Confirmation of a wind focusing in EG Andromedae from the nebular [O III] λ5007 line

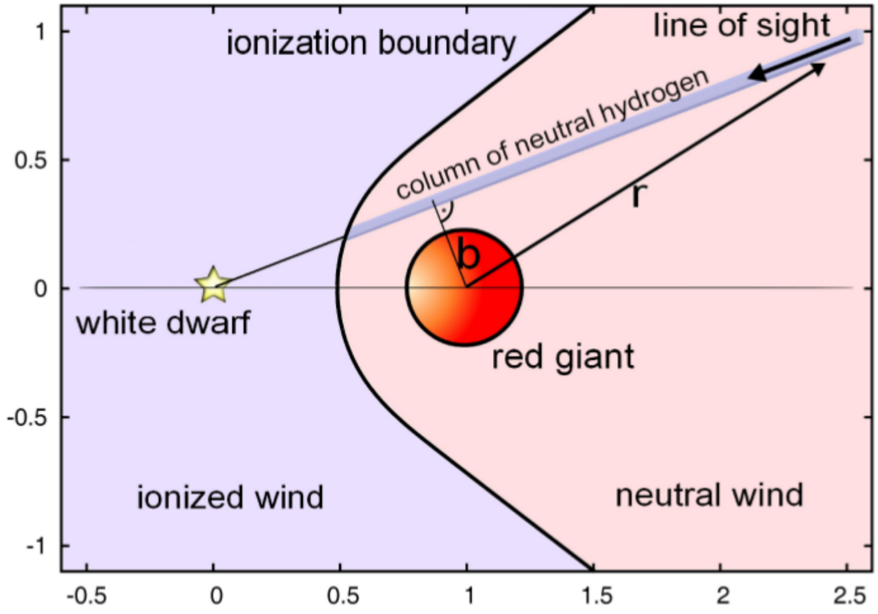
N. Shagatova[1]

A. Skopal[1], S. Yu. Shugarov[1,2], R. Komžík[1], E. Kundra[1], F. Teyssier[3]

[1] Astronomical Institute, Slovak Academy of Sciences, Tatranská Lomnica, Slovakia
[2] P.K. Sternberg Astronomical Institute, M.V. Lomonosov Moscow State University, Russia
[3] Observatoire Rouen Sud (FR) - ARAS group, Rouen, France

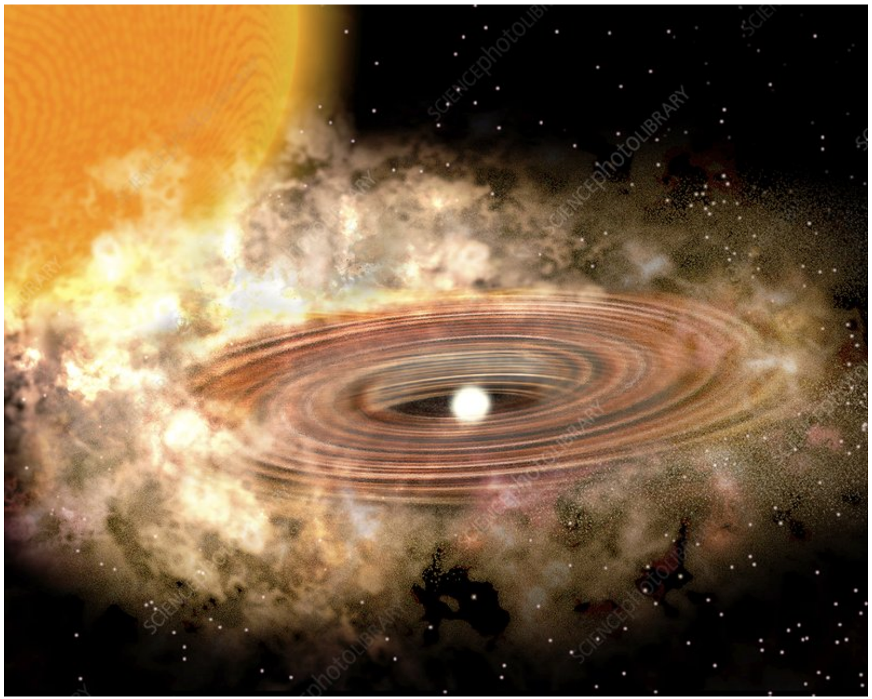
Symbiotic stars

- widest interacting binary stars (P≈few years)
- white dwarf + red giant
- neutral and ionized wind
- quiescent and active phases



The luminosity problem

- accretion heats up the white dwarf up to T ~ 100 000 K, L = 10 - 1000 L_{Sun}



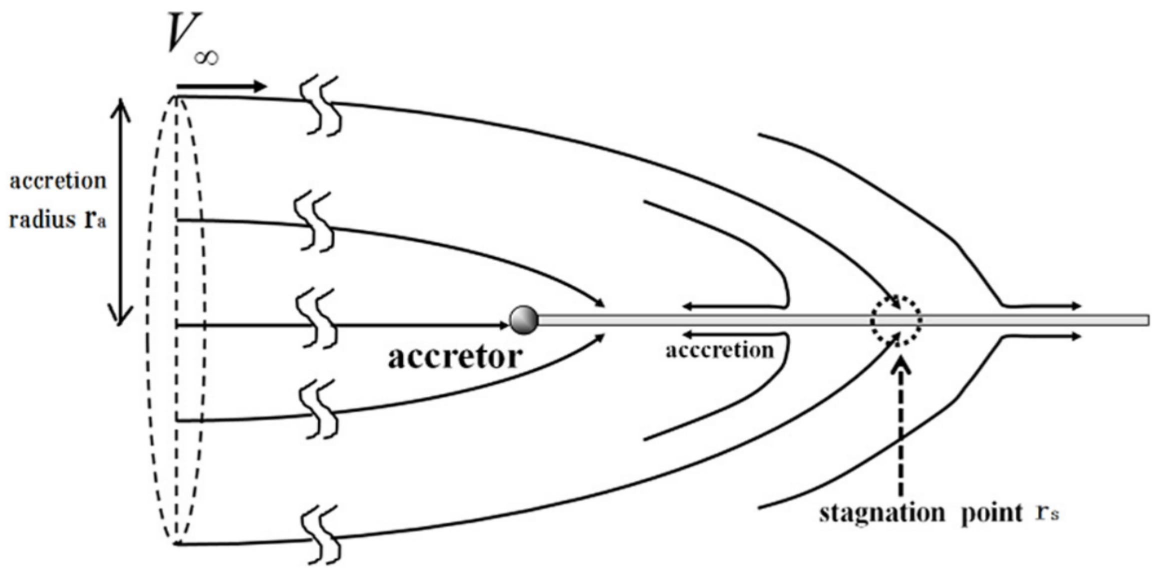
Required **accretion rate** :
10^{-8} – 10^{-7} M_{Sun} / year

Measured **mass-loss rate** :
~ 10^{-7} M_{Sun} / year

Bondi – Hoyle – Lyttleton accretion

- a point star moving through a gas cloud (uniform and free of self-gravity)

- material focused by gravity behind the star and accreted



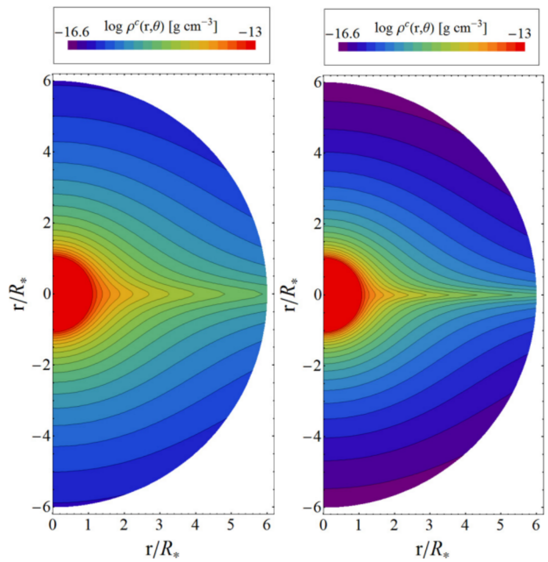
Ohsugi 2018

- binary stars: **mass accretion rate ~ few % of the mass loss rate**

Wind focusing towards the orbital plane

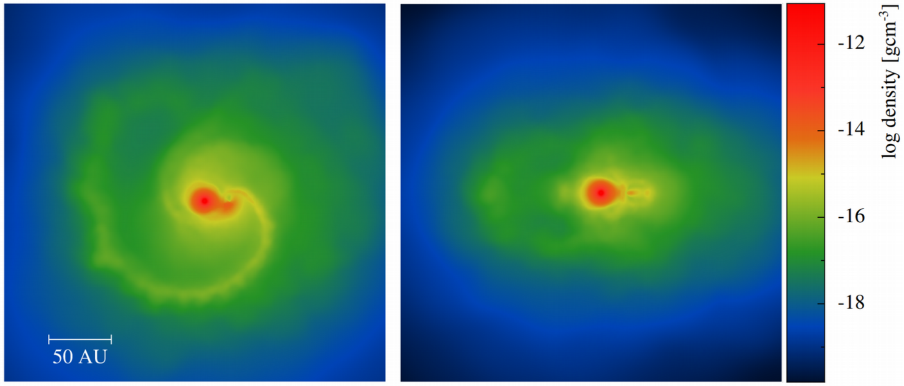
--→ effective wind mass transfer

S-type systems

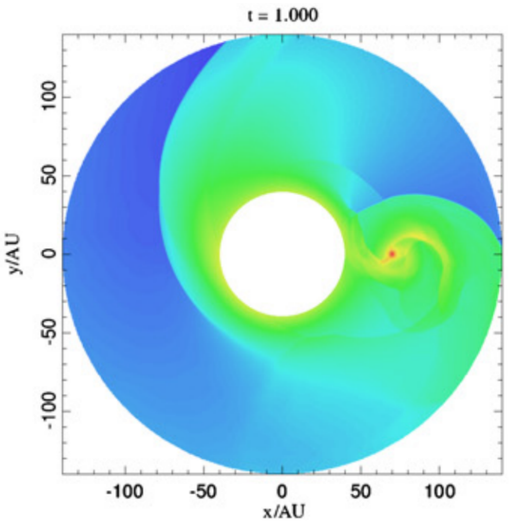


Skopal & Cariková 2015

D-type systems



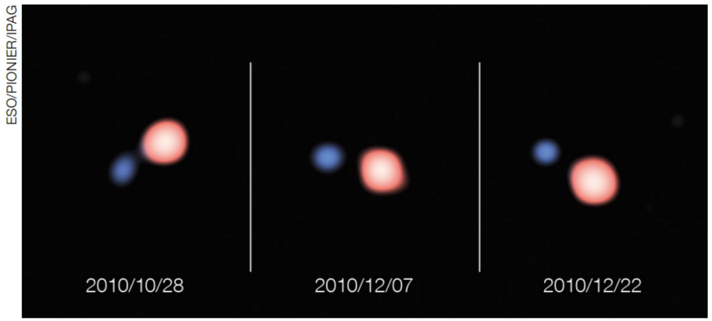
Mohamed & Podsiadlowski 2012



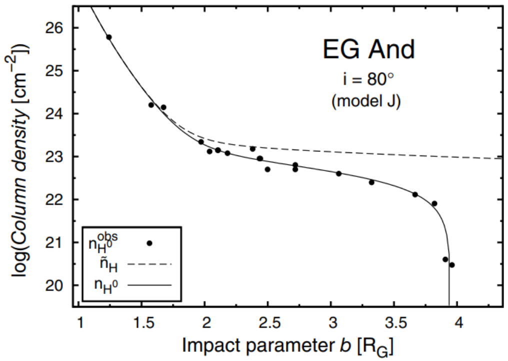
de Val-Borro et al. 2009

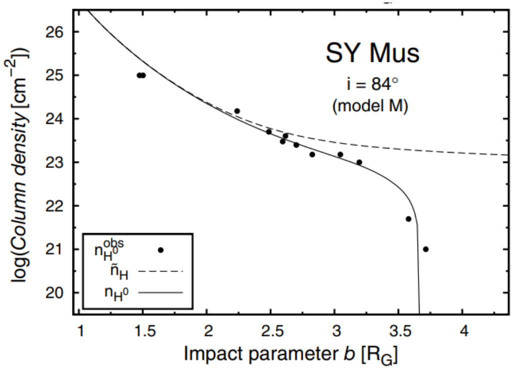
Observational evidence of the wind focusing

S-type systems



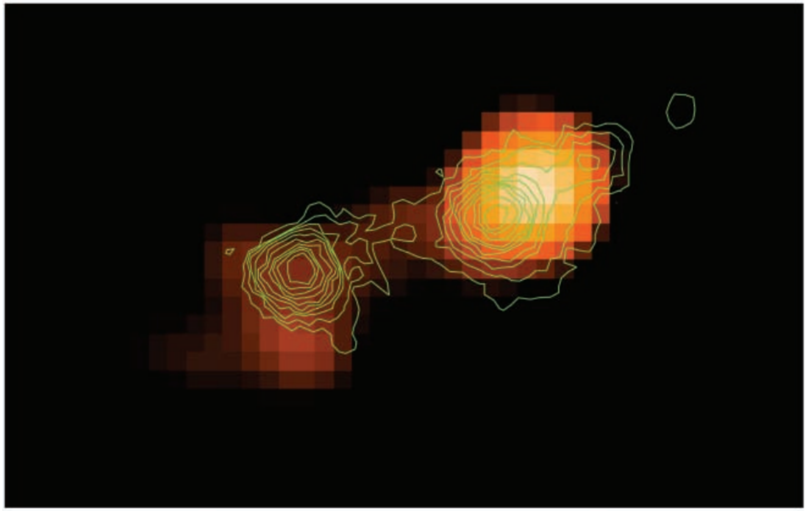
SS Leporis (Boffin et al. 2014)





EG And, SY Mus (Shagatova et al. 2016)

D-type systems



Mira AB (Karovska et al 2005)

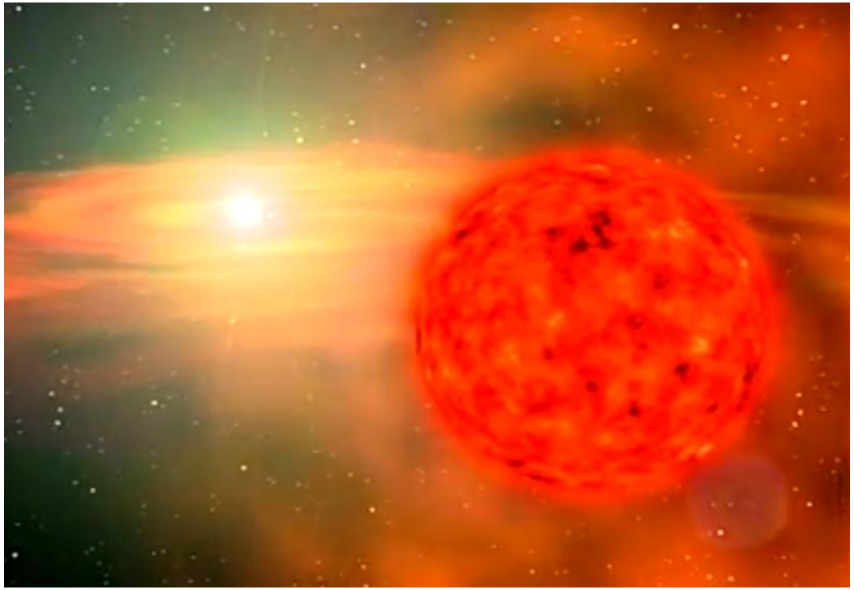
EG Andromedae

- quiet symbiotic star
  (no recorded outburst)

- white dwarf (WD) + red giant (RG)

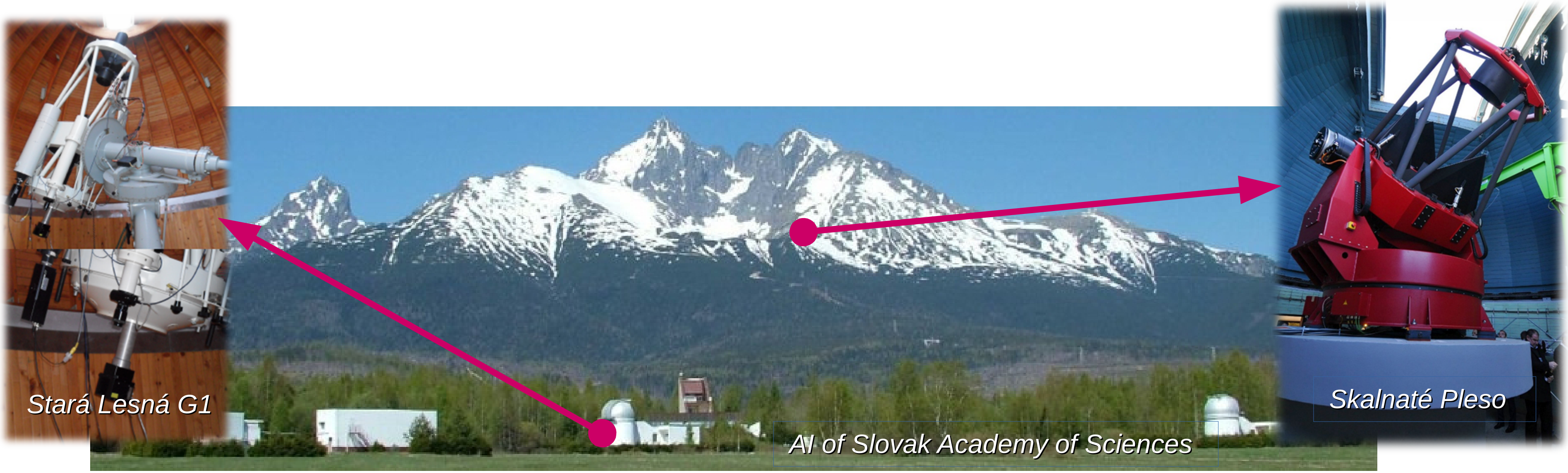
- P = 483 days, $i \approx 80°$

- mass transfer via stellar wind



Observations

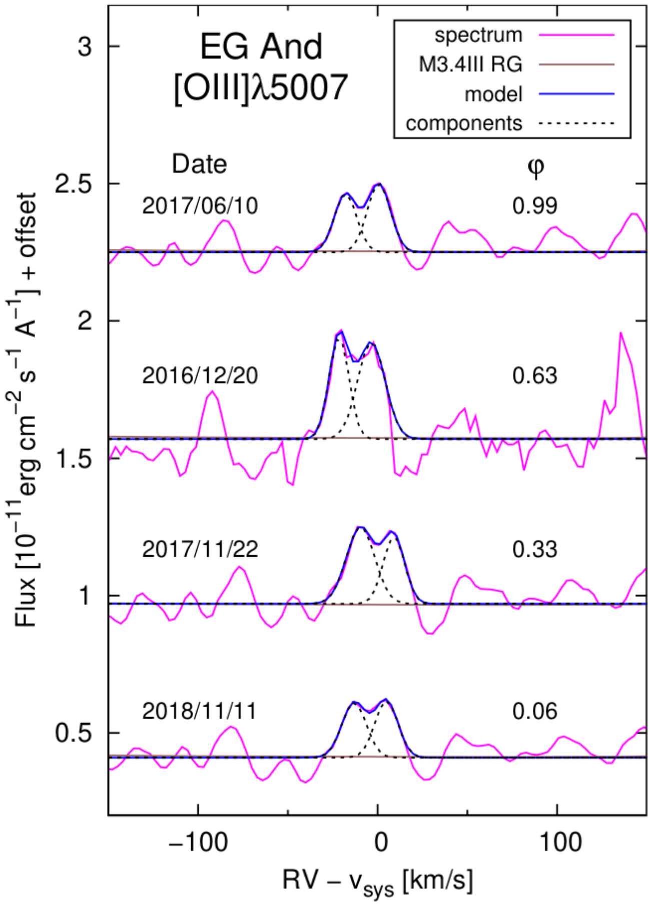
- 120 optical spectra from years 2015 -2020, λ = 420 – 720 nm



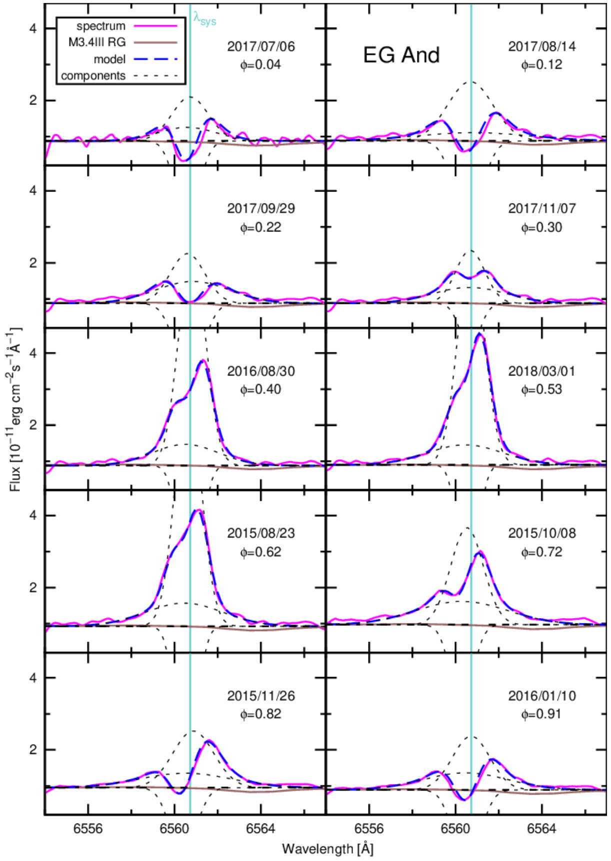
- 0.6m telescope at Stará Lesná (G1), R = 11000
- 1.3m telescope at Skalnaté Pleso, R = 38000
- ARAS database (0.31 – 0.36 telescopes), R = 11000
- $UBVR_C$ photometry for flux calibration (Skopal et al. 2012, Sekeráš et al. 2019)

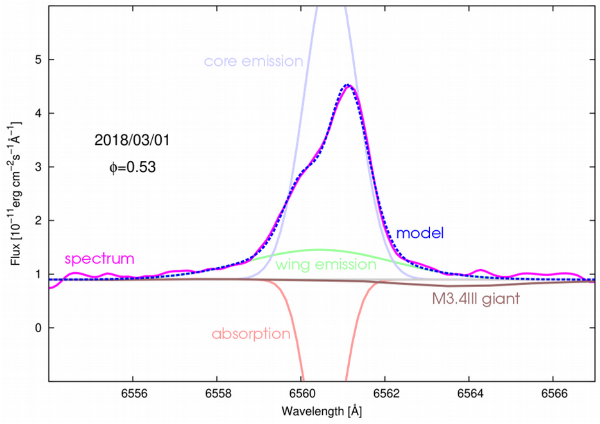
Spectral analysis

[OIII] λ5007



Hα





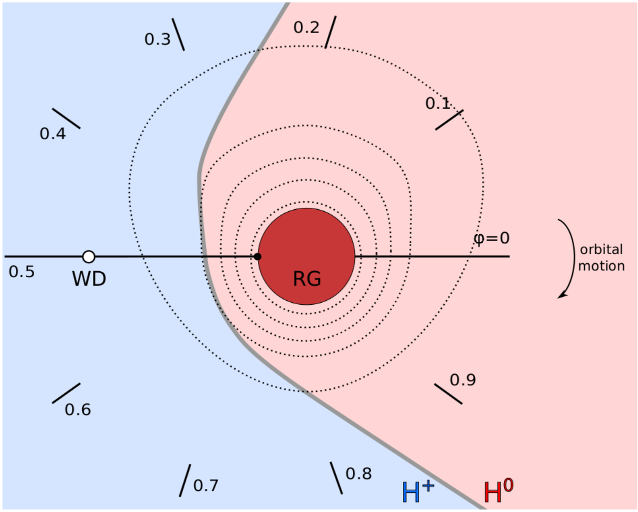
- two and three component models

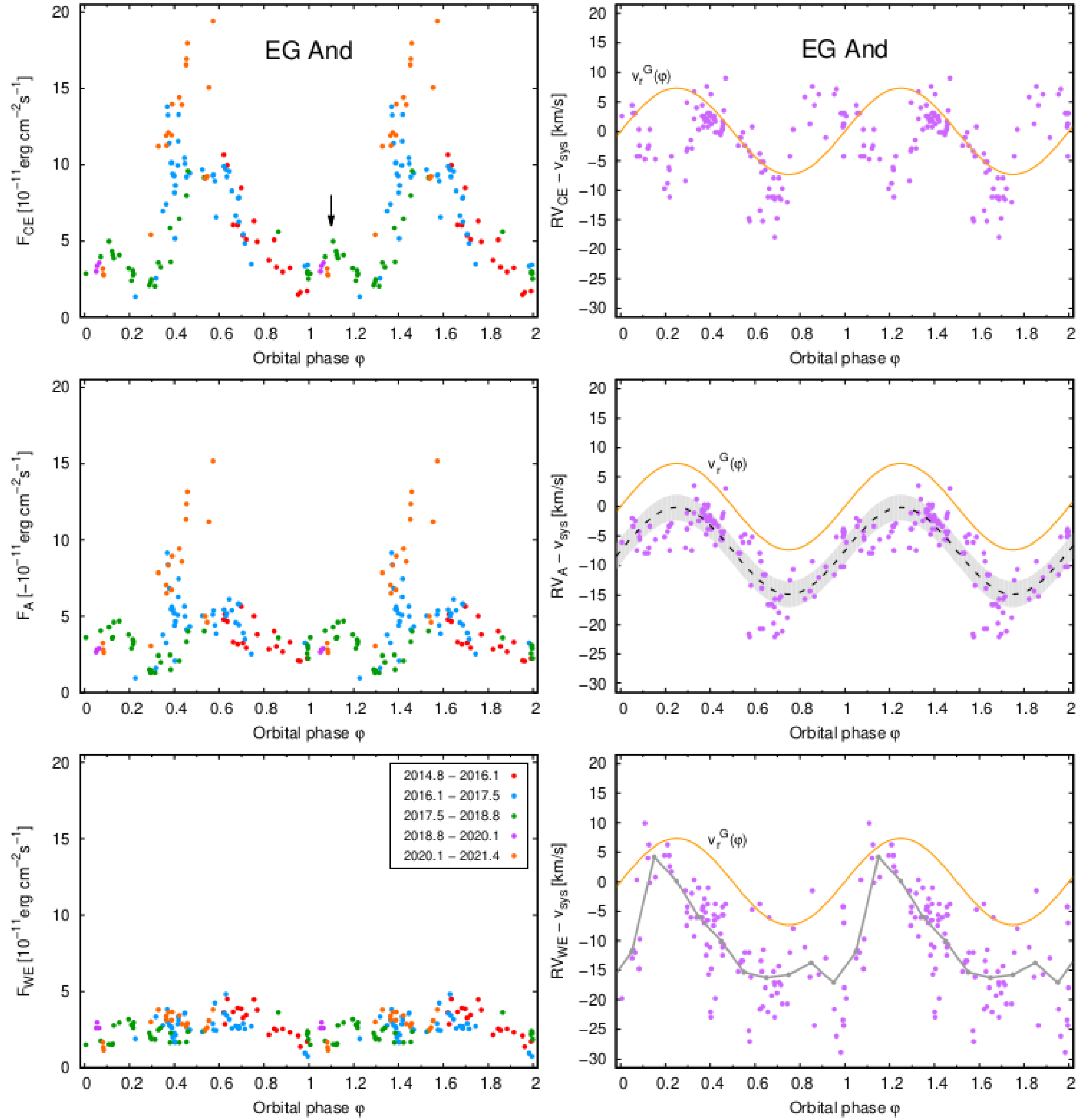
- orbital variability of fluxes and radial velocities

Orbital variability of the Hα-line

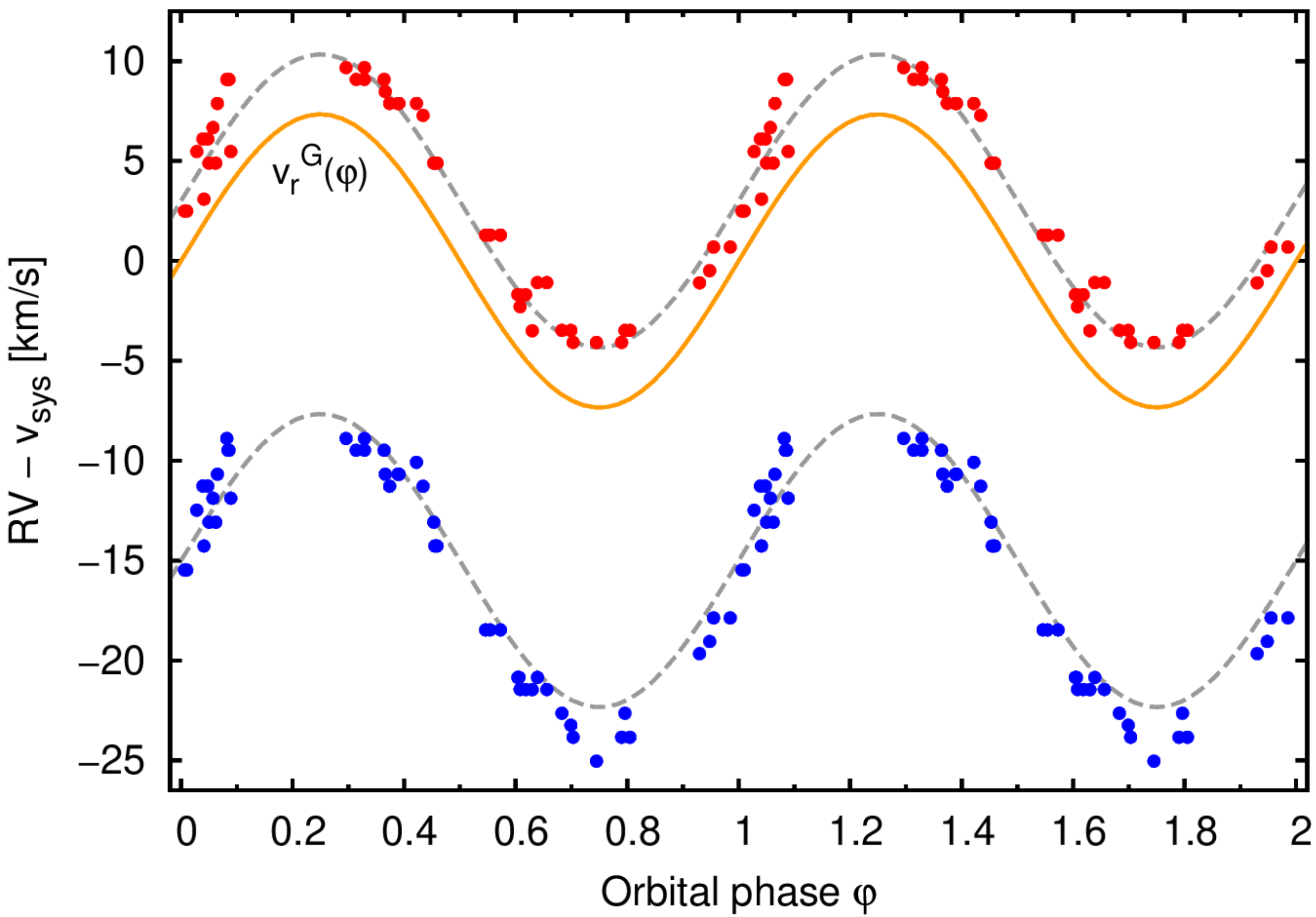
- **core emission** and **absorption** fluxes:
  minima at φ = 0.2 and maxima at φ = 0.4

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





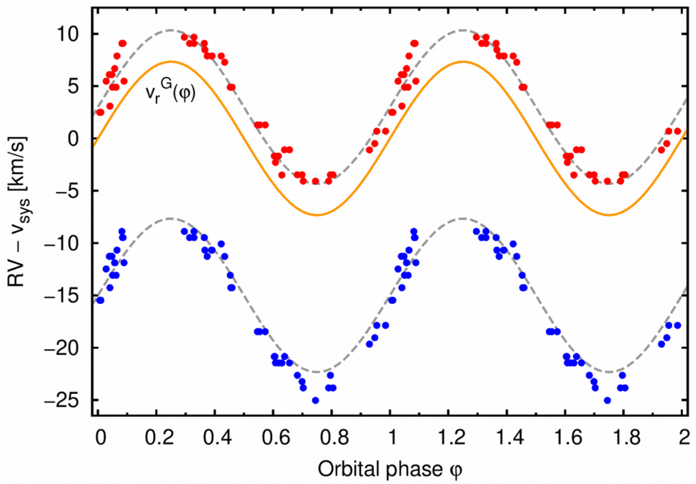
Radial velocities of the [OIII] λ5007 line

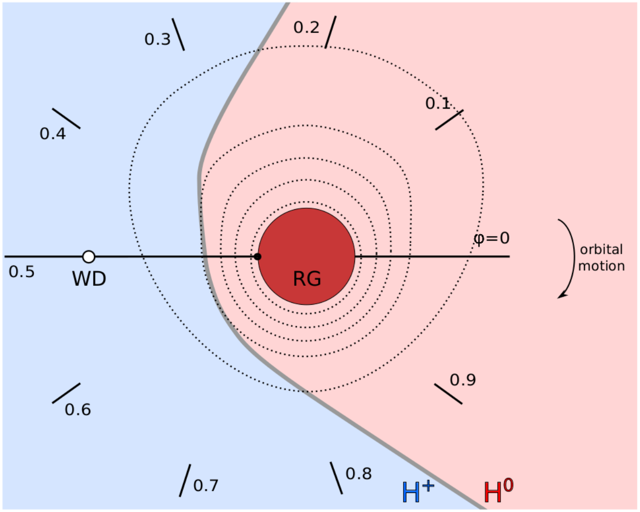


$v_r^G(\varphi)$ – radial velocity of the red giant

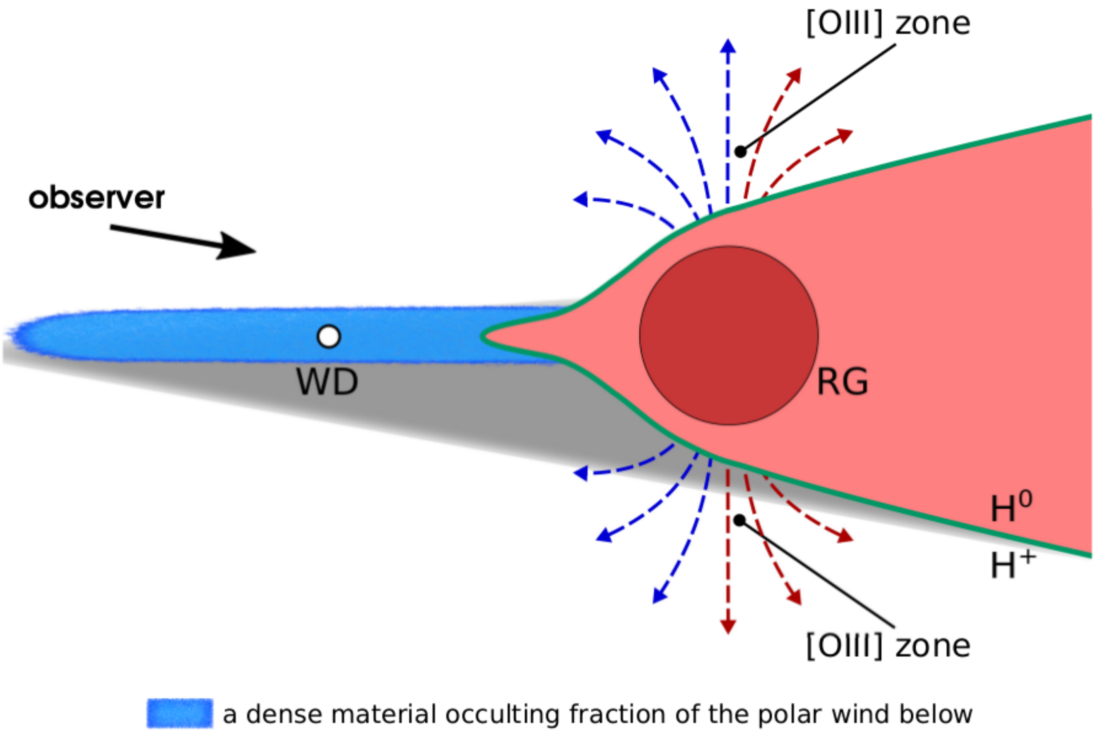
v_{sys} = -94.88 kms^{-1} (Kenyon & Garcia 2016)

Location of [OIII] λ5007 line regions



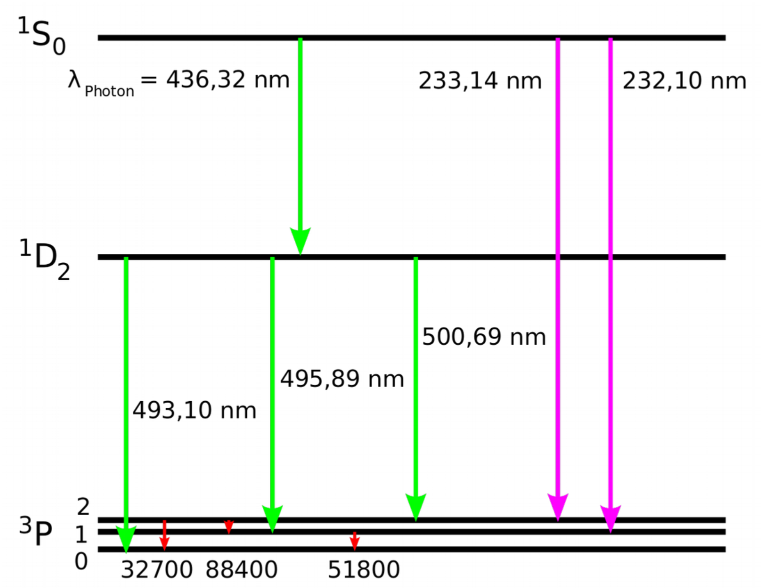


--> ionized regions close to the red giant



Density in the [OIII] λ5007 line regions

- [OIII] nebular lines are **weakened at higher densities** due to the presence of free electrons



- they originate in regions with **n_e ~ 3 x 10^7 cm^{-3}**, with upper limit of ~ 7 x 10^7 cm^{-3} (AX Per, Skopal et al. 2001)

- the limiting mass-loss rate: **~ 10^{-8} M_{Sun} / year** for the density ~ 10^7 cm^{-3} in the vicinity of red giant (1-2 R_g from its surface)

Wind focusing in S-type symbiotic stars

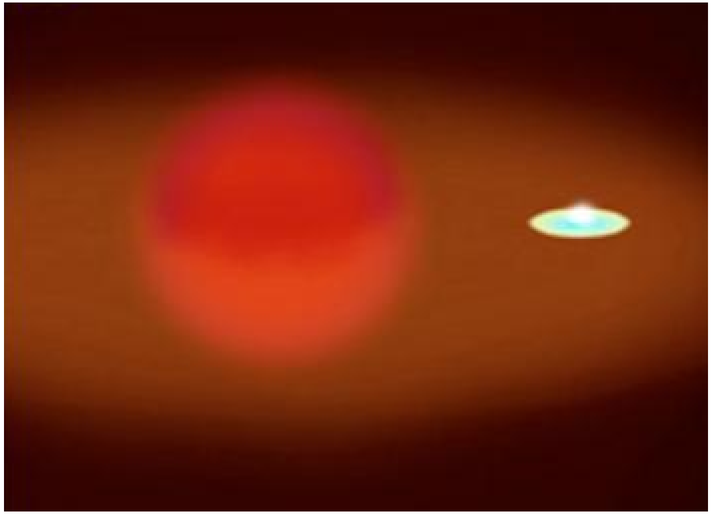
- mass-loss rate from the nebular emission **(independent of the line of sight)**:

  ~ 10^{-7} M_{Sun} / year (Seaquist et al. 1993)

- mass-loss rate from the densities near **RG poles**:

  ~ 10^{-8} M_{Sun} / year (Shagatova et al. 2021)

  ---> **dilution** of the wind



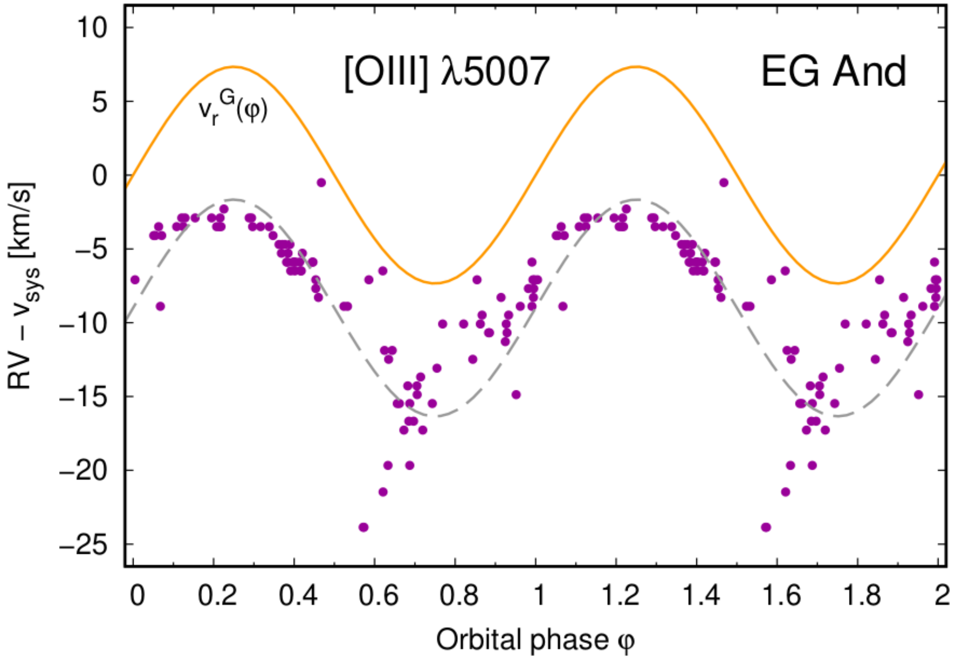
- mass-loss rate from the densities near **orbital plane**:

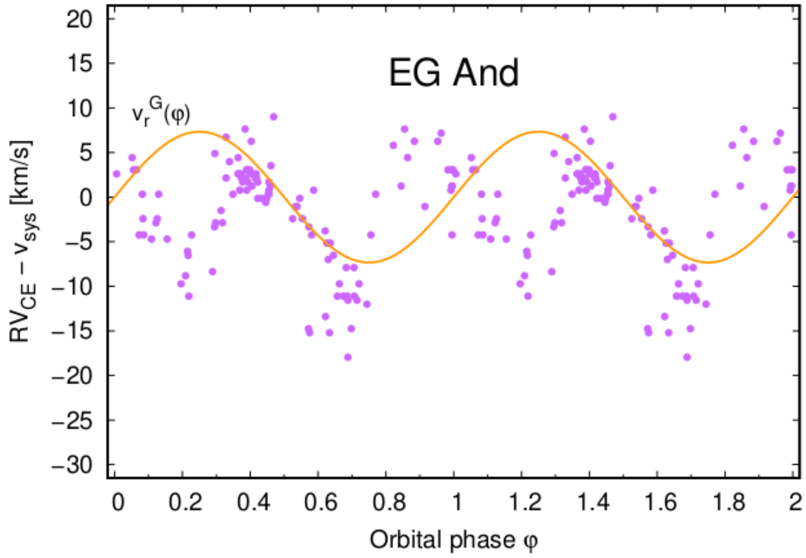
  ~ 10^{-6} M_{Sun} / year (Shagatova et al. 2016)

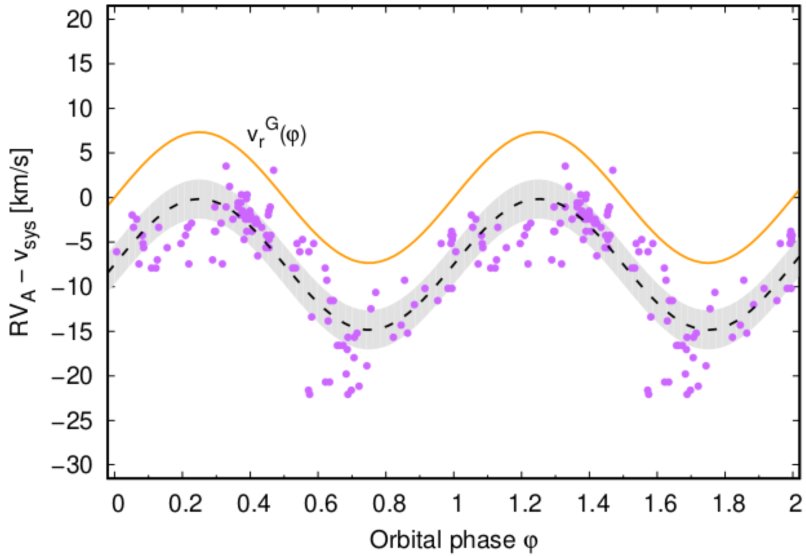
  ---> **enhancement** of the wind

Radial velocities at φ ~ 0.7

- deviation from the RV curve of the red giant

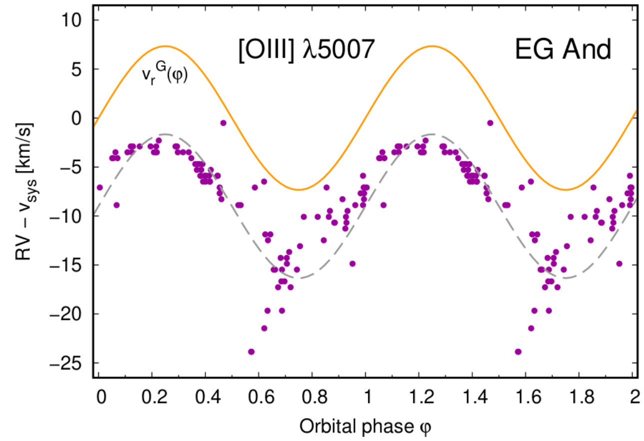


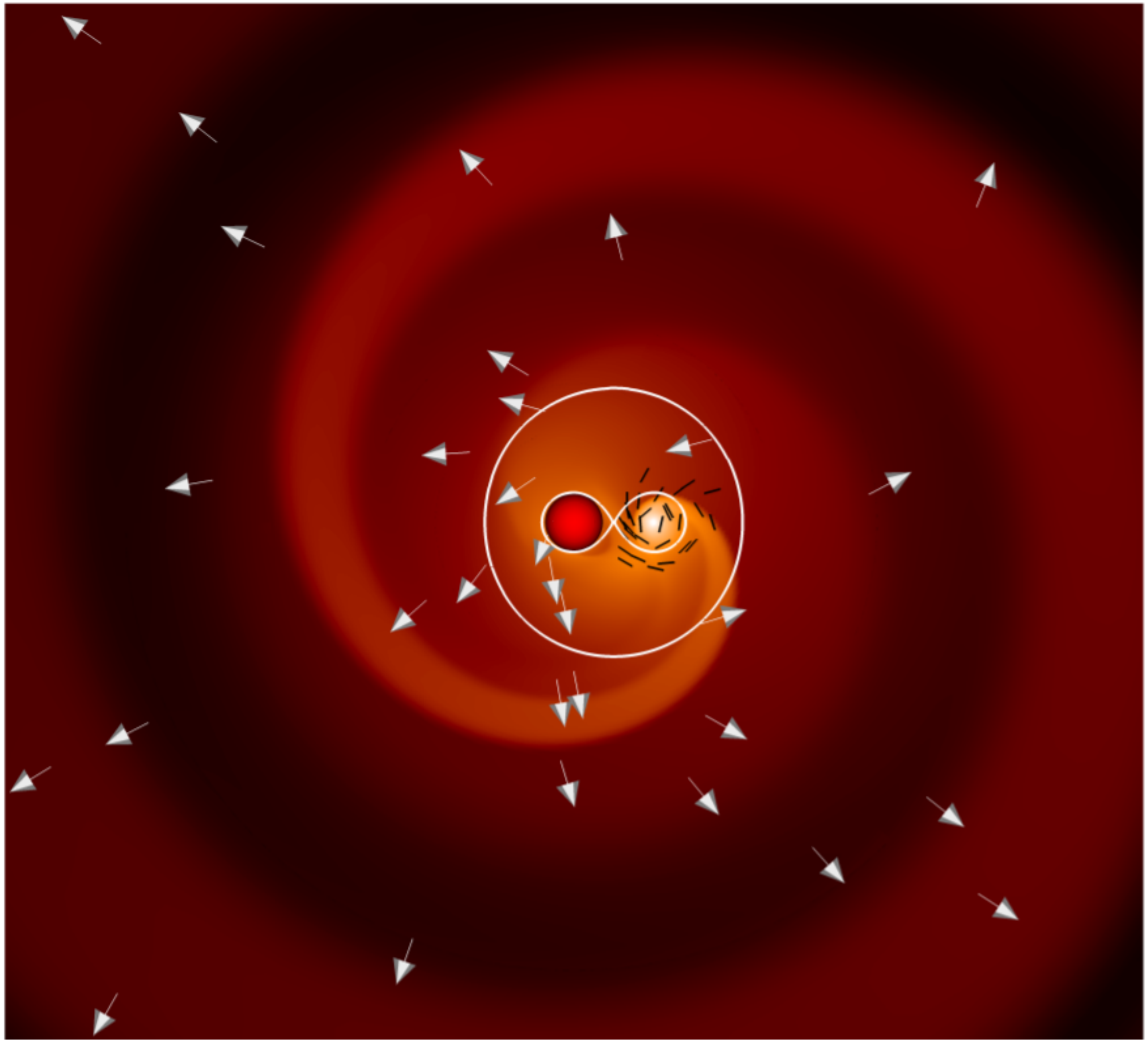




Radial velocities at φ ~ 0.7

- **faster variable outflow** of the wind **and/or alignment** into radial direction





El Mellah et al. 2016

Conclusions

- the **neutral wind zone** is **distributed asymmetrically** at the orbital plane with respect to the binary axis

- the **[OIII] λ5007 zones** in EG Andromedae are located **in the ionized region close to the red giant poles**

- the **wind** from the red giant is substatially **compressed towards the orbital plane** leading to dilution of matter near giant's poles and its enhancement at the orbital plane region

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Thank you for your attention!