EG And: Hα orbital variations from optical spectroscopy

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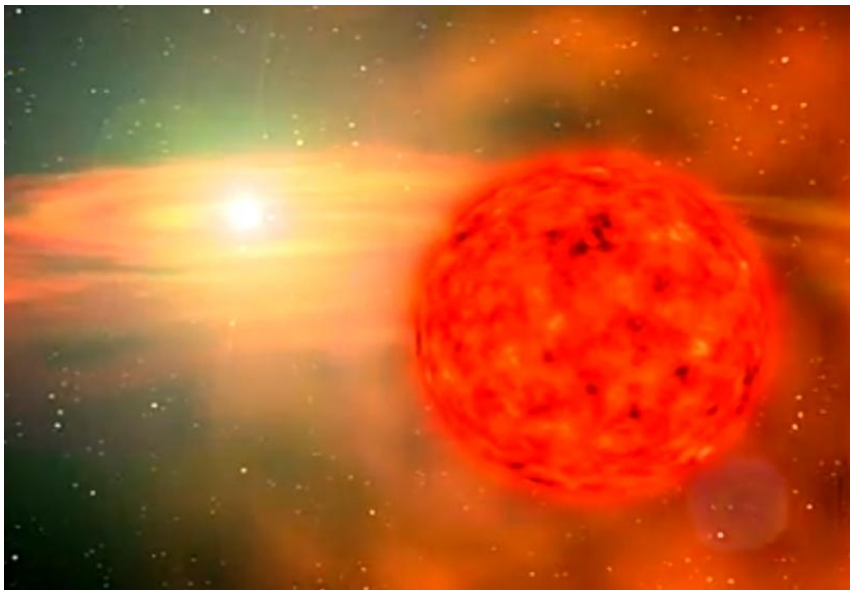
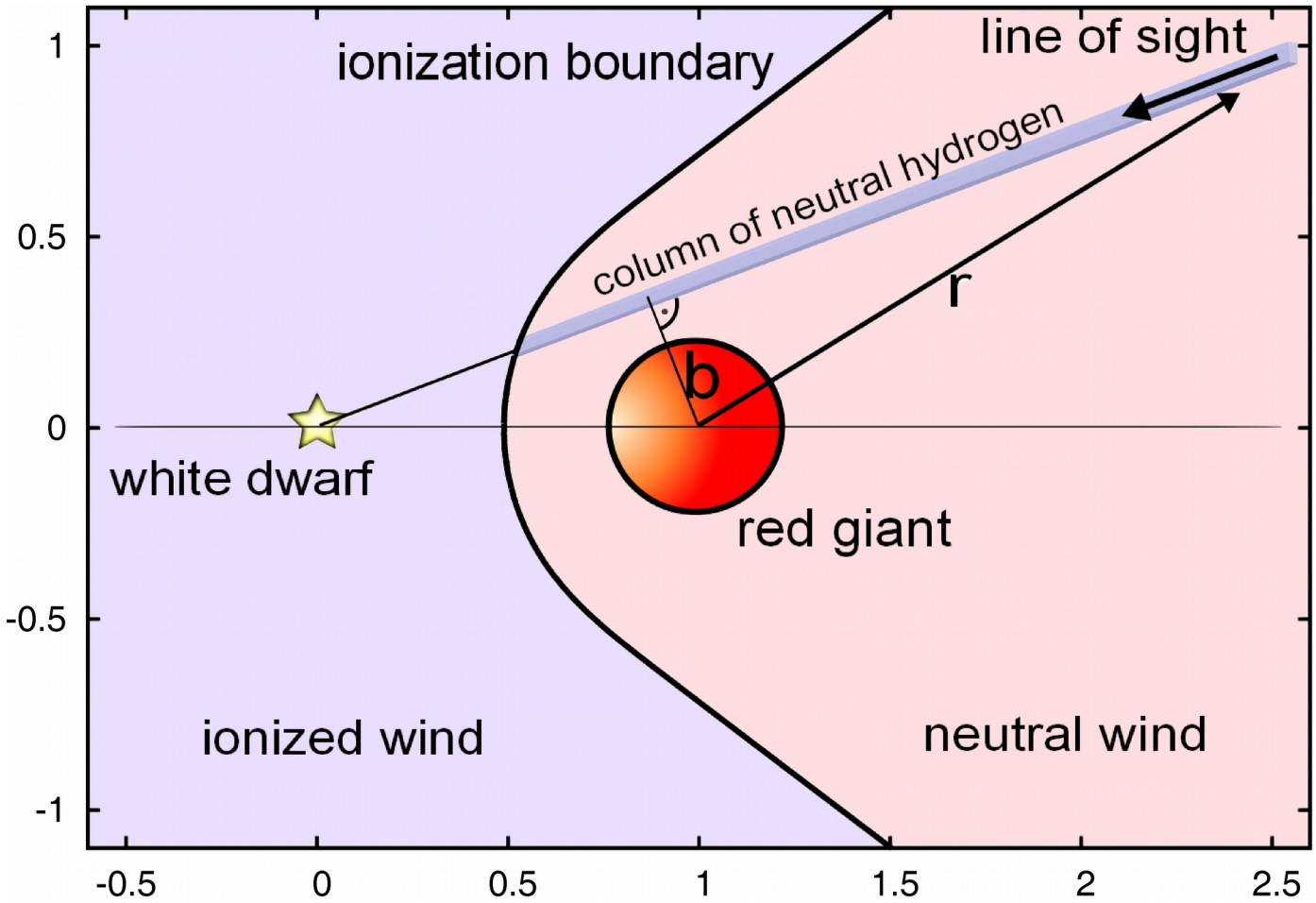
Overview

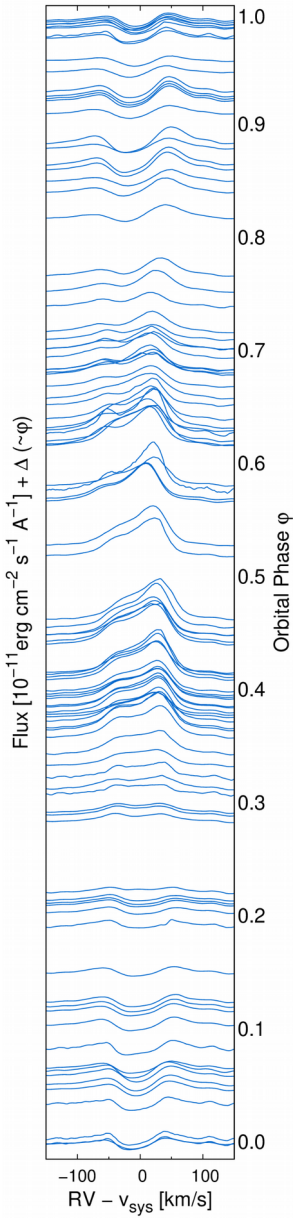
EG And



- quiet symbiotic star
  (no recorded outburst)
- white dwarf (WD) + red giant (RG)
- P = 483 days, i ≈ 80°
- mass transfer via stellar wind
- accretion of the RG wind by WD → $L_{WD} \sim 10 L_{Sun}$

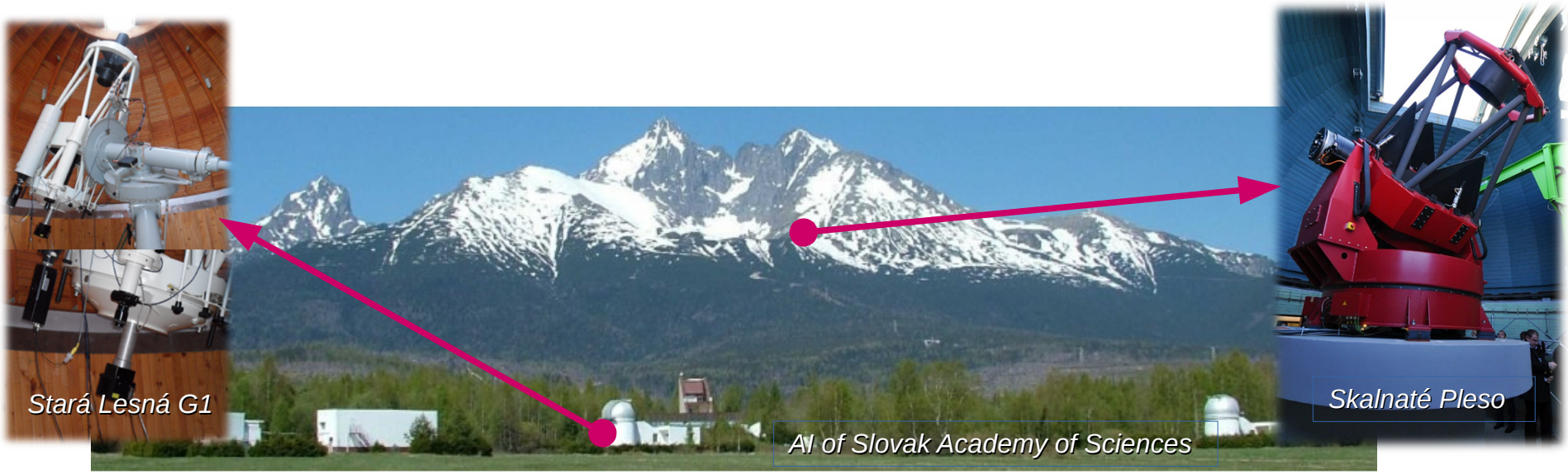
Orbital variability of the Hα line





Observations

- 102 optical spectra from years 2015 -2018, λ = 420 – 720 nm



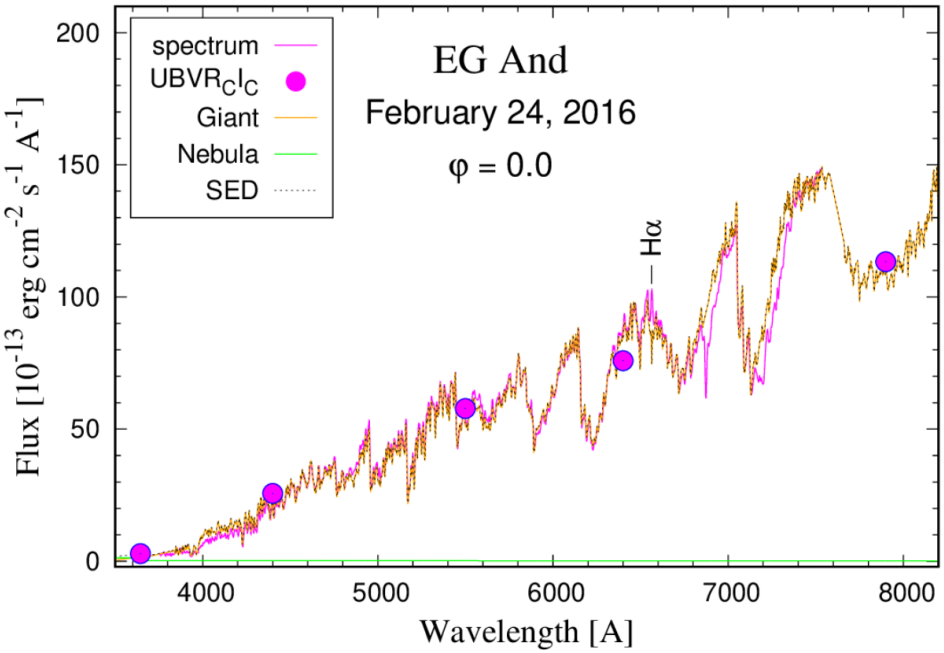
- 0.6m telescope at Stará Lesná (G1), R = 11000

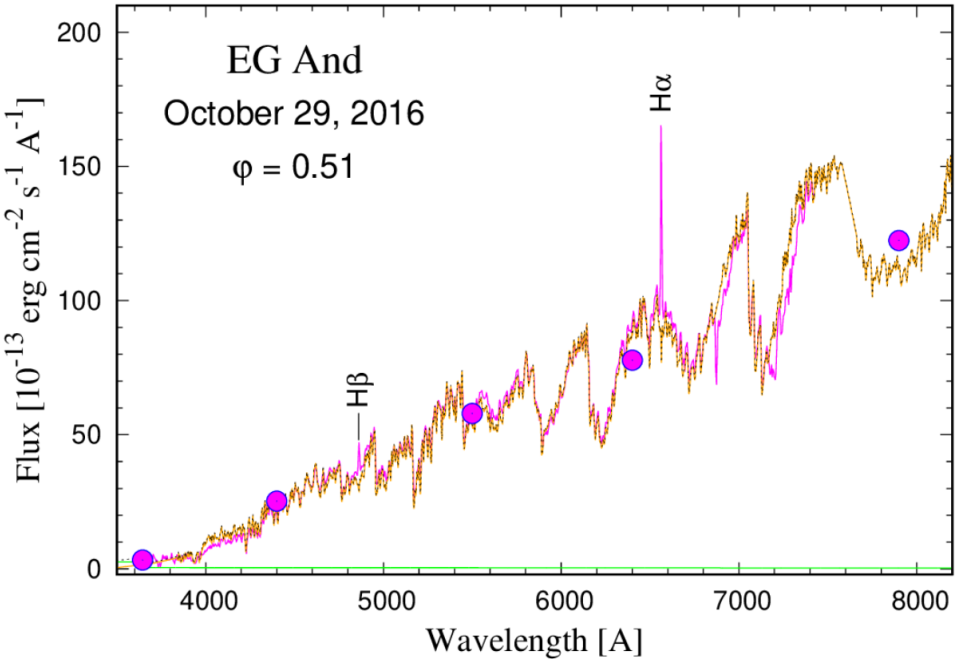
- 1.3m telescope at Skalnaté Pleso, R = 38000

- ARAS database (0.31 – 0.36 telescopes), R = 11000

Astronomical Ring for Access to Spectroscopy
ARAS

Continuum level around the Hα line



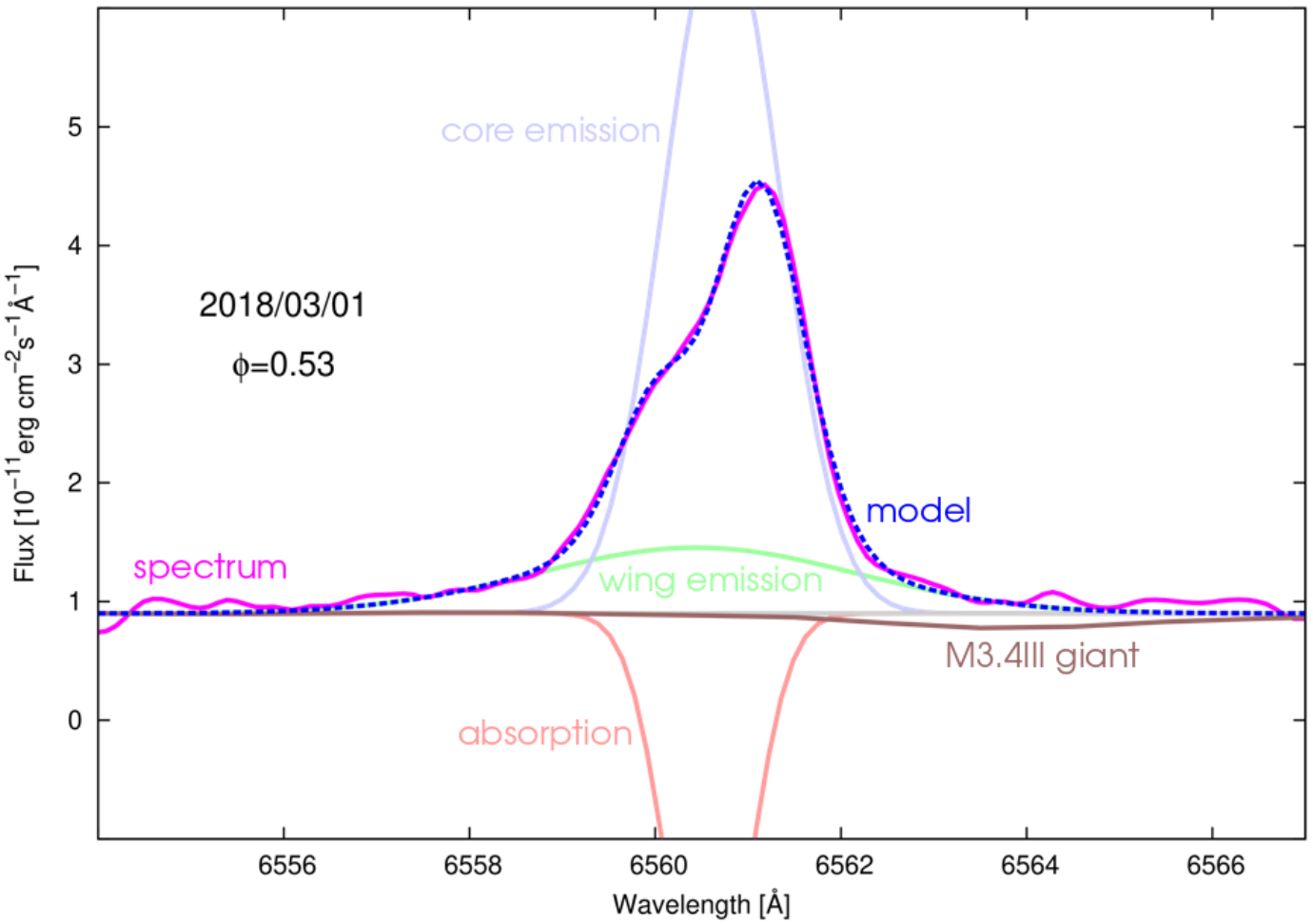


- scaling to photometric fluxes using:

photometry from Skalnaté Pleso

synthetic spectrum of M3.4III giant (Fluks et al. 1994)

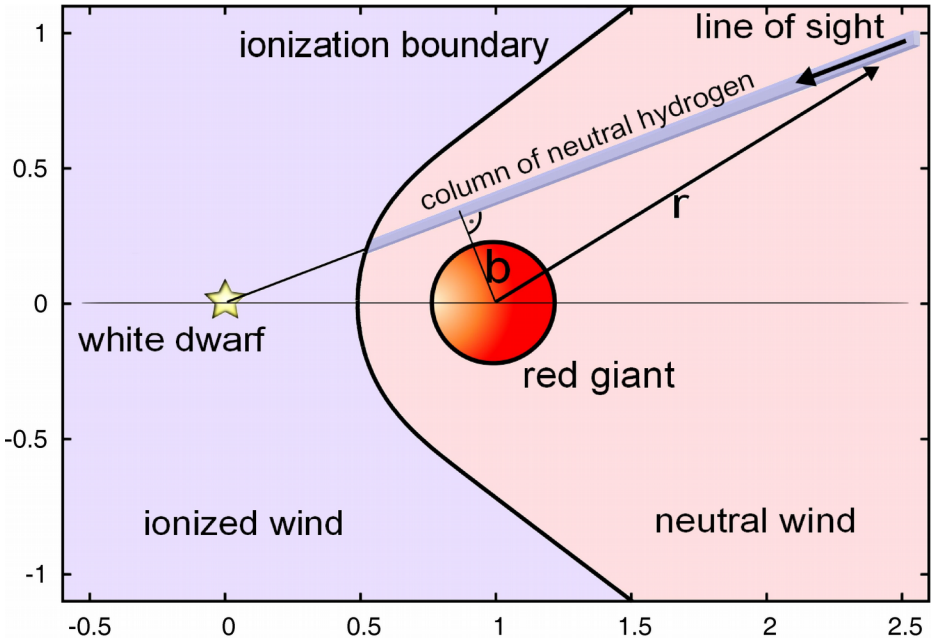
Components of the Hα line

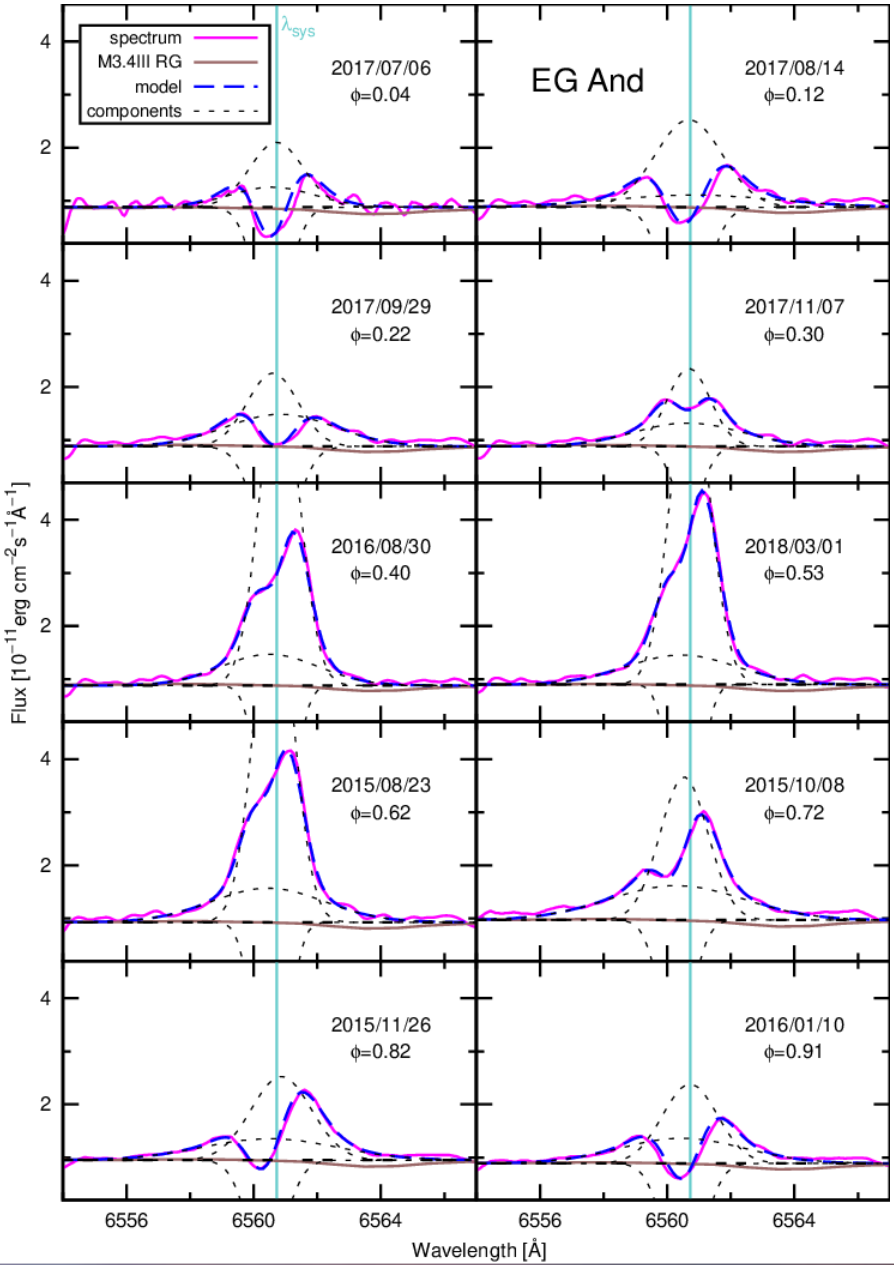


Models

- Fityk software

- average $\chi^2_{red} = 0.004$

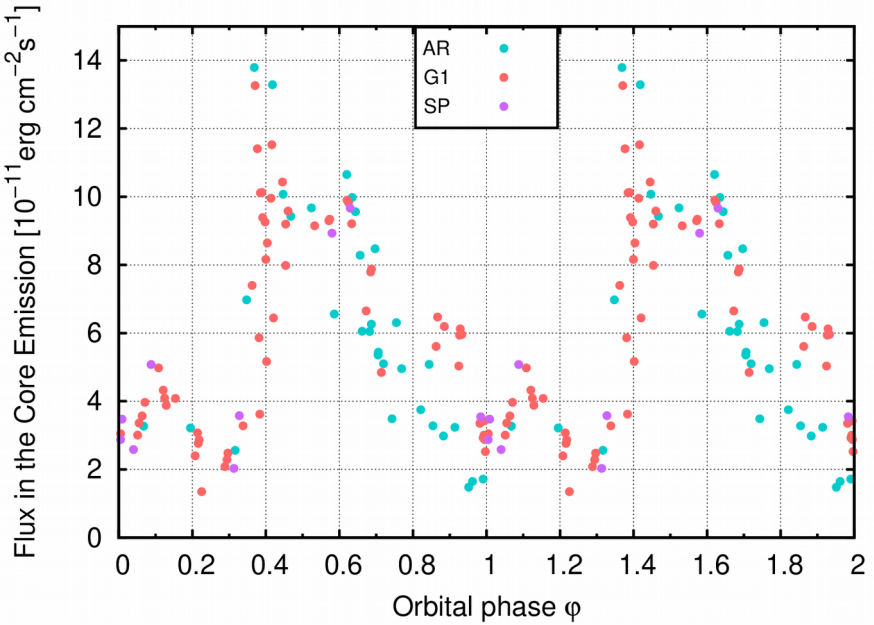


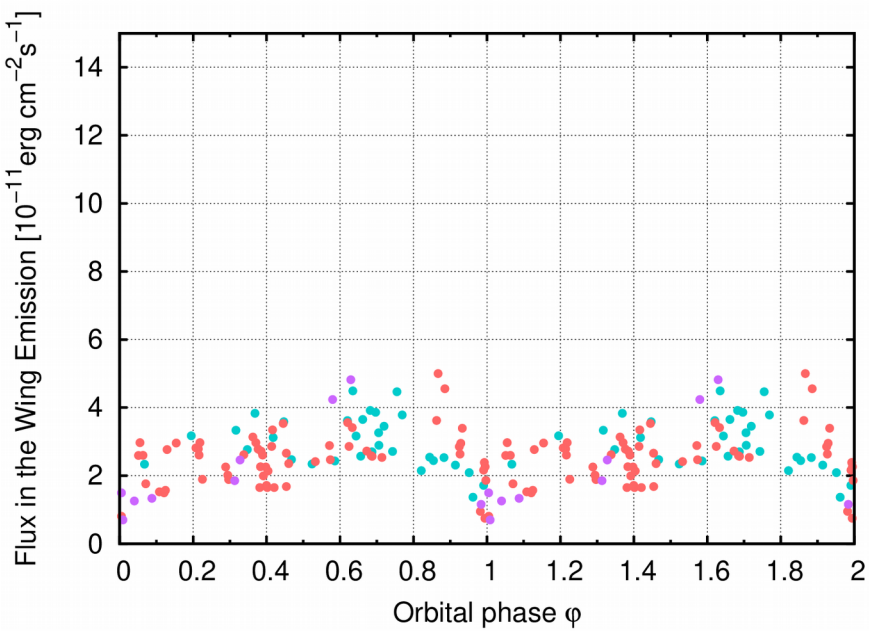


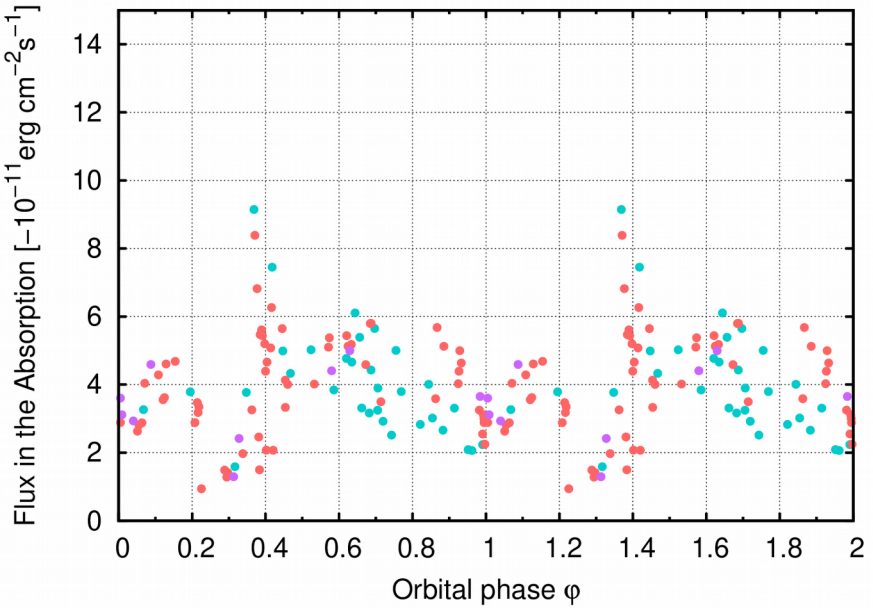
Fluxes in the Hα-line components

- **core emission** and **absorption** fluxes:
  minima at φ = 0.2 and maxima at φ = 0.4

  ---> **asymmetry** of the circumstellar matter distribution



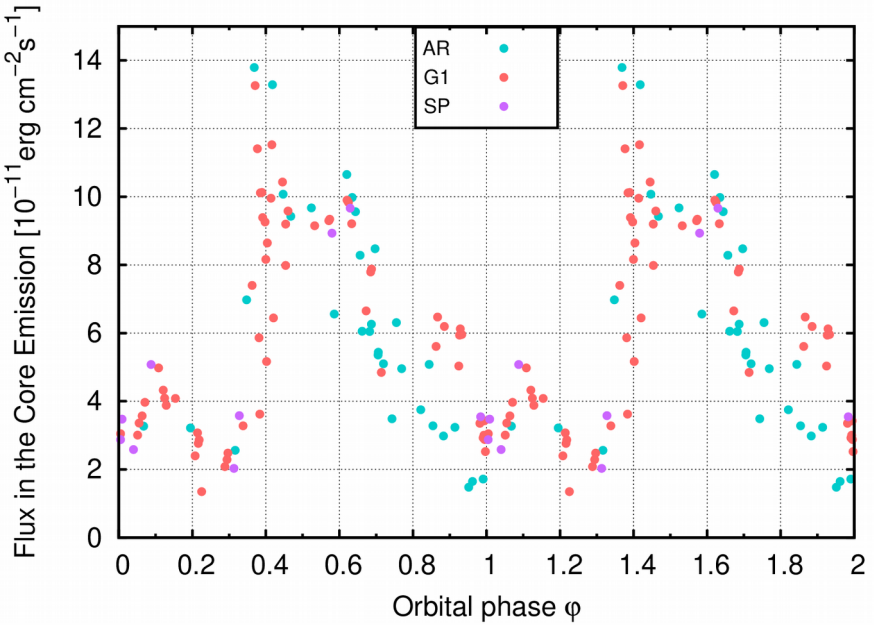


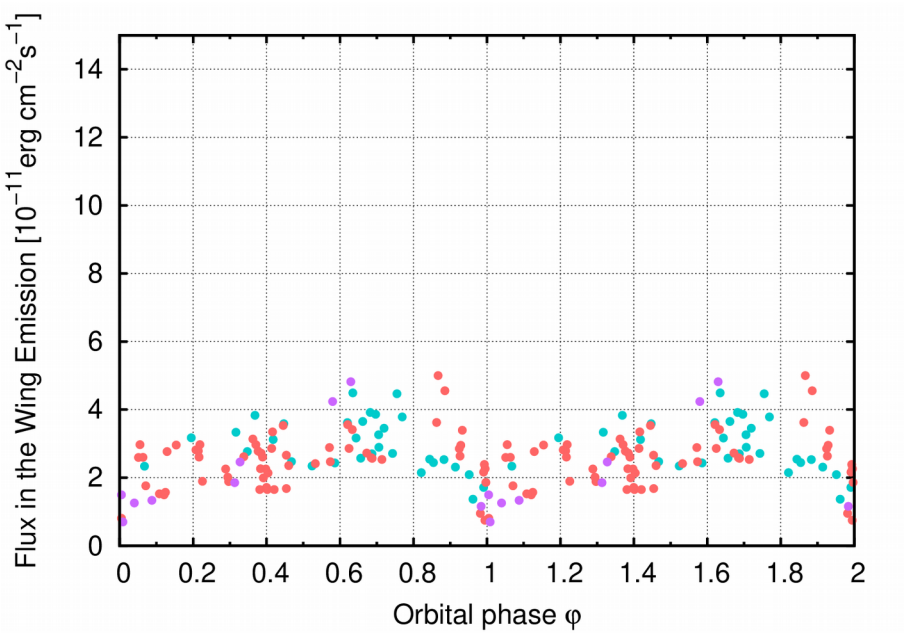


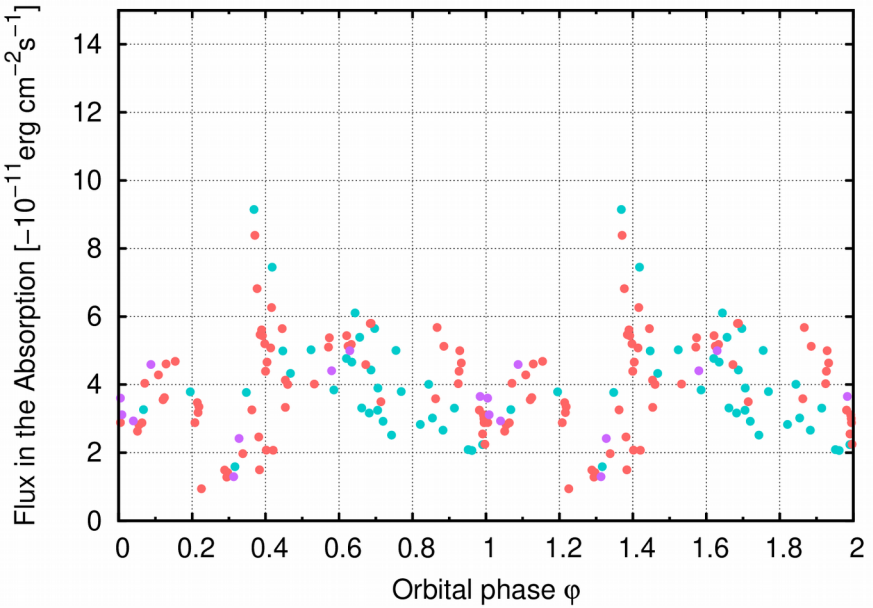
Fluxes in the Hα-line components

- residual **emission** at around φ = 0

--> **nebula is larger in size than red giant**



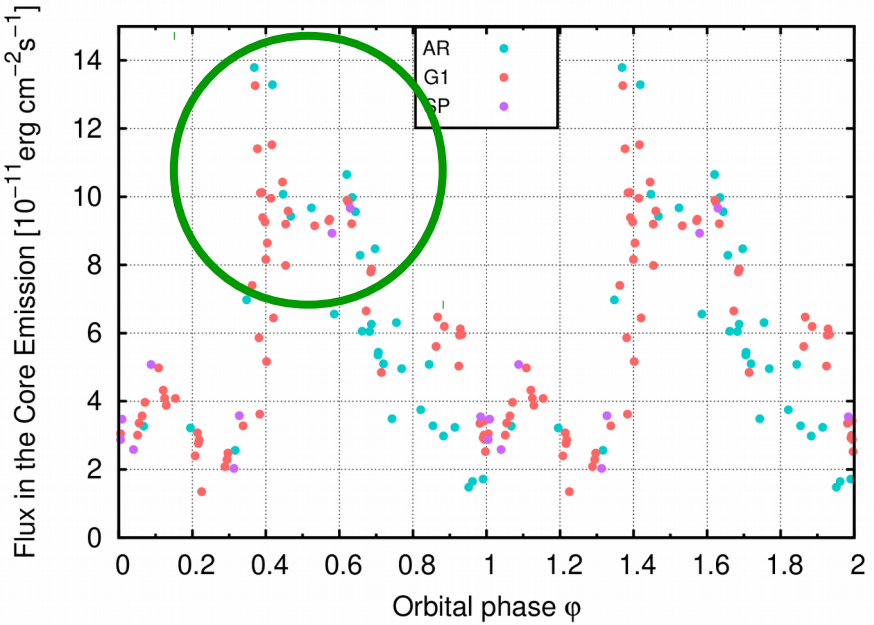


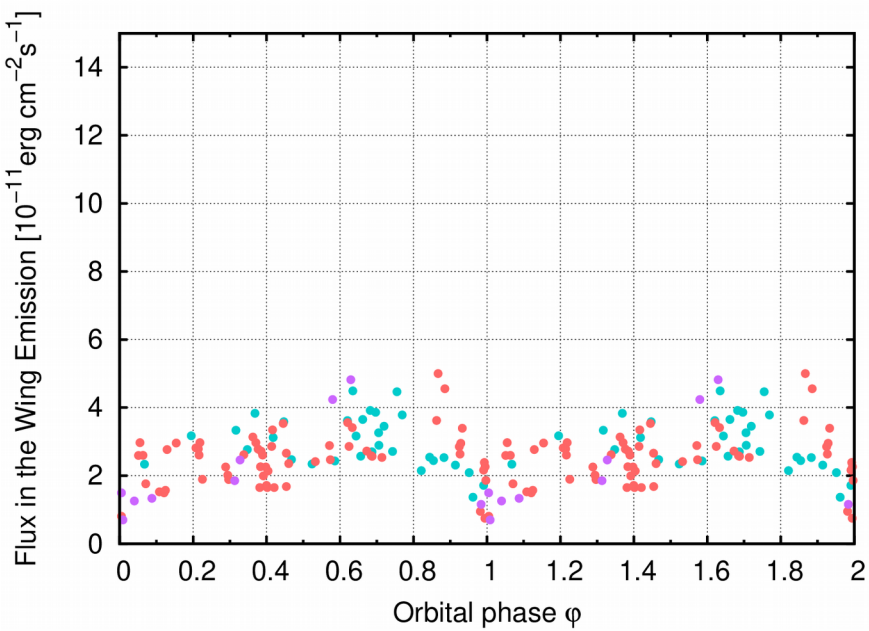


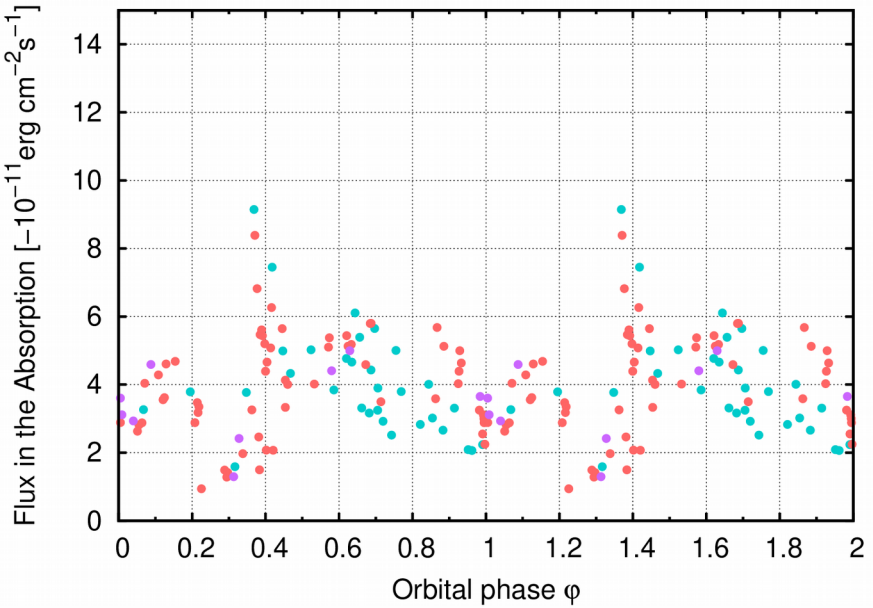
Fluxes in the Hα-line components

- **core emission:**
  U-shaped feature around φ = 0.5

---> **attenuation effect by the nebula with higher opacity**



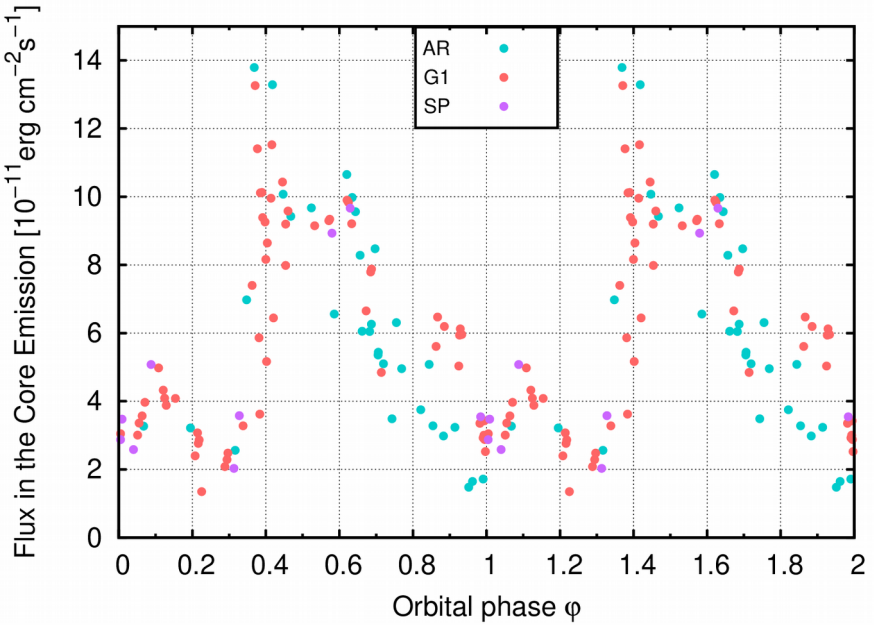


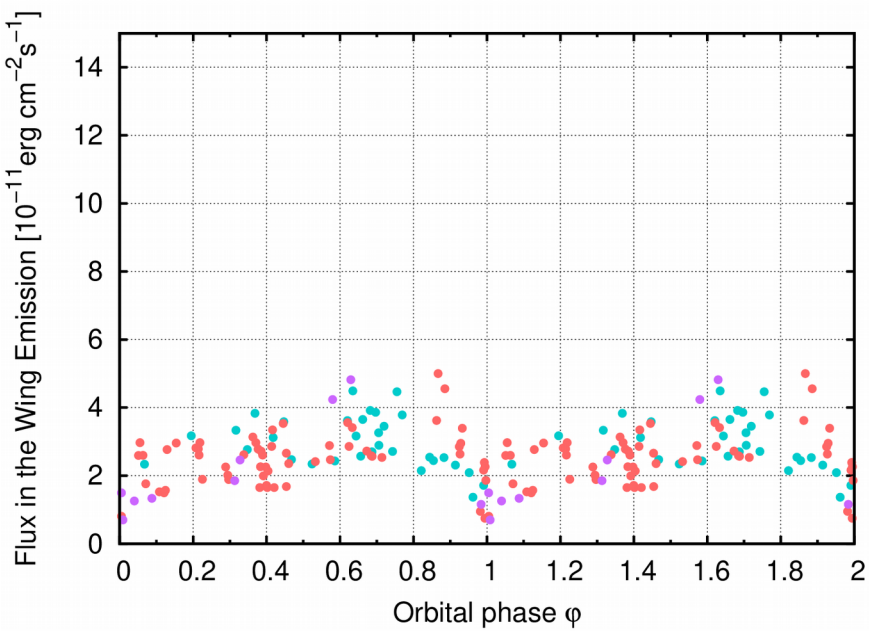


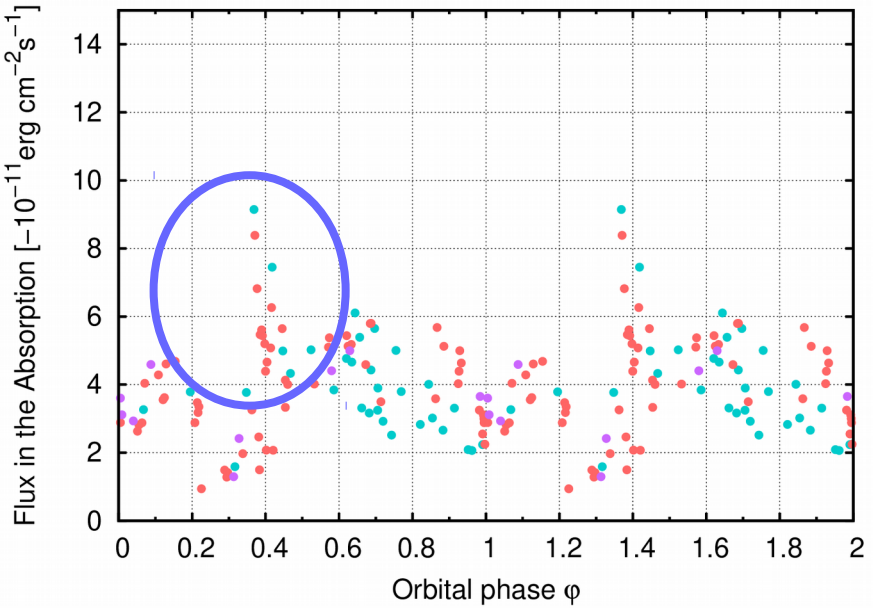
Fluxes in the Hα-line components

- **absorption**:
  maximum at around φ = 0.4

---> **fraction of the nebula is optically thick in the Hα-line**



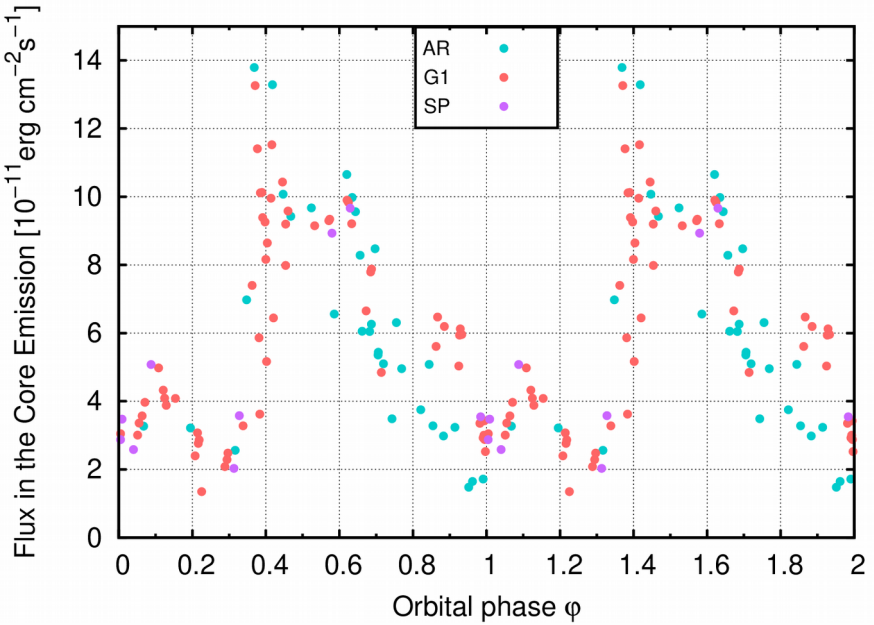


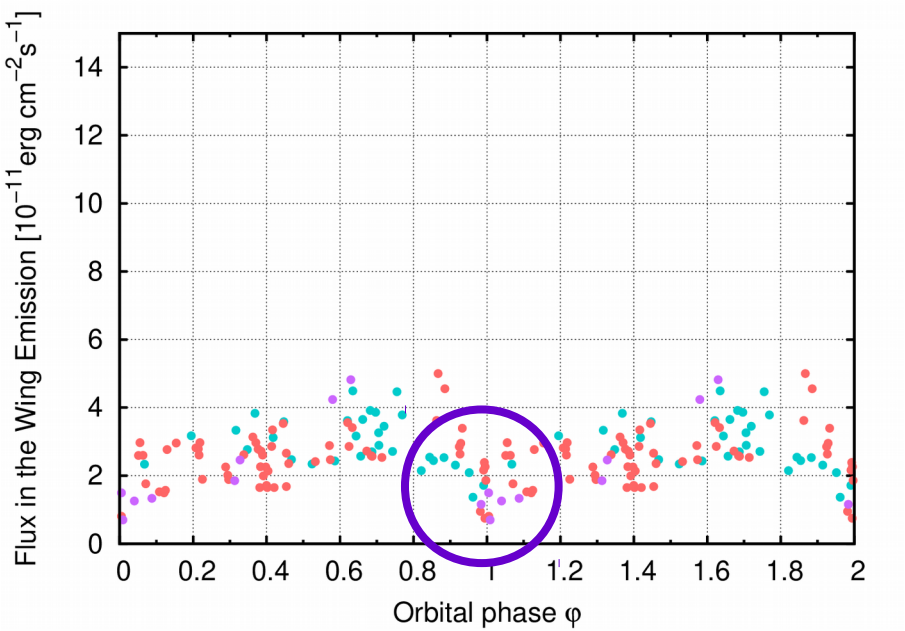


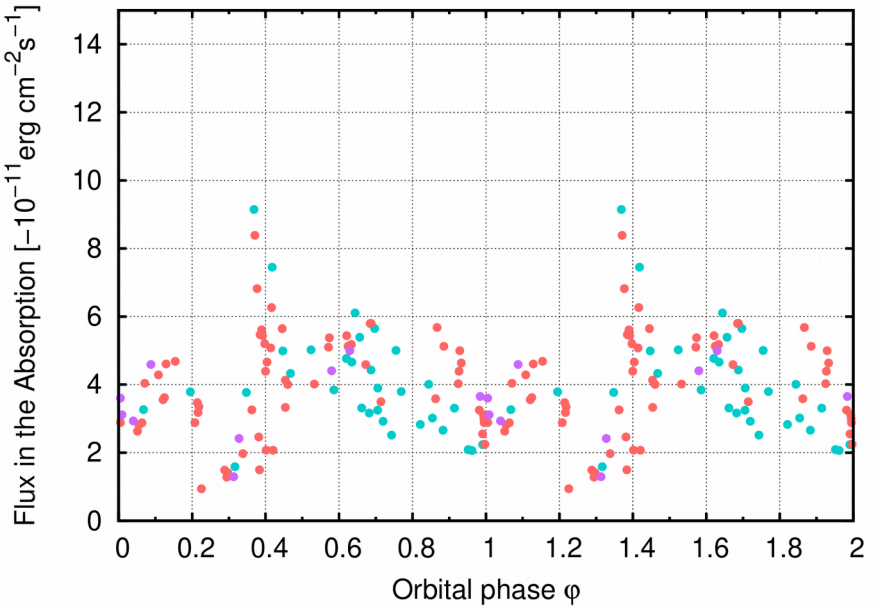
Fluxes in the Hα-line components

- **wing emission:**
  minimum at φ = 0

---> **source of the wing emission is located near WD at the orbital plane**



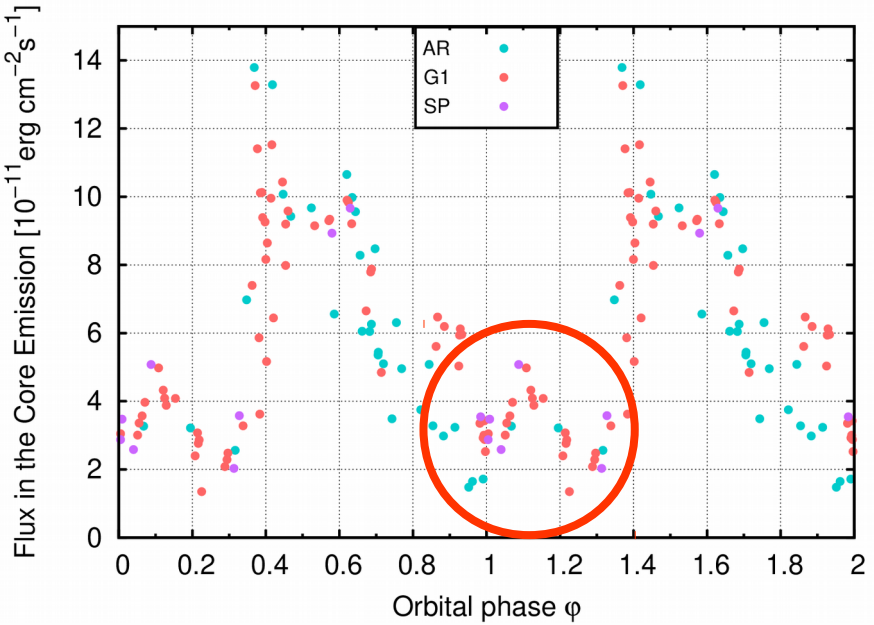


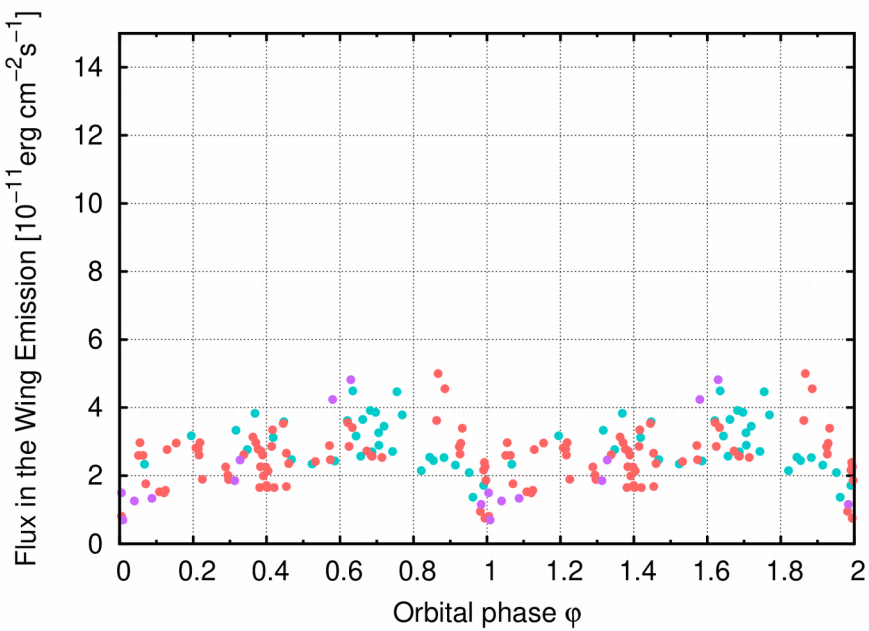


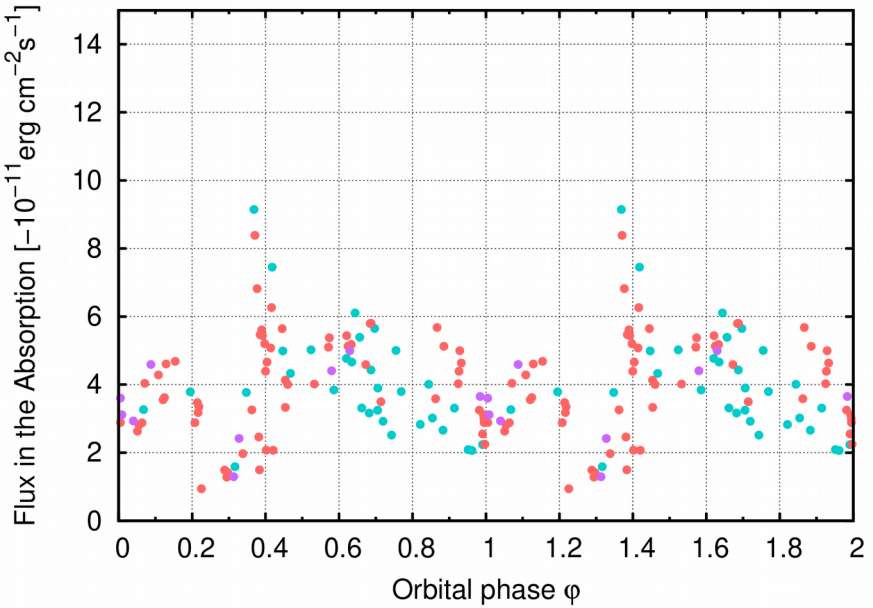
Fluxes in the Hα-line components

- **core emission:**
  secondary maximum at φ = 0.1

---> **refraction in the dense wind of red giant?**







Refraction of light in the atmosphere

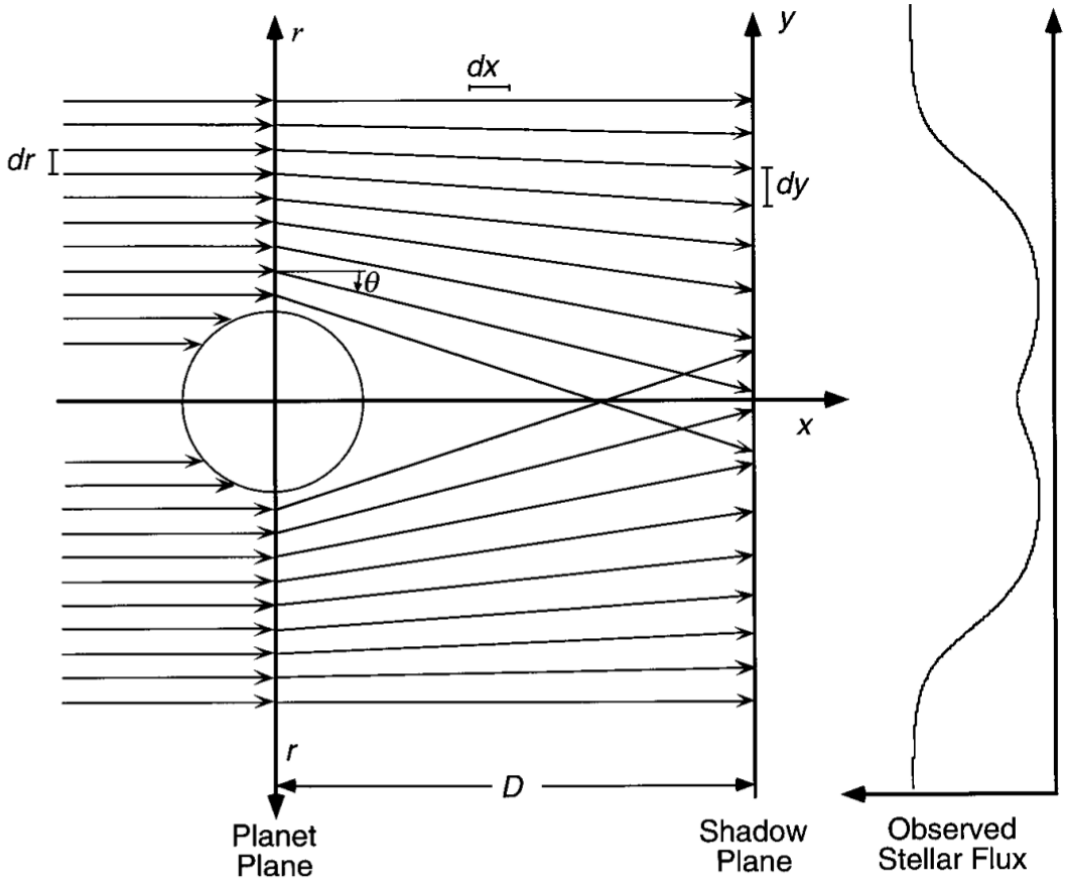


Fig. 1 from Elliot & Olkin 1996

- **planets**: during stellar occultations

(**time delay** between "spikes" at different **wavelenghts**)

Elliot & Olkin 1996, Elliot et al. 2003

- **close binary stars**: during eclipses

Kudzej 1996, 2006

- **symbiotic star CI Cyg**: "two-step" decreasing in the minimum

(explained by the variability of the red giant)

Belyakina 1984

Refraction of light in the atmosphere

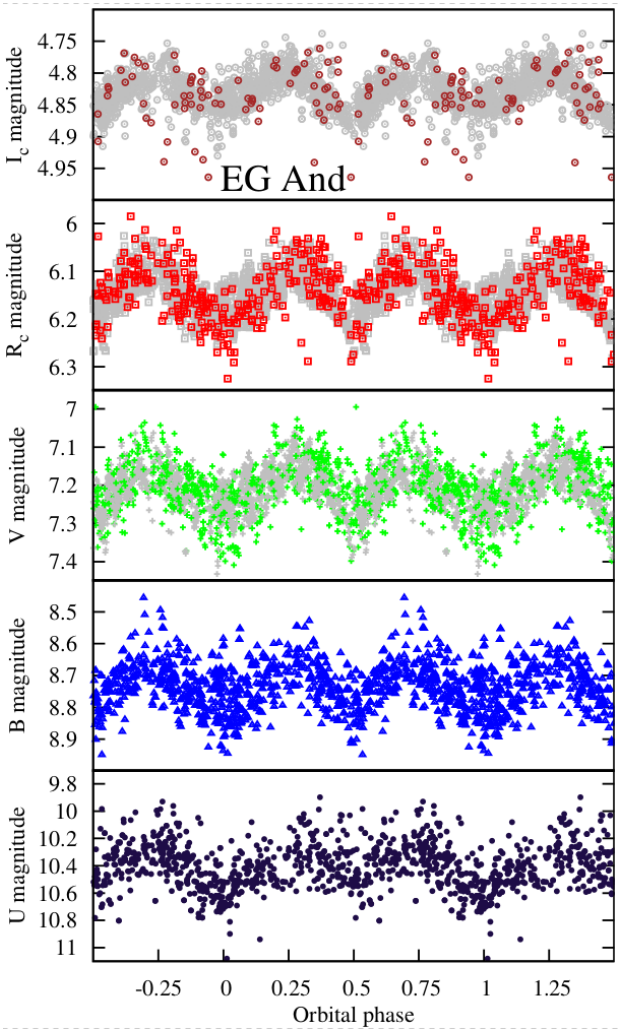
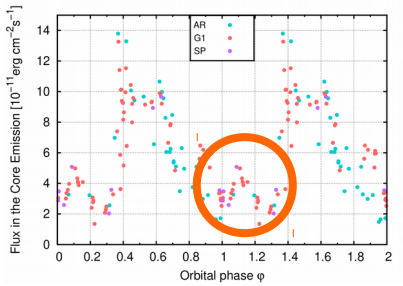
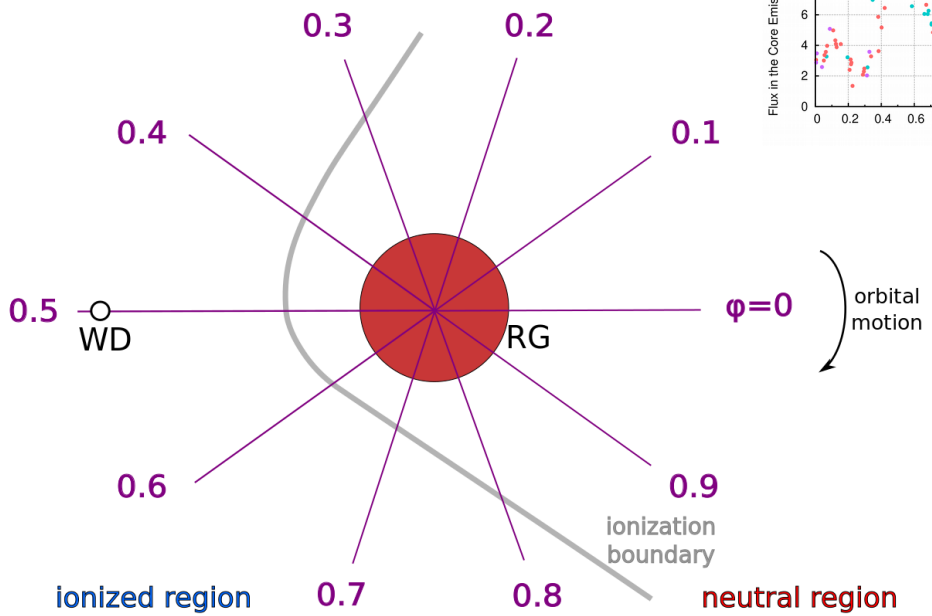


Fig. 2 from Sekeráš et al. 2019

Shagatova et al. 2016:

- focusing of the wind towards orbital plane
  --→ dense material along the lines of sight





Radial velocities

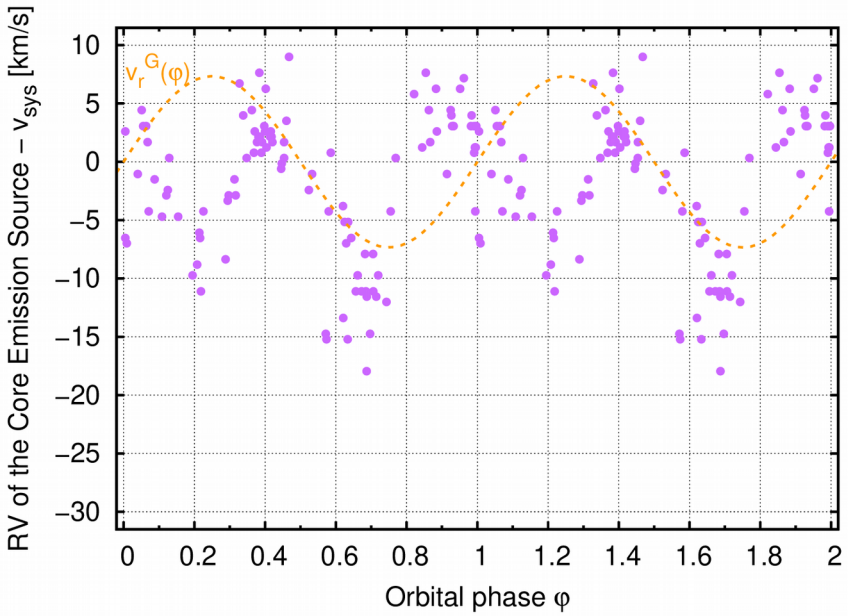
$v_r^G(\varphi)$ – radial velocity of the red giant

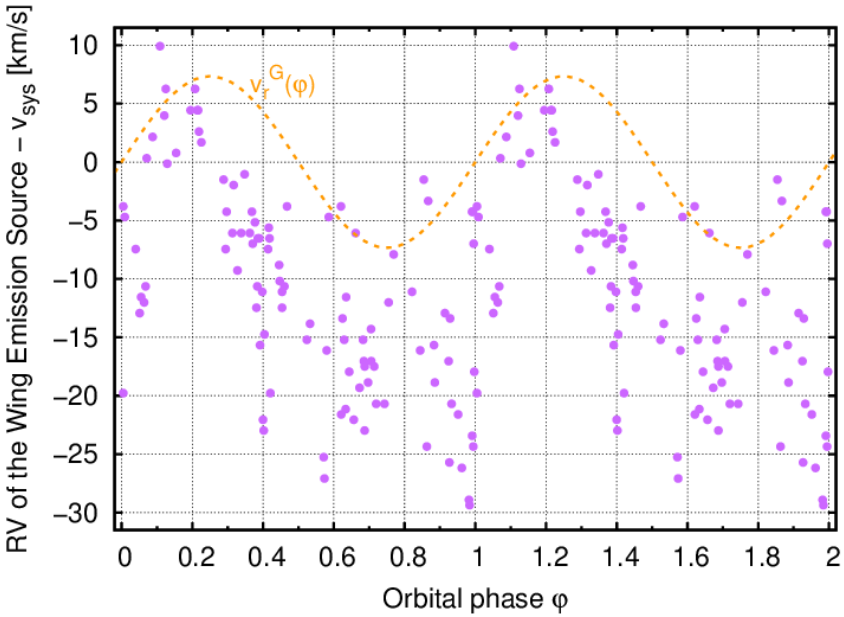
v_{sys} = -94.88 kms^{-1}

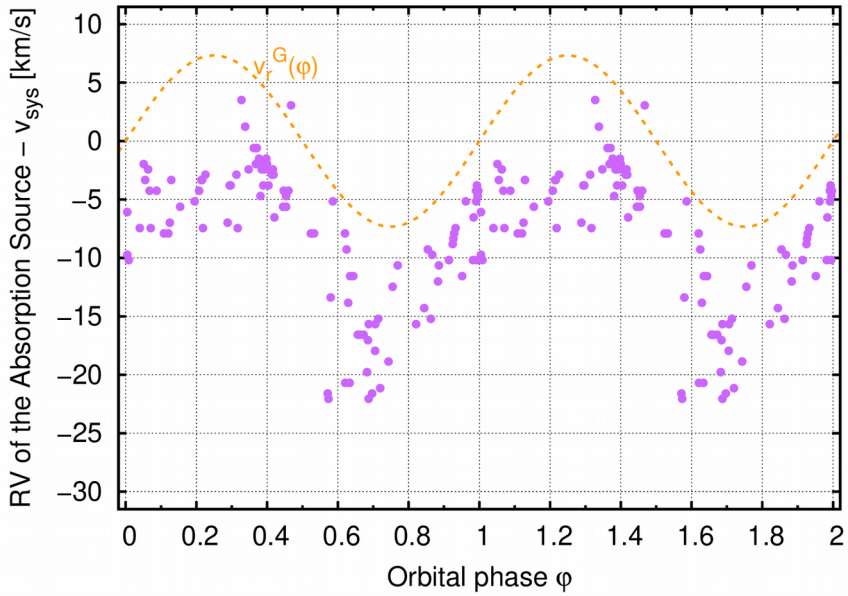
Kenyon & Garcia 2016

Wind velocity from Shagatova et al. 2016:

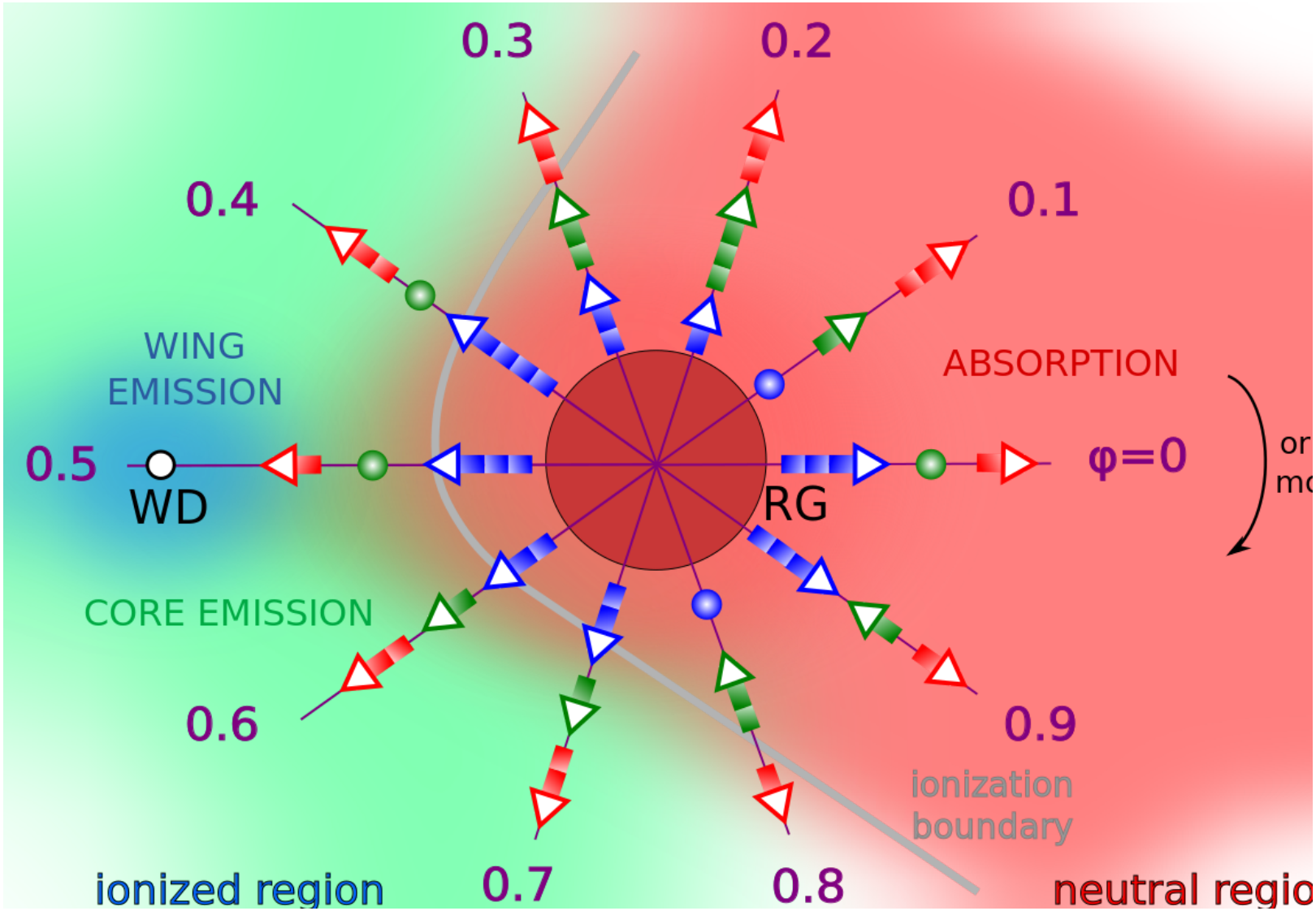
--> absorption up to around 1 red giant radius from its surface







Relative radial velocities v_r^{rel}



Conclusions

- the **circumstellar matter** is distributed **asymmetrically** with respect to the binary axis

- the **nebula** comprise the region located near the binary axis that is **partially optically thick** in the Hα line

- the **nebula** is **larger** in size **than the red giant**

- substantial fraction of the source of the **wing emission** component is located at the **orbital-plane area**

- substantial fraction of the source of the **absorption** component is located **up to the distance of ~1 RG radii** from its surface, comprising not only neutral wind, but also a part of the **ionized wind** area

- the **core emission** is produced by **expanding nebula**

- the **wing emission** is produced by **high-velocity matter near the WD**

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Thank you for your attention!