The Symbiotic Recurrent Nova V745 Sco at Radio Wavelengths

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What are Novae?

- **Novae are stellar eruptions that occur in a binary system.**
- **The companion star transfers material onto the surface of the White Dwarf (WD).**
- **Circumstellar Medium (CSM) is produced from the winds coming from an evolved companion.**

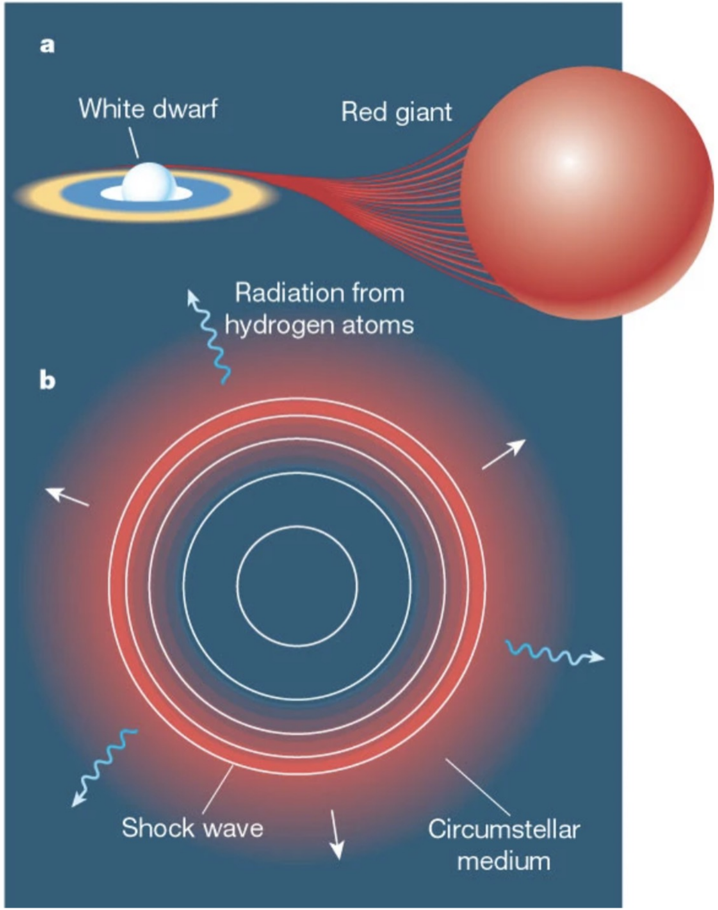
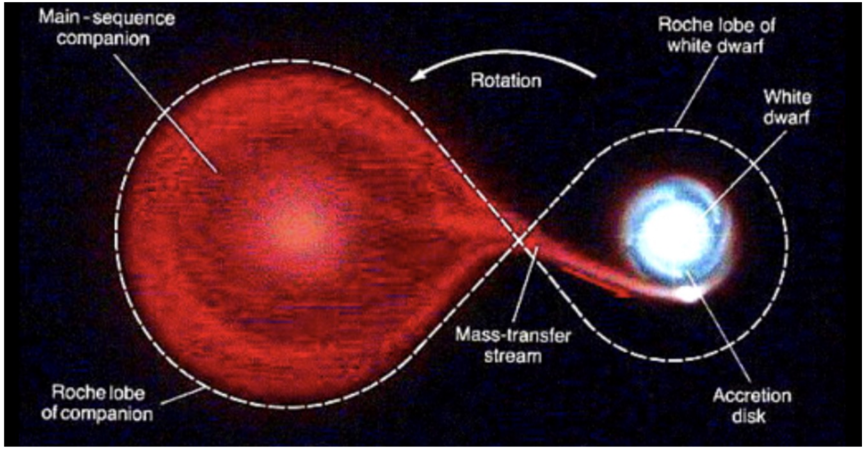


Image Credit: Nature

Types of Binaries

Main Sequence Companion



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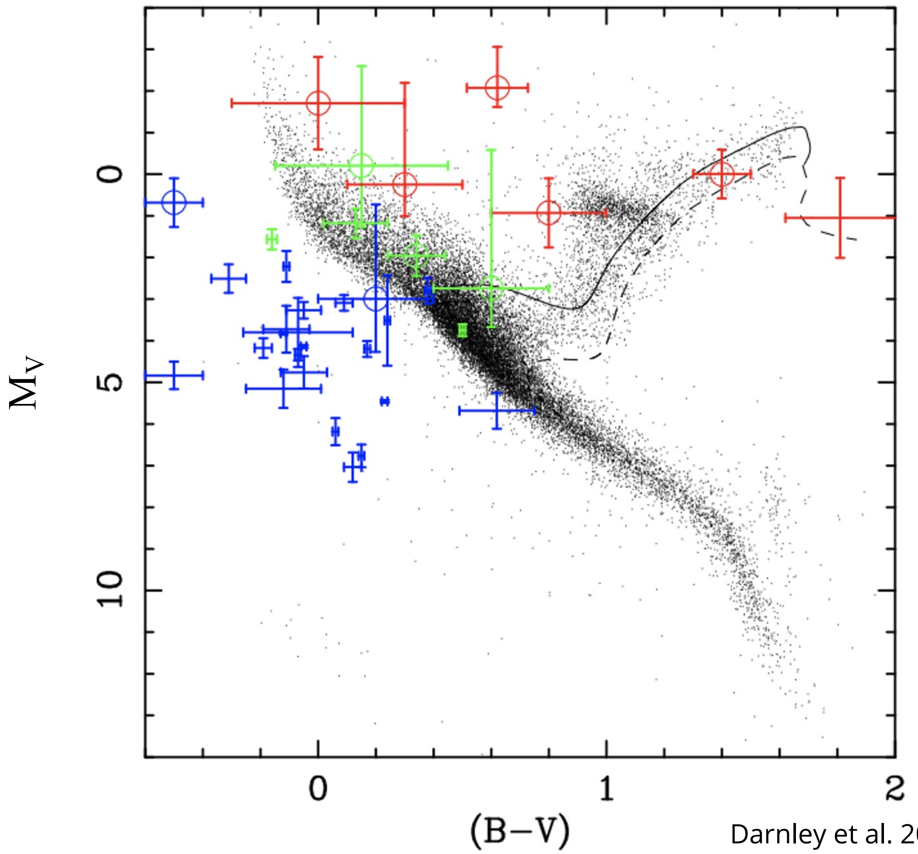
Giant Companion

Romano Corradi / Instituto de Astrofísica de Canaria

Novae with Evolved Companions

- Majority of novae have main sequence companions
- Novae with evolved companions would have sub giant, giant or AGB companions
- CSM around evolved companions is more dense

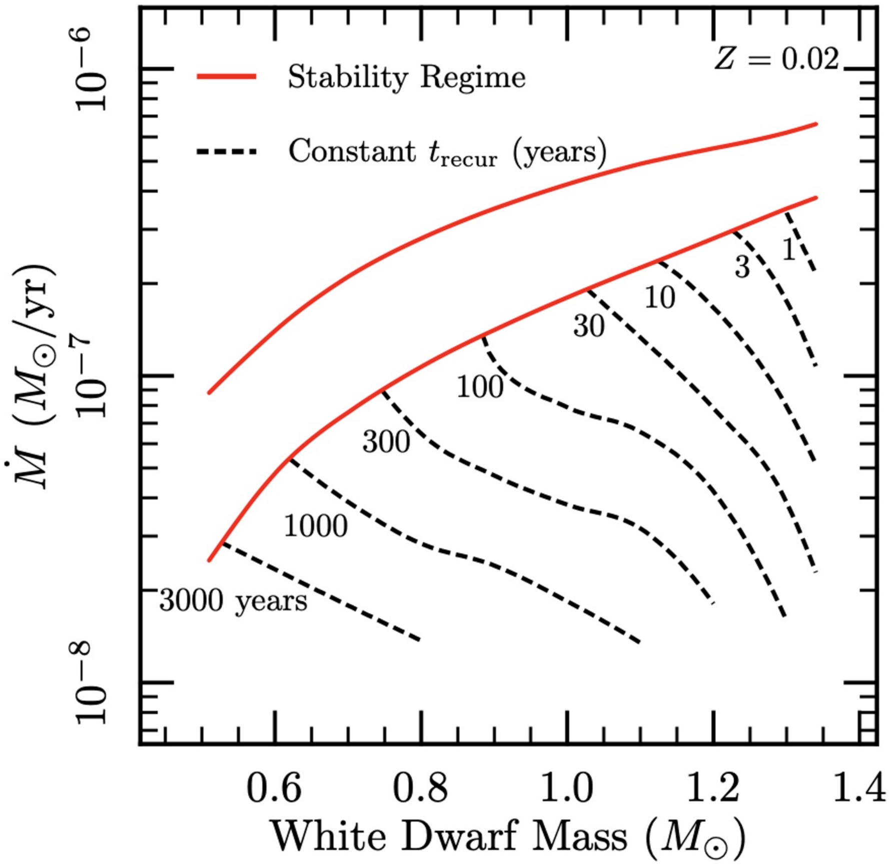


Darnley et al. 2012

When Do We Get TNR?

Wolf et al. 2013

- **WD mass and accretion rate are factors**
- **Short recurrence times imply high WD masses and high accretion rates.**



Recurrent Nova V745 Sco

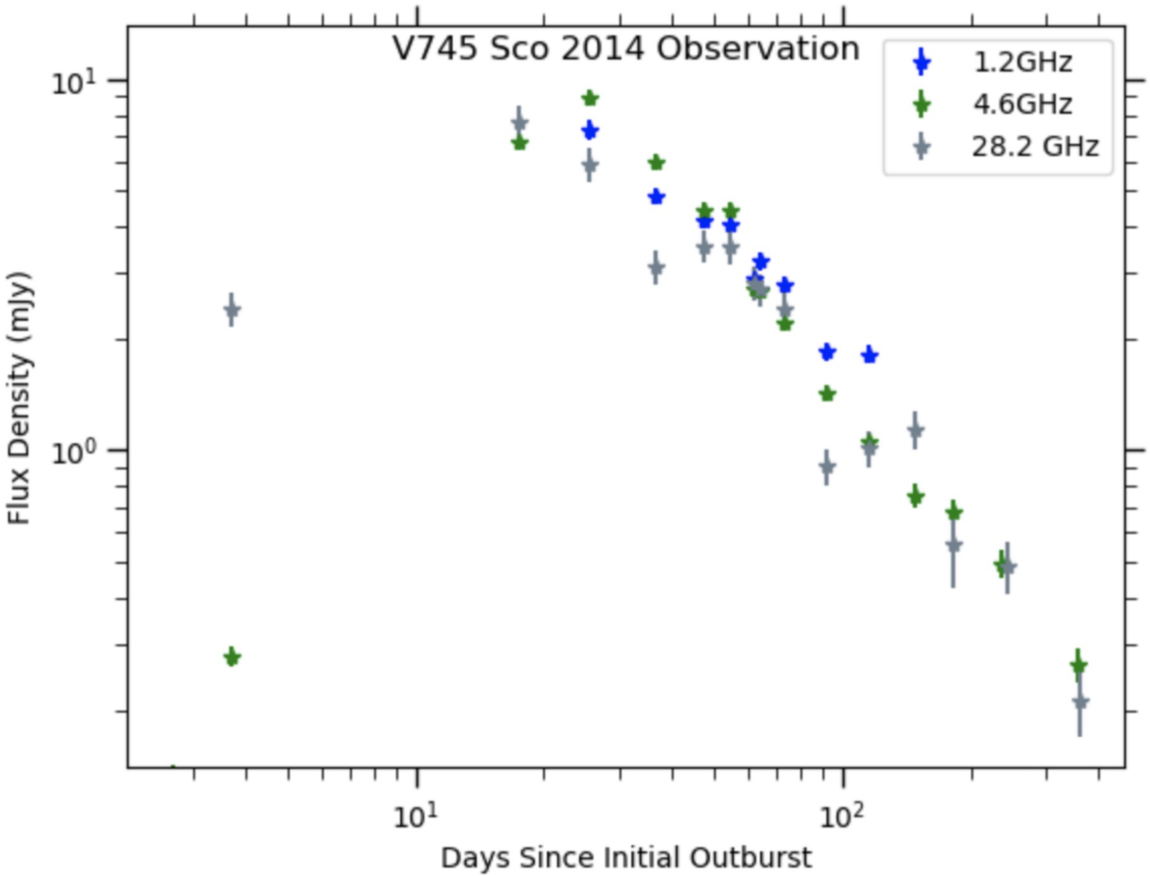
- **Symbiotic binary - white dwarf and a red giant star**
- **Nova outbursts observed in 1937, 1989, and 2014**
- **10 known recurrent novae in the Milky Way, and only 4 have giant companions**
- **Quick recurrence time implies a massive WD and a high accretion rate**

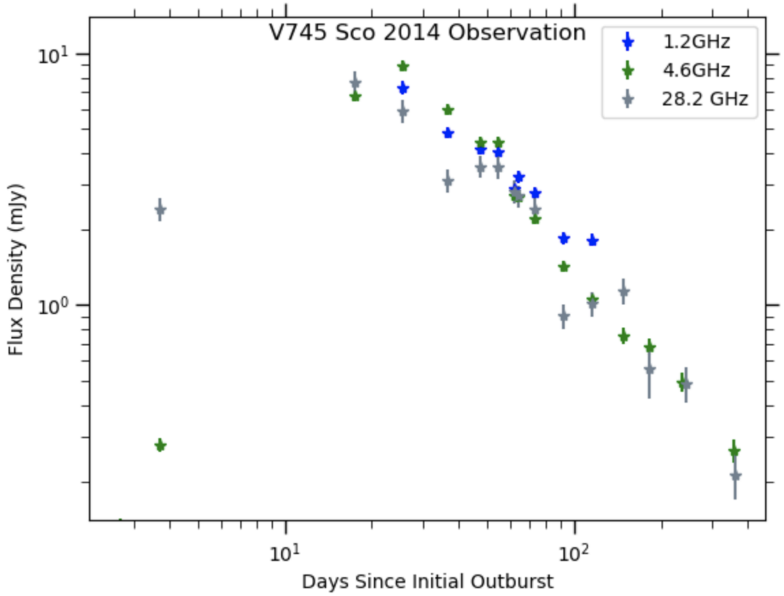
Image Credit: Credit: S. O'Connor (OCN, St. Georges, Bermuda)

VLA Observations of 2014 Outburst

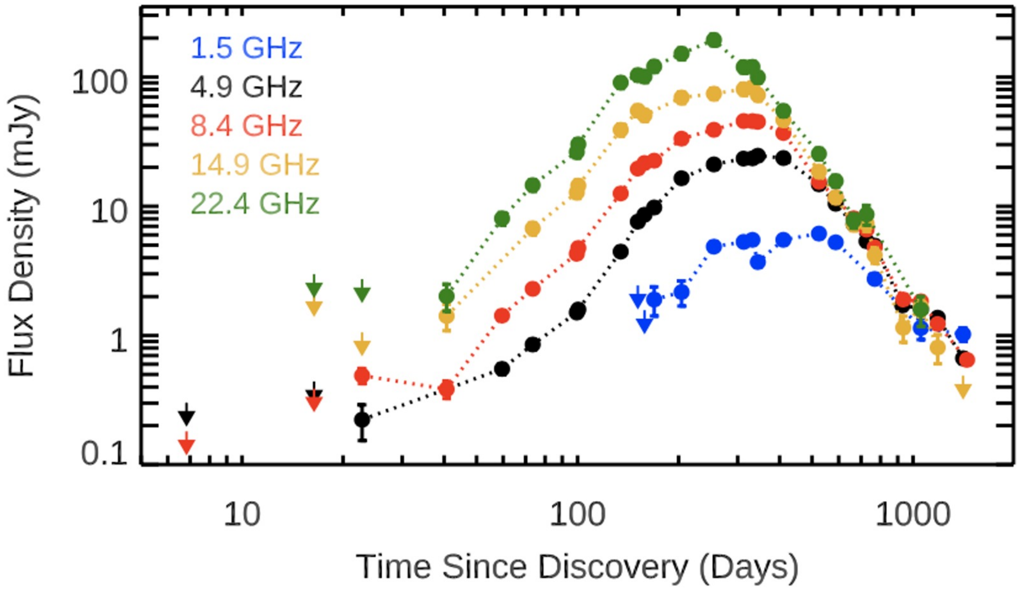
Molina et al. in prep.

- **Outburst Feb. 6, 2014**
- **Monitored V745 Sco with the Jansky VLA from Feb. 8, 2014 to Feb. 1, 2015**
- **Receiver bands used: L, C, Ku, and Ka**



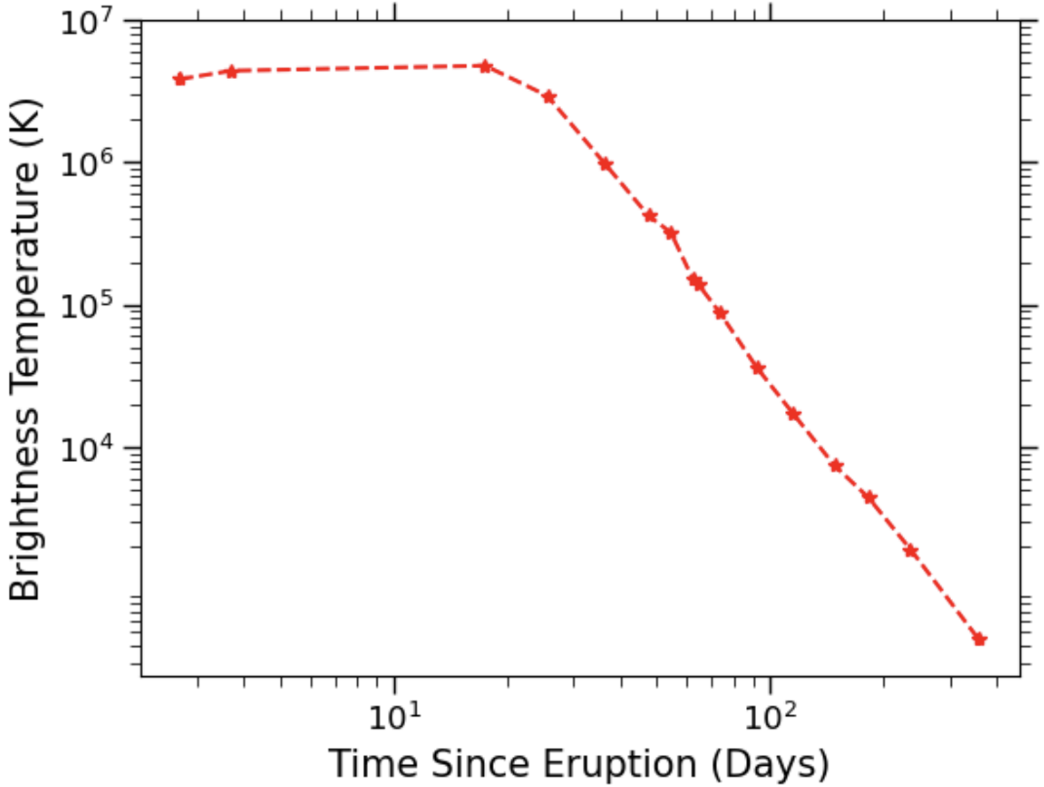


V1974 Cyg Observations



Chomiuk et al. 2021

Brightness Temperature



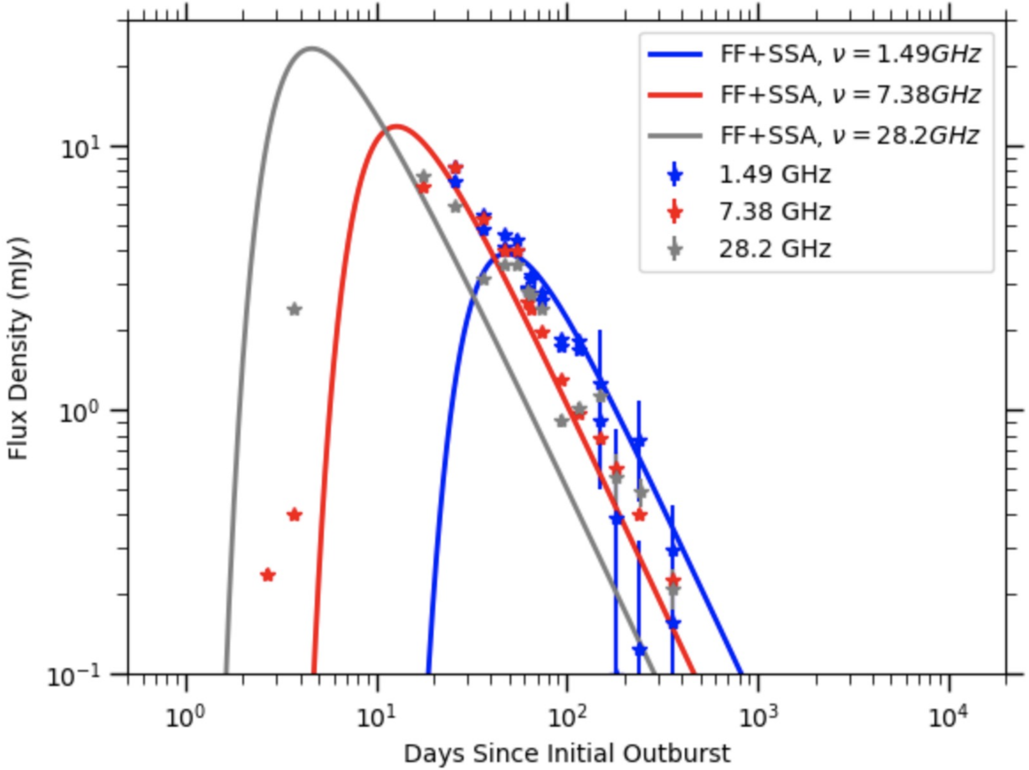
Molina et al. in prep.

- **Useful for distinguishing thermal from non-thermal emission**
- **A brightness temperature > 5 x 10^4 K is greater than expected for a photo-ionized gas, must be synchrotron dominated**

Modeling Synchrotron Emission

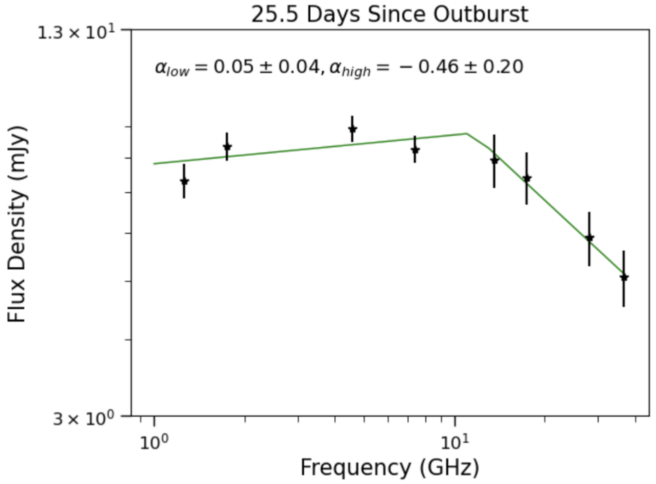
- **Simple model for synchrotron emission**
- **Model peaks at earlier times for different frequencies**
- **Does not match radio behavior we see from the light curve.**

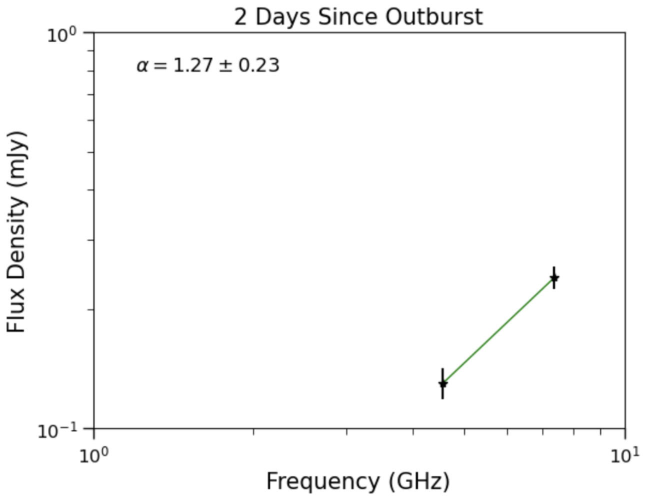
$$\rho_{\rm CSM} = \frac{\dot{M}}{4\pi v_{\rm wind}} r^{-2}$$

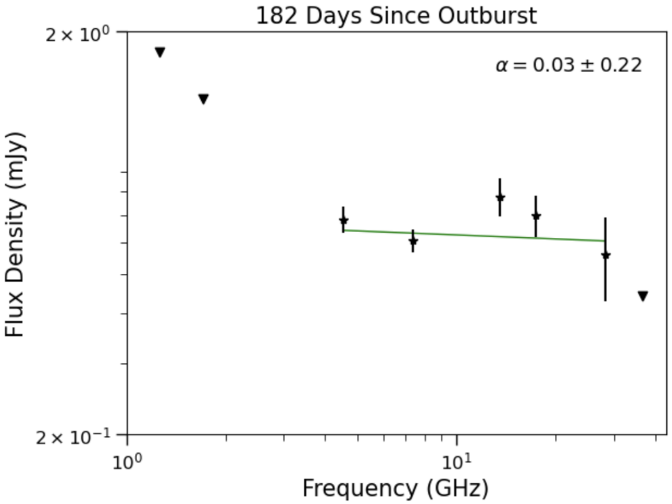


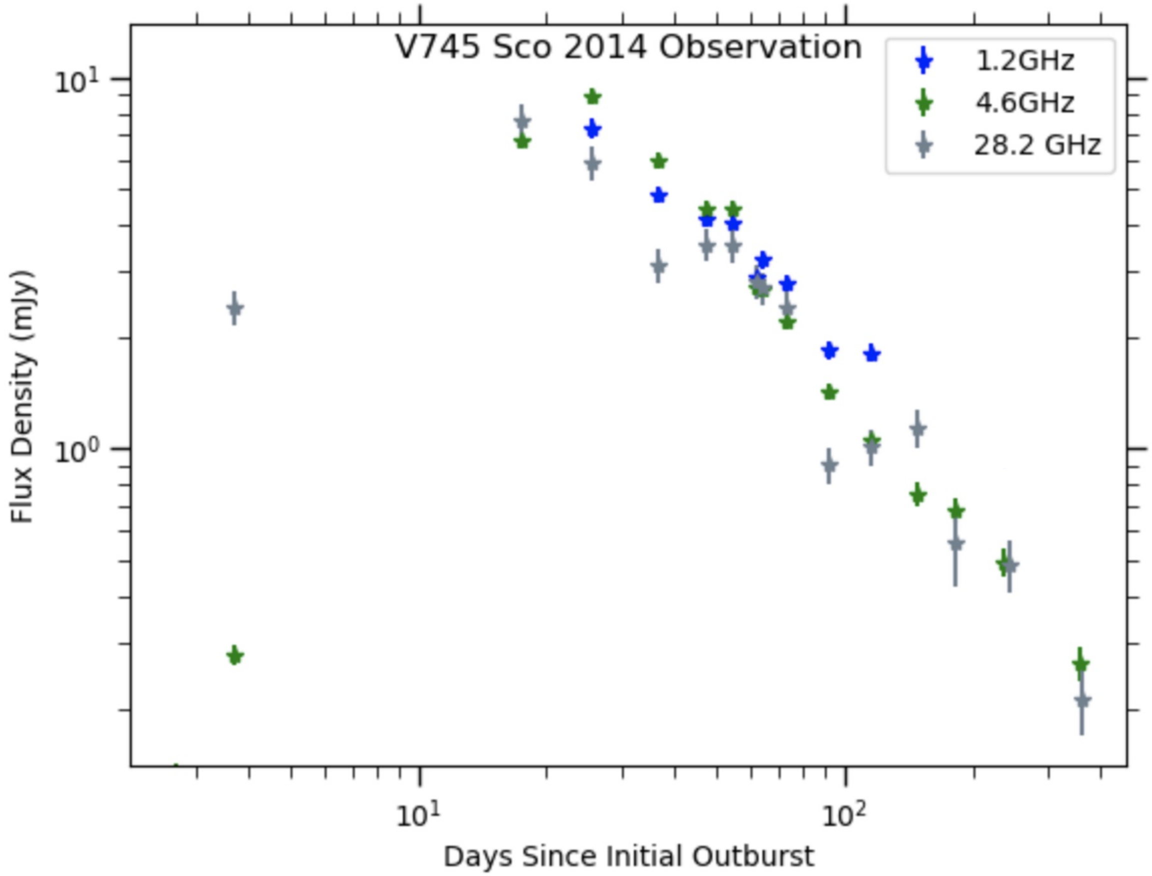
Molina et al. in prep.

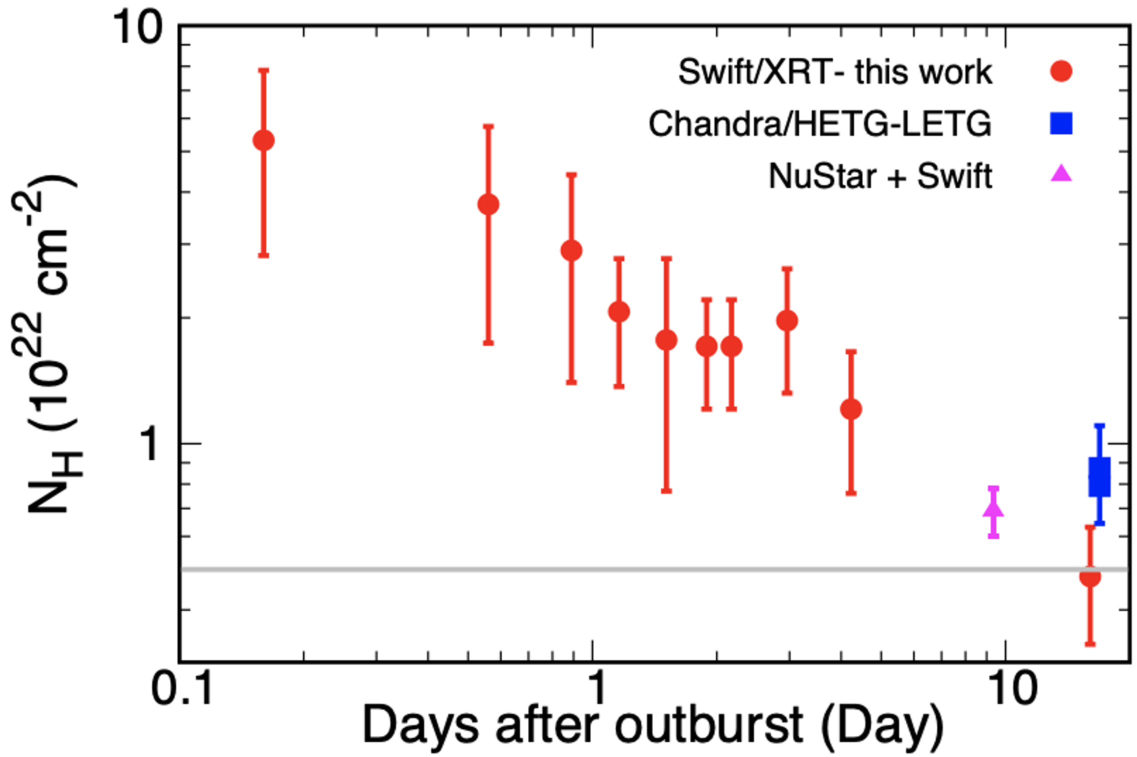
$$S_\nu \propto \nu^\alpha$$



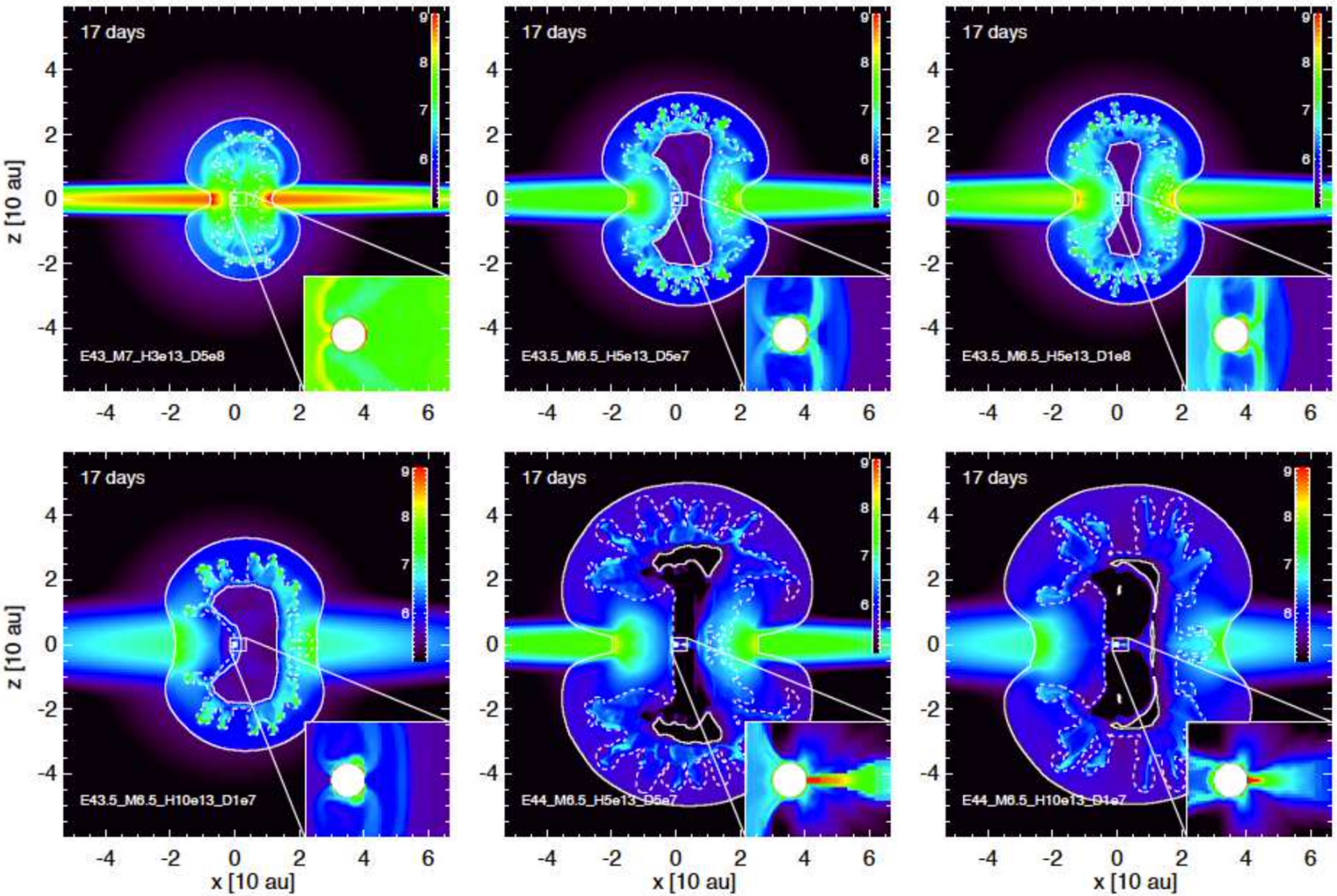





V745 Sco 2014 Observation
1.2GHz
4.6GHz
28.2 GHz
Flux Density (mJy)
Days Since Initial Outburst
10^1
10^0
10^1
10^2



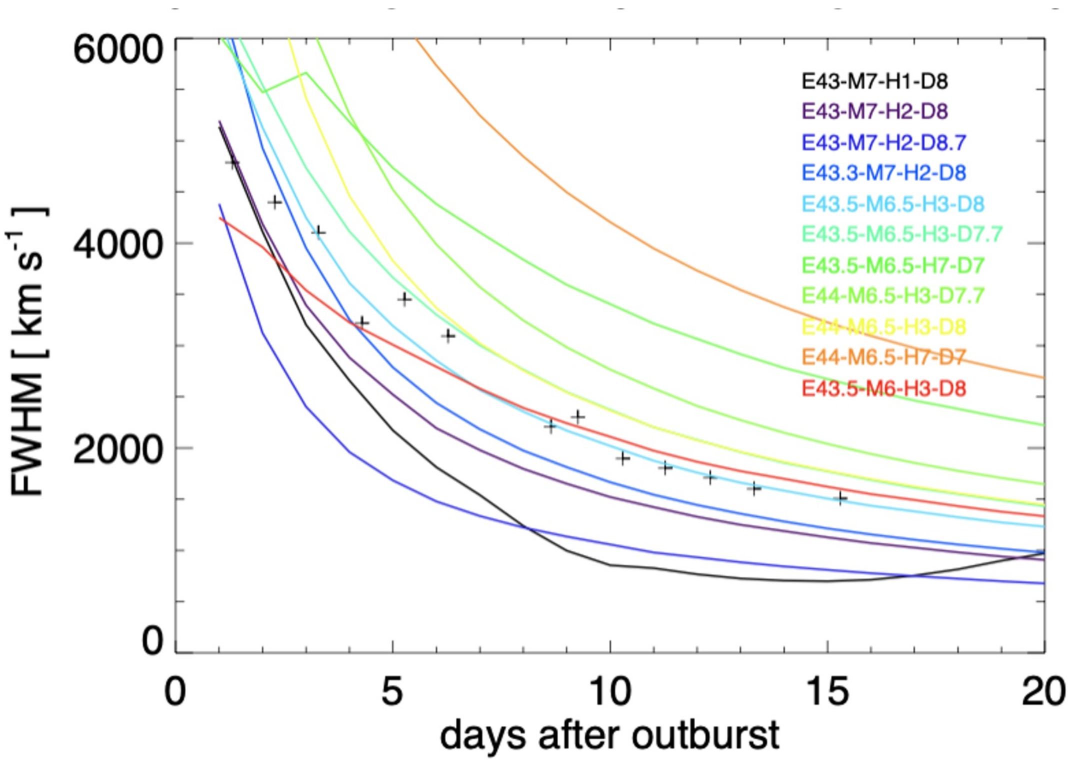
Delgado and Hernanz 2019



Orlando, Drake & Miceli 2016

Simulation Results

- They check their results with X-ray observations.
- Each line is a different model.
- We hope to do the same in the radio!

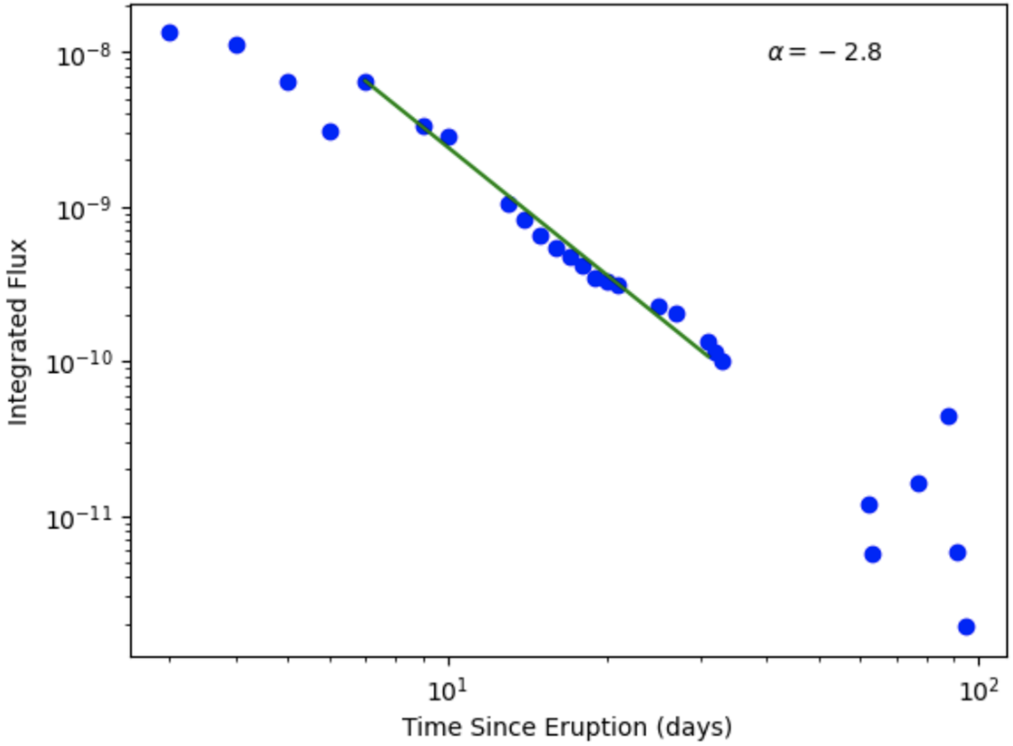


Orlando, Drake & Miceli 2016

SUMMARY

- **The radio light curve is synchrotron dominated, as we can see from the brightness temperature, but more complicated than what can be described by a simple wind like CSM model.**
- **The radio spectrum seems to become optically thin.**
- **We will be working with Orlando and Drake on extending their simulations into the radio.**

FWZI and the Blast Wave



- **Flux calibrated the spectra data**
- **The calibrated data was then analyzed**
- **Integrated flux declines steeply around day 10**
- **This slope is close to t^-3, what is expected for recombining optically thin gas (Munari et al. 2018)**

Temperature and Velocity

- **Plasma temperature measurements from Swift and NuStar were used to get velocity**
- **This also shows a very steep decline, slope = -0.7**
- **Hard to explain by changing the CSM density profile**