The Orbit and Companion of PSR J1622-0315: Variable Asymmetry and a Massive Neutron Star

Sen et al. 2024
Accepted in ApJ

Spider Systems

- Redbacks:
  - $M_2 \sim 0.1 M_\odot$
  - Irradiated and non-irradiated systems
- Black Widows:
  - $M_2 \sim 0.01 M_\odot$
  - Irradiated systems

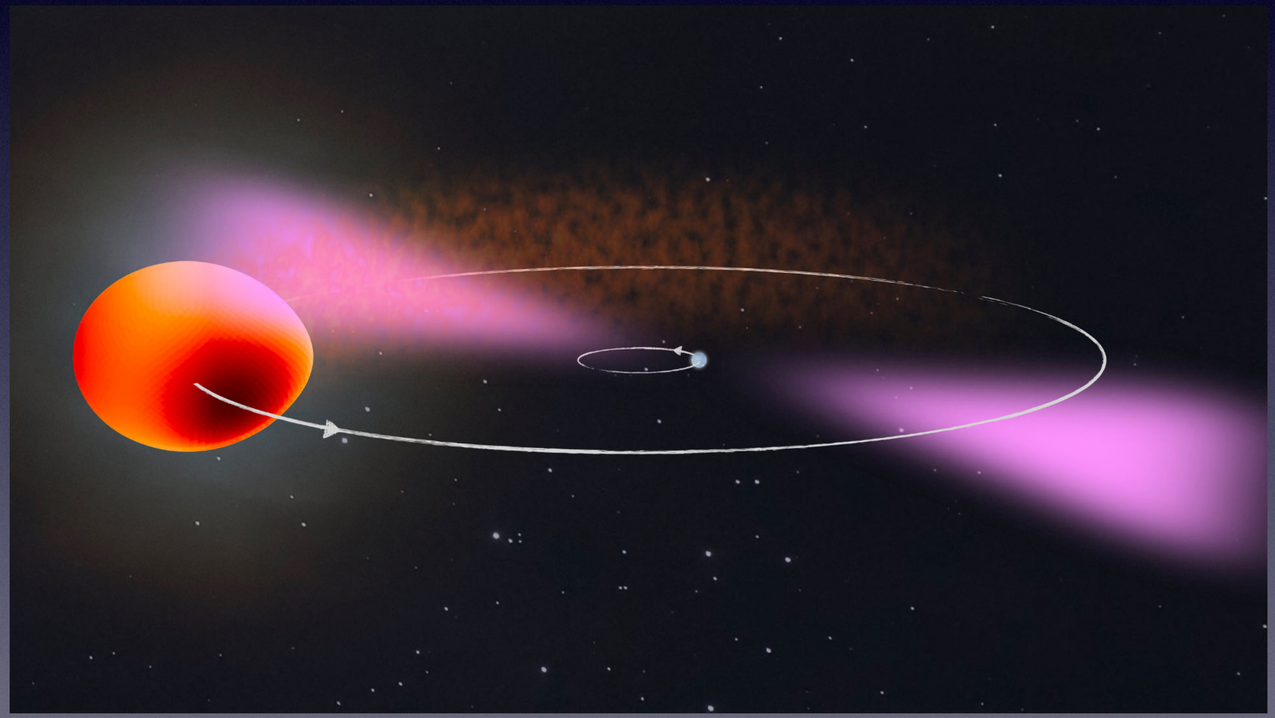

Image credit: B. Knispel / C.J. Clark / Max Planck Institute for Gravitational Physics / NASA's Goddard Space Flight Center.

Doubled peaked light curves indicate little irradiation

- Irradiated black widow:

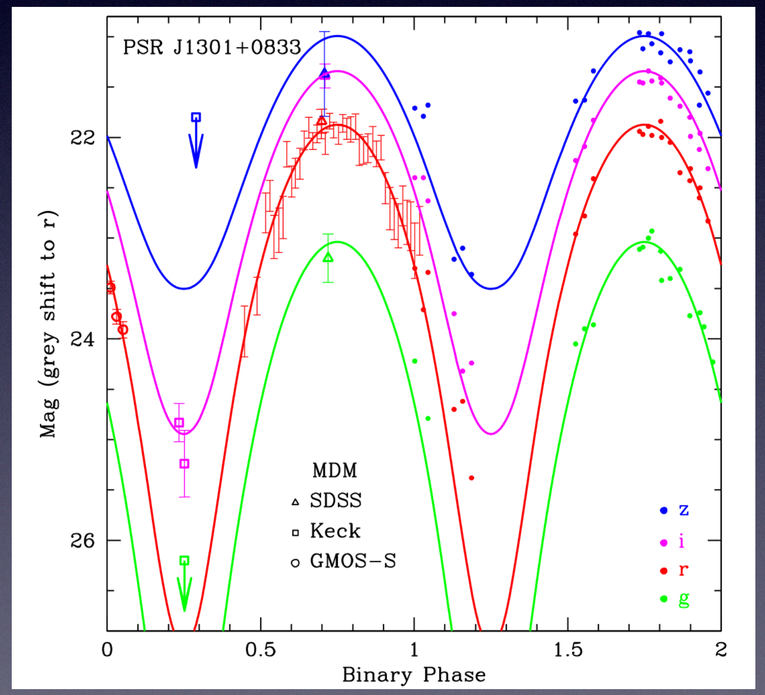

Fig. 4 Romani et al., ApJ, 2016

- Not irradiated redback:

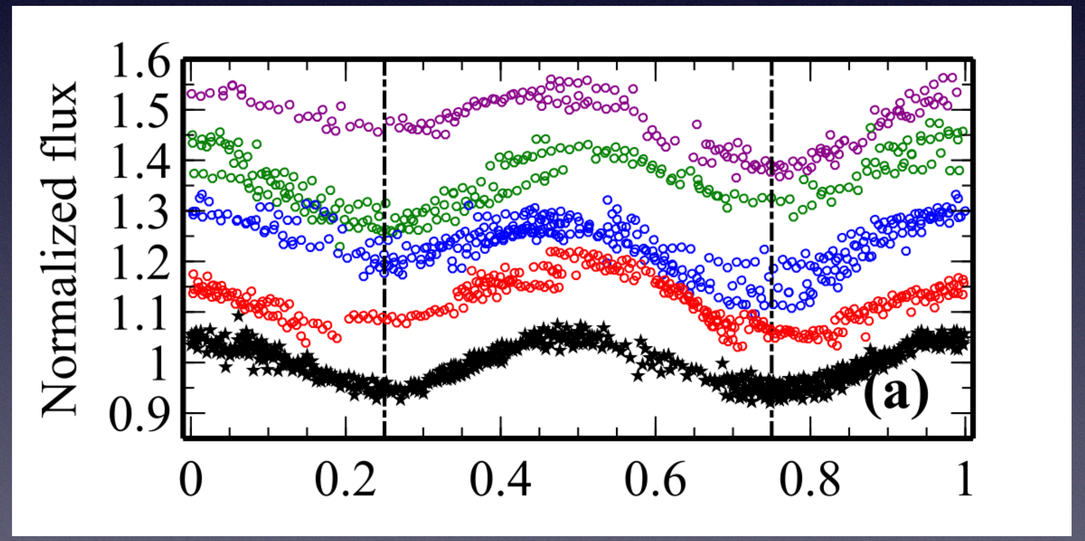

Fig. 2 D. van Staden and Antoniadis, ApJL, 2016

Discovery of J1622

- Discovered by Green Bank Telescope
- Orbital period of 3.9 hours
- Not enough X-ray counts to find variability
- Inclination constraint from not detecting gamma ray eclipses

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- Inclination constraint from not detecting gamma ray eclipses
- Yap et al. 2023 find no irradiation in models

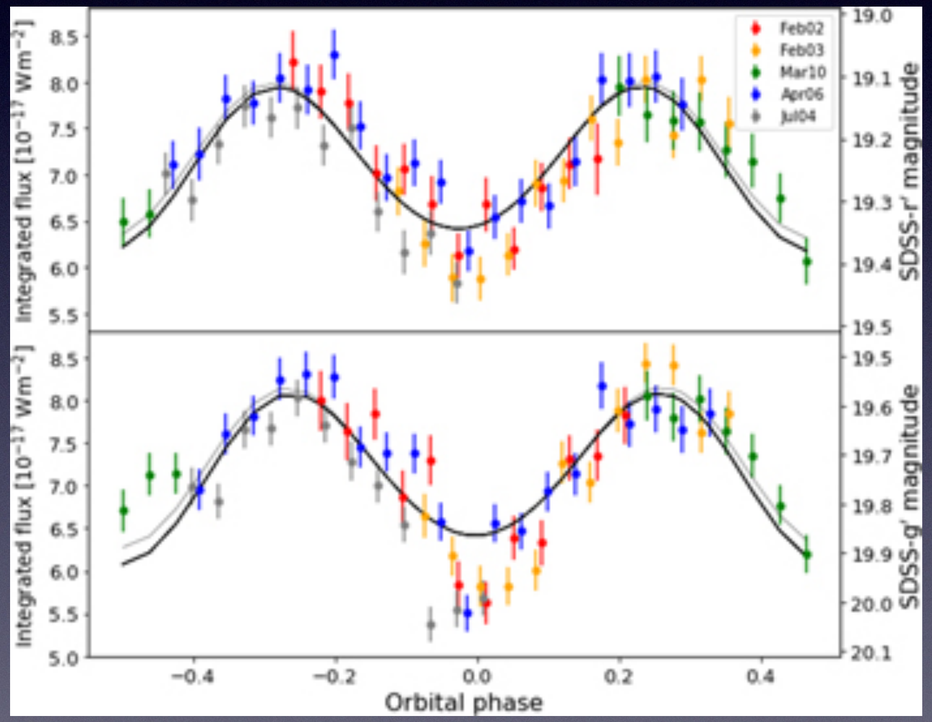

Fig. 2 Yap et al., ApJ, 2023

Flat colors discovered in Turchetta et al. 2023

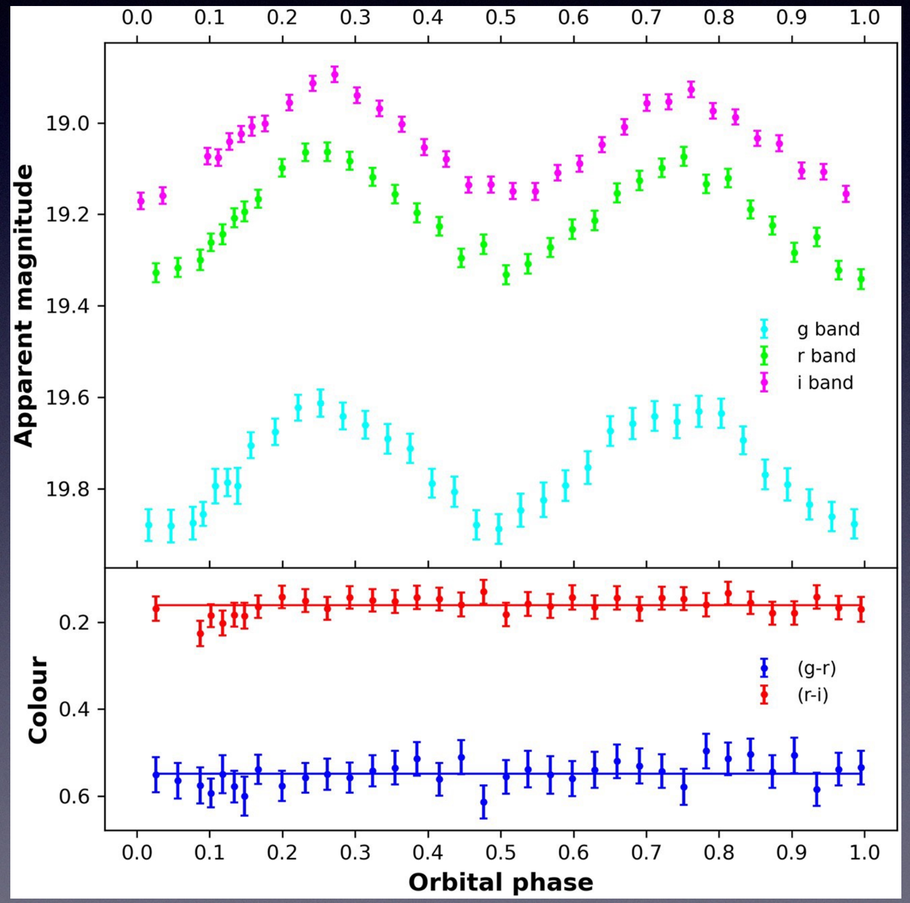

Fig. 1 Turchetta et al., MNRAS, 2023

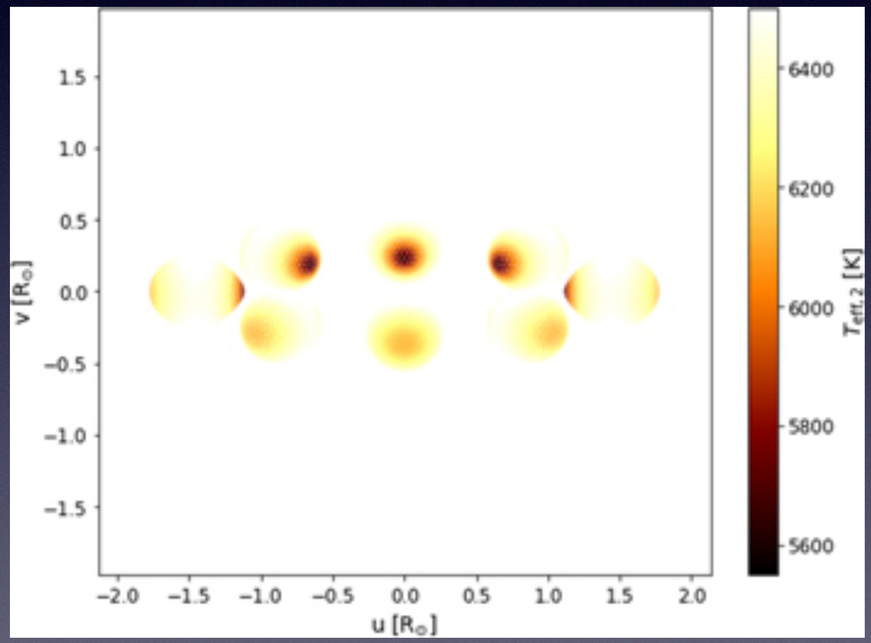

Fig. 3 Yap et al., ApJ, 2023

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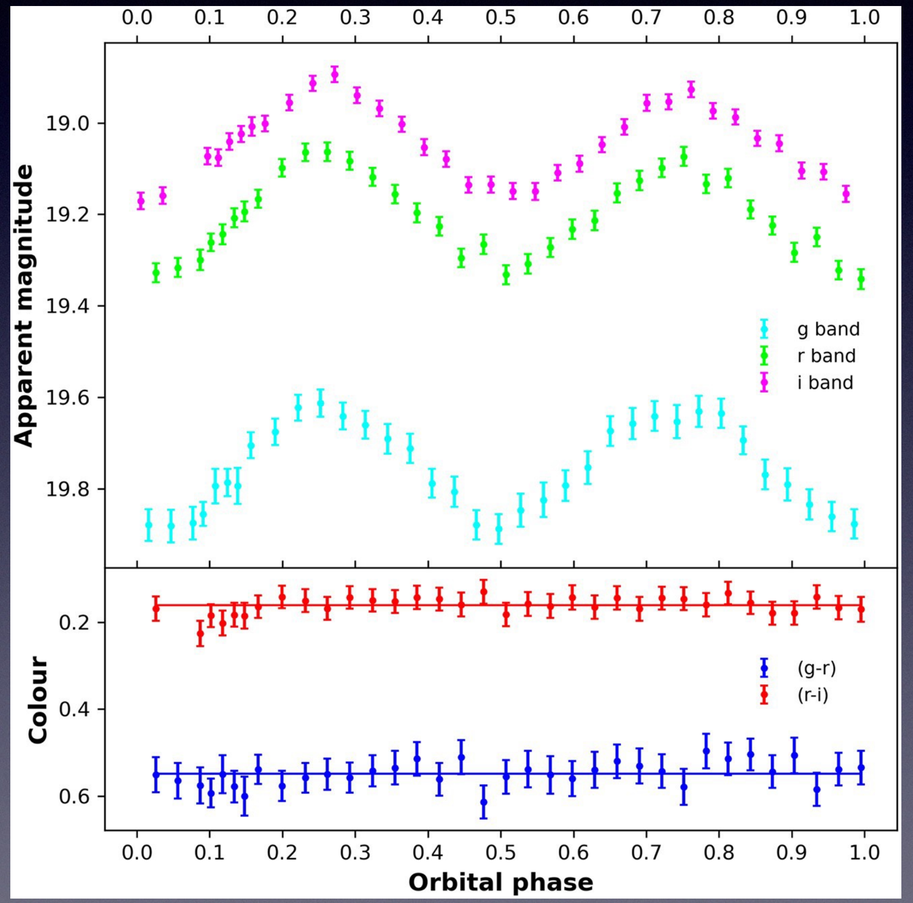

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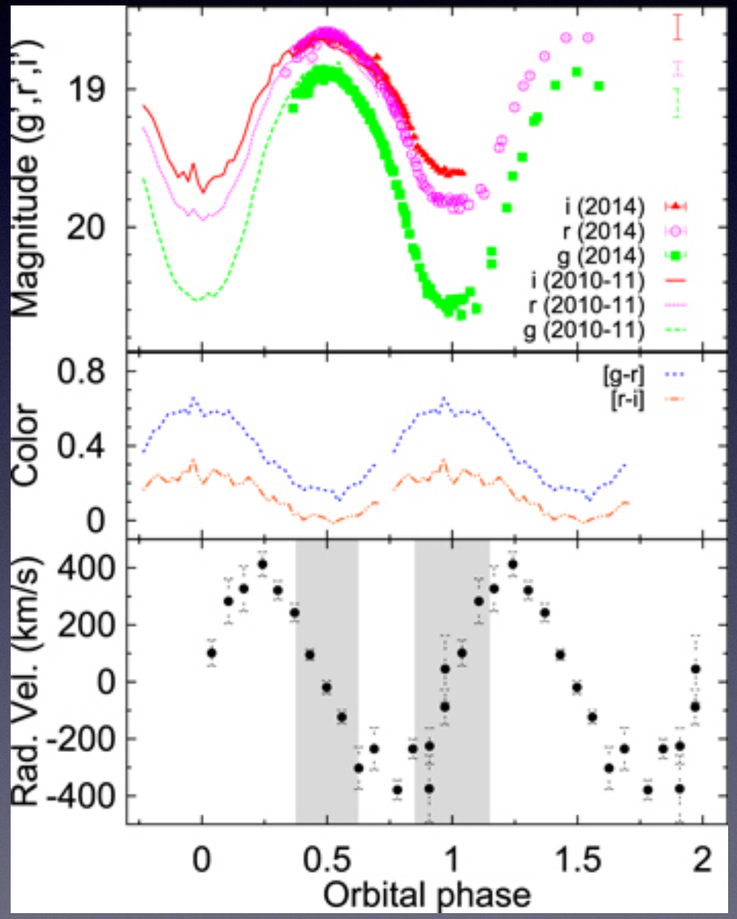

Fig. 1 Linares et al., ApJ, 2018

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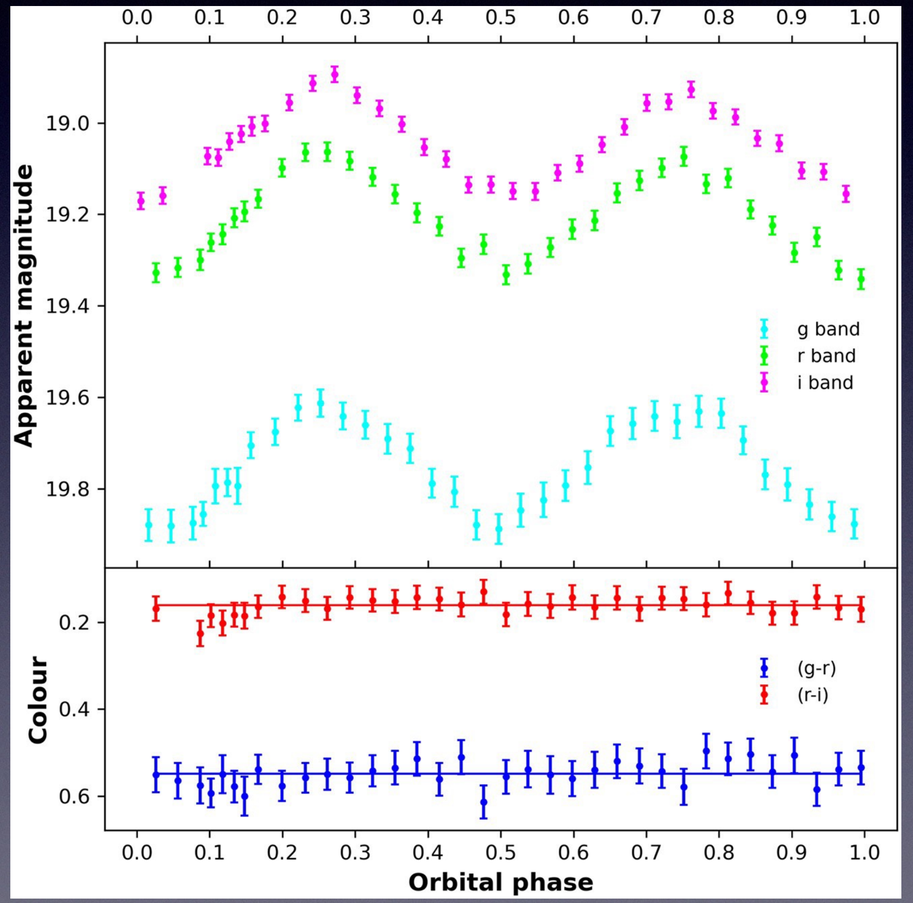

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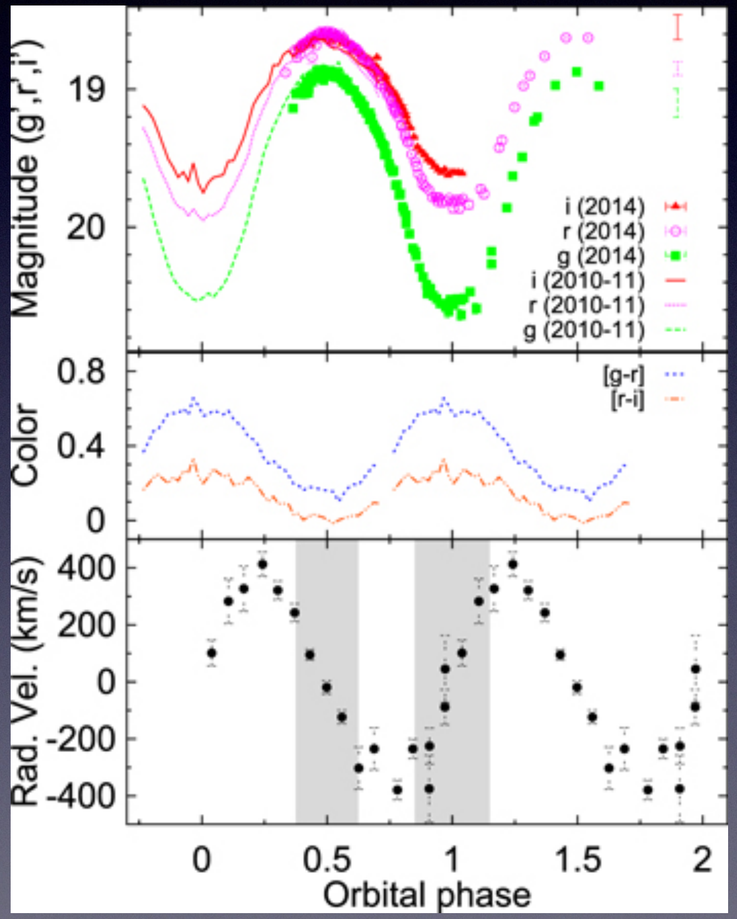


Fig. 1 Linares et al., ApJ, 2018

Conclusion: little irradiation present

New NTT data from 2017

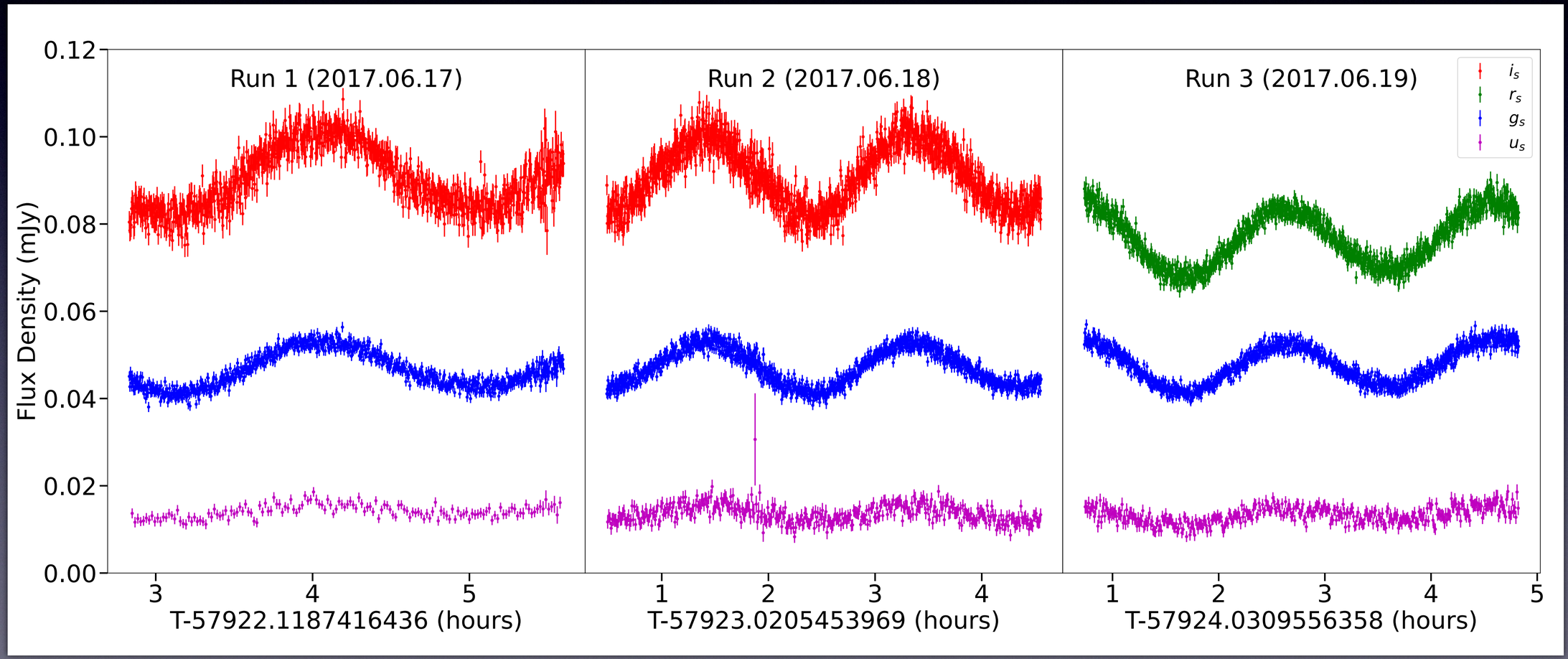


Fig. 1 Sen et al., ApJ, 2024

Direct heating models were diagnostics…

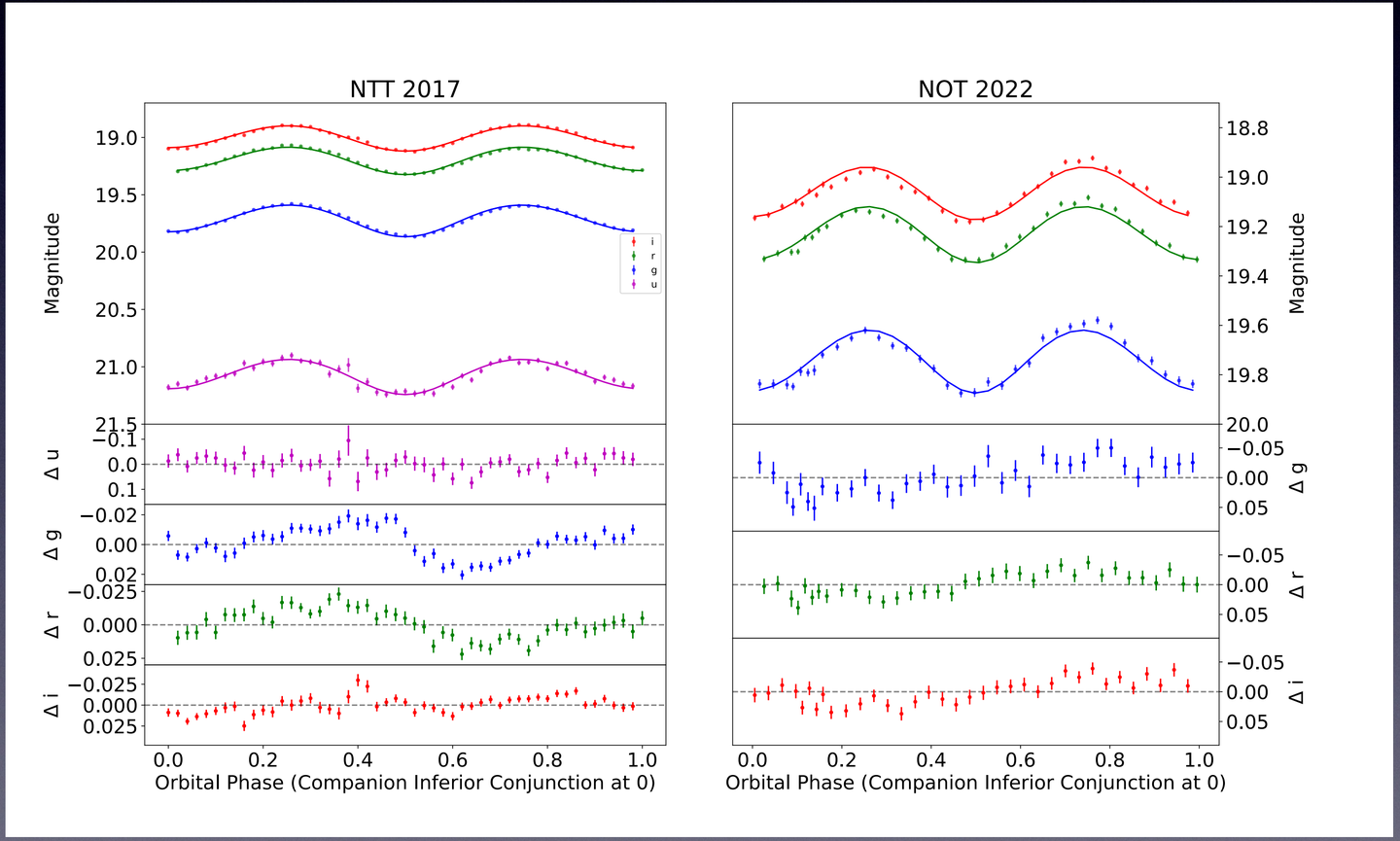


Fig. 4 Sen et al., ApJ, 2024

…to put star spots on our model companion

- NTT 2017: cold spot at 36°
- NOT 2022: hot spot at 90°

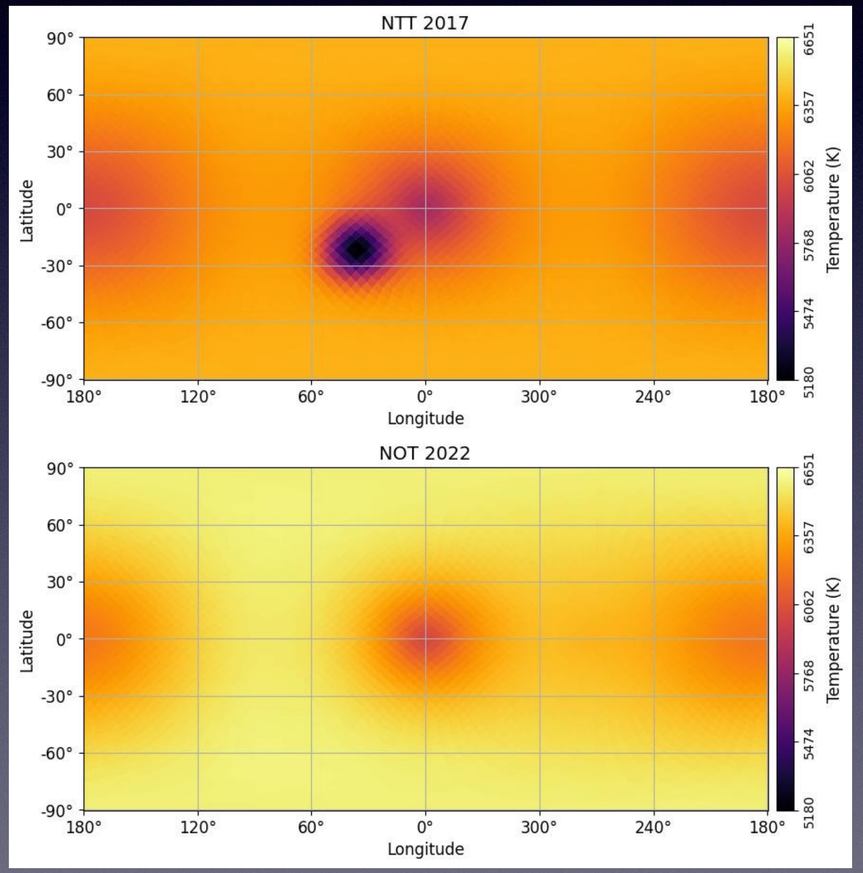
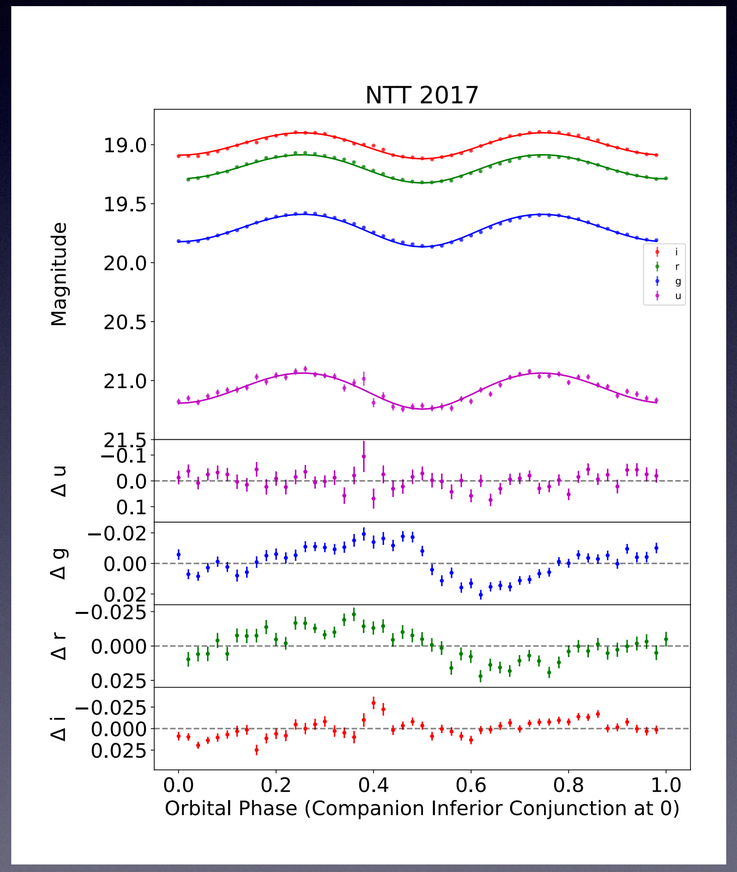
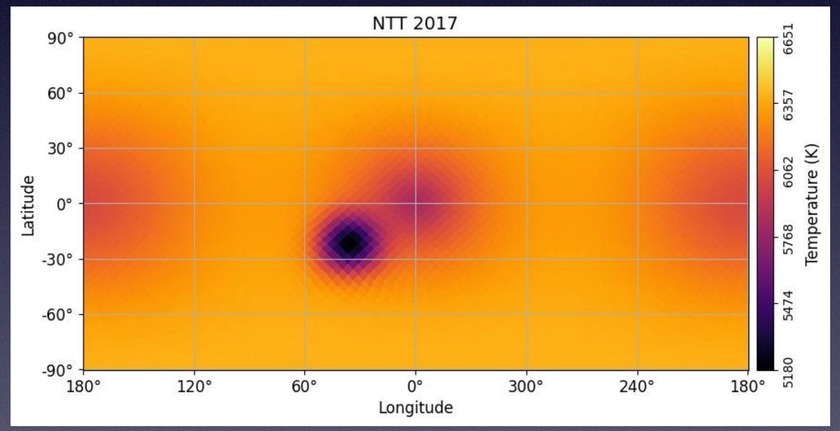
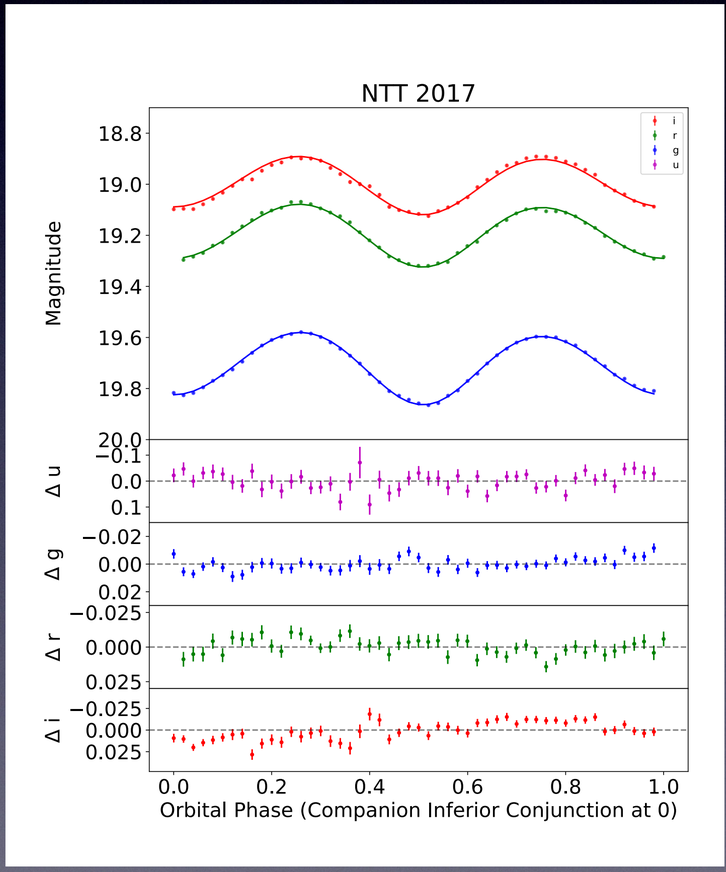


Fig. 6 Sen et al., ApJ, 2024

NTT 2017 cold spot at 36°







From Figs. 4,5,6 Sen et al., ApJ, 2024

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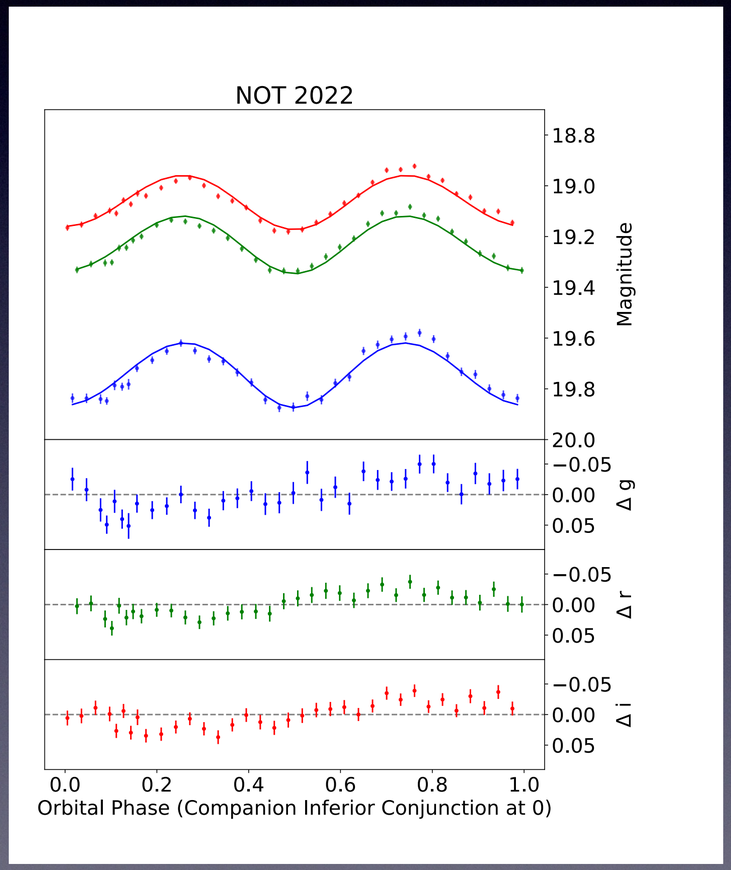

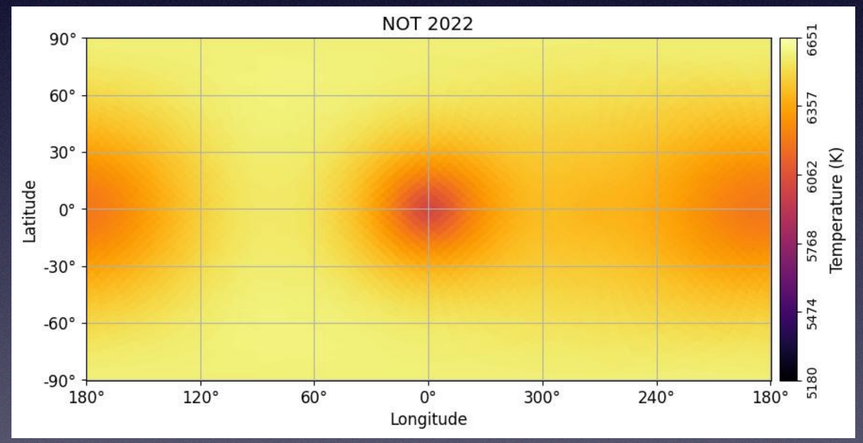

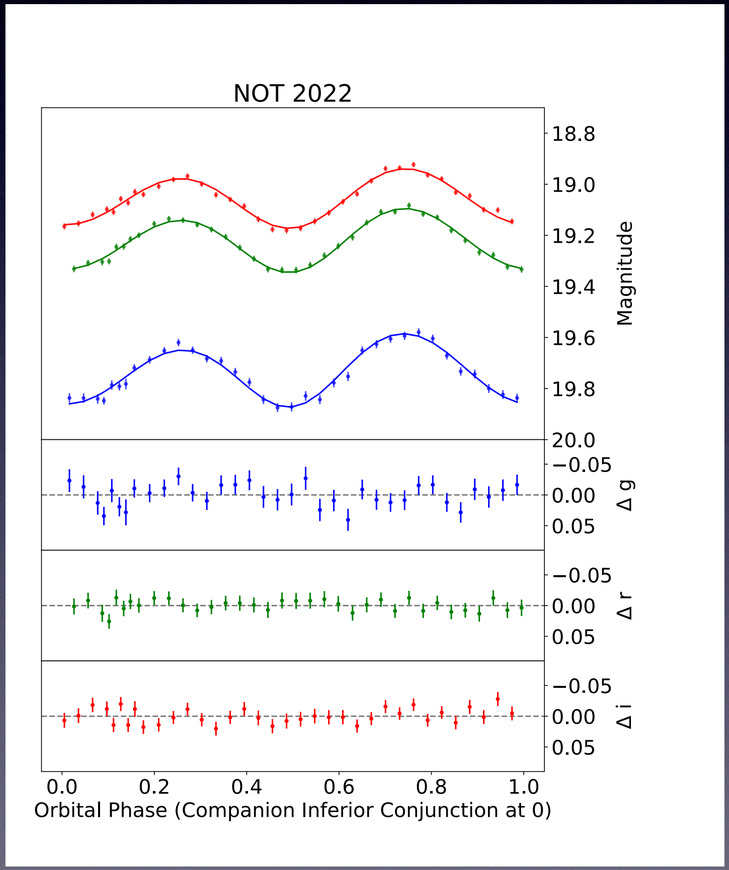

From Figs. 4,5,6 Sen et al., ApJ, 2024

Linked fit gives us the best parameter estimates

Fitted	NTT 2017	NOT 2022
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$R_{\rm spot}$ (deg)	10 ± 2	127^{+50}_{-42}
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Derived		
q	$14.8^{+0.8}_{-0.7}$	
$M_1(M_\odot)$	2.3 ± 0.4	
$M_2(M_\odot)$	0.15 ± 0.02	
$T_{\rm day}$ (K)	6085^{+100}_{-60}	6071^{+110}_{-140}
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- $M_1 > 2M_\odot$: Support for supermassive neutron star

Irradiation is low, but significant

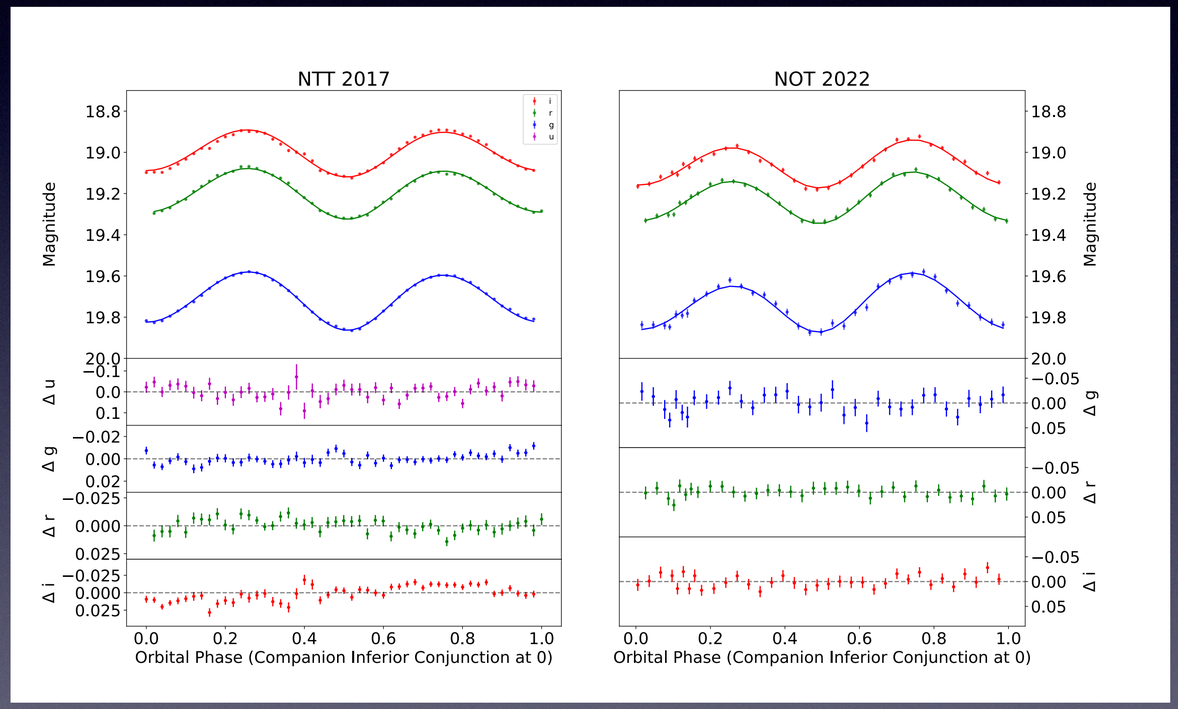

Fig. 7 Sen et al., ApJ, 2024

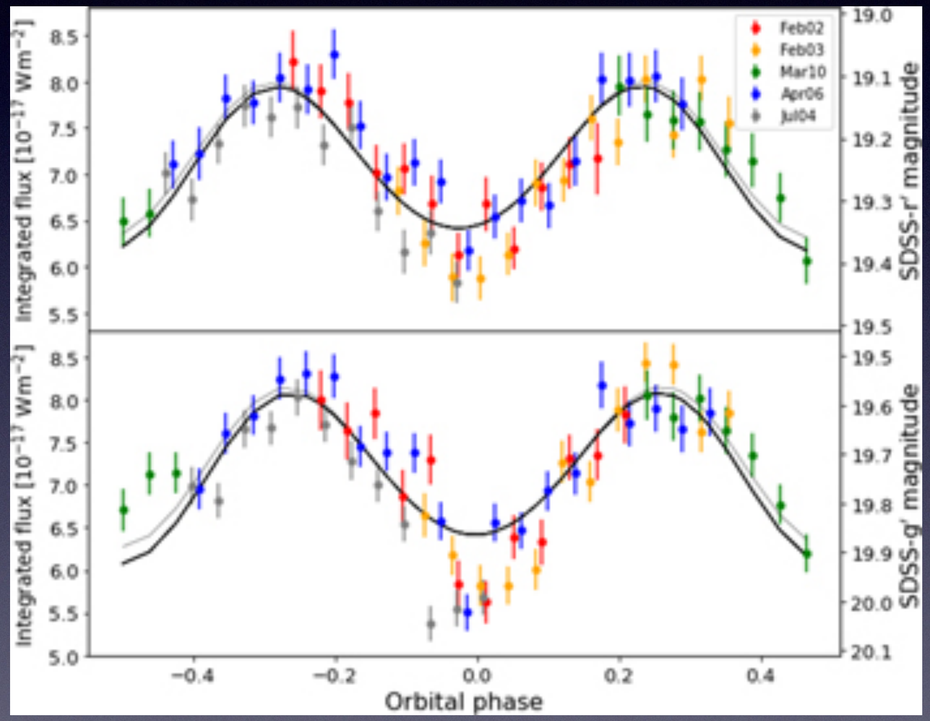

Fig. 2 Yap et al., ApJ, 2023

Orbital parameters differ with and without irradiation

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From Table 2 Sen et al., ApJ, 2024

Fit Parameter(s)	Result(s)
$q_{\rm binary}$ [$M_{\rm comp}/M_{\rm NS}$]	$0.066^{+0.005}_{-0.003}$
$T_{\rm eff,2}$ (K)	6383^{+89}_{-98}
$i_{\rm binary}$ (°)	$78.1^{+7.9}_{-6.9}$
$R_{\rm equiv,2}$ ($R_\odot$)	$0.279^{+0.004}_{-0.004}$
$A_{\rm V}$ (mag)	$0.81^{+0.06}_{-0.07}$
d (kpc)	$2.06^{+0.04}_{-0.04}$
Derived Parameter(s)	
$M_{\rm primary}$ ($M_\odot$)	$1.84^{+0.19}_{-0.19}$
$M_{\rm secondary}$ ($M_\odot$)	$0.122^{+0.007}_{-0.006}$

Table 3 Yap et al., ApJ, 2023

Absolute maxima changes orbital phase

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“Shrugging shoulder” light curves have been observed before

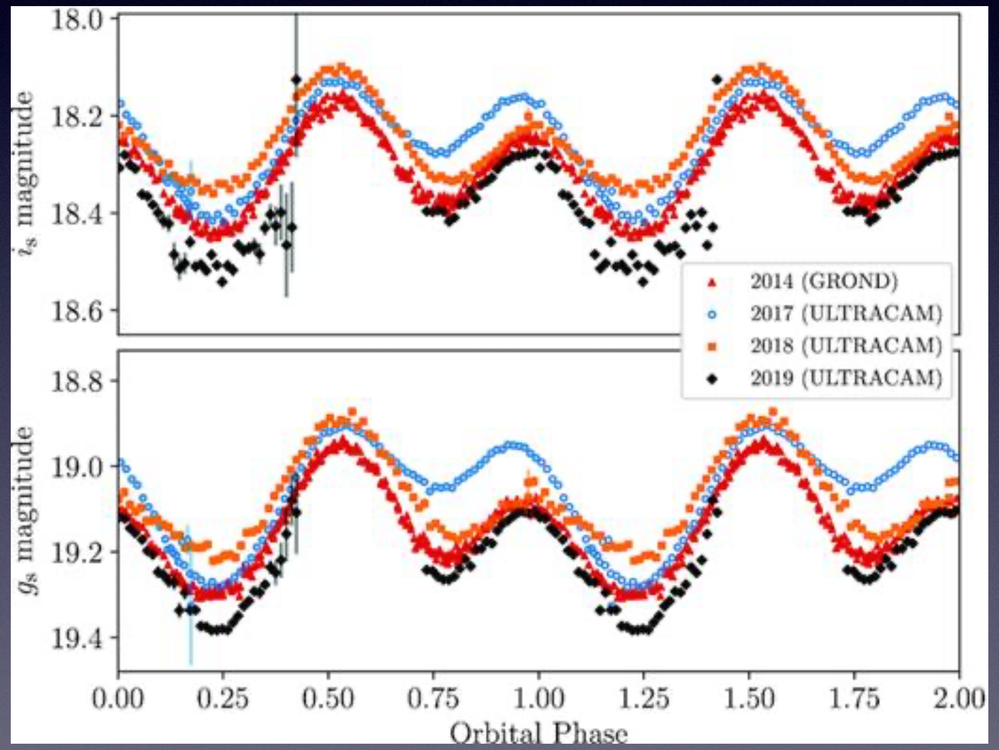


Fig. 6 Clark et al., MNRAS, 2021

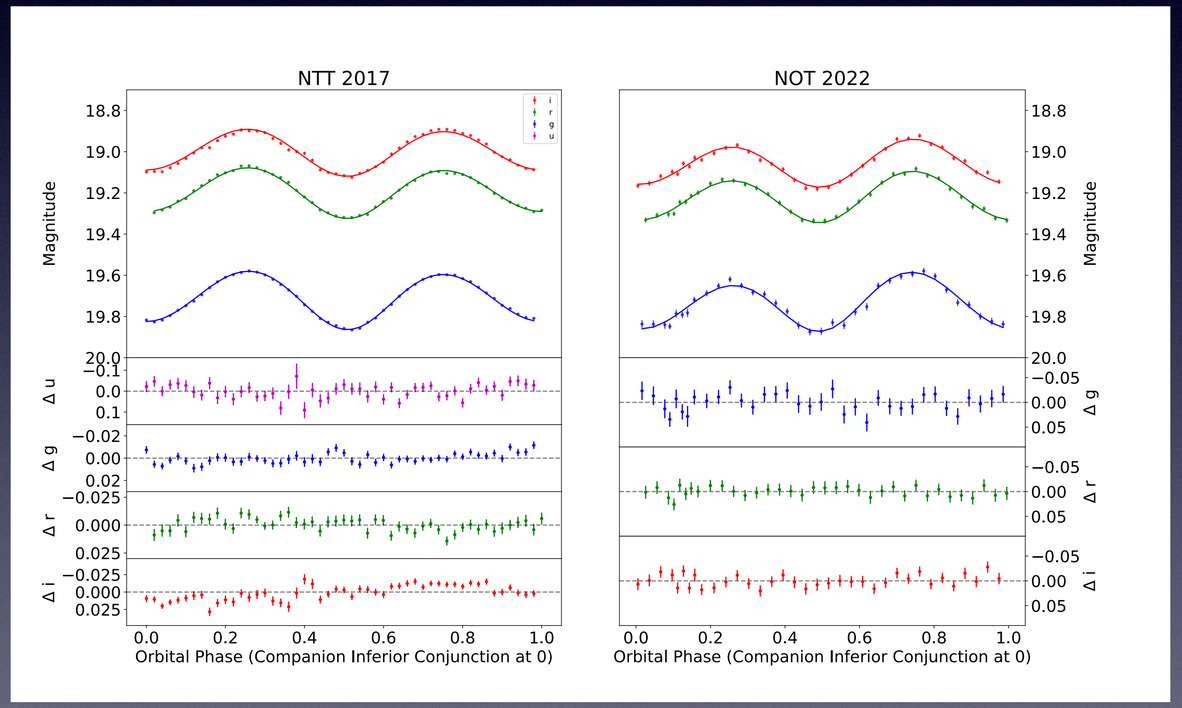


Fig. 7 Sen et al., ApJ, 2024

Intrabinary shock can cause asymmetric light curves

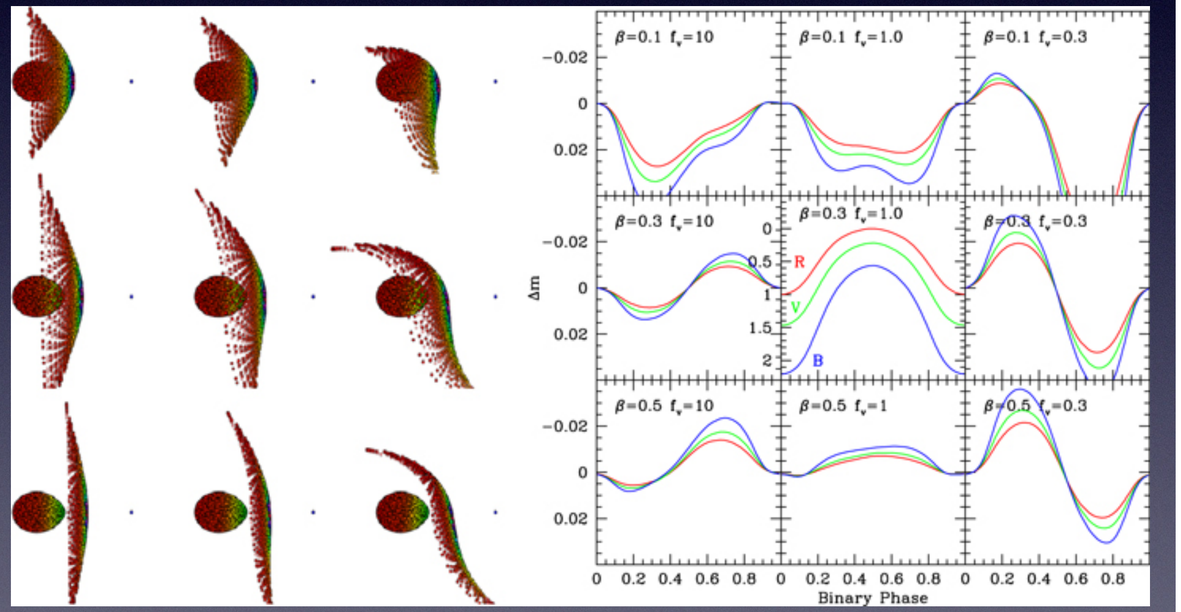
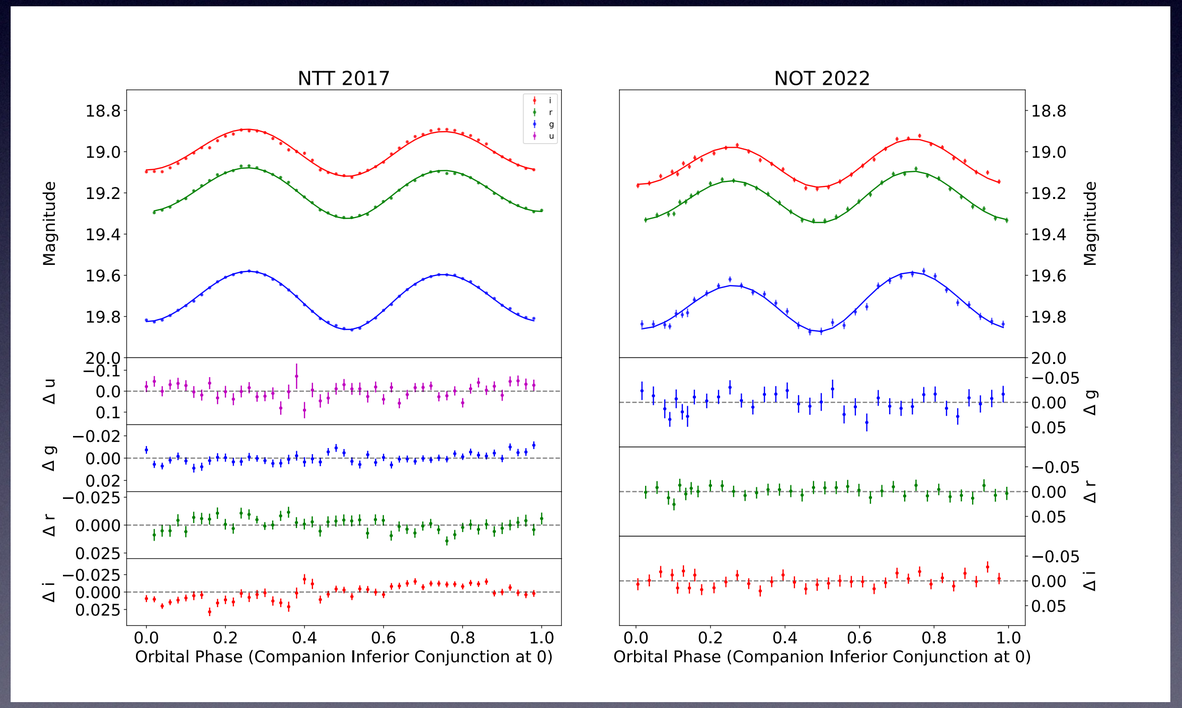


Fig. 4 Romani & Sanchez, ApJ, 2016



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From Table 2 Sen et al., ApJ, 2024

- PSR J2215: redback with $M_1 = 2.3 \pm 0.2 M_\odot$
  - Spectral lines constrained day and night side temperatures
- PSR J0952-0607: black widow with $M_1 = 2.4 \pm 0.2 M_\odot$

Mass constraints depend on inclination and K_2 constraints

- Constrain inclination with photometric data
- Better constraints on K_2 allow for better estimates of M_1
- K_2 constrained by spectroscopic data

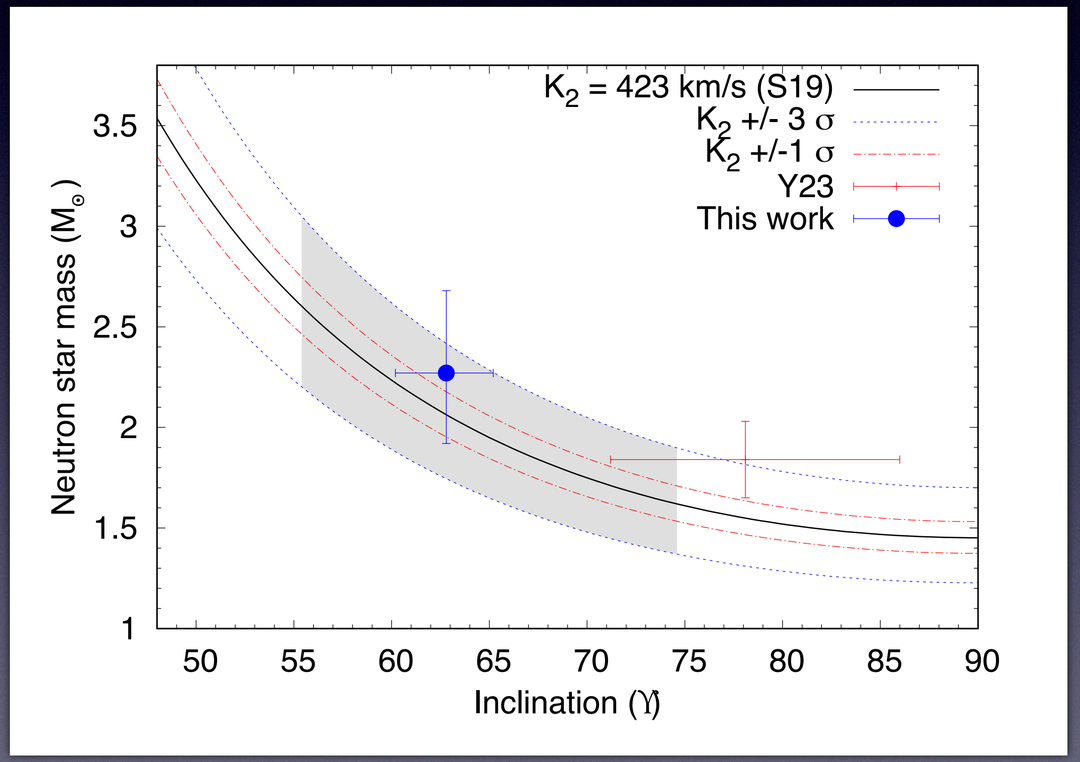

Fig. 8 Sen et al., ApJ, 2024

Orbital parameters differ with different constraints on K_2

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Table 3 Yap et al., ApJ, 2023

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- K_2 constrained by spectroscopic data
- Model GTC spectroscopic data of J1622 in future

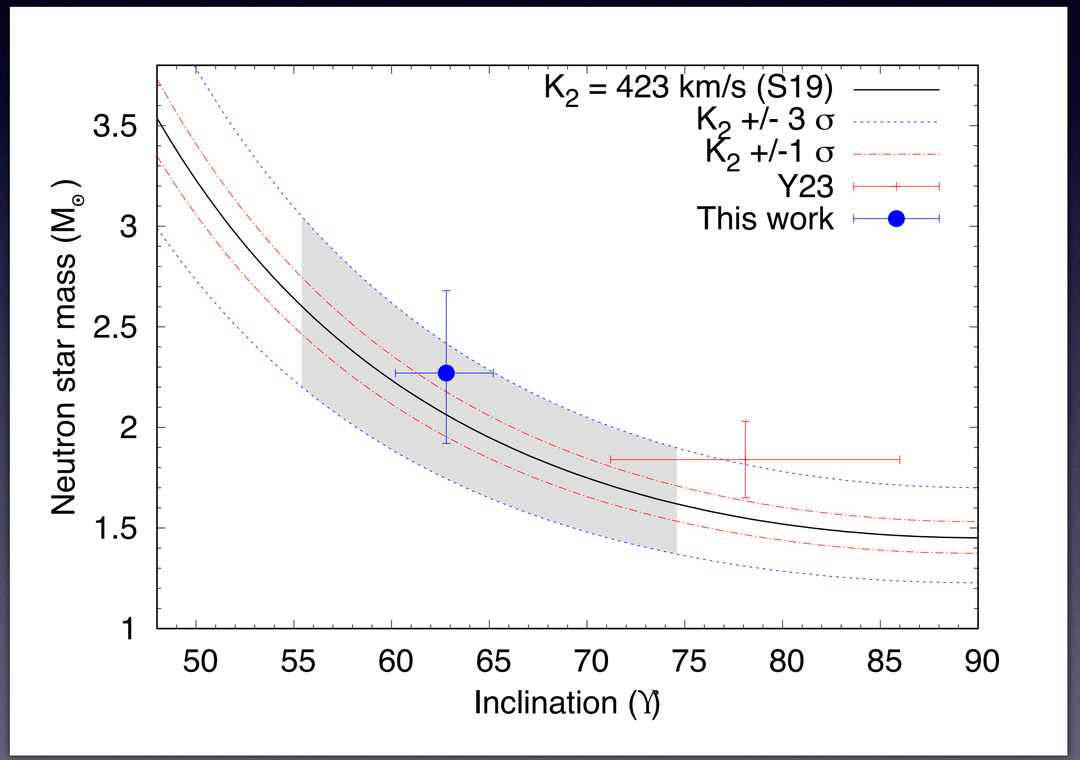

Fig. 8 Sen et al., ApJ, 2024

An irradiated redback with variable asymmetries and massive neutron star

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Thank you!