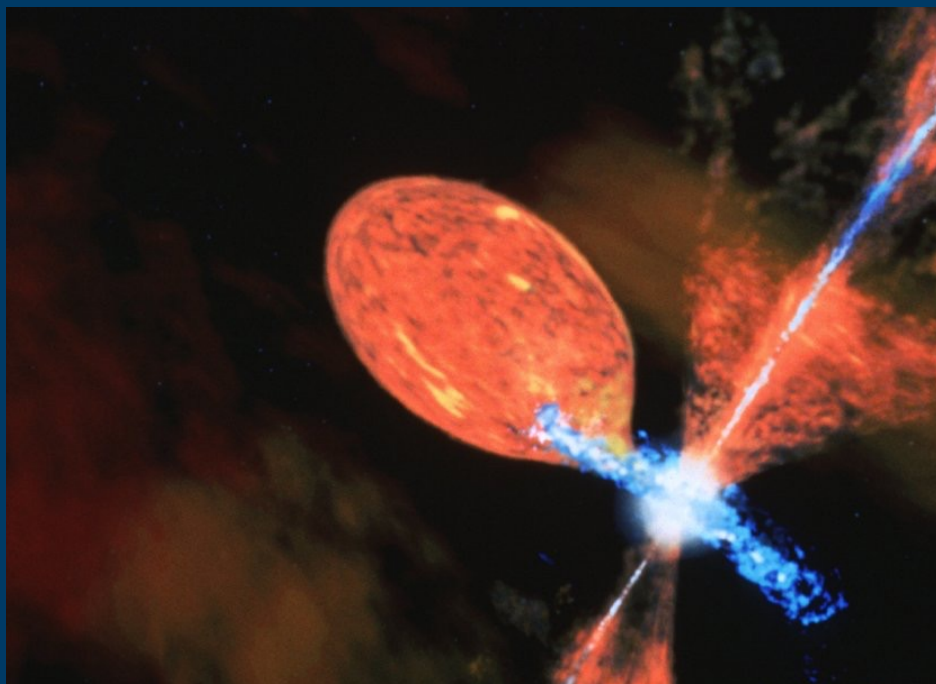


# Investigating Mass Transfer in Symbiotic Stars

Thomas Gaudin

New Mexico Tech

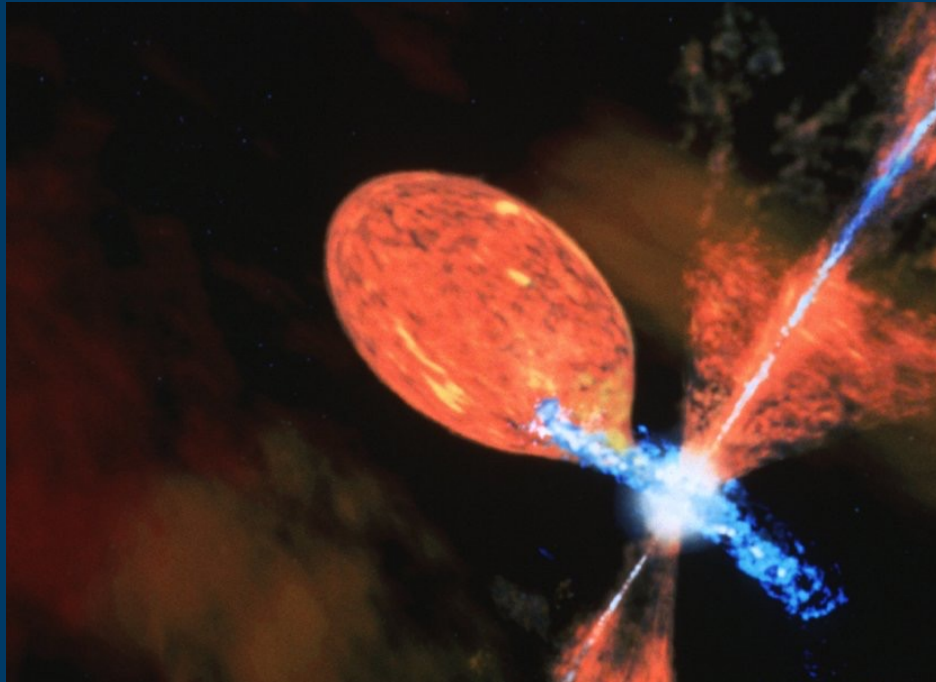
# What are Symbiotic Stars?



- **3 components:**
  - **Cool Giant**
  - **Hot Compact Object**
  - **Dense Circumstellar Medium**
- **Widest type of interacting binary**
  - **Periods of  $\sim 100$ s of days**
  - **Orbital Separation of  $\sim 1$  AU**

Image courtesy of NASA, ESA, and D. Berry (STSci)

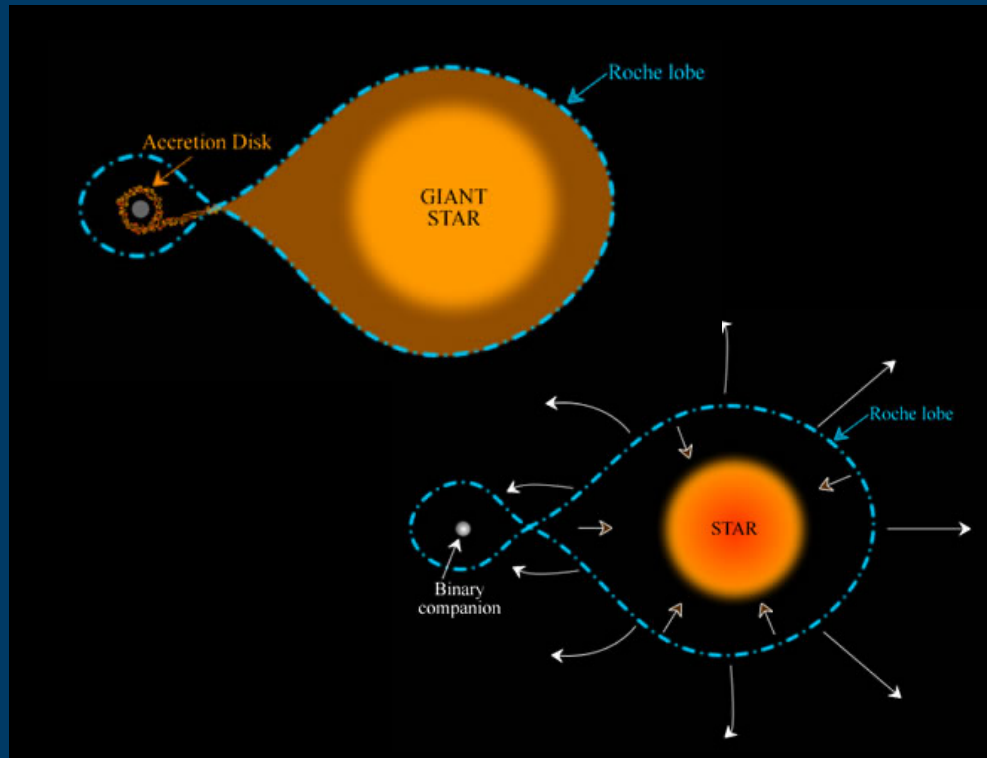
# What are Symbiotic Stars?



- **Connected to important late-stage stellar objects:**
  - Planetary nebulae
  - Soft/hard X-ray sources
  - Cataclysmic variable stars
- **Possible progenitors of Type Ia supernovae**

Image courtesy of NASA, ESA, and D. Berry (STSci)

# Mass Transfer in Symbiotic Stars



- **What mechanism drives mass transfer?**
  - Is the giant filling its Roche lobe?
  - If not, does the giant's stellar wind play a large role?
- **Knowing the mechanism of mass transfer will help inform models for evolution of a system**

# Mass Transfer in Symbiotic Stars

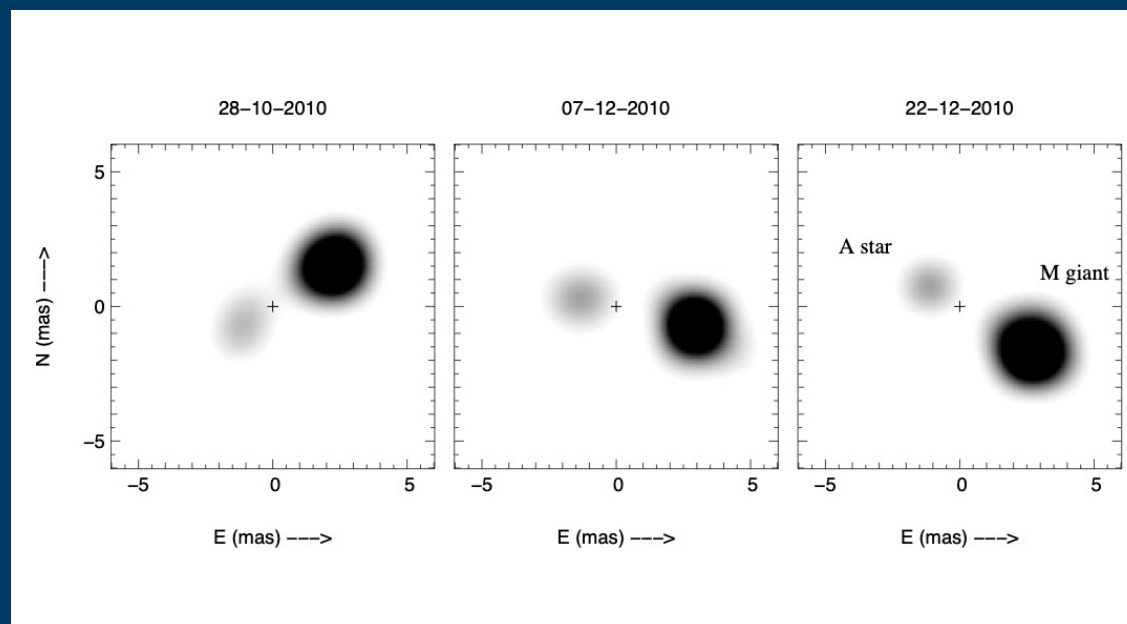


Image reprinted from Blind, N., Boffin, H. M. J., Berger, J.-P., Le Bouquin, J.-B., Mérand, A., Lazareff, B., & Zins, G. (2011). An incisive look at the symbiotic star SS Leporis-Milli-arcsecond imaging with PIONIER/VLT. *Astronomy & Astrophysics*, 536, A55.

- Investigated by several authors using photometry
  - Analysis of light curve variations informs geometry
- Investigated using Optical Interferometry
  - Blind et al. (2011) observed SS Lep
  - Boffin et al. (2014) observed 6 more systems
- So far results have been inconclusive



# How do we best investigate mass transfer?



- **Need to resolve the surface of the giants to check for asymmetry**
- **Optical interferometry is needed to achieve high enough resolution**
- **CHARA Array: Resolves features as small as 0.5 mas.**
  - **Can resolve the surface of most giants within  $\sim 1$  kpc**

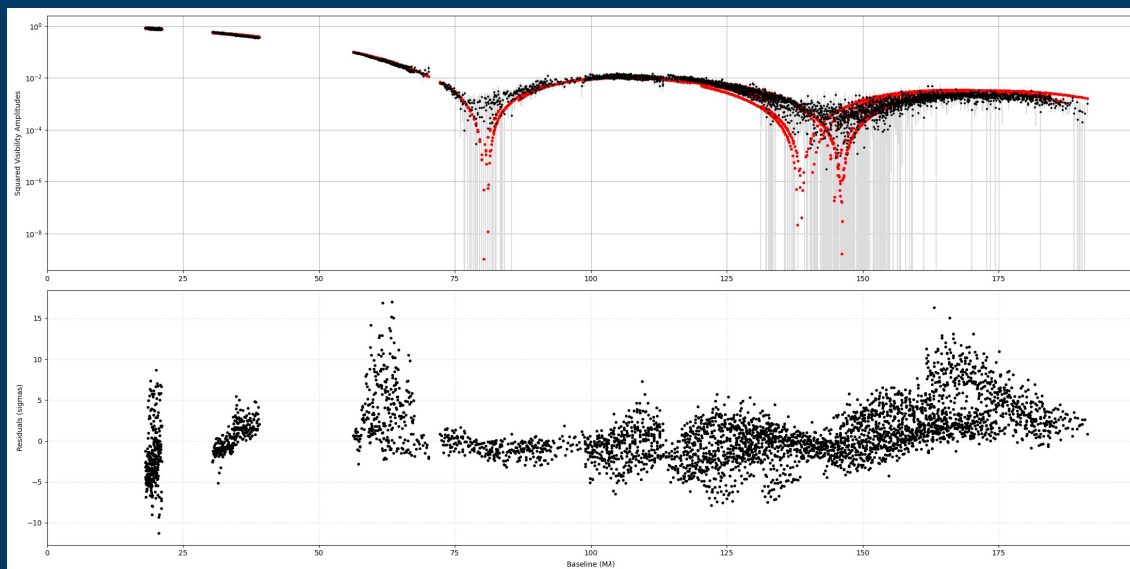
Image courtesy of Eric Simison, Sea West Enterprises

# Methodology

Target	Distance (pc)
V1724 Aql	$250.4 \pm 4.4$
EG And	$607.8 \pm 12.4$
BD Cam	$234.3 \pm 14.2$
SU Lyn	$728.6 \pm 33.4$

- **Observed 4 nearby symbiotic stars using the CHARA Array**
  - **Observation dates: 9/20/21 – 9/22/21 UTC**
- **Used MIRC-X beam combiner with all 6 telescopes**
- **Analyzed each target using a combination of model fitting and image reconstruction**

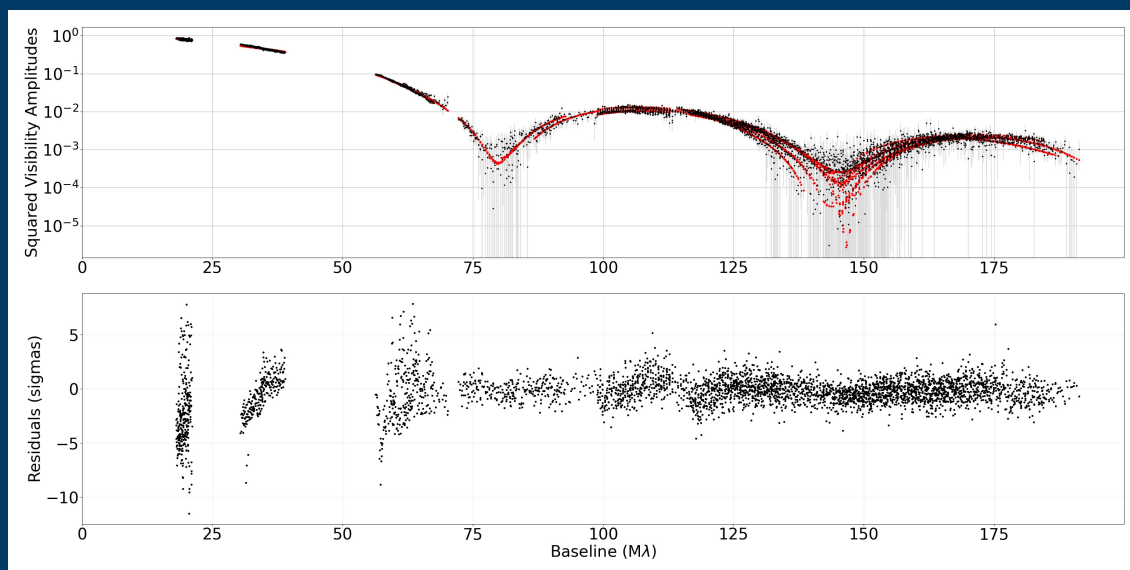
# Model Fitting



- **Used OITOOLS to fit 3 different geometric models to observed visibility data**
- **Best-fitting model provides information about the shape of the stellar disk**
- **Three models:**
  - **Uniform Disk**
  - **Elongated Disk**
  - **Hybrid Uniform/Elongated Disk**



# Imaging

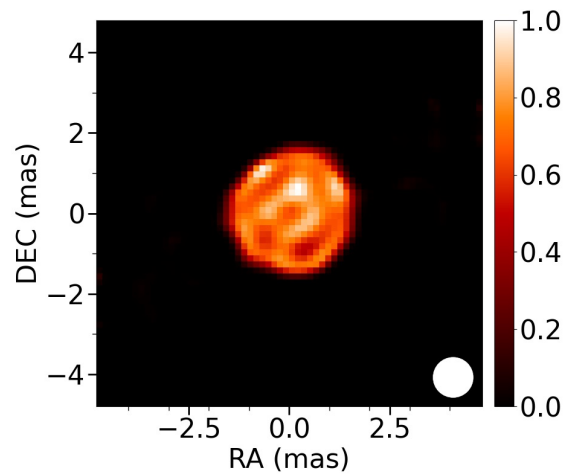


- Reconstructed images of each target using SQUEEZE
- Reconstructions completed both with and without a prior of a uniform disk
  - Regularizers:
    - Total Variation, L0, and Laplacian
- Simulated observations of reconstructed images and fit the data to observations using OITTOOLS

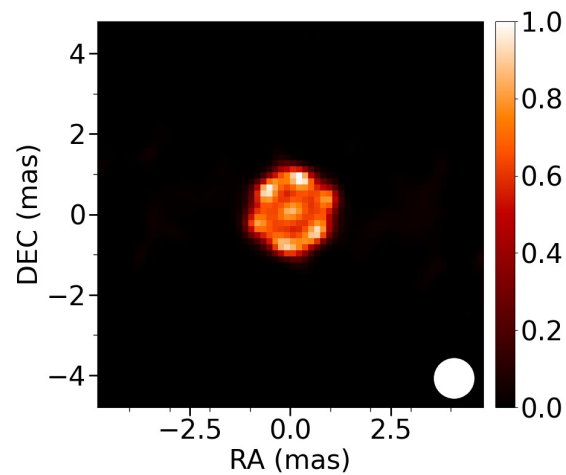
# Results – Model Fitting

V1472 Aql				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	$\chi^2$
uniform disk	2.37	–	–	11.7
elongated disk	2.41	0.98	164.3	10.7
hybrid model	2.39	0.97	155	5.53
EG And				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	$\chi^2$
uniform disk	1.7	–	–	2.67
elongated disk	1.71	0.99	92.5	2.54
hybrid model	1.73	0.98	-74.97	2.37
BD Cam				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	$\chi^2$
uniform disk	5.35	–	–	33.96
elongated disk	5.6	0.94	-14.8	24.1
hybrid model	5.53	0.96	177.5	14.04
SU Lyn				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	$\chi^2$
uniform disk	3.21	–	–	30.1
elongated disk	3.24	0.98	97.9	29.5
hybrid model	3.3	0.95	122.97	14.59

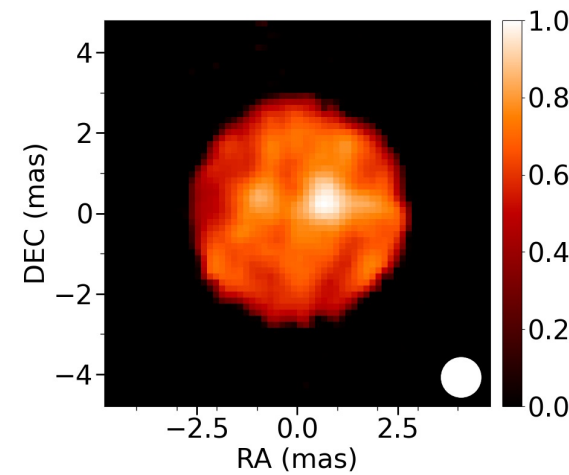
# Results - Imaging



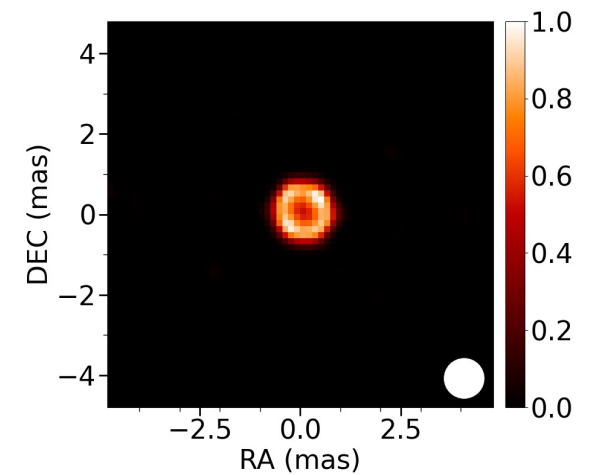
SU Lyn



V1472 Aql

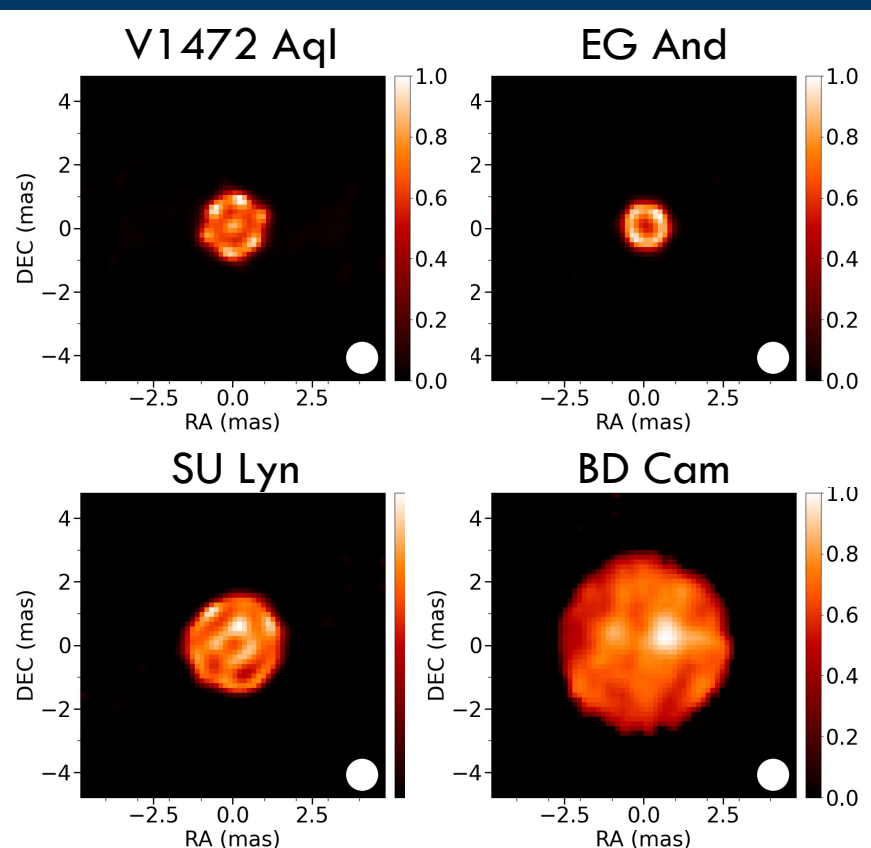


BD Cam



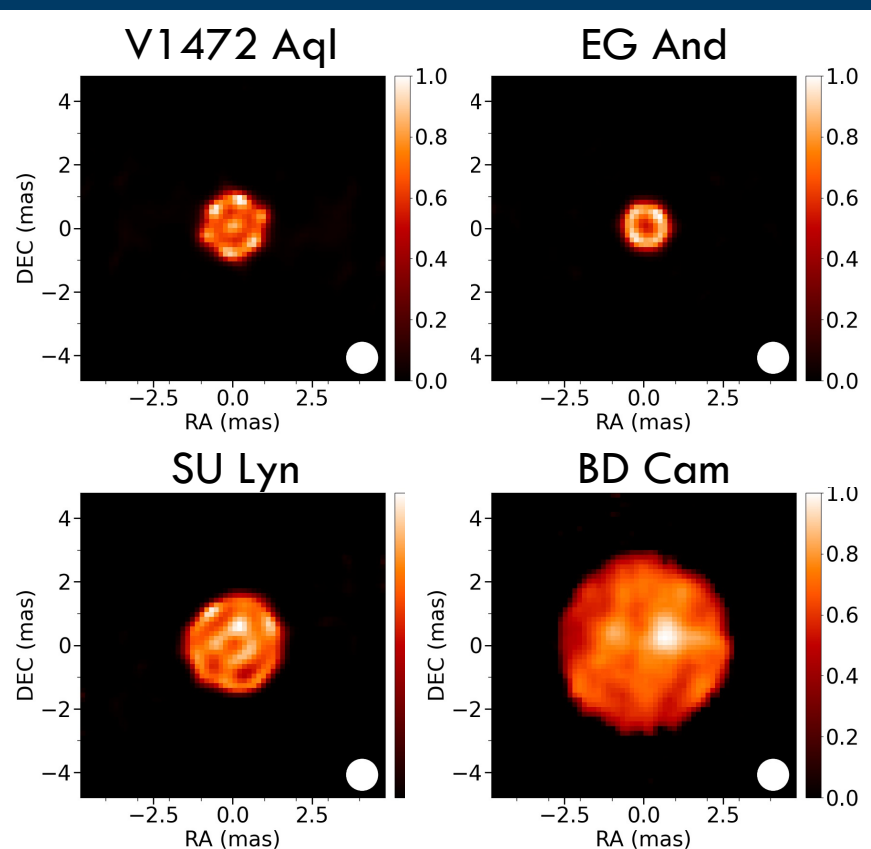
EG And

# Conclusions



- **Little evidence of any target filling its Roche lobe at this epoch**
- **Unlikely that Roche lobe overflow is the dominant mass transfer mechanism**
- **Role of the giant's wind in mass transfer is inconclusive**
- **Motivates a need for future study**

# Future Work



- **Only seeing each star at one point in the orbit**
  - Long term monitoring needed to confirm that the Roche lobe teardrop is not visible at other geometric configurations
- **Sample size is only 4 targets**
  - Need to observe more targets to draw more general conclusions



# Questions?