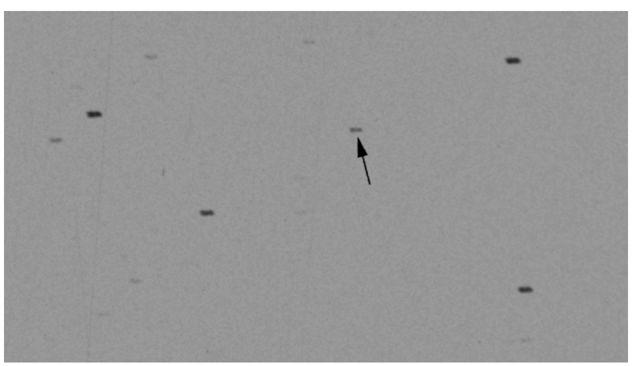
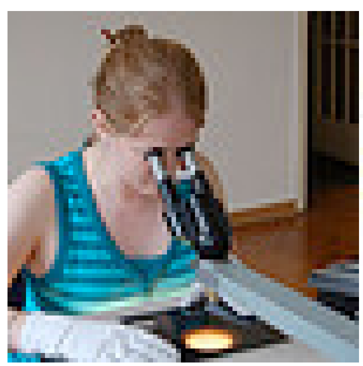
FRONT-LINE RECURRENT NOVA SCIENCE REQUIRES CENTURY OLD DATA

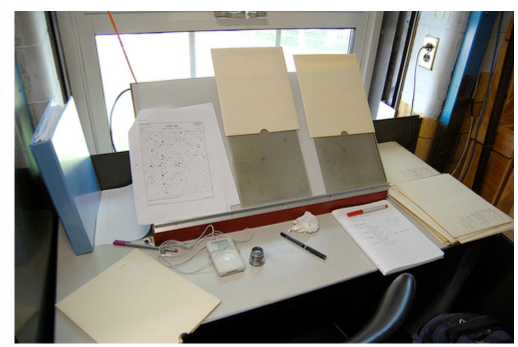
Bradley E. Schaefer

(Louisiana State University)

- What stars create Type Ia Supernova? Now a big-money question.
- Recurrent novae (RN) are a likely progenitor. But two big problems…
- Archival data is the *only* way to answer the big question
- Now, huge & comprehensive set of archival RN data

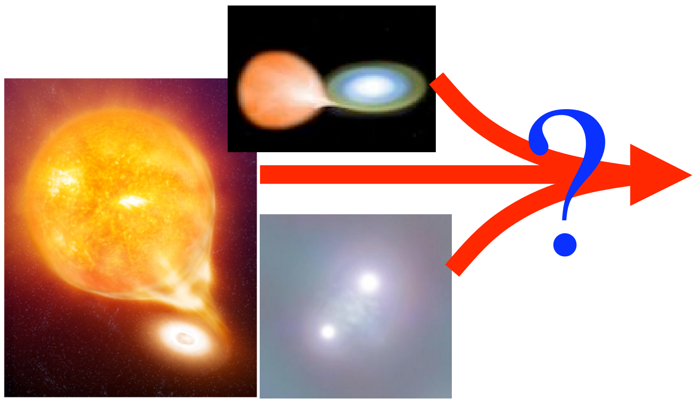


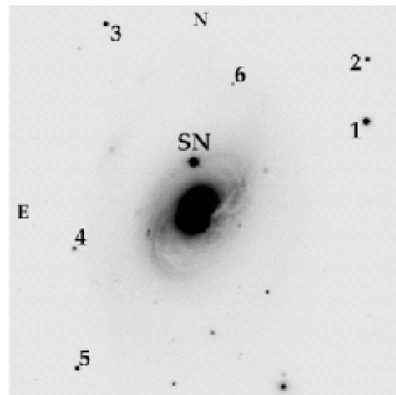


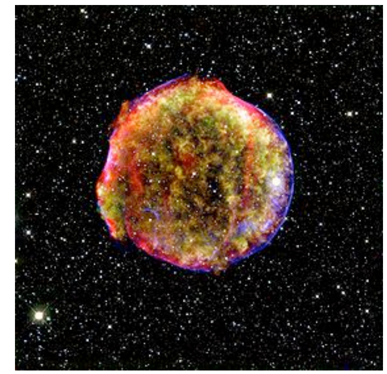


Perennial problem:

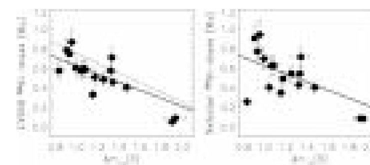
WHAT IS THE PROGENITOR SYSTEM FOR TYPE Ia SUPERNOVAE?



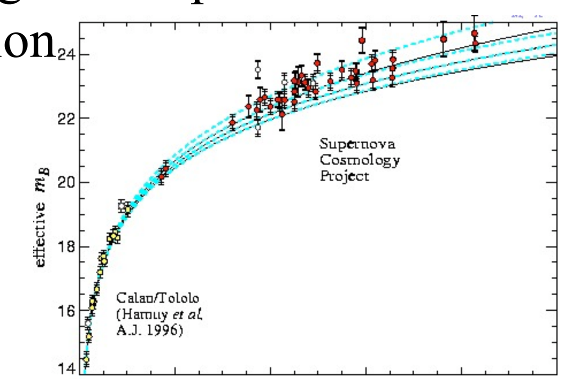




SUDDENLY A VITAL BIG-MONEY PROBLEM:

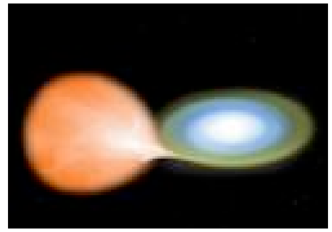


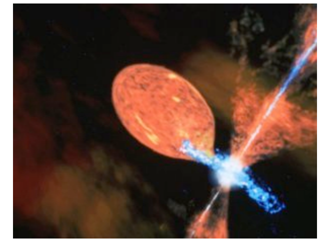
- Must know progenitor to calculate change in SN Ia $M\text{-}\Delta t_{15}$ relation
- Evolution of metalicity in old Universe → change Hubble Diagram shape
- *SNAP* cannot achieve goal without progenitor/evolution solution



PROPOSED PROGENITORS:

- Recurrent Novae
- Symbiotic stars
- Super-soft sources
- Double White Dwarf Binaries






RECURRENT NOVAE:

- Recurrent Novae are just a subset of ordinary novae that happen to go off more than once per century
- As such, they are binary systems with matter flowing off a companion star onto a white dwarf, accumulating on its surface until the pressure gets high enough to trigger a thermonuclear runaway (like an H-bomb) that is the nova
- Only 10 known in our Milky Way galaxy, including:
    - U Sco (1863, 1907, 1917, 1936, 1945, 1969, 1979, 1987, 1999)
    - T Pyx (1890, 1902, 1920, 1944, 1967)
    - T CrB (1866, 1946)
    - RS Oph (1898, 1907, 1933, 1945, 1958, 1967, 1985, 2006)

RECURRENT NOVAE ARE LIKELY SOLUTION:

To recur with τ_{rec}<100 years, RNe must have:

- High WD mass ($1.2M_{\odot} < M_{WD} < M_{Chandra}$)
- High accretion rate ($\dot{M} \sim 10^{-7}\ M_{\odot}/yr$)

M_{WD} will exceed $M_{Chandra}$ any year now…

SN Ia

TWO PROBLEMS:

- Does the White Dwarf eject more mass each eruption than it gains between eruptions?

  $M_{ejecta} < \tau_{rec}\,\dot{M}$?

- Are there enough RNe to produce the observed Type Ia SN rate?

  $R_{RNdeath} = R_{SNIa}$? $R_{RNdeath} = N_{RN} / (\dot{M} / 0.2M_{\odot})$

SOLUTION NEEDS GOOD RN DEMOGRAPHICS:

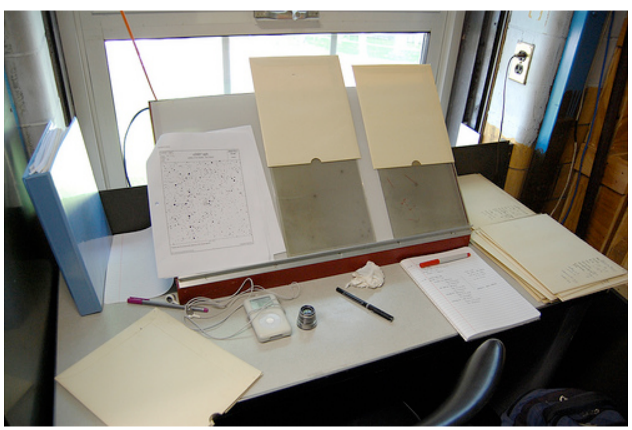
- τ_{rec} - recurrence time scale
- N_{RN} - number of RNe in Milky Way
- $\dot{M}$ - mass accretion rate onto white dwarf
- M_{ejecta} - mass ejected in eruption

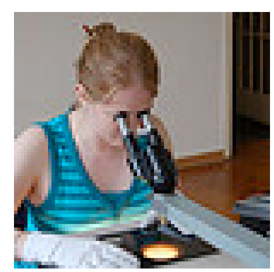
CAN GET THESE ONLY FROM HISTORICAL/ARCHIVAL DATA:

- τ_{rec} - can only look in archival plate collections
- N_{RN} - archival plates and AAVSO data only way to measure discovery efficiency
- $\dot{M}$ - changes on all time scales, but we need average over the last century
- M_{ejecta} - must have pre-eruption eclipse timings

Harvard College Observatory

Sonneberg Observatory



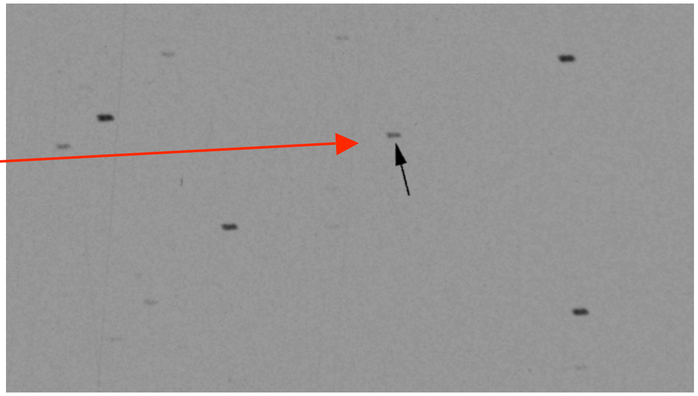


PRODUCTS: [also, see http://www.phys.lsu.edu/recurrentnova/]

- Modern measures of all comparison stars
- Remeasure *all* archival plates [*only* data for half the eruptions]
- *Complete* light curves for *all* 37 known RN eruptions
- B & V light curve templates for each RN in eruption
- 10,000 CCD magnitudes during quiescence [essentially *only* data for 7 RNe]
- Year-by-year discovery efficiencies for all RNe
- Recurrence time scales and predicted next dates of eruption
- Best distances and extinctions for all 10 RNe
- Intrinsic absolute magnitudes and colors at peak and quiescence
- UBVRIJHK spectral energy distribution for all 10 RNe

HIGHLIGHTS:

- 6 newly-discovered RN eruptions
- 1 newly-discovered RN
- 5 newly-discovered orbital periods
- U Sco will next erupt any month now
- Horrifyingly low nova discovery efficiencies
- 5 accurate distance measures (based on companion stars)



RESULTS: [also, see my Poster 491.04 on Wednesday]

- U Sco will go off any month now…
  - ➔ First time a nova eruption has been predicted for a given star and year
  - ➔ Great opportunity to prepare; large international USCO2009 collaboration

- Discovery efficiencies ~ 4% for average nova
  - ➔ Huge opportunity for amateurs to discover the missing novae
  - ➔ ~80 of 'classical novae' now in catalogs are really recurrent

- Discovery of sudden sharp drop in eruption light curves
  - ➔ Mystery for theorists

- $M_{ejecta} << \tau_{rec} \dot{M}$ for CI Aql and U Sco
  - ➔ White dwarves are gaining mass ➔ RNe will collapse as Type Ia SNe

- $R_{RNdeath} \sim R_{SNIa}$ for Milky Way, M31, & LMC
  - ➔ There are enough RNe to supply the Type Ia events

STORYLINES:

MOST NOVA ERUPTIONS ARE *NOT* DISCOVERED

- Discovery efficiency is <10%
- This opens up a tremendous opportunity for enterprising amateurs to use the latest in off-the-shelf cameras and a nightly observing cadence to discover many novae
- Roughly a third of so-called ‘Classical Novae’ are actually recurrent novae with multiple eruptions in the last century (all but one of which were missed)

RECURRENT NOVAE AS LIKELY PROGENITORS OF TYPE Ia SUPERNOVAE

- Long-lasting progenitor problem of vital importance for supernova cosmology & *SNAP*
- Recurrent novae must have high-mass white dwarfs and high accretion rates, so they are a likely solution to the progenitor problem
- Two big questions, for which the *only* solution can come from archival data
- I have collected a huge and exhaustive database from Harvard plates and the AAVSO
- Results show that white dwarf is gaining mass and there are ~10,000 RN in the Milky Way

ARCHIVAL DATA HAS FRONT-LINE ASTROPHYSICS

- Archival data sources (e.g., the Harvard Plates and the AAVSO data base) have wonderful discoveries and front-line astrophysics tucked away.
- Archival material is often the *only* way to get coverage in the time domain longer than a few years, and this is often critical for astrophysics
- Worldwide collections of archival astrophotos need conservation and digitization
- The younger generation of astronomers needs to learn how to use the archival data, and to realize that the riches are there for the taking