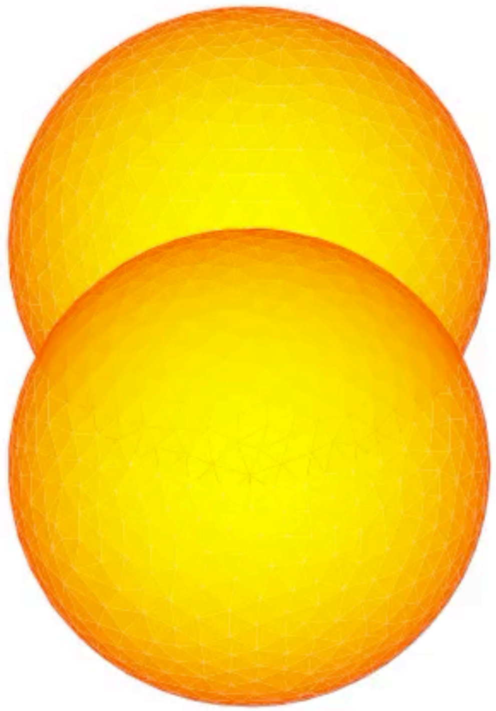
BINARIES

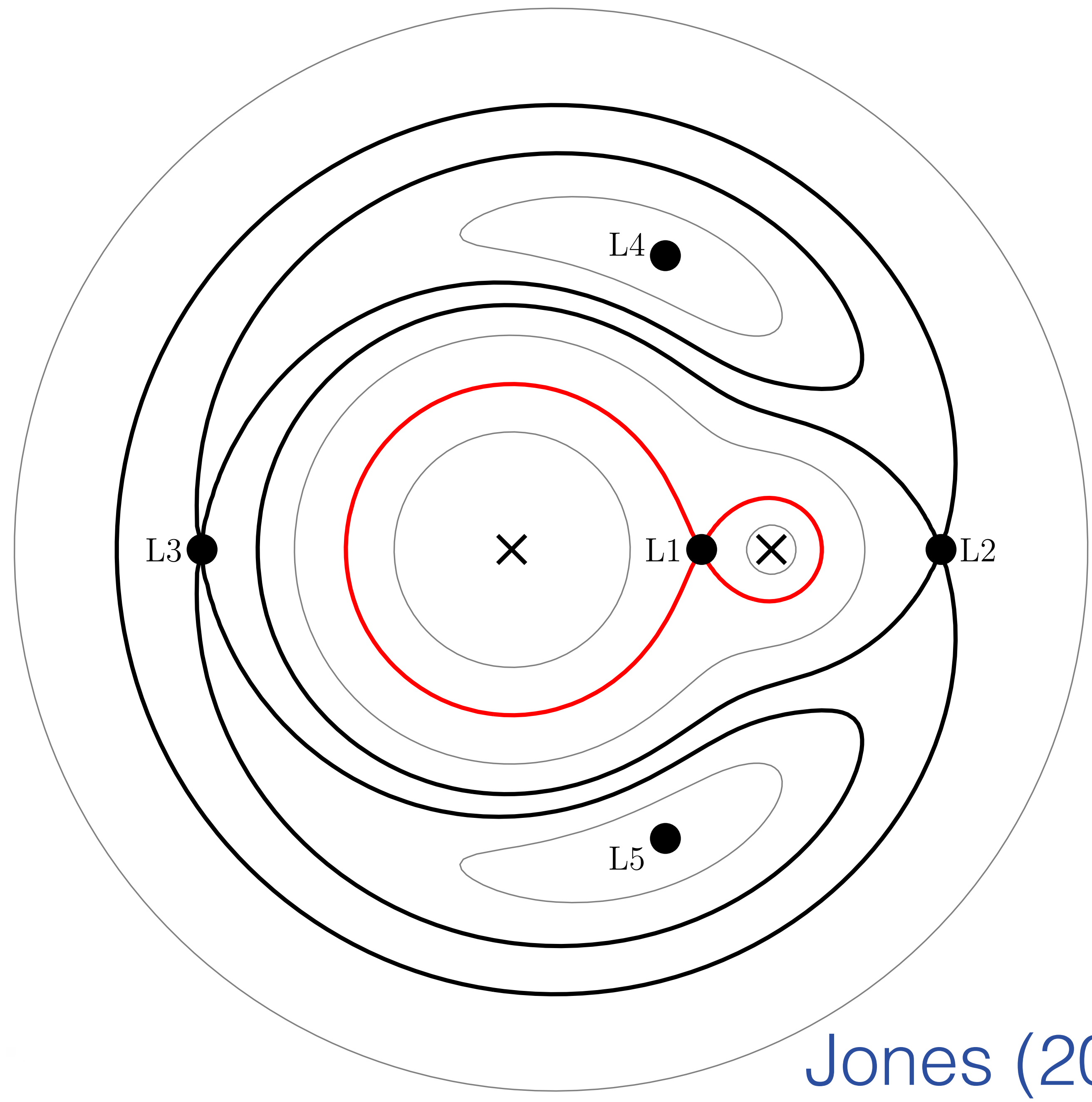


Binary basics

Different “classes” of binary:

- Visual
- Spectroscopic
- Eclipsing (more generally, photometrically variable)
- Astrometric

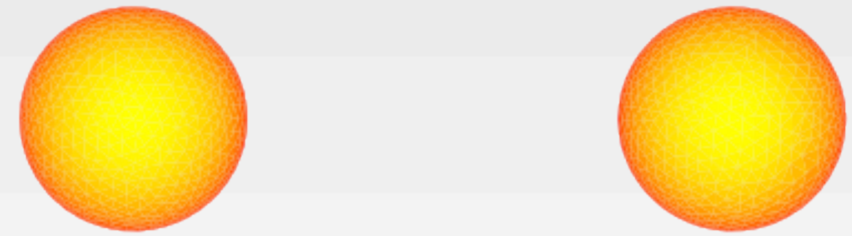
Binary basics



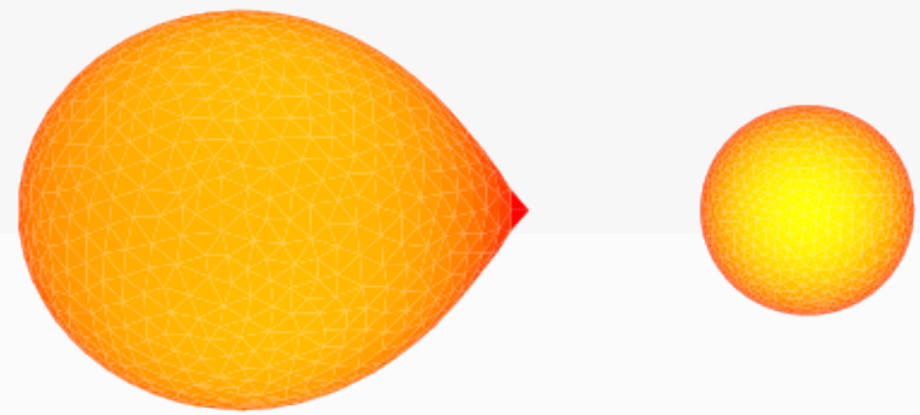
Jones (2020)

Photometric variables

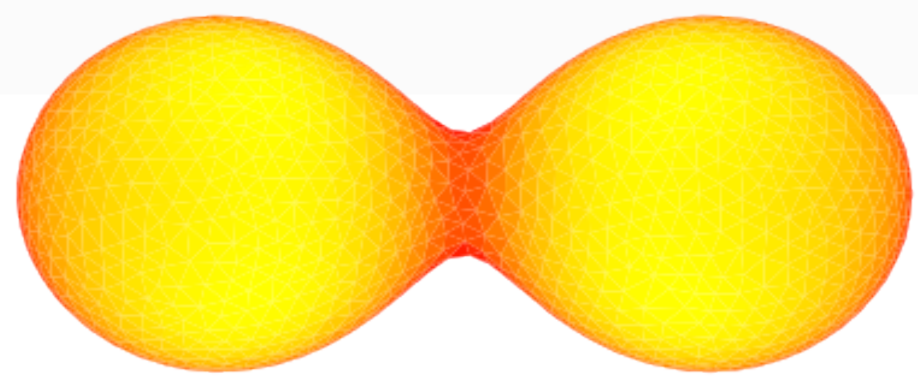
- Detached (Algol-type / EA)



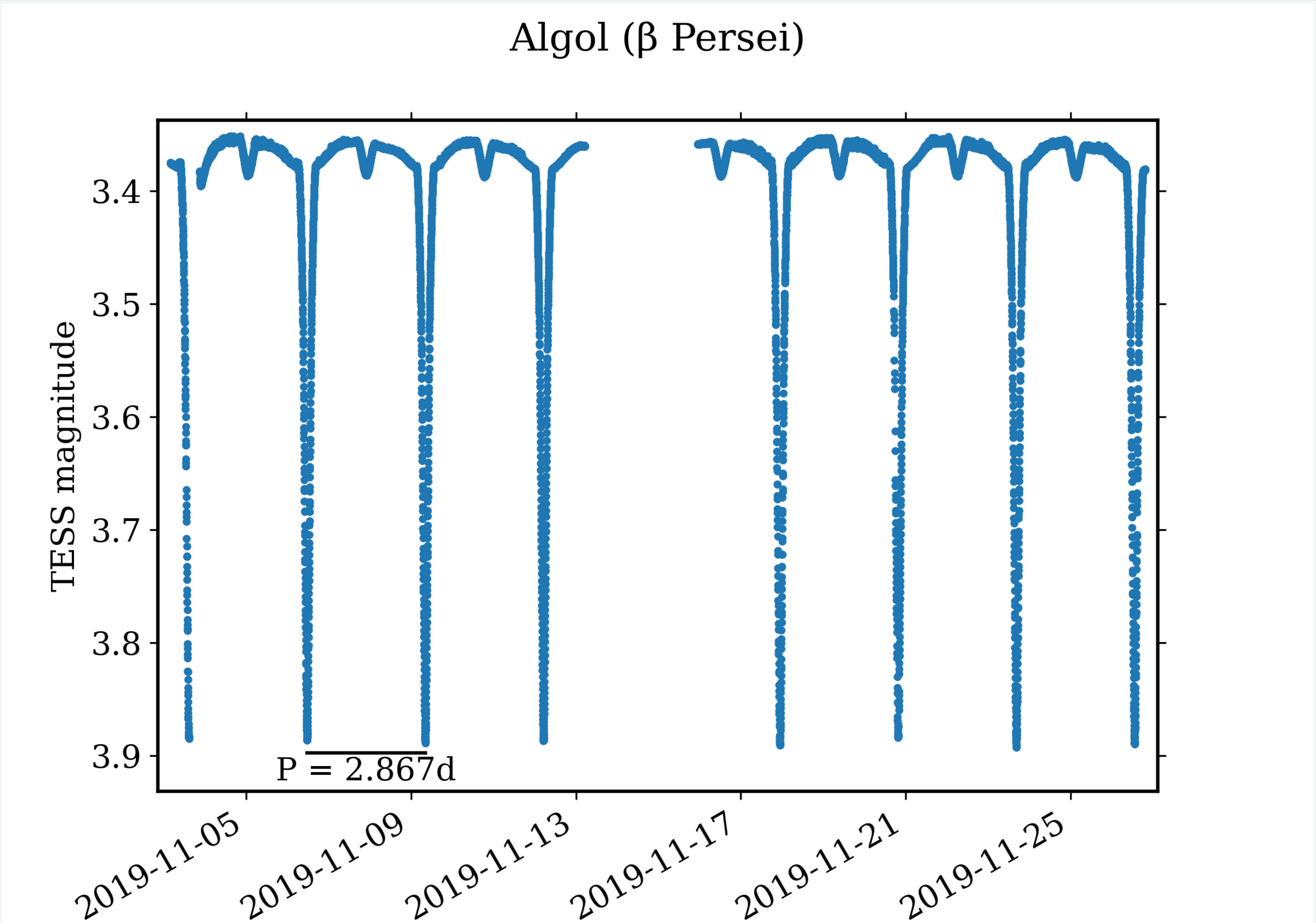
- Semi-detached (β Lyr-type / EB)



- Contact (W UMa-type / EW)



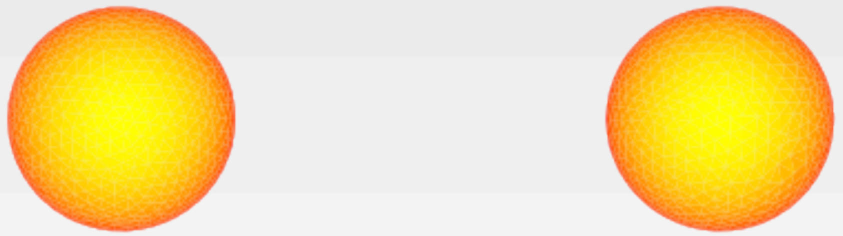
Detached



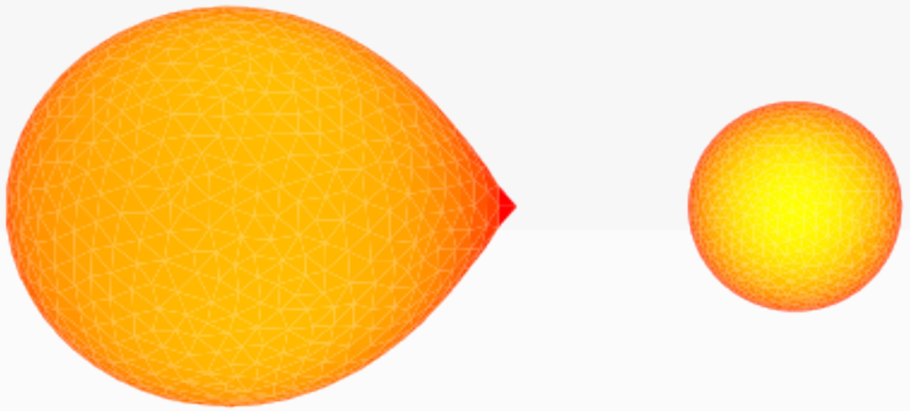
Credit: Warwick Ball

Photometric variables

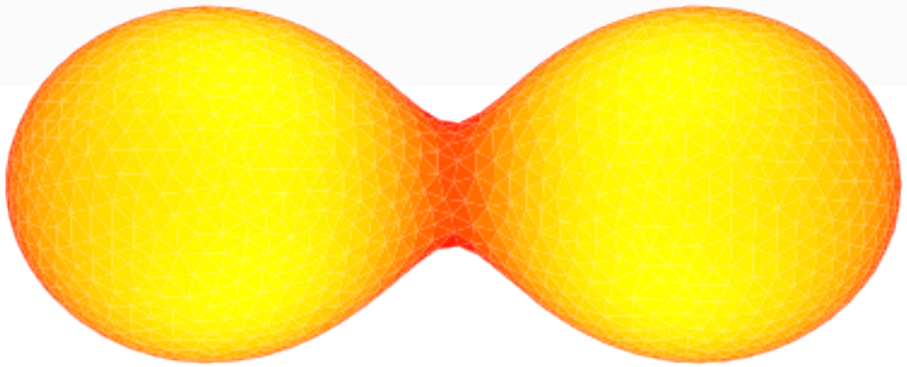
- Detached (Algol-type / EA)



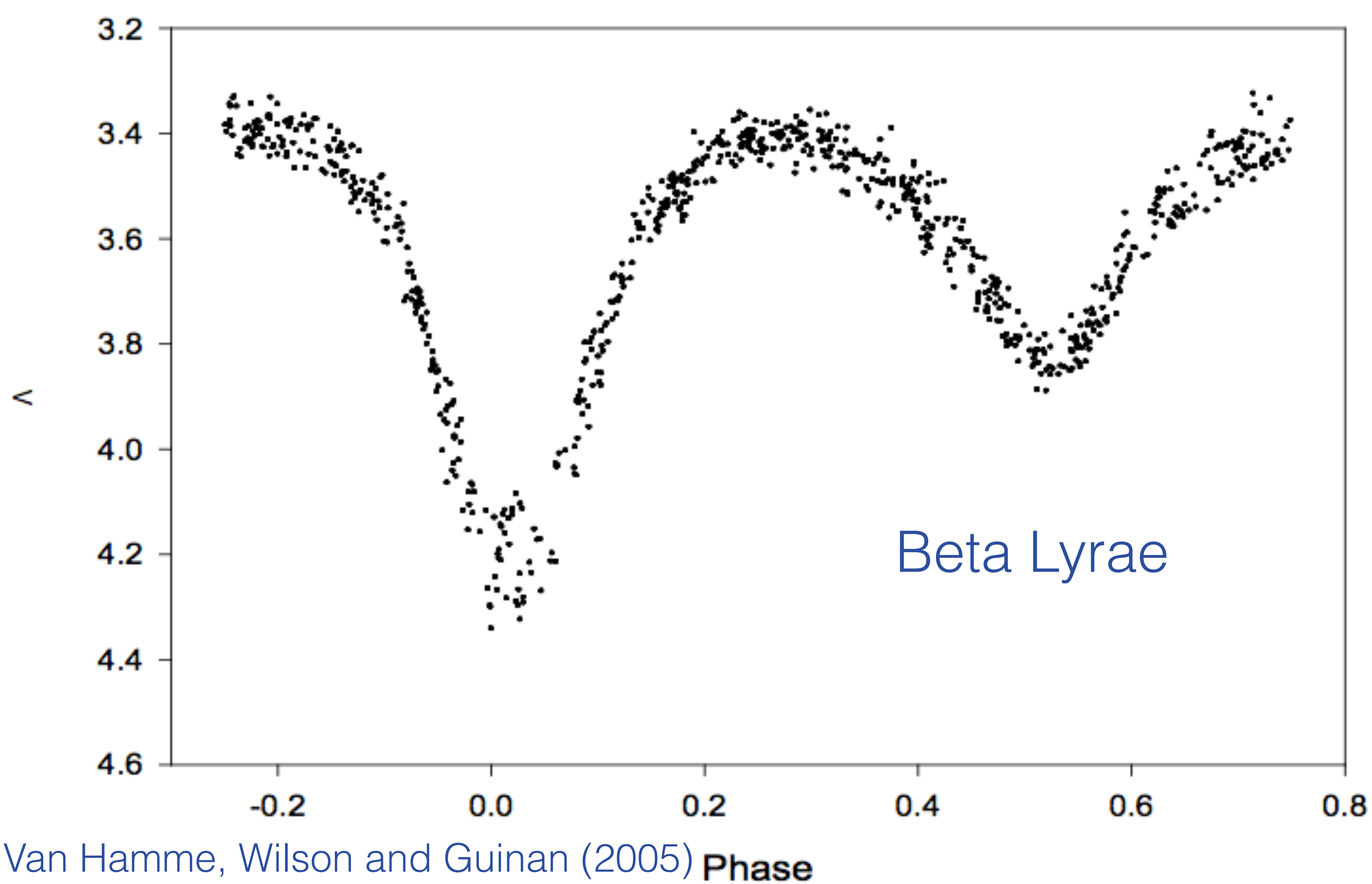
- Semi-detached (β Lyr-type / EB)



- Contact (W UMa-type / EW)



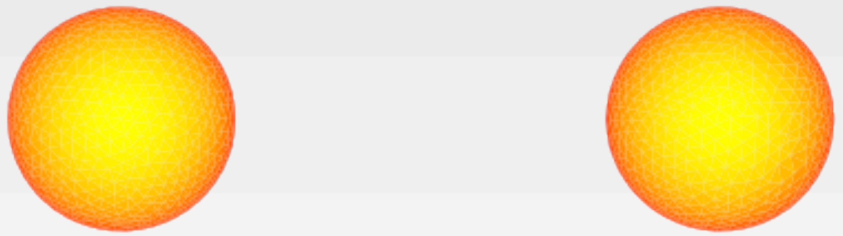
Semi-detached



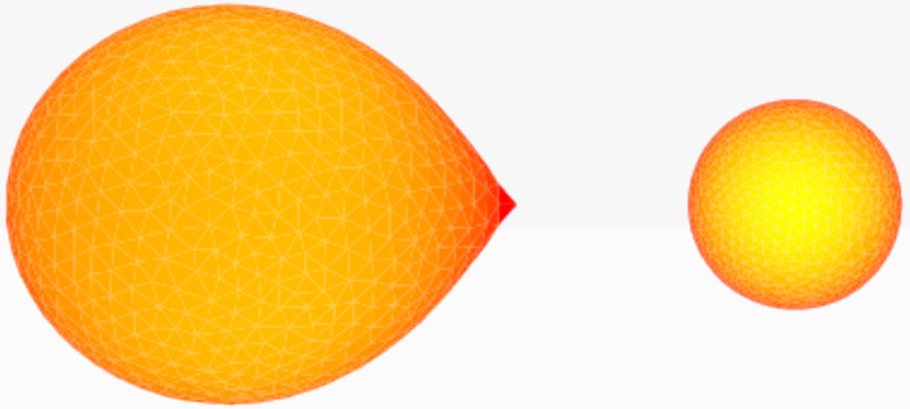
Van Hamme, Wilson and Guinan (2005)

Photometric variables

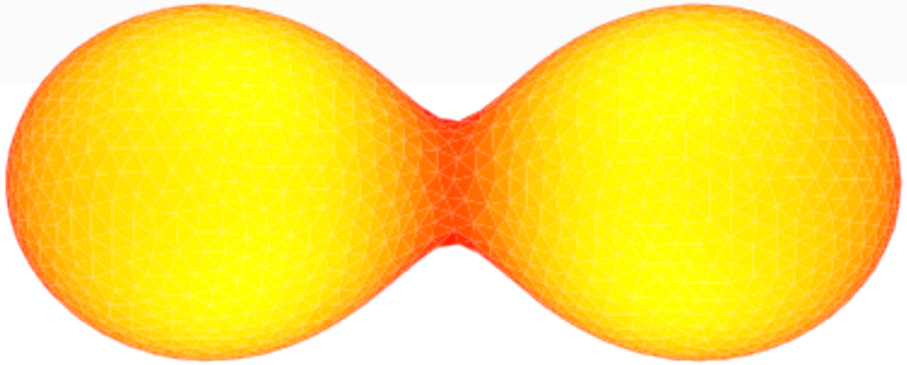
- Detached (Algol-type / EA)



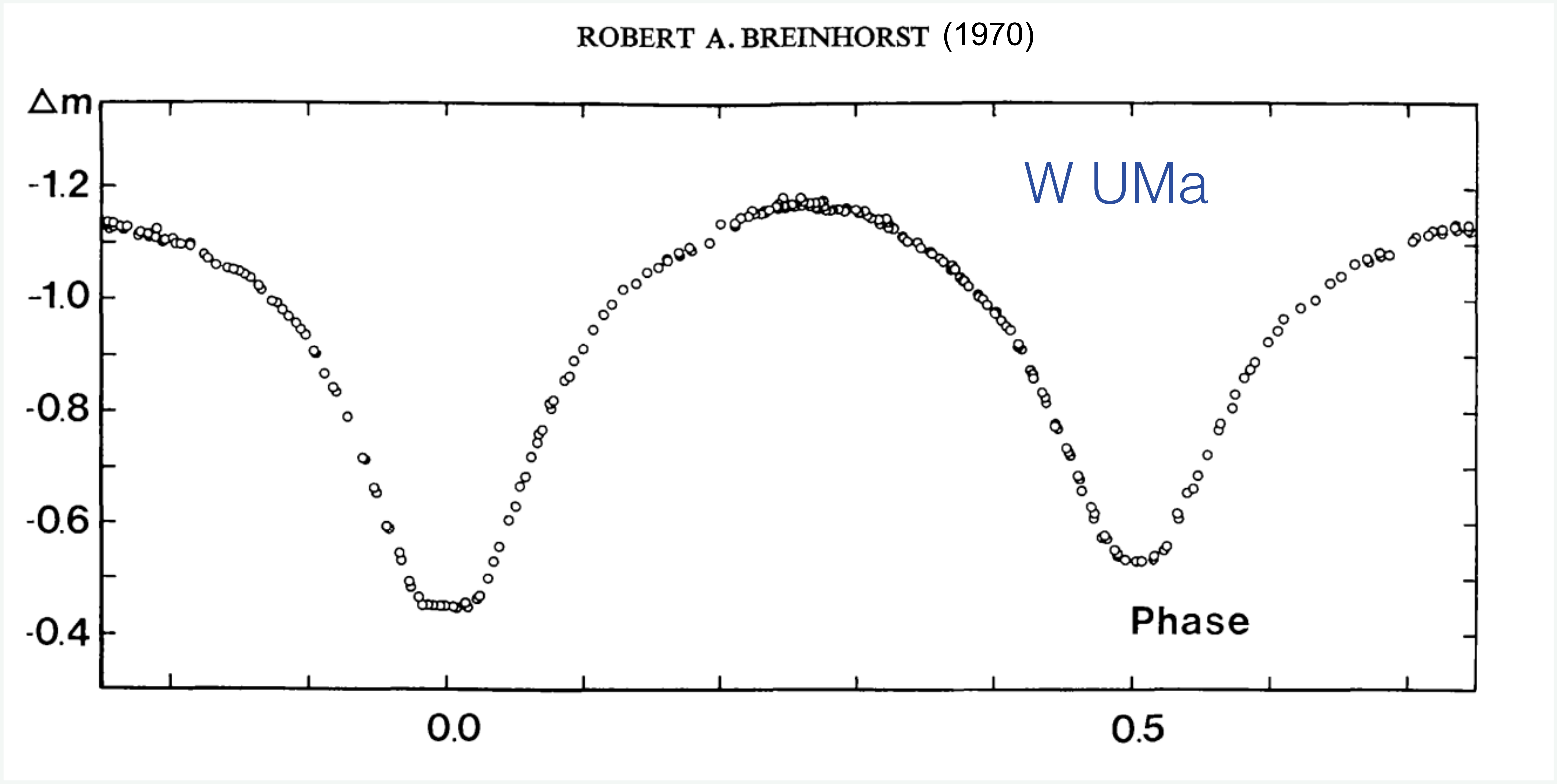
- Semi-detached (β Lyr-type / EB)



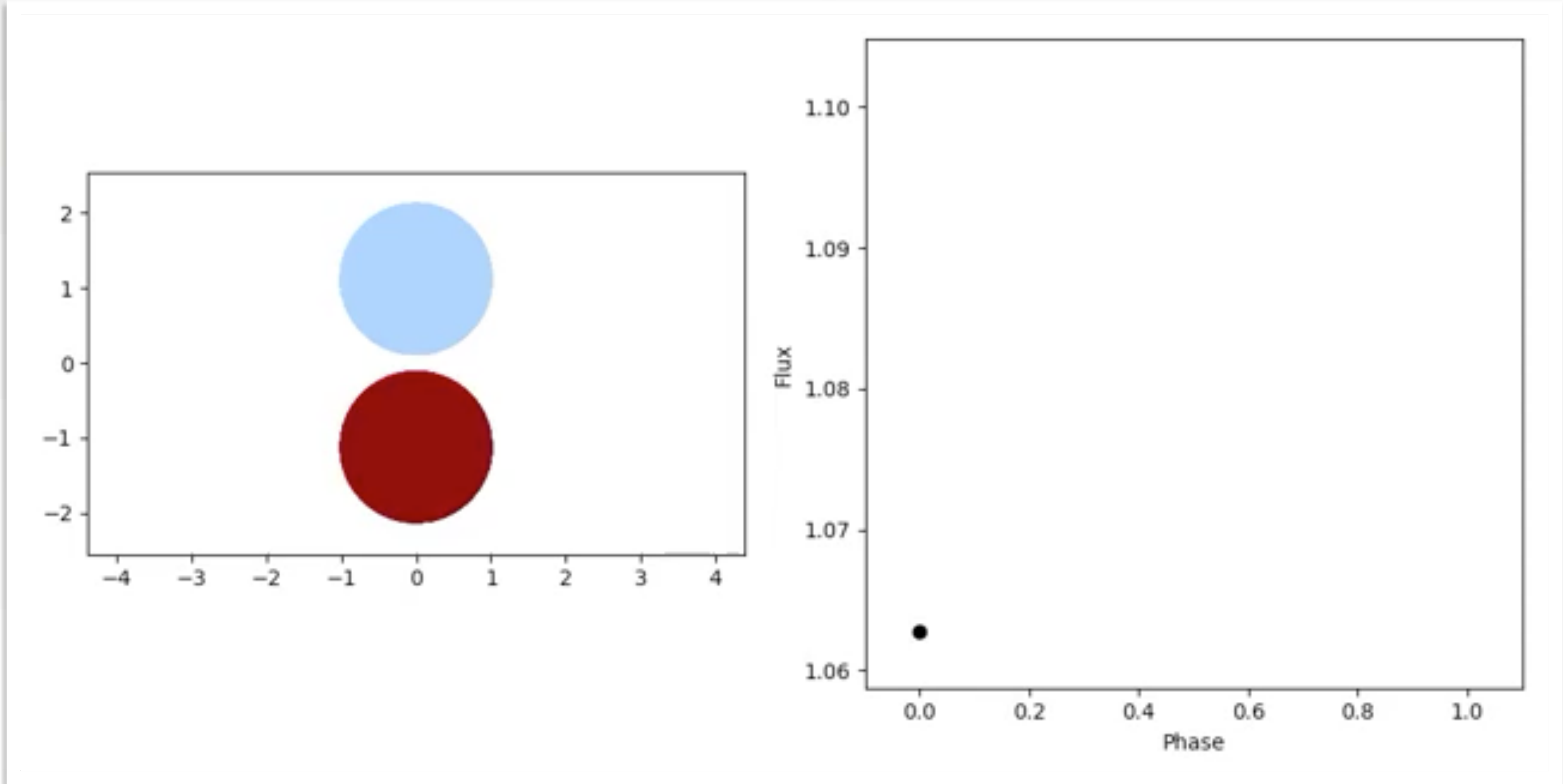
- Contact (W UMa-type / EW)



Contact



Irradiated



2
1
0
−1
−2
−4
−3
−2
−1
0
1
2
3
4
Flux
1.10
1.09
1.08
1.07
1.06
0.0
0.2
0.4
0.6
0.8
1.0
Phase

Parameterisation

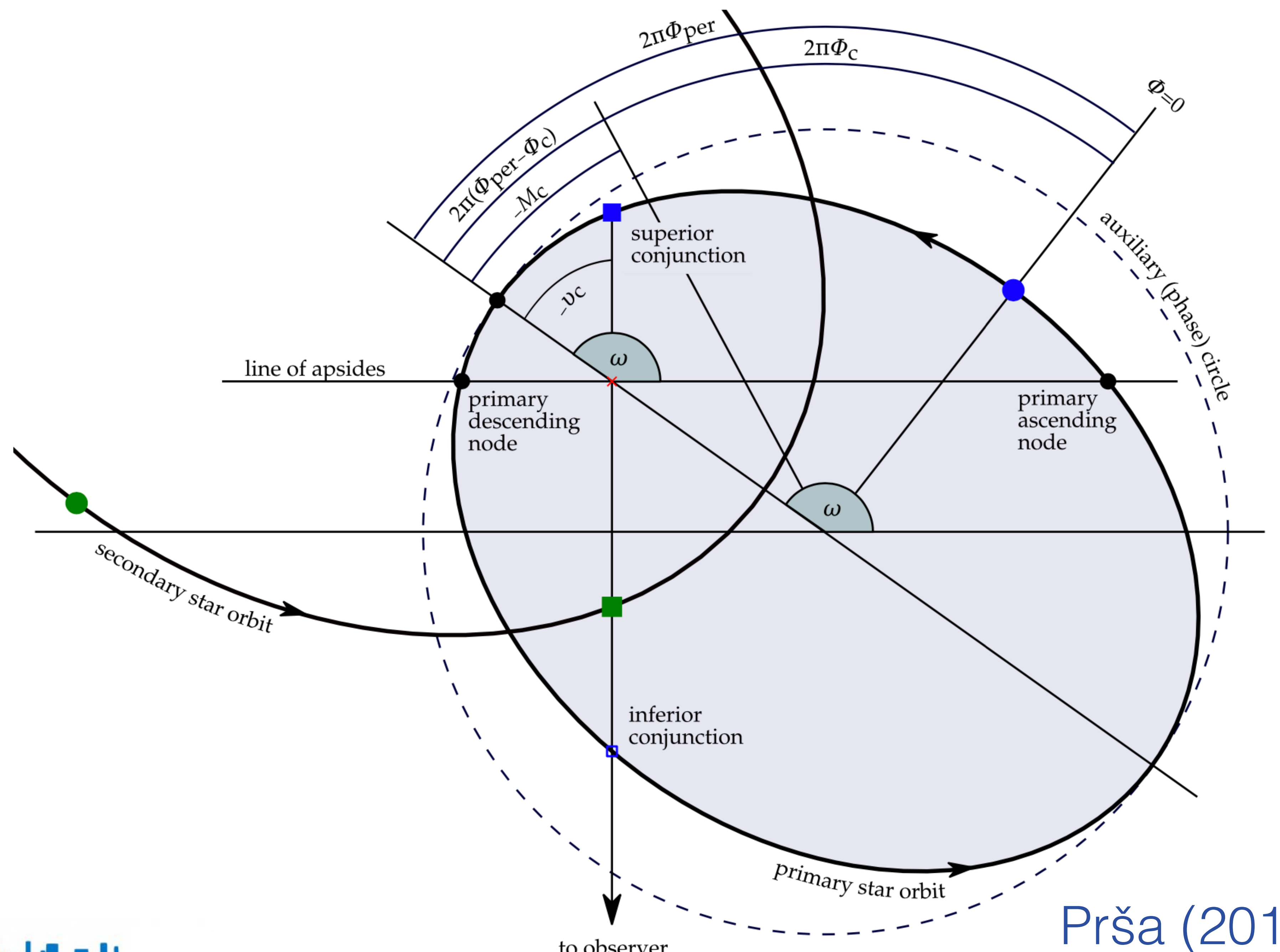
Stellar parameters

- Masses, temperatures, radii

Orbital parameters

- Period (plus time of superior conjunction and dp/dt)
- Eccentricity (and argument of periastron)
- Inclination

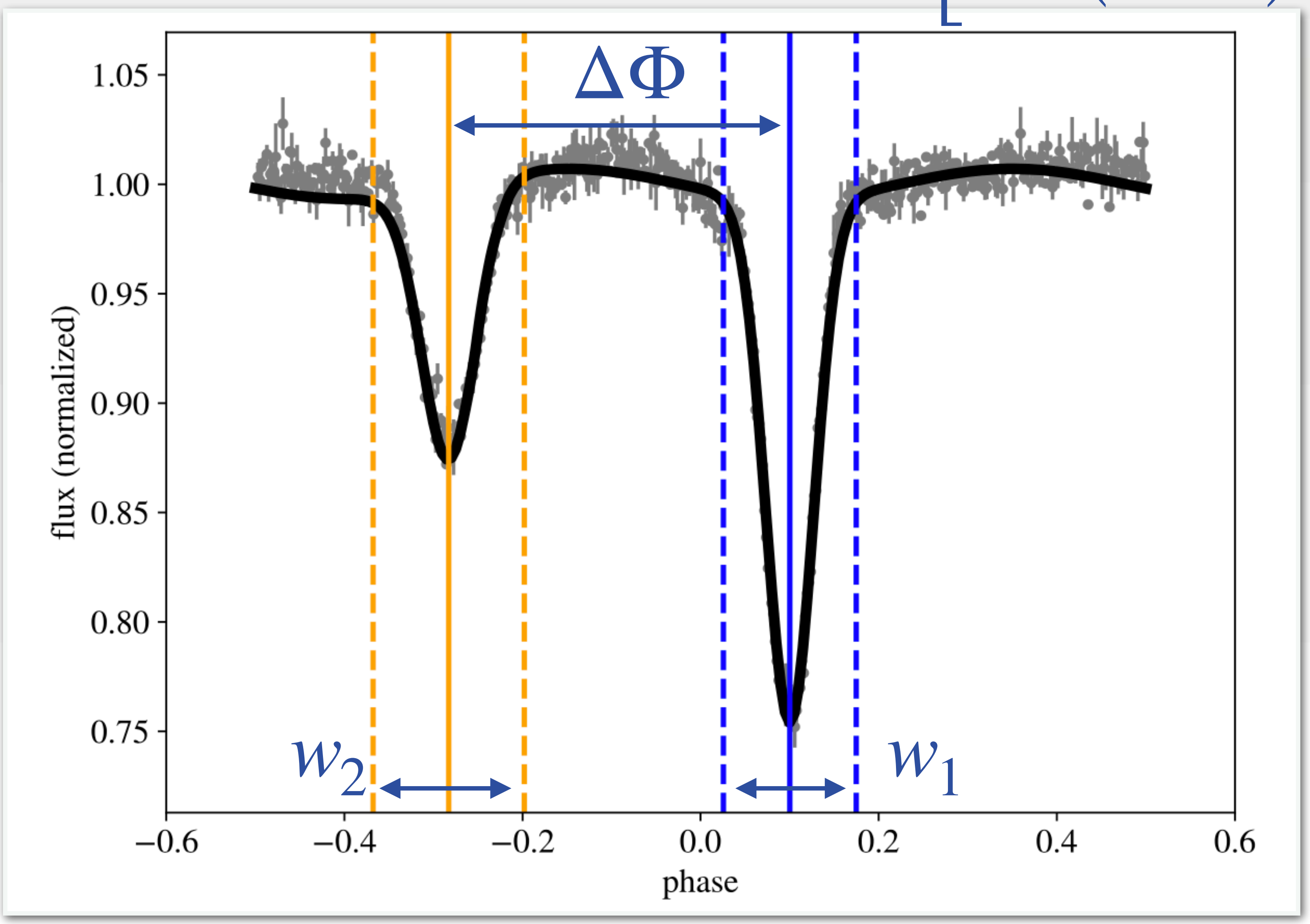
Parameterisation



Prša (2018)

Direct from observations

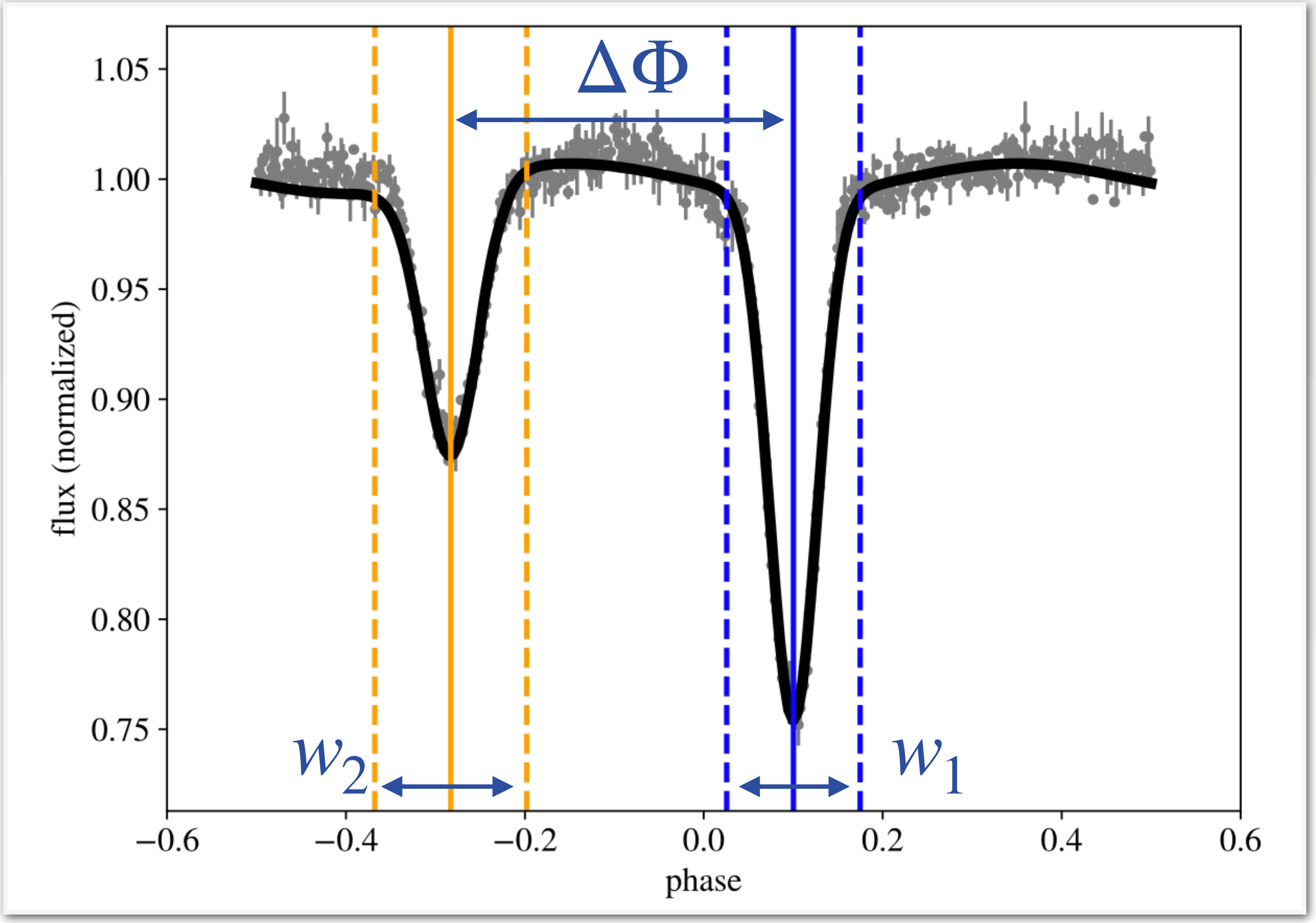
$$e = \left[\sin^2\left(\frac{\psi - \pi}{2}\right) + \left(\frac{w_2 - w_1}{w_2 + w_1}\right)^2 \cos^2\left(\frac{\psi - \pi}{2}\right)\right]^{1/2}$$



$$2\pi\Delta\Phi = \psi - \sin\psi$$

Conroy et al. (2020)

Direct from observations



Conroy et al. (2020)

$$\omega_1 = \arcsin\left(\frac{1}{e}\frac{w_2 - w_1}{w_2 + w_1}\right)$$

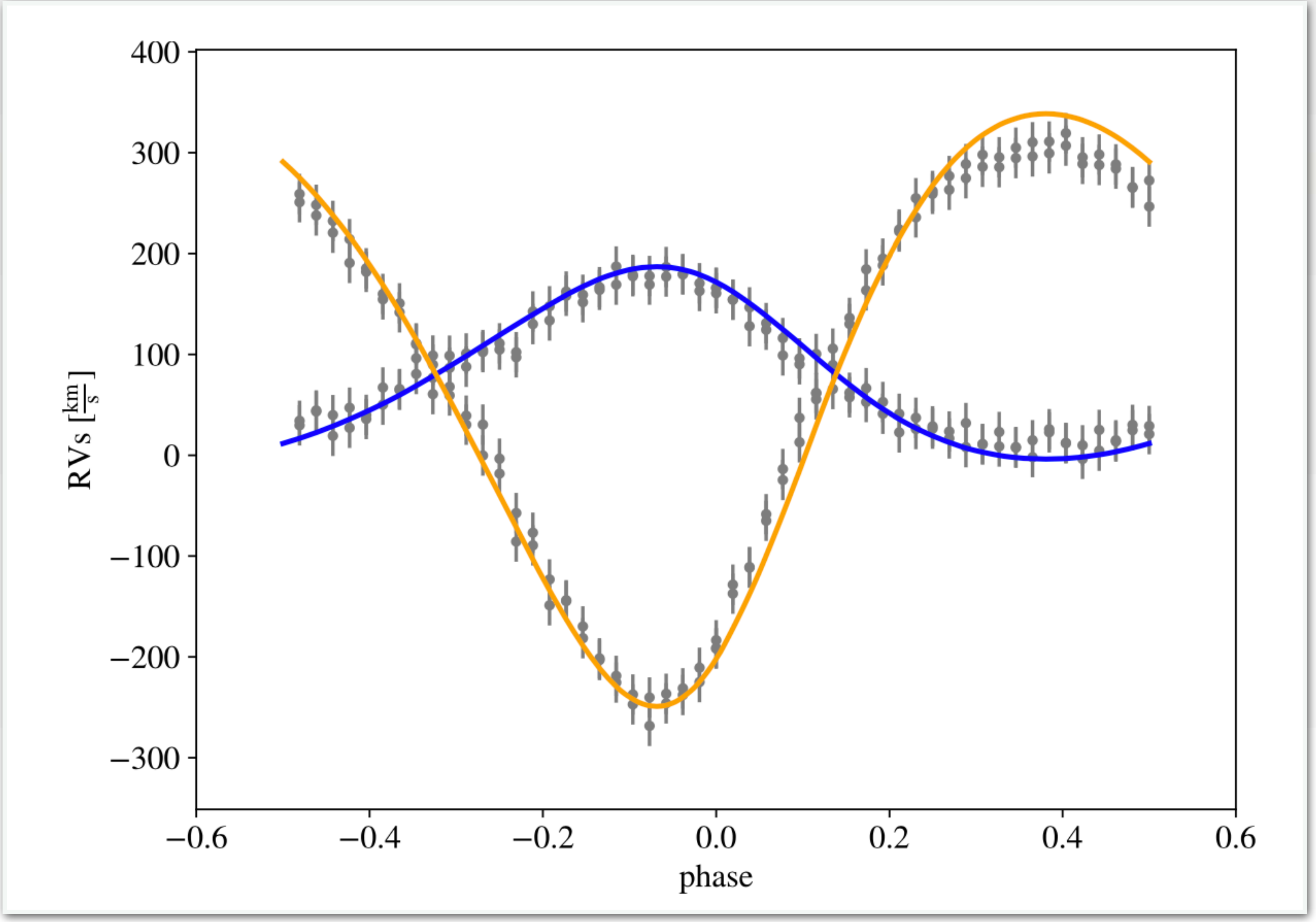
$$\omega_2 = \arccos\left(\frac{\sqrt{1-e^2}}{2e\tan(\psi - \pi)}\right)$$

If $\omega_1 \geq 0,\ \omega = \omega_2$

else if
$\omega_1 < 0,\ \omega = 2\pi - \omega_2$

$$\psi = \pi + 2\arctan\frac{e\cos\omega}{\sqrt{1-e^2}}$$

Direct from observations

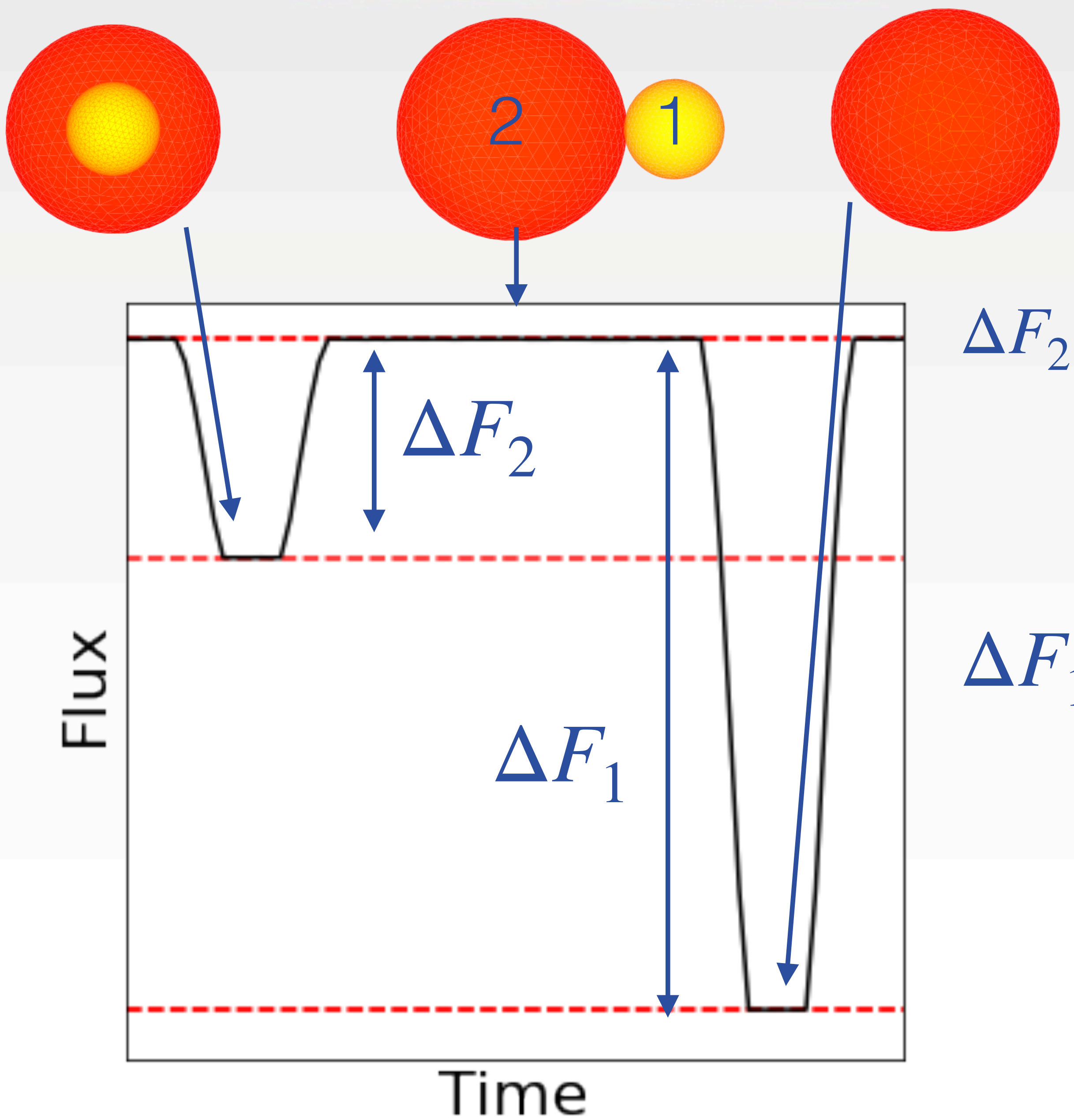


Conroy et al. (2020)

$$v_\gamma = \frac{\mathrm{RV}_1(\theta) + q\ \mathrm{RV}_2(\theta)}{1+q}$$

$$q = \frac{\mathrm{RV}_1(\theta) - v_\gamma}{-\mathrm{RV}_2(\theta) + v_\gamma}$$

Rough temperatures



For blackbodies:

$$F \propto R^2 T^4$$

$$\Delta F_2 = R_1^2 T_1^4 \; + \; R_2^2 T_2^4 \; - \; [(R_2^2 - R_1^2) T_2^4 \; + \; R_1^2 T_1^4]$$

$$\Delta F_2 = R_1^2 T_2^4$$

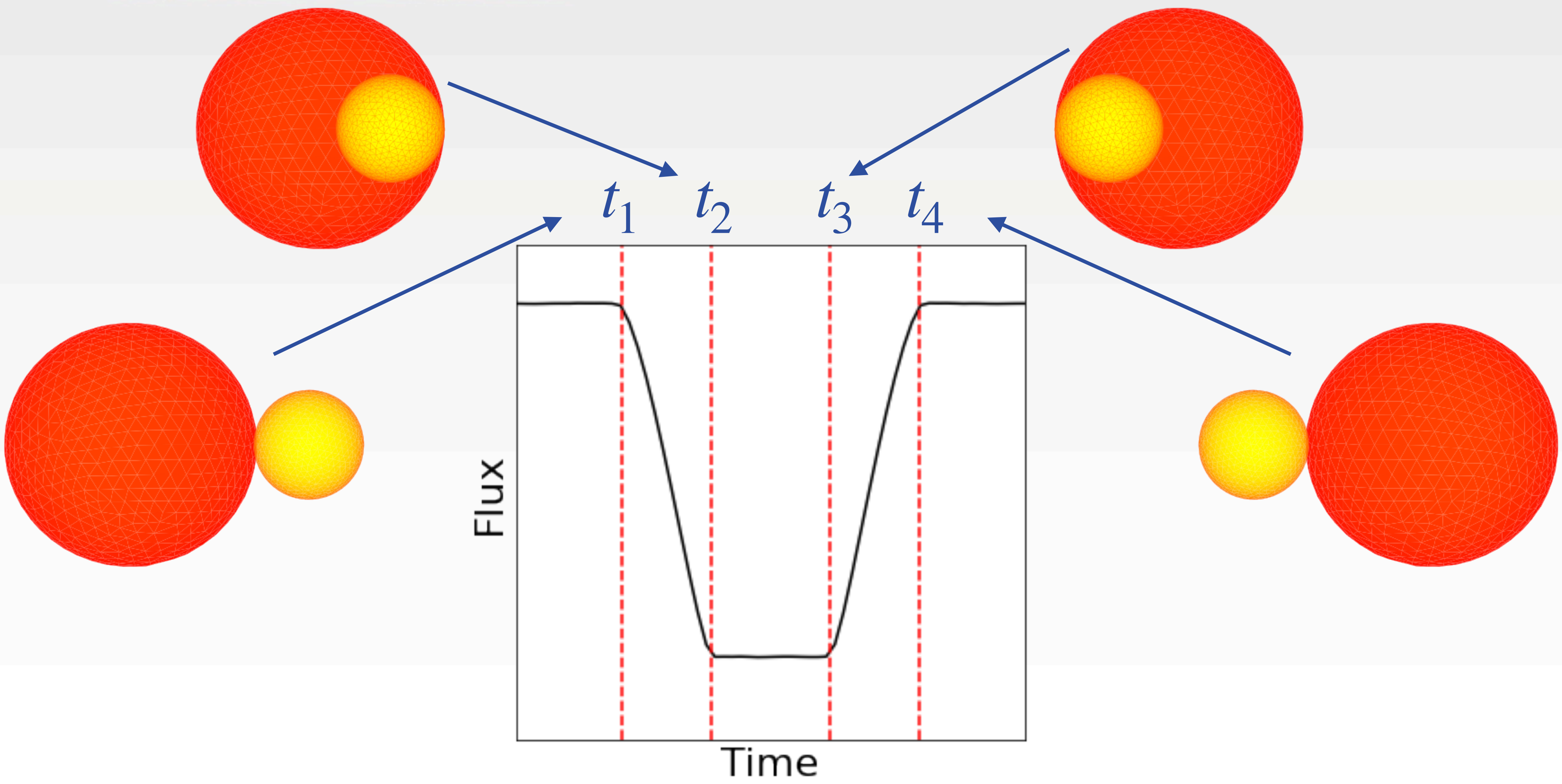
$$\Delta F_1 = R_1^2 T_1^4 \; + \; R_2^2 T_2^4 \; - \; R_2^2 T_2^4$$

$$\Delta F_1 = R_1^2 T_1^4$$

$$\frac{\Delta F_1}{\Delta F_2} = \left(\frac{T_1}{T_2} \right)^4$$

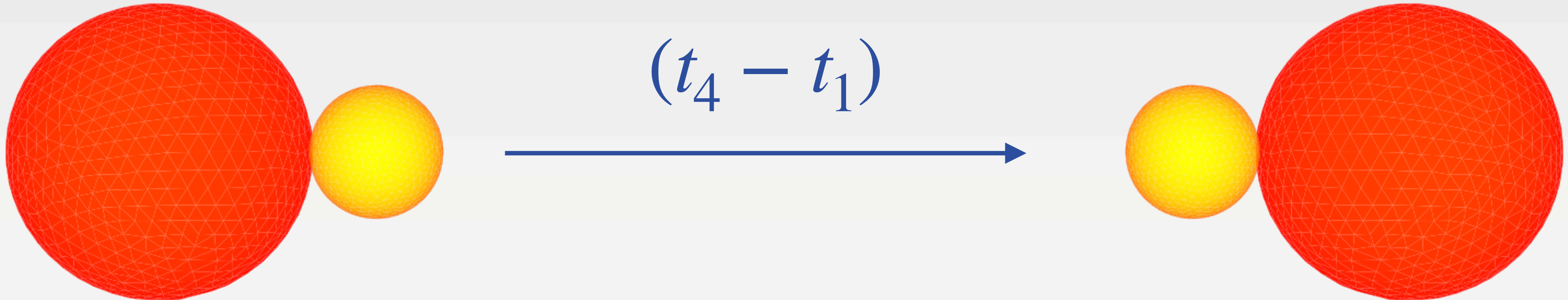
Assumes blackbodies, bolometric observations and total eclipses

Rough radii

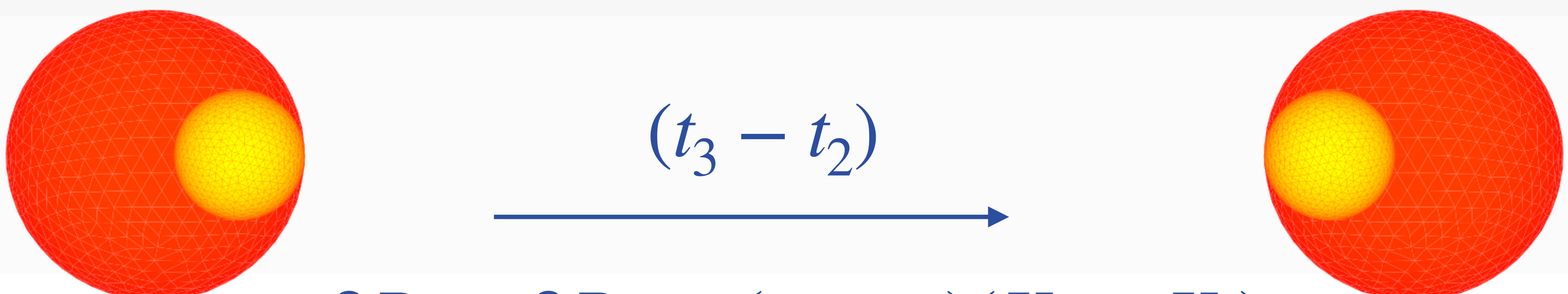


Rough radii

Assumes e=0 and i=90°



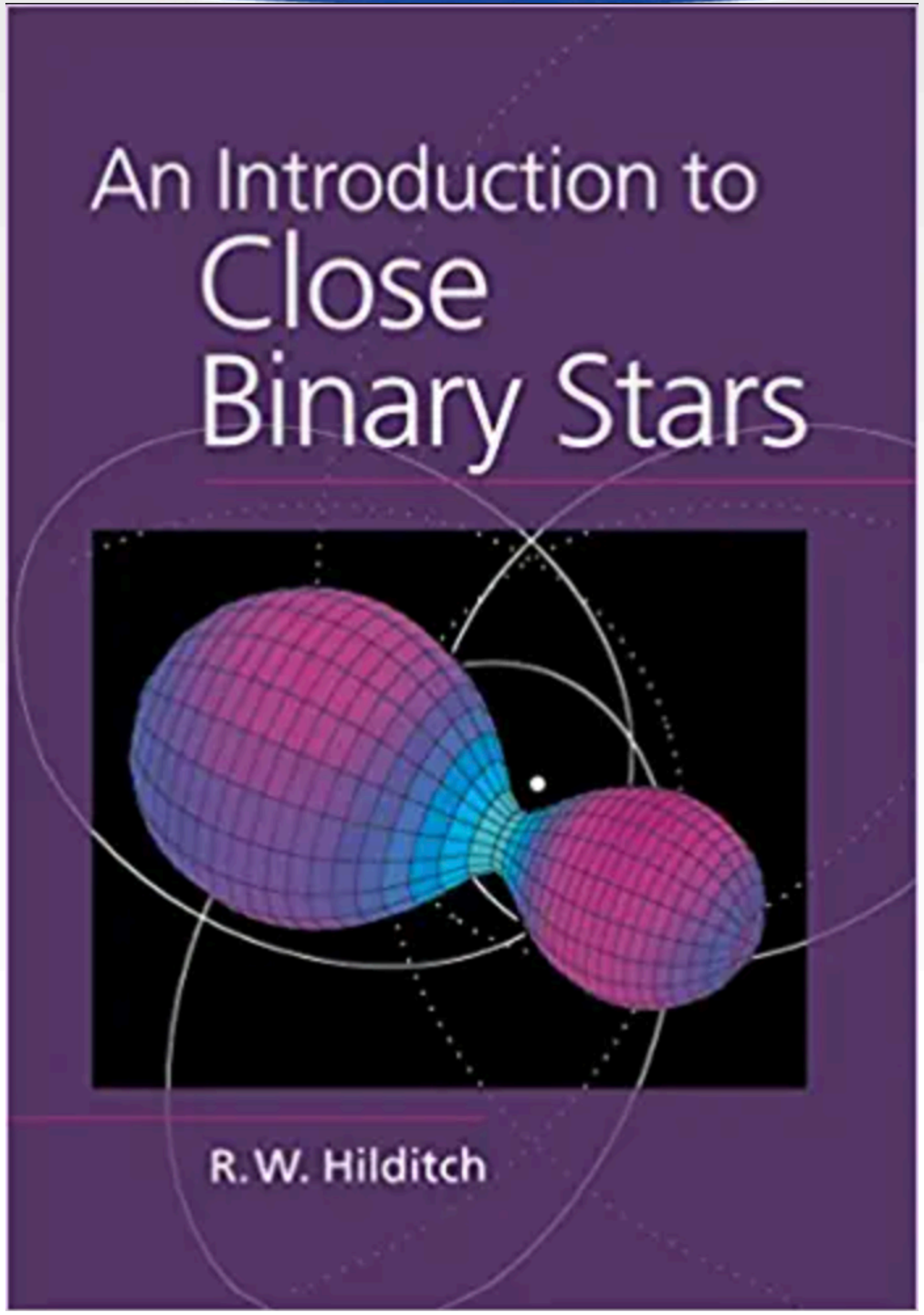
$$2R_1 + 2R_2 = (t_4 - t_1)(K_1 + K_2)$$

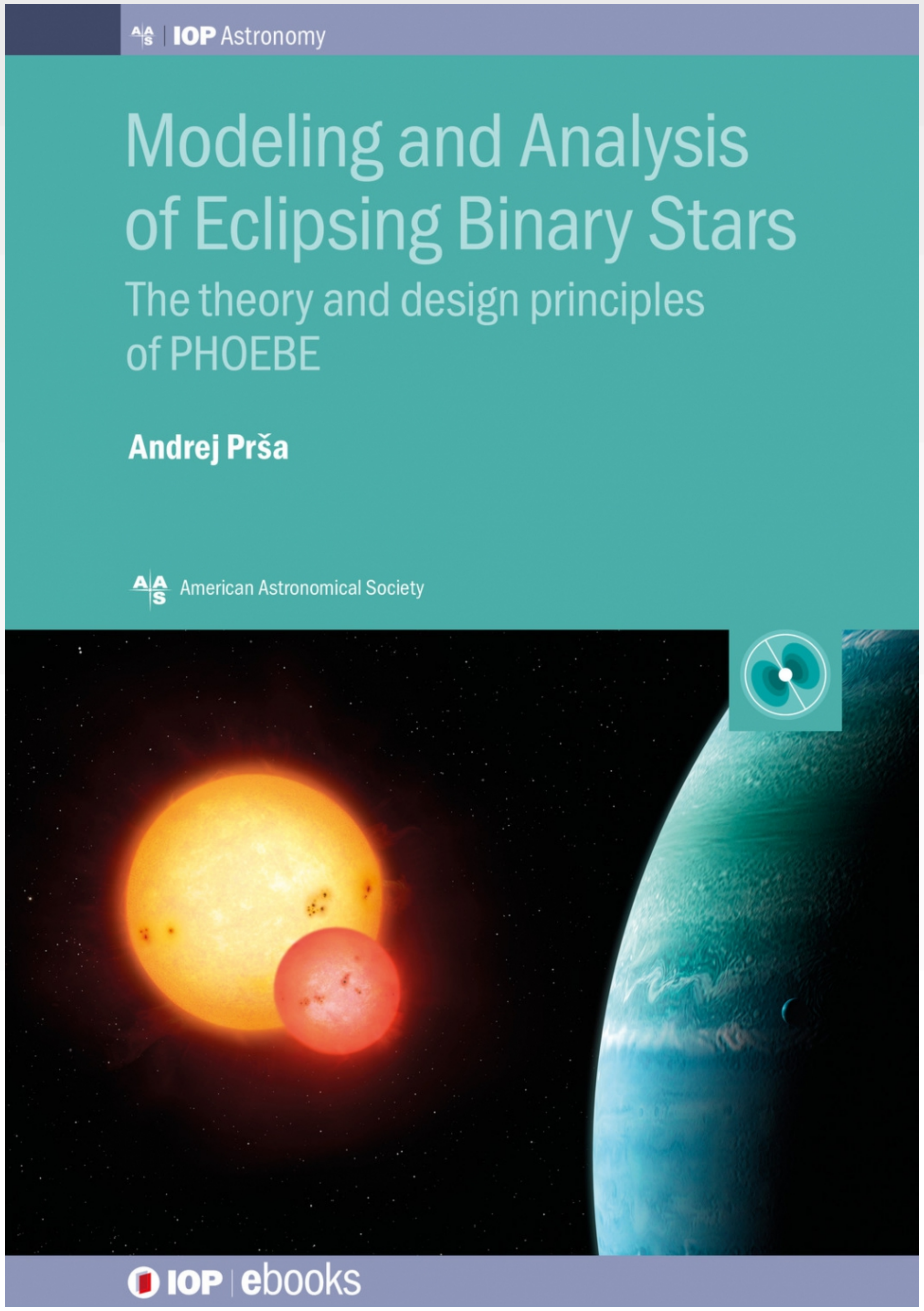


$$2R_2 - 2R_1 = (t_3 - t_2)(K_1 + K_2)$$

Add or subtract and solve for the radius!

Further reading...





Simulating a binary

- Geometric model and choice of meshing
  - Informed by orbital and stellar parameters

- Emergent flux
  - Model atmosphere
  - Limb-darkening
  - Gravity brightening

- Integrate exposed mesh elements at chosen times/phases