Classical Novae: The Connections Between Radio and Gamma-Rays

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Radio Light Curves

• Radio emission persists for years
• Turnover of radio light curve is dependent on density profile of ejecta
• Can calculate ejecta mass from density profile
• “Typical” ejecta mass: $10^{-5}$ to $10^{-4} \, M_\odot$

V1974 Cygni VLA light curve
(From Hjellming 1996)
Radio Light Curves

V1974 Cyg
From Hjellming 1996

V1723 Aql
From Weston et al. 2016

V392 Per
PRELIMINARY

V5855 Sgr
PRELIMINARY

Non-thermal "flare"

Late peak

Day 0 = 2018-04-29 (MJD 58237)

long plateau

Day 0 = 2016-10-20 (MJD 57681)
Radio Spectral Index: $S_\nu \propto \nu^\alpha$

- In theory, optically thick bremsstrahlung radiation should have $\alpha=+2$
  - We have never seen this
- Optically thin bremsstrahlung: $\alpha=-0.1$
- Optically thin synchrotron: $\alpha=-0.7$

*See Franckowiak et al. 2018 for discussion of V1535 Sco as a candidate Fermi source*
High-Resolution Imaging: VLA

V959 Mon (2012)

Can get distances with expansion parallax (e.g., Linford et al. 2015)
High-Resolution Imaging: VLA

More examples of non-spherical morphology
High-Resolution Imaging: VLBI

RS Oph (2006): VLBA

V959 Mon (2012): VLA + VLBA

Compact non-thermal knots (VLBA)

See Rupen et al. 2008, Sokoloski et al. 2008

See Chomiuk et al. 2014
The Two-Flow Model

See Chomiuk et al. 2014, Metzger et al. 2015, Li et al. 2017, Martin et al. 2018
V392 Per (2018)

- Nova eruption 2018-04-29
- Known CV
- ~4 kpc (Gaia DR2)
- Fermi detections for ~11 days
- VLA, AMI-LA*, VLBA, EVN

Gray region = Fermi detection
Vertical dotted lines = VBLA/EVN observations

*15.5 GHz Arcminute Microkelvin Imager – Large Array (AMI-LA) data provided by Joe Bright (Oxford)
V392 Per (2018): VLBA

Color = Day 18, 8.4 GHz
Contours = Day 22, 4.9 GHz

White = Day 22, 4.9 GHz
Blue = Day 46, 4.9 GHz
Green = Day 86, 4.9 GHz
Summary: Radio & Gamma-rays

- Radio imaging reveals multiple ejecta components leading to shocks and gives expansion parallax distances
  - Are the Fermi-detected novae the nearer ones?
  - Are all Fermi-detected novae non-spherical?
  - Are ALL novae non-spherical?
- Radio VBLI directly images regions of accelerated particles
  - How much does non-thermal emission contribute to total radio flux density during Fermi detection?
- Radio monitoring reveals non-thermal emission
  - Are we missing radio “flares” and “bumps” due to low observing cadence?
Active and Upcoming Programs

• AMI-LA high-cadence monitoring at 15 GHz
• VLA high-cadence monitoring program at 5 GHz begins November 2018
• eMERLIN 5 GHz imaging of V392 Per this month (hopefully)
• EVN observations of V392 Per just completed
• VLA high-resolution imaging proposal for 2019
• VLBA early observation proposal for 2019
Looking To the Future

• MeerKAT began full operations in July 2018
  • ThunderKAT transient program (PIs: P. Woudt & R. Fender)
  • MeerLICHT 0.65m for simultaneous radio + optical

• SKA1 construction to start in 2019
  • Great sensitivity (~4x VLA collecting area)
  • Great angular resolution (~4x VLA longest baseline)

• AMEGO will be great for novae
  • Good energy range for novae
  • Survey mode
  • See Sylvain Guiriec’s talk – Thursday, 3:30
• 10x the sensitivity of the VLA
• 10x the resolution of the VLA
  • ALL THE TIME!
  • Every light curve data point is also a frame in an ejecta expansion movie!
• Optimized for thermal emission
• Possibly adding very long baselines