Classical Novae

Fermi 2018 Pisa; 15/3/2018

Axiomatics: What do we know?

- All novae are binary systems in which a degenerate (WD) accretes mass, depending on the composition of the companion, that eventually reaches a critical base pressure and ignites a nuclear reaction (CNO).
- The nova phenomenon is largely *independent of the evolutionary state of the companion*;
- The nuclear burning produces a thermonuclear runaway reaching $L_{max} \geq L_{Edd}(1.4M_{\odot}))$
- The explosion ejects material in a dynamically short timescale, but ...
- The WD survives the explosion and the ejecta are filters,
- The ejecta are optically thick and the nova light curve is produced by variable opacity and changes in the underlying source (planetary nebulae and LBVs in fast forward).
- The ejecta aren't spherical (not a trivial point!) and dominate the phenomenology
- Novae form dust

What do we want to know?

- The TNR produces a broad range of enhancements of elements, possibly up through Ca; what is the nova signature (i any) in Galactic abundances?
- The WD masses are high, $\geq 1 M_{\odot}$, how much mass remains (if any) after each explosion?
- What happens internally and dynamically to the WD?
- Whence these systems? whither these systems?

The two varieties

Compact systems

- All "classical" novae and compact recurrents, known in MW, LMC, and M31
- Periods distributed between 1.5 hrs (T Pyx, IN Nor) to 2.9 days (OGLE-2018-NOVA-01LMC)
- $1 < M_{WD} < 1.4 M_{\odot}$, $0.2 < M_{K,M} < 1 M_{\odot}$
- Two subtypes: CO, ONe: depends on WD mass
- Polars (magnetic domination of acretion): V1500 Cyg, DQ Her, Nova 1437 , connection with cataclysmics?
- Recurrence times: 1 yr (M31N 2008-12a) to >500 yr (Nova 1437 Sco)
- Disk accretion, RLOF driving
- γ-ray emission to 1.3-7 GeV (cutoff energy), timescale roughly a few weeks

The two varieties
Symbiotic-like systems

- All evolved systems are recurrents, known (to date) only in MW
- Periods distributed between a few years (T CrB, RS Oph) to almost a century (V407 Cyg)
- $1 < M_{WD} < 1.4 M_{\odot}$, $0.5 < M_{K,M} < 2 M_{\odot}$(?)
- γ-ray emission to 1.3 (cutoff energy), timescale roughly a a week
- Not clear about subtypes
- Disk accretion but powered by stellar wind (and possibly focused winds), companion K,M giants
- Recurrence times: 20 yr to nearly a century
- All ejecta low mass

Some questions

- Why, since the ejecta aren't spherical, is there (apparently) a *bolometrically constant* stage? What sets the covering factor for the highly inclined systems?
- What is the origin of the fine structure? What determines the filling factor of the fragmentation?
- What is the origin of the bipolar symmetry?
- What mixes the ejecta? Is there a signature in the ejecta?
- Is there a wind at *any* stage of the outburst?
- Are there feedback effects from the companion (is it just the proverbial "innocent bystander" who happens to witness the crime)?

Some speculation

- Are there *any* standard candles?
- Is the boundary layer as simple as we want it to be?
- Is the MMRD relation related to ejecta geometry and orientation?
- Is there a pulsational (shell flash) instability possibly due to sporadic re-start of accretion?
- Do magnetic fields control the initiation of the explosion (is this the mechanism for the pile-up)?