Stella Novae: Past and Future Decades

or

The Mystery of T Pyx

Conference Summary

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At the beginning, we thought that:

We basically understand the Nova mechanism.

As we went along, we learned that:

There are some details that remain to be explained.

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Lord Kelvin, 1900: *physics was over, except for two small clouds on the horizon.*

These "clouds" turned out to be the clues that led to quantum mechanics and the theory of relativity.

What have we learned ?

Review talks

- Michael Shara (*overview*)
- Steve Shore (*spectroscopic evolution*)
- Jordi Jose (*Multi-D modeling*)
- Jennifer Sokoloski (*symbiotic systems*)
- Laura Chomiuk (transients with SKA)

About the Nova Binary System

- Primary
  - WD composition: CO or O-Ne-Mg → O-Ne
  - Massive WD in RNe - from strong Ne lines (Elena Mason)

- Secondary
  - RG not only in some RN systems, but in CN as well (Mike Bode, …) → New nova classification, according to secondary type (MS, SG, RG) (M. Darnley).
  - RG secondary rate higher in M31 than in Galaxy (Steve Williams)

- Period

  Standard period evolution (reviewed by Chris Knigge) challenged by:
  - 2 high mass transfer systems in the period gap (*born there?*)
  - 4 low mass transfer systems at 3-4 hr period (*hibernation?*) (Linda Schmidtobreick)
  - RG or SG secondaries (above)

About the Outburst

- Secondary maxima
  - Detected in both slow and fast novae (Ulisse Munari)
  - Multiple maxima
- SSS phase

  End of wind phase (Marina Orio, Julian Osborne)
  - Variability
  - 30-35 sec periodicity (in 2 objects) – *rotation ?*
- γ – ray
  - Visual maximum after 511 keV γ-ray (Margarita Hernanz)
  - Novae detected by FERMI
  - GeV photons detected (acceleration), but no MeV
- Correlations
  - MMRD questionable
    (for M31 not tight, but generally valid)
  - UV –X light curves anti-correlated (Greg Schwartz)

About Nova Shells

- Mass
  - Correlation: $t_2 \ \alpha \ m_{ejecta}$ (Greg Schwartz)

  Mass determination from IR (Bob Gehrz)
  - Still larger than models predict
  - Shells that form dust are least massive
- Composition

  Bright novae – extreme overabundances: CNO, Ne, Mg, Al, Si

  Dust grains similar to those detected in comets
- Structure

  Generally, Complex, no spherical symmetry (in most)

  1901 Nova GK Per: analysis of 282 knots (Tina Liimets):
  - Wide range of velocities: 13-1005 km/s
  - Moderate deceleration over 100 yr
  - Knots exhibit abrupt changes in brightness
  - Shell becomes circular with time
- Dust formation

  Dust takes longer to form in slower novae (Mike Bode)

From Surveys

- Nova rates

  15 Galaxies with known nova rates (Allen Shafter)
  - Nova frequency: 30-50/year
  - No apparent correlation between rate and population age, although theory suggests lower rate in older populations: cooler WD ➔ longer accretion time.
  - Rne: 2% - 8% (Galaxy: ~ 3%)

- Dust formation

  M31 and Galaxy (Mike Bode) ➔ correlations:
  - $t_{condensation} \alpha\ t_2$
  - $t_{IR\text{-}max} \alpha\ t_2$
  - Optical light curve: $A \alpha\ t_2$

- Decline (SSS phase)

  M31 – 78 Novae (Martin Henze) ➔ more correlations:
  - $t_{turn\text{-}on} \alpha\ t_{turn\text{-}off}$
  - $t_{turn\text{-}off} \alpha\ t_2$
  - $t_{turn\text{-}off} \alpha\ 1/T_{BB}$
  - $t_{turn\text{-}on} \alpha\ 1/v_{exp}$

From models

- Multidimensional

Mixing at the WD boundary (Jordi Jose):
- Convective mixing requires 3D (different from 2D)
- 2D convective overshoot: results similar to 1D on the large scale(Ami Glasner)
- Large-scale inhomogeneity – promising!
- Significant enrichment in **all** cases
- Very short-term calculations (time consuming)

- HD simulations

3D simulation of RS Oph (Shazrene Mohamed)
3D SyS accretion (Joana Mikolajewska) – rather than RLOF or spherical wind
3D Sys active phase (Dmitri Bisikalo)

- Parameter studies

TNR without mixing ➔ (??) SN Type Ia (Sumner Starrfield)
- Objects cannot be CN – highly enriched compositions
- Secondary must be prohibitively large (net mass accretion inefficient)
- Eventual He flash may remove most of the mass

Light curves based on Prialnik & Kovetz grid (Yael Hillman)
- Prediction: UV-X-ray flash preceding the outburst

Hands-free MESA code (Pavel Denisenkov)

All models are wrong,

but some of them may be useful…

Martin Henze

About some individual novae

Best Actors

- RN T Pyx
  - Identical light curves for 1966 and 2011 (Aless. Ederoclite), although $t_{acc}(2011) \approx 2\ t_{acc}(1966)$
  - Low M_{WD}: $0.7 \pm 0.2\ M_{\odot}$ contrary to expectation for RN
  - Mass transfer rate 1000 times higher than indicated by P=1.83hr (Joe Patterson)
  - Ejected mass estimate ($6 \times 10^{-5}\ M_{\odot}$) >> typical Rne
  - Expansion velocity: initially very high, drops abruptly and rises again (Farung Surina) …
- RN RS Oph

  Dust features variable for 3 yr after outburst (Mark Rushton)
  X-ray emitting, bipolar structure (Rodolfo Montez)
  Not a standard RN – no regular eruptions
- HeN V445 Pupis
  - Very high expansion velocity: 6720 km/s (Sally Macfarlane), knot velocity even higher: 8450 km/s

Supporting Actors: KT Eri, GK Per, BK Lyn …

How have we learned ?

Better instruments

- Telescopes
    - Multi-wavelength surveys
    - Large populations surveys

- Computers
    - Multi-dimension
    - Extended parameter studies

What next ?

Goals for the Conference Program

- Confrontation of observational surveys with theoretical parameter studies to work out the details

- Consistent simulation of a nova outburst including the nova shell (3D-simulation)

- Consistent simulation of the long-term evolution of a nova binary (including primary, secondary and the interaction between them)

- Continuous, panchromatic (from Radio to γ) observation a full nova outburst (from early rise to late decline) in all wavelengths
- More surveys…

- Open questions:

  * What is T Pyx and why didn't it erupt in ~ 1988 ?
  * Can an accreting WD lead to a SN Type Ia ?

  Yes!

- Prediction of a nova outburst (Mike Shara)

Thanks to the organizers

for a

fantastic Scientific Program !