



Images and Models of the Epsilon Aurigae System

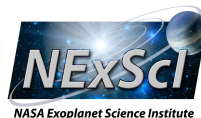
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Ming Zhao, Fabien Baron, Hal McAlister, Theo ten Brummelaar,
Xiao Che, Chris Farrington, Ettore Pedretti, PJ Sallave-Goldfinger,
Judit Sturmann, Laszlo Sturmann, Nathalie Thureau
Nils Turner, Sean M. Carroll



LESIA



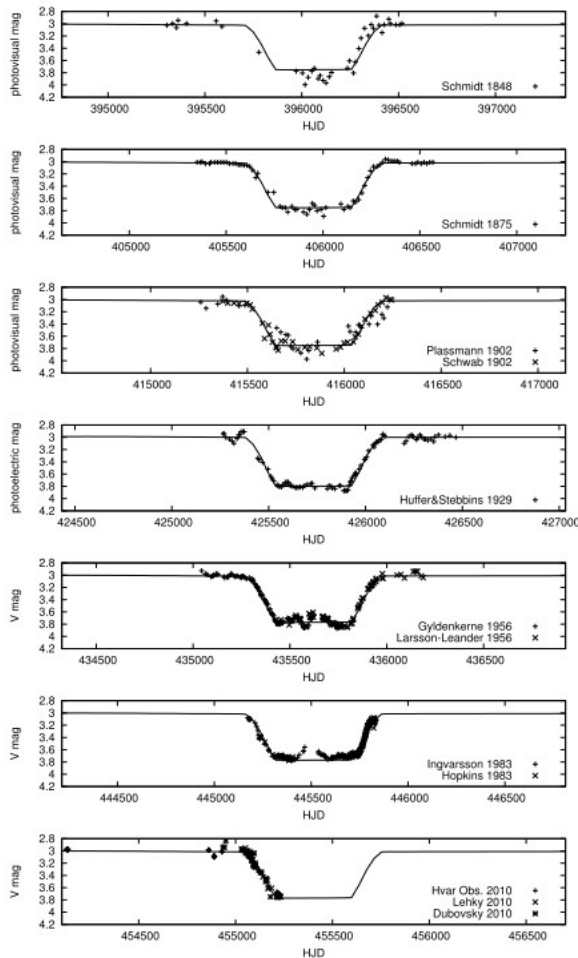
Observatoire
de la CÔTE d'AZUR



Outline

- Introduction to eps Aur
- Images
 - Artifact Discussion
 - All 9 in-eclipse epochs
- Model Fitting
- Future Work

Pre-Eclipse Understanding



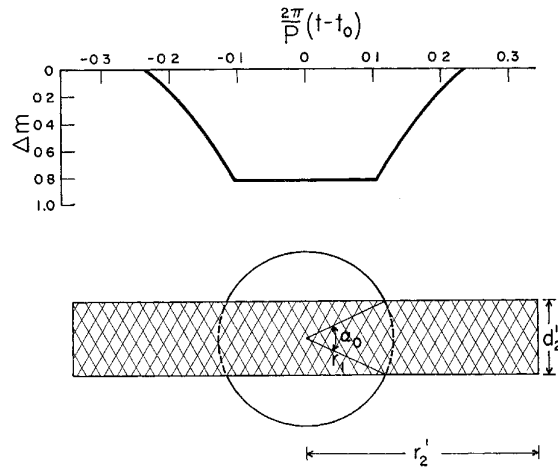
- Discovered in 1821
- 27.1 Year Period
- Confirmed 1903

Explaining The Eclipses

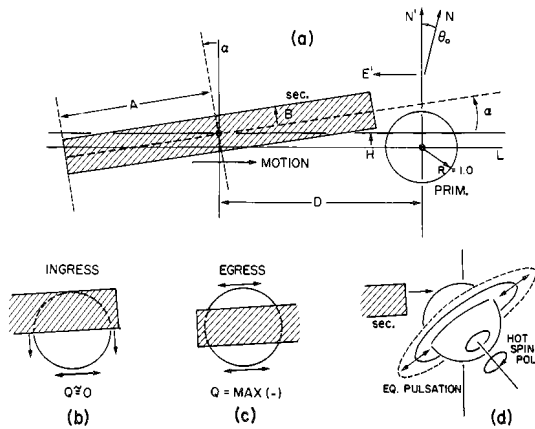
- Hyperionized IR Star
- Black Hole

Chadima (2010)

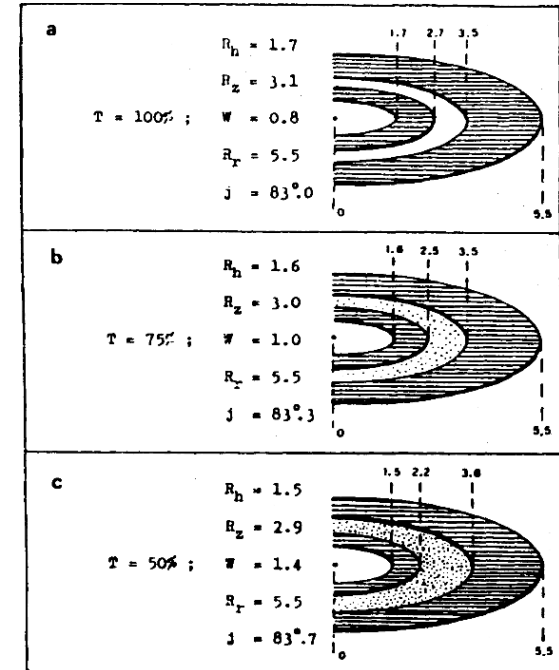
Pre-Eclipse Understanding



Huang (1965)



Kemp (1986)



Ferluga (1990)

1965: Block of Opaque Material

1986: Block is tilted

1990: Disk consists of rings of material, is also highly inclined.

Evolutionary Scenarios

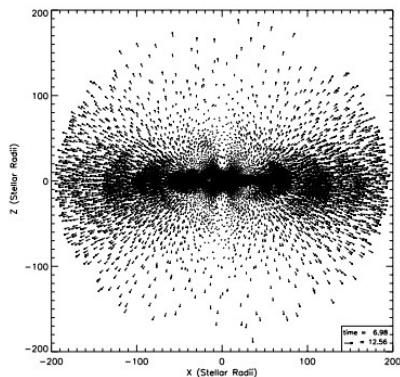


FIG. 17a

Mastrodemos (1999)

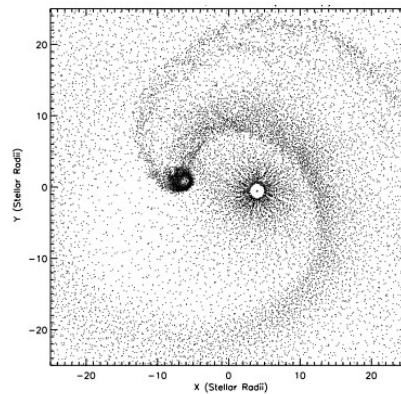


FIG. 17b

27.3 yr Period
12 AU separation
2.6 E-5 M/yr

Supergiant

- F-star $\sim 15 M$
- Disk+Star $\sim 15 M$

Post-AGB

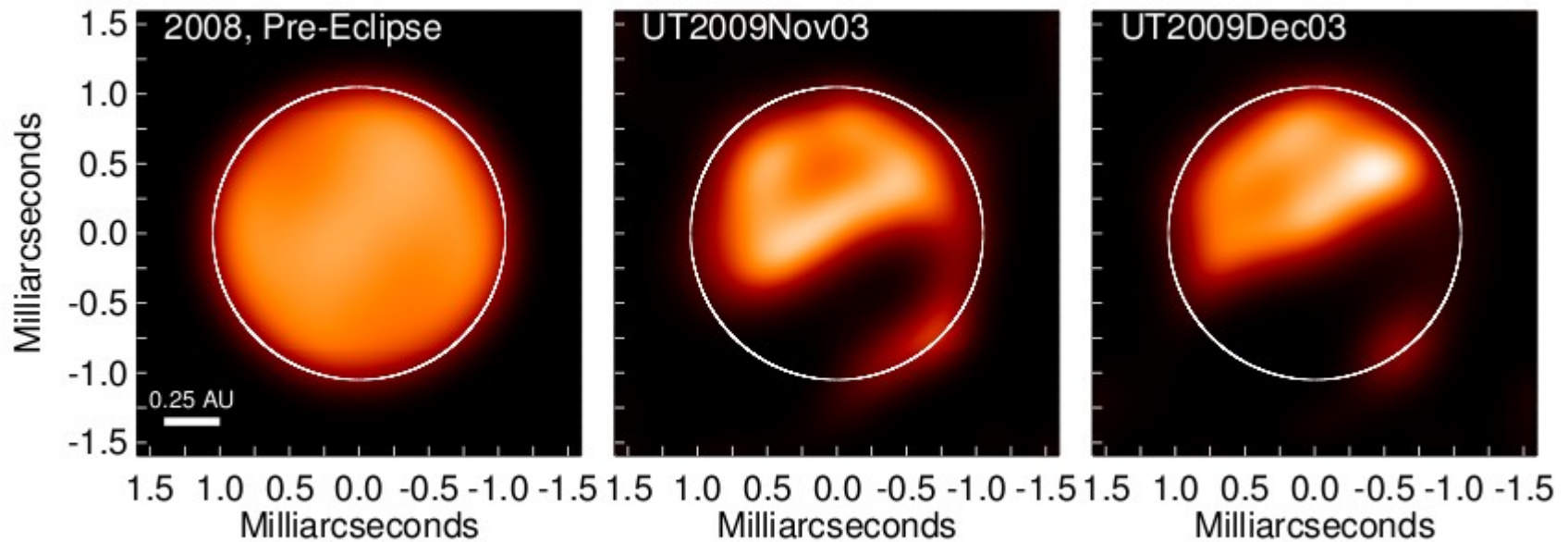
- F-Star $\sim 4 M$
- Disk + Star 6-7

RGB

- New, not fully explored

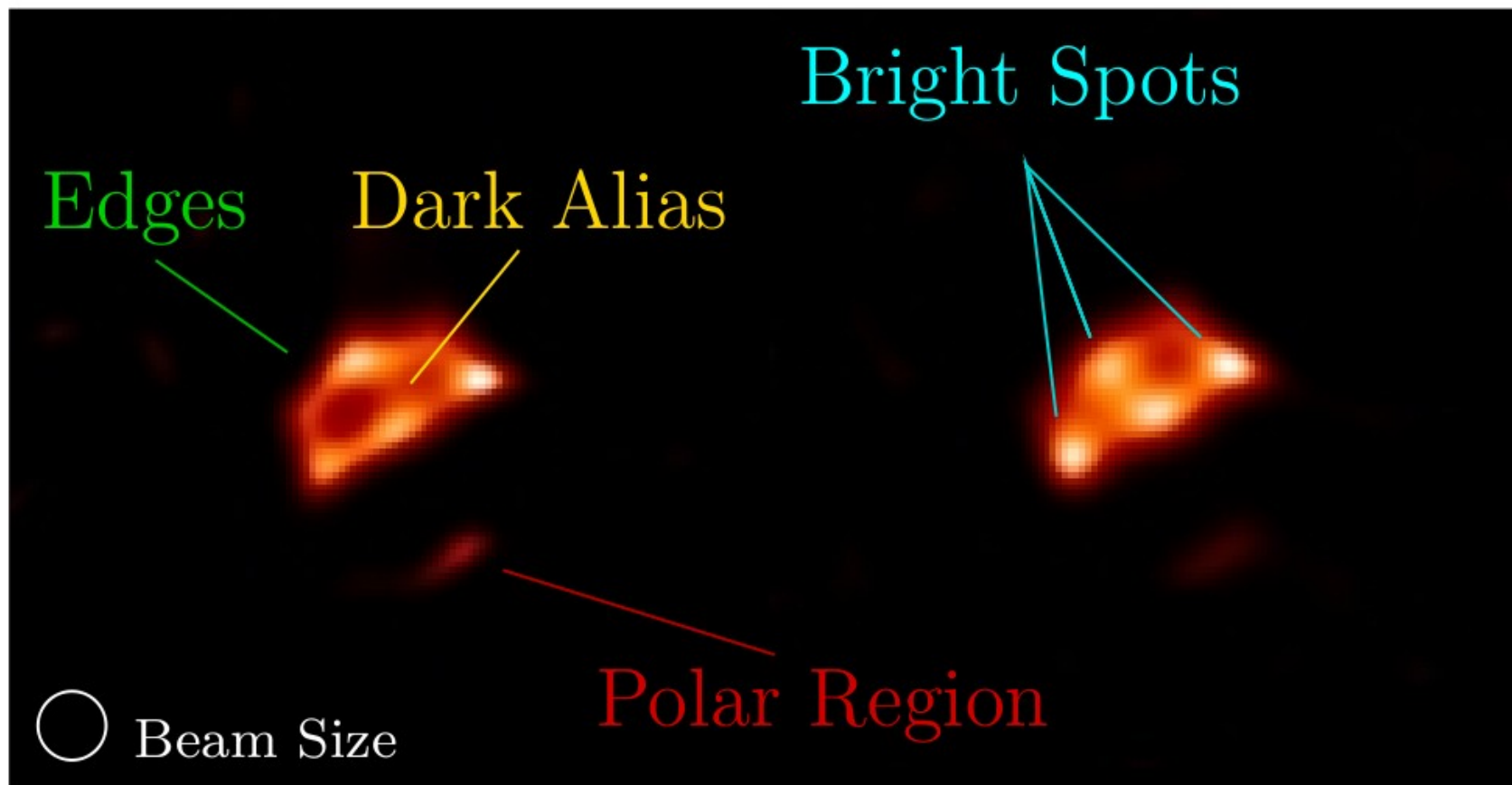
Ingress Imaging

Epsilon Aurigae Eclipse (CHARA-MIRC)

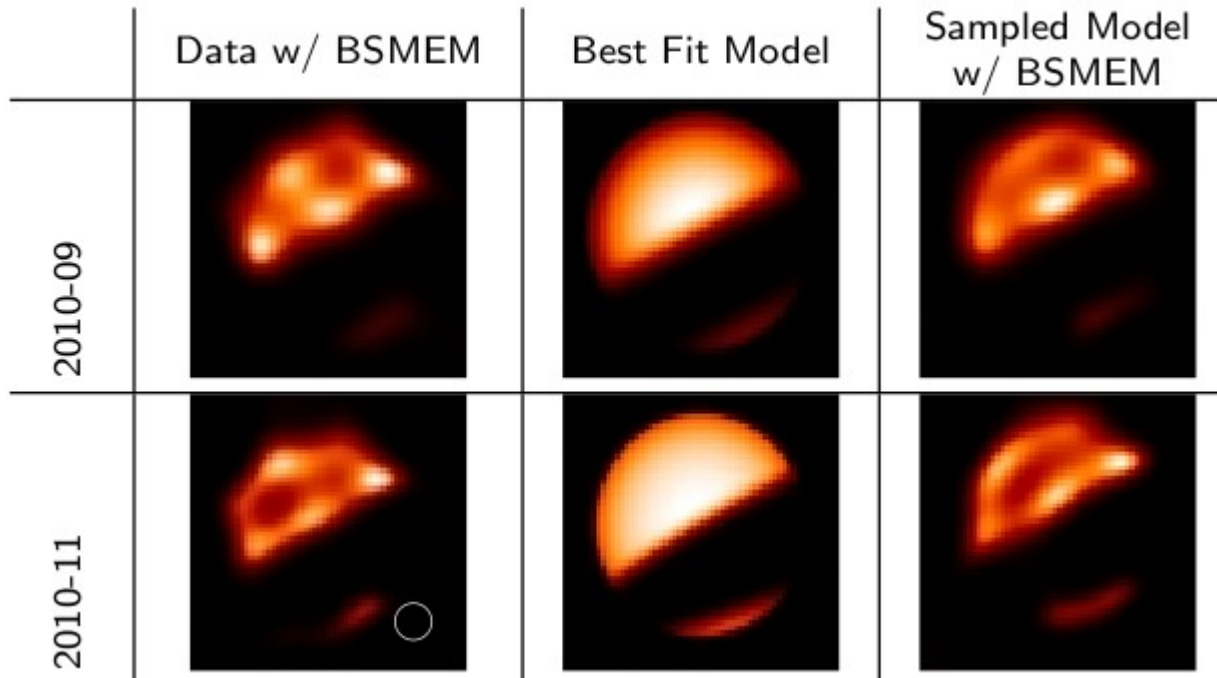


Ingress Imaging of epsilon Aurigae. Kloppenborg et. al. 2010

Potential Artifacts



Artifact Discussion



Likely Artifacts:

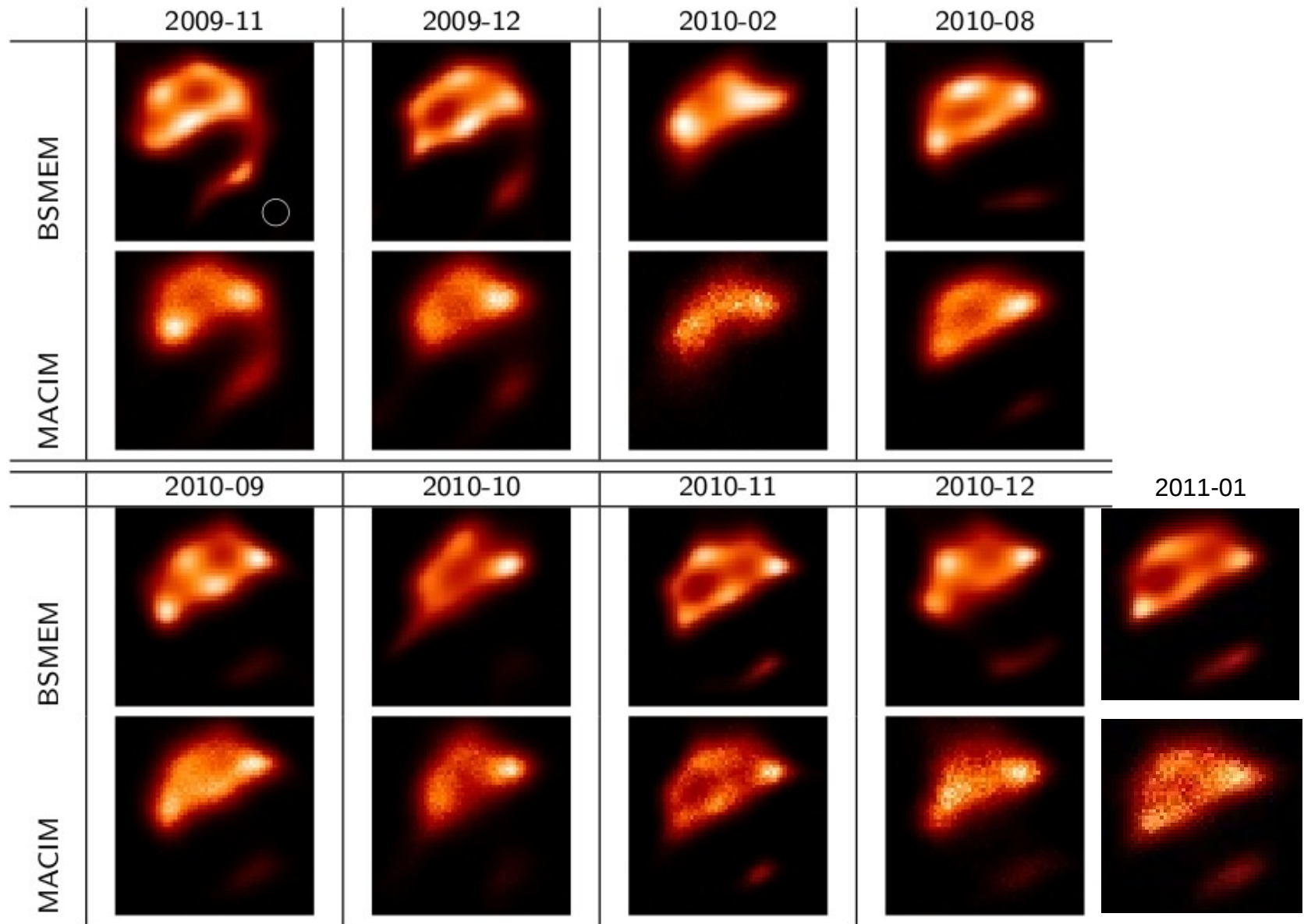
- Bright Spots along equator
- Bright spot at North Pole
- Dark alias in northern hemisphere
- Scalloped Edge of disk

Not Artifacts:

- Southern Pole

Undecided:

- Straight Edges on F-star

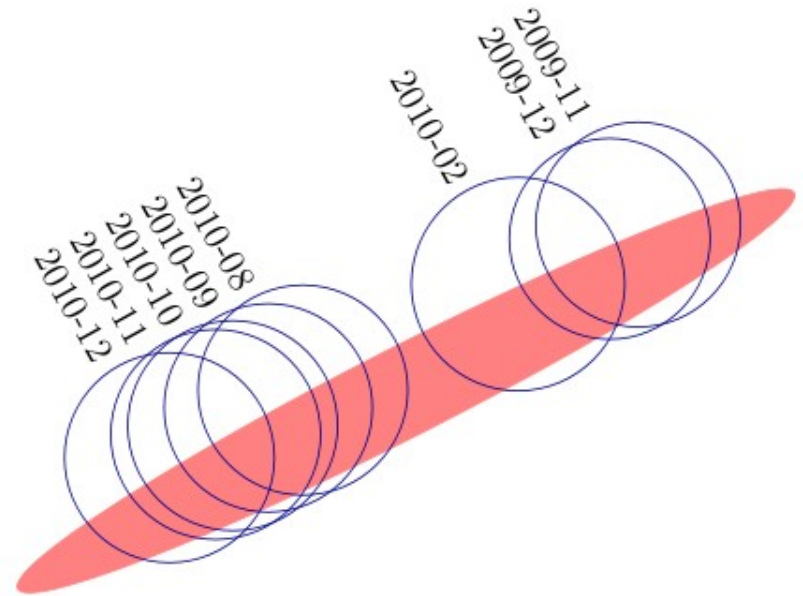
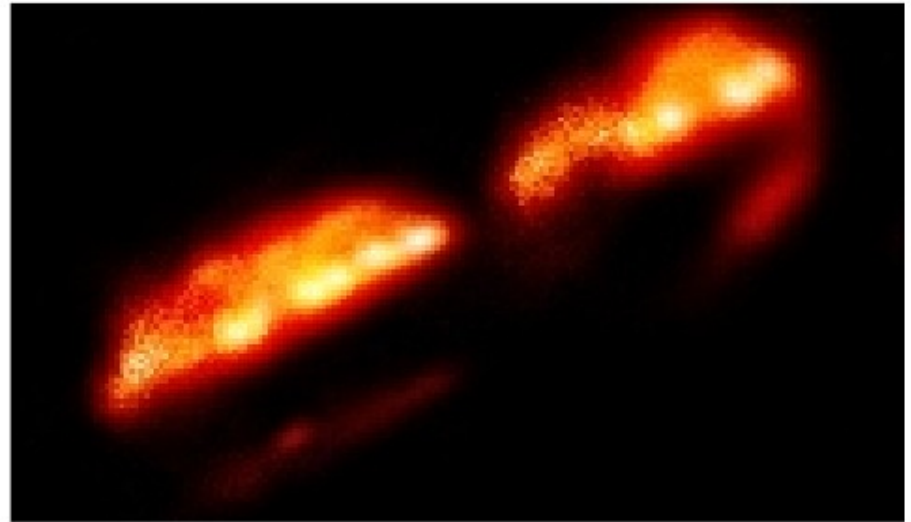




Single Epoch Model Fitting

Date	MJD	F-Star	Disk		Reduced
		LDD (mas)	Semi-Minor Axis (mas)	Smoothing Coefficient	
2009-11	55138	2.304	0.417	0.221	2.38
2009-12	55168	2.257	0.489	0.240	7.59
2010-02	55243	2.398	0.550	0.240	2.39
2010-08	55430	2.353	0.536	0.270	9.21
2010-09	55462	2.340	0.508	0.232	3.60
2010-10	55492	2.358	0.523	0.240	3.22
2010-11	55504	2.354	0.570	0.233	5.28
2010-12	55543	2.364	0.562	0.403	4.67

Silhouette



*figure manually adjusted from initial orbital fit



Multi-Epoch Model Fitting

- Starting Simple (2D):
 - Rectangle, Ellipse
- More Complicated (3D projected to 2D):
 - Torrid, Lopsided Torrid
 - YSO / Debris Disk
- But, these require an orbital solution....

Current solutions don't work

$$\Omega \sim 92 \pm 3 \text{ (VdK)}$$

$$\omega = 39.2 \text{ (Stefanik)}$$

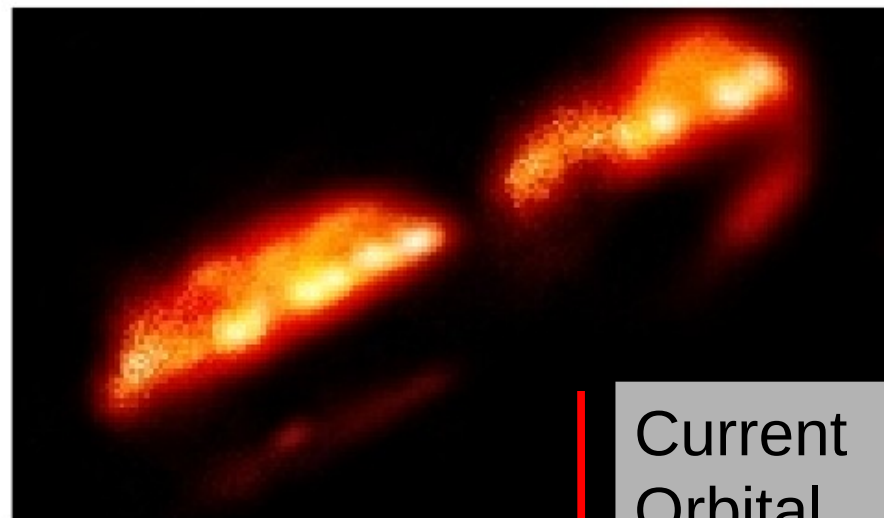
$$i = 89-90$$

$$T \sim 27.1 \text{ yr (Stefanik)}$$

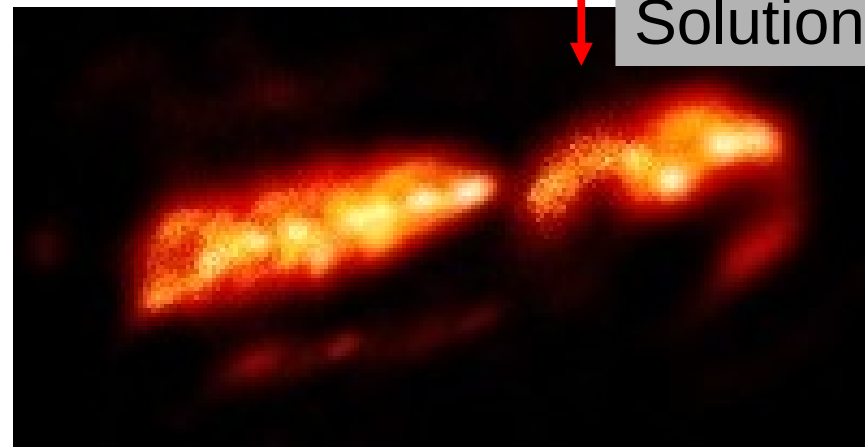
$$e = 0.227 \pm 0.011 \text{ (Stefanik)}$$

$$\tau \sim 2,454,515 \text{ (Stefanik)}$$

$$a \sin(i) \sim 1800 \text{ E9 km (Stefanik)}$$

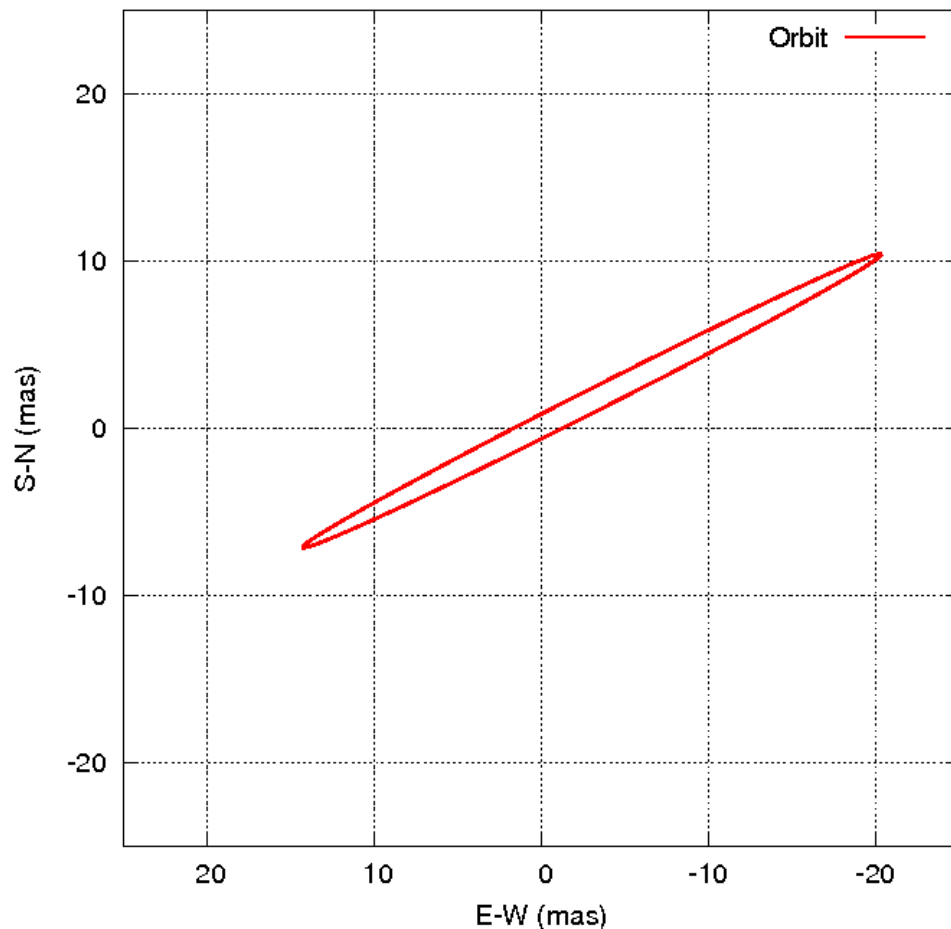


Current
Orbital
Solution



Towards a new orbital solution

F-star Orbit (implied by interferometry)



Simultaneously Fit

- Astrometry
- Radial Velocity
- Interferometry

Constraining Results:

$\Omega \sim 110$ (from CHARA)

$\omega = 39.2$ (from RV)

$i = 89-90$

$e = 0.227 \pm 0.011$

$T \sim 27.1$ yr

$\tau \sim 2,454,515$

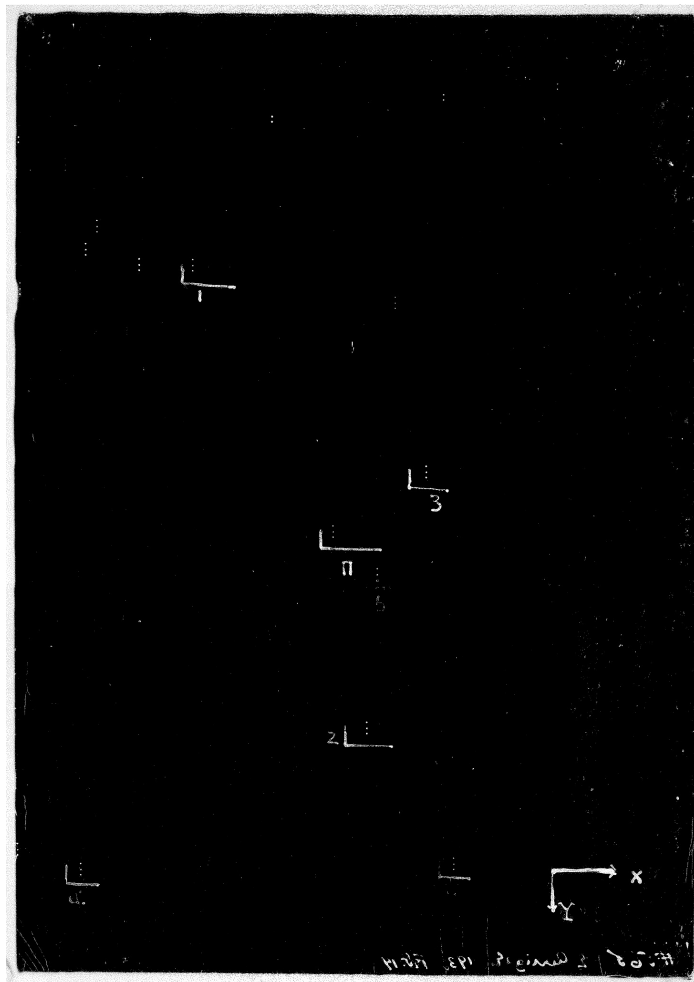
$a_1 \sin(i) \sim 1800 \text{ E9 km}$

$\alpha_1 = ?, a_2 = ? \alpha_2 = ?$

$d = ?$

RV data from
Stefanik et al. 2010
Chadima et al. 2010

Back to Astrometry



Sproul Observatory:

1051 Plates

301 Nights