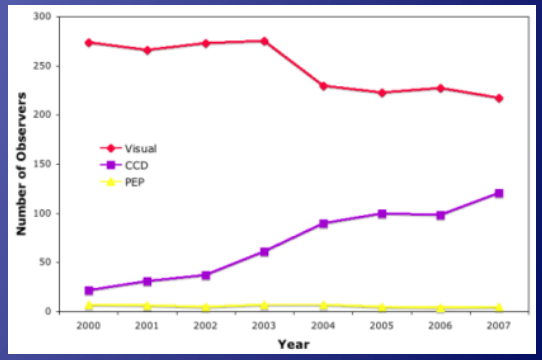
Amateur Association of Variable Star Observers

AAVSO Mission:

The AAVSO is an international non-profit organization whose mission is: to observe and analyze variable stars; to collect and archive observations for worldwide access; to forge strong collaborations between amateur and professional astronomers; and to promote scientific research and education using variable star data.

Key Benefits:

- Become part of the amateur/professional community
- Submit variable star observations; have access to 17 million observations made since 1911
- Detailed Sky Charts for comparison stars
- Excellent training material on variables and observing
- Special sections focus on Long Period Variables, Cataclysmic Variables, and Data Mining
- Free mentoring
- Free access to remote telescope network
- Two annual meetings with numerous valuable presentations
- Speakers Bureau with Outreach material



More and More observers are shifting to CCD's

AAVSO Web Site

Nerve center for active amateurs!

AAVSO Web Site:
www.aavso.org

Outreach Request –
Help teach the next generation astronomy and science

Questions from High School Seniors – May, 2009

- Why is the Milky Way called the Milky Way?
- Why are stars so far away yet easy to see with the human eyes?
- Is it really possible for us to live in space one day?
- What gases make up stars? What happens if something touches a star?
- What is going to make the sun die?
- What makes the planets follow their orbit and not move off course?
- How fast do stars move?
- How long does a star usually live?
- How were planets made?
- What makes planets different from one another?
- Why do stars go through different stages to become giant stars or dies?
- What do you do on cloudy nights?
- What would happen if we didn't have any stars in our universe?

The Best Example: Dr. Michelle Thaller's - "New Worlds: Exoplanet Discoveries from the Spitzer Space Telescope" - http://www.jpl.nasa.gov/events/lectures.cfm?year=2008&month=11

References

- One Universe – Tyson, Liu, Irion
- Astronomy Today – Chaisson, McMillan
- Modern Astrophysics – Carroll, Ostlie
- Cataclysmic Variable Stars – How and Why They Vary – Coel Hellier (Springer Praxis publisher)
- Pro-Am Collaboration – Pamela Gay (AAVSO Presentation)
- Variable Stars and the Stories They Tell – Mike Simonsen (AAVSO Presentation)

- Key Websites:
  - www.aavso.org
  - http://www.vikdhillon.staff.shef.ac.uk/seminars/lives_of_binary_stars/cv.html
  - www.cbastro.org
  - http://galileo.rice.edu/sci/fabricius.html
  - http://www.physics.usyd.edu.au/~bedding/animations/visual.html
  - www.jpl.nasa.gov
  - www.hubblesite.org

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