Investigating Mass Transfer in Symbiotic Stars

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What are Symbiotic Stars?

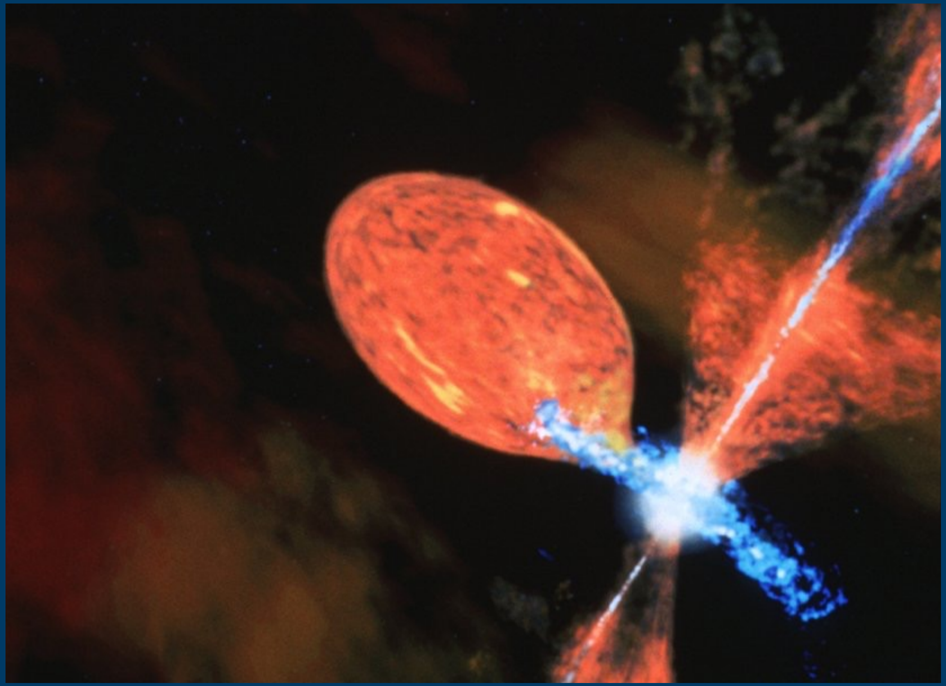


Image courtesy of NASA, ESA, and D. Berry (STSci)

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

What are Symbiotic Stars?

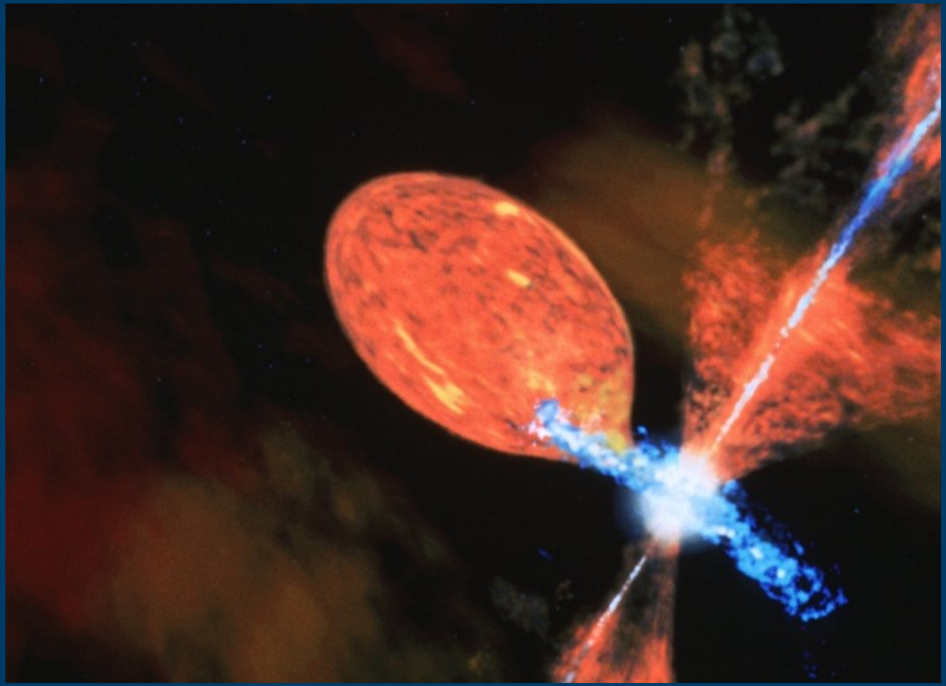


Image courtesy of NASA, ESA, and D. Berry (STSci)

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

Mass Transfer in Symbiotic Stars

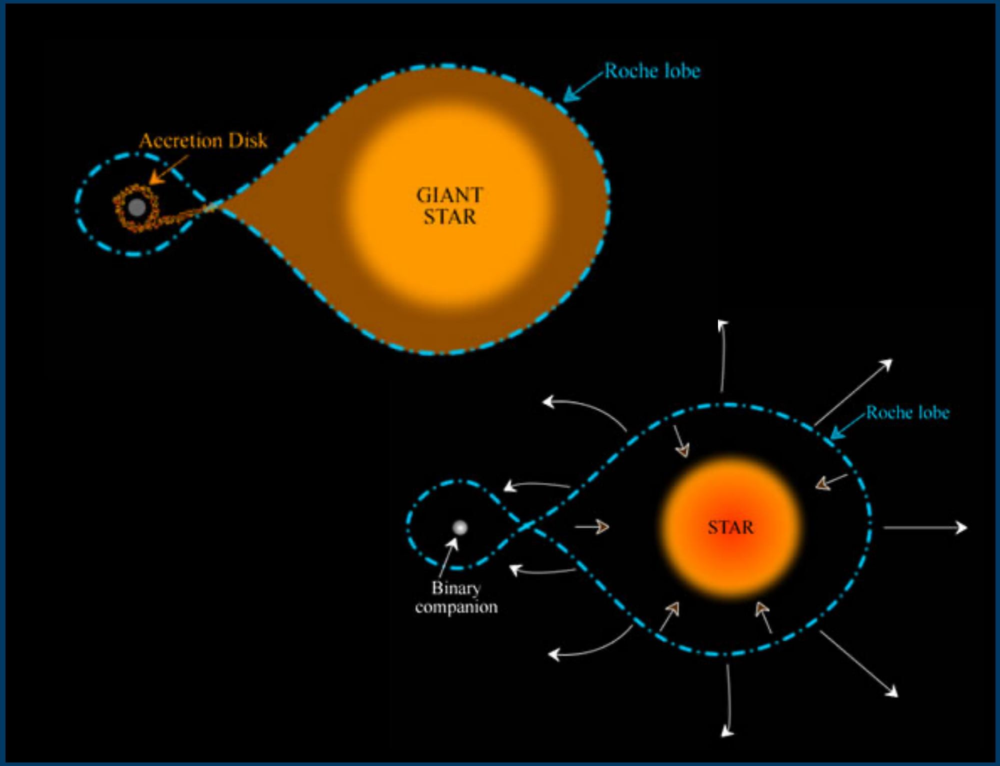


Image courtesy of Swinburne University of Technology

- **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

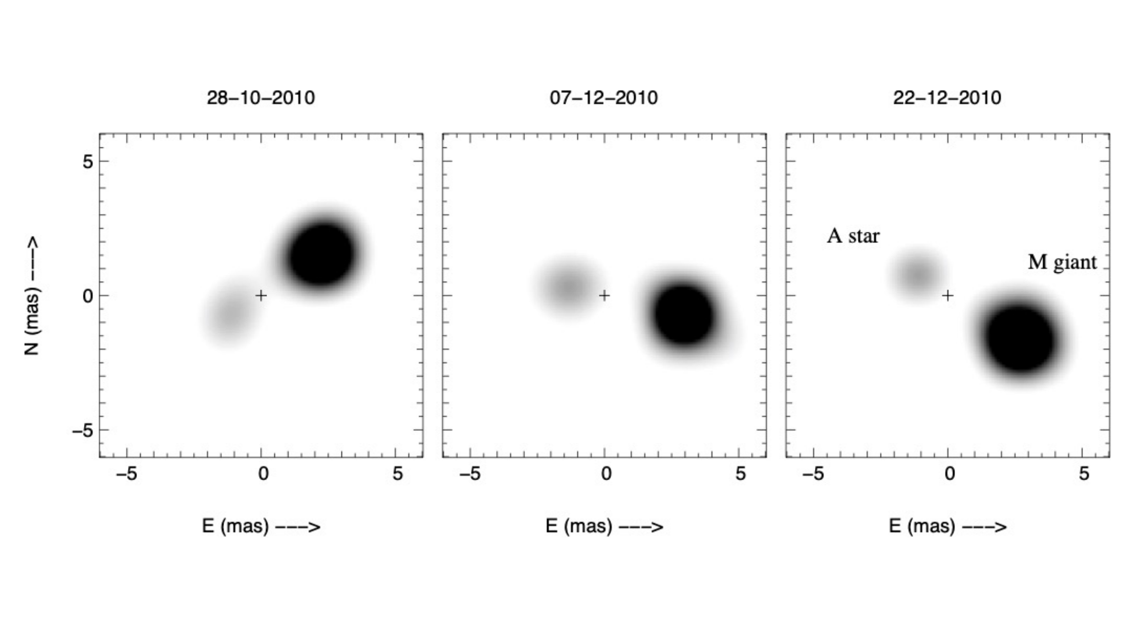


Image reprinted from Blind, N., Boffin, H. M. J., Berger, J.-P., Le Bouquin, J.-B., Mérand, A., Lazareff, B., & Zins, G. (2011). An incisive look at the symbiotic star SS Leporis-Milli-arcsecond imaging with PIONIER/VLTI. *Astronomy & Astrophysics*, *536*, A55.

- **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?

Image courtesy of Eric Simison, Sea West Enterprises

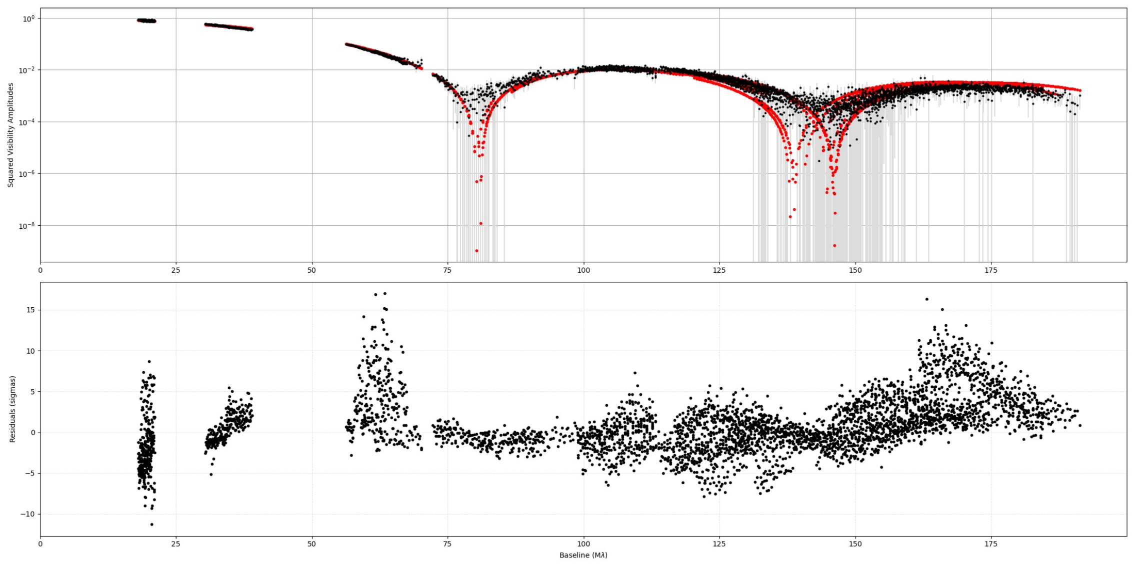
- Need to resolve the surface of the giants to check for asymmetry
- Optical interferometry is needed to achieve high enough resolution
- CHARA Array: Resolves features as small as 0.5 mas.
  - Can resolve the surface of most giants within ~1 kpc

Methodology

Target	Distance (pc)
V1472 Aql	250.4 ± 4.4
EG And	607.8 ± 12.4
BD Cam	234.3 ± 14.2
SU Lyn	728.6 ± 33.4

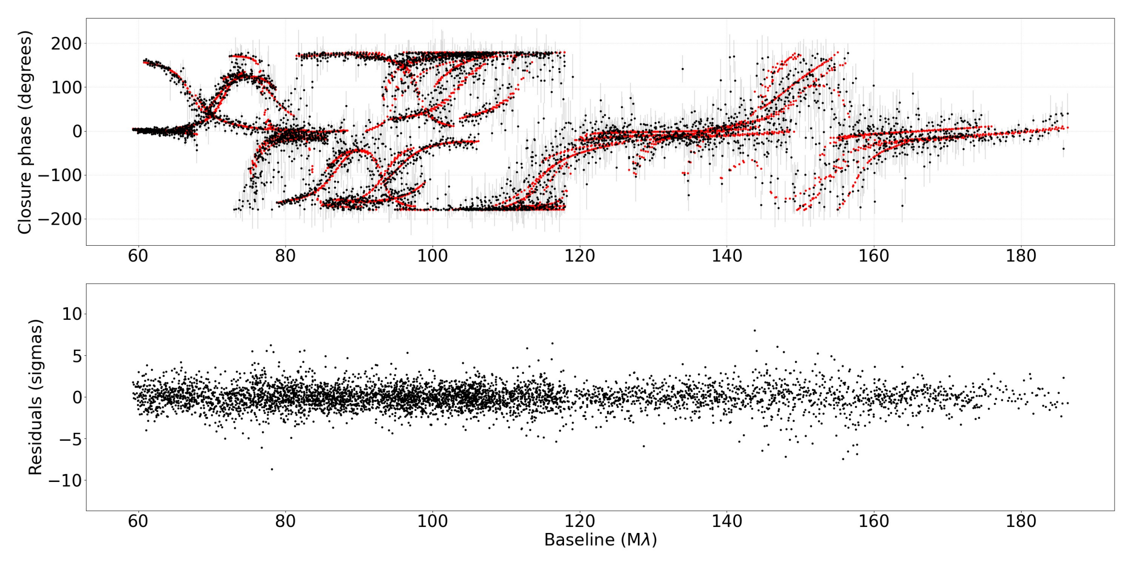
- Observed 4 nearby symbiotic stars using the CHARA Array
  - Observation dates: 9/20/21 – 9/22/21 UTC
- Used MIRC-X beam combiner with all 6 telescopes
- Analyzed each target using a combination of model fitting and image reconstruction

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

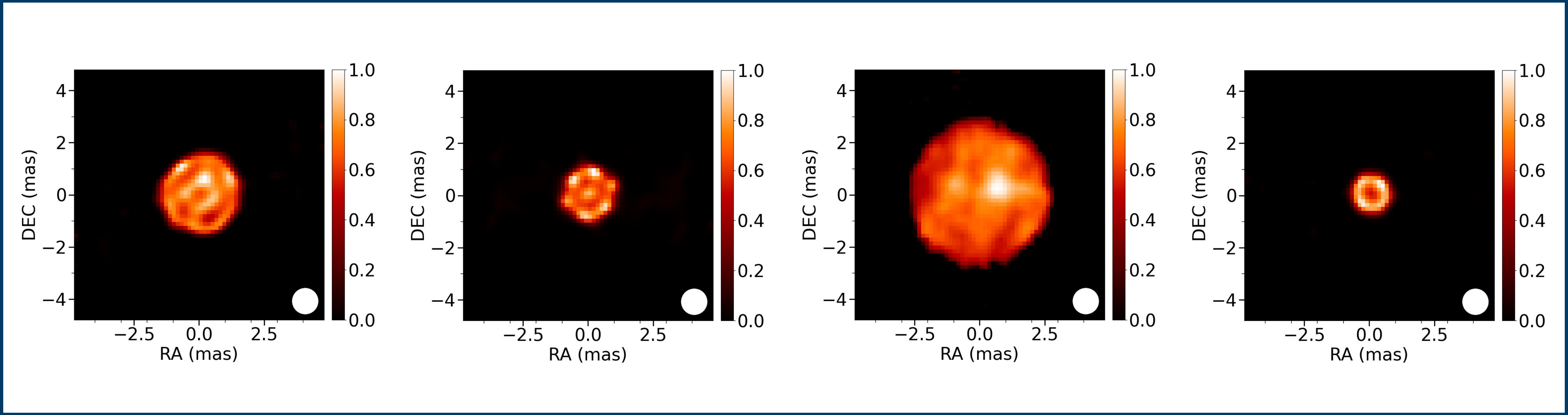


- Reconstructed images of each target using SQUEEZE
- Reconstructions completed both with and without a prior of a uniform disk
  - Regularizers:
    - Total Variation, L0, and Laplacian
- Simulated observations of reconstructed images and fit the data to observations using OITOOLS

Results – Model Fitting

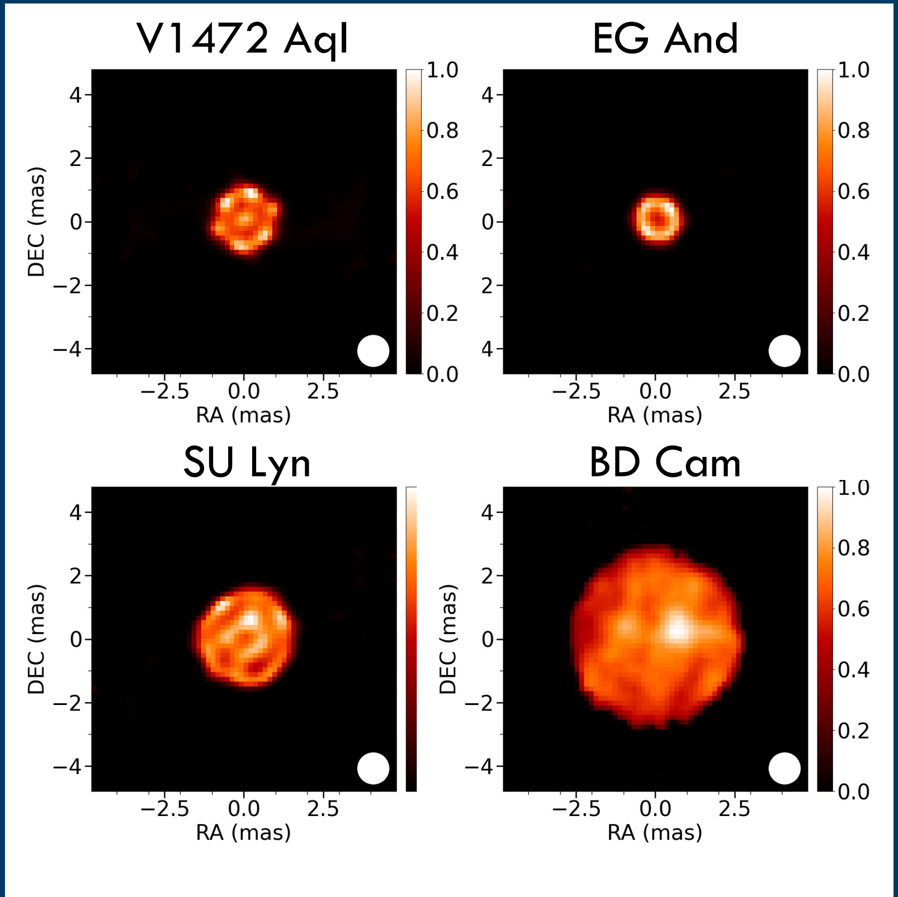
V1472 Aql				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	χ^2
uniform disk	2.37	–	–	11.7
elongated disk	2.41	0.98	164.3	10.7
hybrid model	2.39	0.97	155	5.53
EG And				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	χ^2
uniform disk	1.7	–	–	2.67
elongated disk	1.71	0.99	92.5	2.54
hybrid model	1.73	0.98	-74.97	2.37
BD Cam				
Model	Diameter (mas)	Eccentricity	Position Angle (degrees)	χ^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)	χ^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



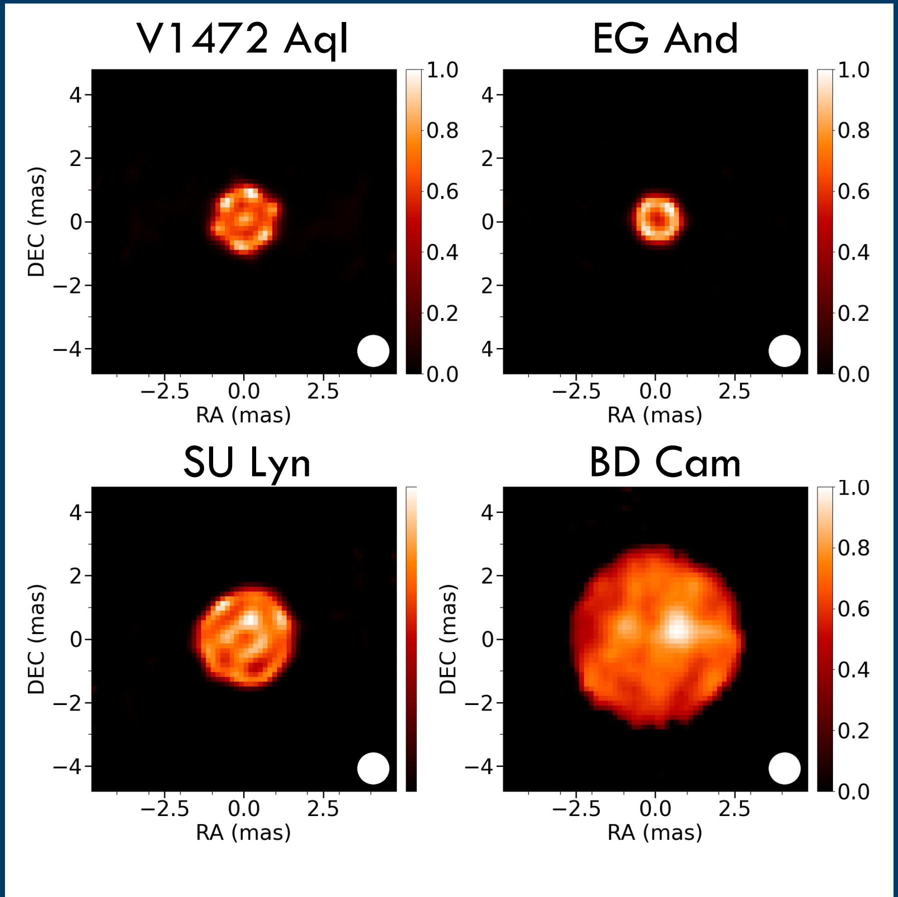
SU Lyn | V1472 Aql | BD Cam | EG And

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?