Resolving Thermal and Non-thermal Radio Emission in Classical Novae

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Image credit: NAOJ
Radio Observations of Novae

• E-Nova team: monitors novae in the radio at several wavelengths (21 cm to about 0.8 cm)
• We use radio telescopes all over the world
• Sensitive to both thermal (un-shocked) and synchrotron (shocks) emission
### Current Understanding of Novae

| Color-scale | e-MERLIN Day 87  
(54 mas resolution) | VLA Day 126  
(43 mas resolution) | VLA Day 615  
(106 mas resolution) |
|-------------|-------------------|--------------------|---------------------|
| Black Contour | EVN Day 91  
(7 mas resolution) | EVN Day 113  
(7 mas resolution) | VLA Day 126  
(43 mas resolution) |

V959 Mon

From Chomiuk et al. 2014
Does This Model Work for Other Novae?

GK Per (Hα + [NIII], Romano Corradi)

From O’Brien & Bode 2008 (Ch. 12 in Bode & Evans 2008)

QU Vul (HST, Ringwald)

V351 Pup

V1974 Cyg (HST, from Paresce et al. 1995)
V339 Del (2013)

- Peak optical (V) magnitude \(\sim 4.3\)
- Detected by Fermi for 27 days (Ackermann et al. 2014)*
- IR interferometry during the first \(\sim 50\) days indicated a “ring + core” structure (Schaefer et al. 2014)

*Only 9 detections \(\geq 3\sigma\), most points after Day 12 are upper limits
V339 Del: Thermal Ejecta

What the radio light curve is supposed to look like

V339 Del’s radio light curve

V1974 Cyg (from Hjellming 1996)
V339 Del: Resolved Ejecta

VLA, A-configuration images

Day 711 (2015-07-26)

13.5 GHz

16.5 GHz

29.5 GHz

35.0 GHz

Day 758 (2015-09-11)

13.5 GHz

16.5 GHz

29.5 GHz

35.0 GHz

Preliminary
Hypothesis

Our point of view for V339 Del

Our point of view for V959 Mon
Hypothesis

Our point of view for V339 Del

Optically thick at early times & hides synchrotron emission
Hypothesis

Our point of view for V339 Del

Optically thin at late times, so we can see the torus
Hypothesis

Fast rise after initial common envelope phase

Slow rise/plateau due to confined non-spherical flow

Ejecta becomes optically thin

Preliminary
Why Aren’t All Novae Detected By Fermi?

• Luminosity range
  • V959 Mon: $L_\gamma \sim 0.6 \times 10^{35} \text{ erg s}^{-1}$ (Linford et al. 2015)
  • V1324 Sco: $L_\gamma \geq 18 \times 10^{35} \text{ erg s}^{-1}$ (Finzell et al. 2015)

• What can lead to the luminosity range?
  • Ejecta velocity range
  • White dwarf mass range
  • Accretion rate range
  • Some novae are embedded in red giant wind which leads to stronger shocks (e.g., V407 Cyg & V745 Sco)
The Other Post-2012 Fermi-Detected Novae

- **V1369 Cen** (2013, peak V mag ~ 3.3)
  - Limited data due to its declination of -59°
  - Some ATCA observations

- **V745 Sco** (2014, peak V mag ~ 9.0)
  - VLA and VLBA observations
  - X-ray observations with multiple instruments

- **V5668 Sgr** (2015, peak V mag ~ 4.0)
  - VLA observations ongoing
  - X-ray observations with Swift and Chandra ongoing
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Recurrent nova with red giant companion