Detailed physical modeling of Be star β CMi

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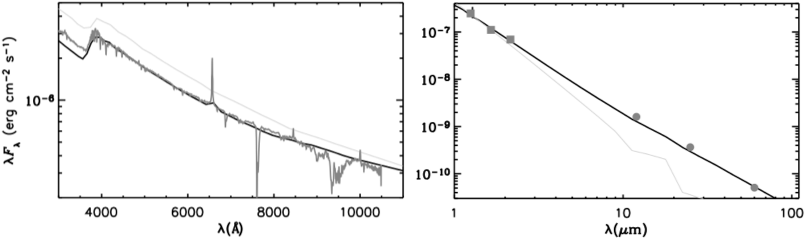

Carciofi et al. 2009, A&A 504, 915

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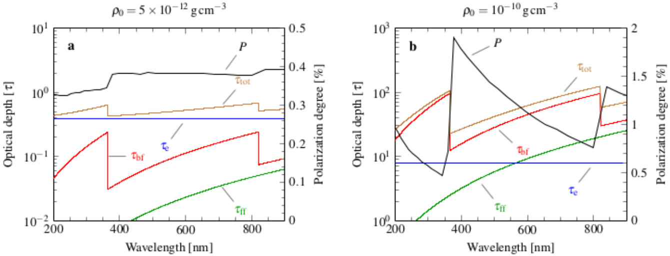

Rivinius et al. 2013, A&ARv 21, 69

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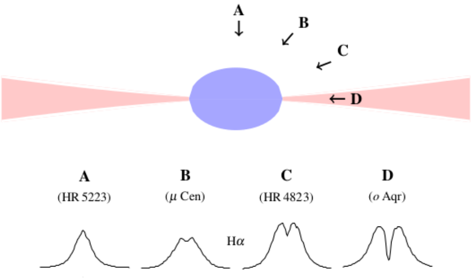

Rivinius et al. 2013, A&ARv 21, 69

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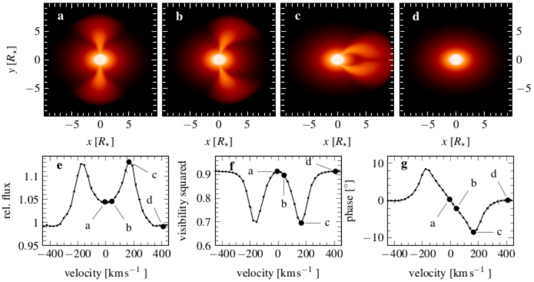
  - Infrared excess indicates the presence of circumstellar material
  - Intrinsic polarisation implies that the material is aspherical
  - Double peaked emission lines indicate rotating material
  - Interferometry consistent with a thin disk rotating in a Keplerian way



Rivinius et al. 2013, A&ARv 21, 69

Be phenomenon and viscous decretion

- *Be phenomenon* (mass ejection process) acting on top of a rotation rate of $\sim 75\%$ of critical or above
    - non-radial pulsations
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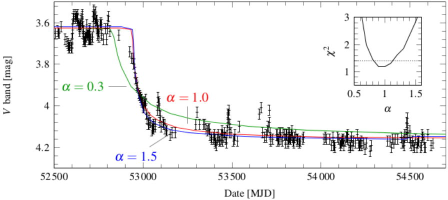
- *Be phenomenon* (mass ejection process) acting on top of a rotation rate of $\sim 75\%$ of critical or above
  - non-radial pulsations
  - small scale magnetic fields
- after ejection into Keplerian orbit material is governed by viscosity - The viscous decretion disk (VDD) model (Lee et al. 1991, MNRAS 250, 432)

Succesful applications of the VDD model to individual targets

- χ Oph, κ Dra, β Psc and ν Cyg - fit of interferometry and line profiles using a time-independent parametric model (BEDISK)
- ζ Tau and δ Sco - fit of interferometry, polarimetry, spectroscopy and photometry using time-independent self-consistent model (HDUST)
- temporal variability of ω CMa - fit of visual photometry during disk dissipation - first determination of viscosity parameter $\alpha \sim 1$ (HDUST)



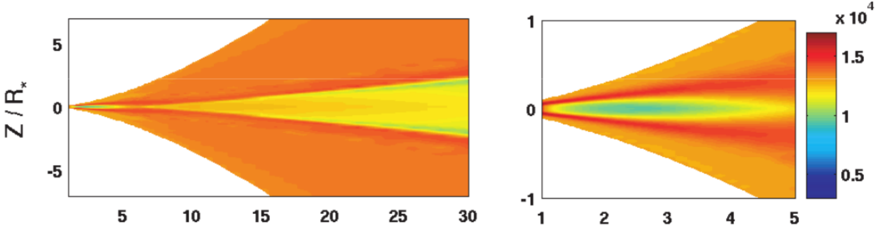
Carciofi et al. (2012, ApJ 744, 15)

HDUST (Carciofi & Bjorkman 2006, ApJ 639, 1081)

- 3D NLTE Radiative transfer Monte Carlo code
  - Samples photon absorption rates to solve the statistical equilibrium equations $\rightarrow$ level populations, degree of ionisation, radiative equilibrium temperature
  - Computes model observables:
    - SED in the chosen wavelength ranges
    - Line profiles
    - Intrinsic polarisation
    - Synthetic images - allow to compute interferometric observables for a given baseline

Model description

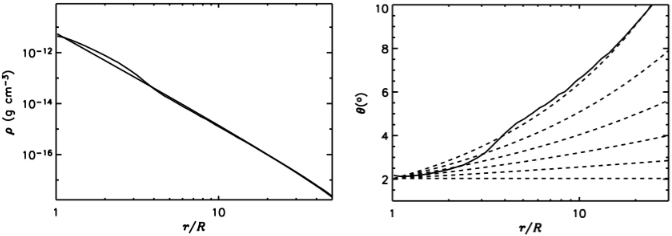
- Hybrid model
  - isothermal density structure - $\rho(r,z) = \frac{\Sigma_0}{\sqrt{2\pi}H_0}(\frac{r}{R_e})^{-n}\exp(-\frac{z^2}{2H^2})$; $H(r) = (c_s/v_\Phi)r$ - but non-isothermal temperature structure!
  - input parameters: M_{star}, R_{pole}, $W = \frac{v_{rot}}{v_{orb}}$, $GD_{exponent} = 0.25$ (von Zeipel), Σ_0, n ($n = 2.0$ for isothermal disk), i, R_{disk}, v_{turb}



Jones et al. 2008, ApJ 687, 598

Model description

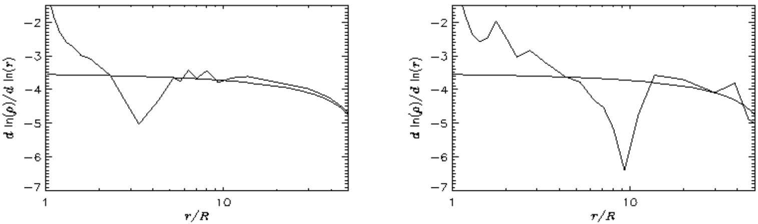
- Hybrid model
- Combined hybrid model - vertical HEQ structure consistent with temperature solution



Carciofi & Bjorkman 2008, ApJ 684, 1374

Model description

- Hybrid model
- Combined hybrid model
- Steady-state VDD model - density & velocity field consistent with temperature solution
  - radial temperature gradient negative $\rightarrow n < 2.0$; positive $\rightarrow n > 2.0$
    - input parameters: Σ_0, $n \rightarrow \dot{M}, \alpha(= 0.1)$; $R_0(= R_{disk}$ but it should be $R_{disk} \neq R_0)$



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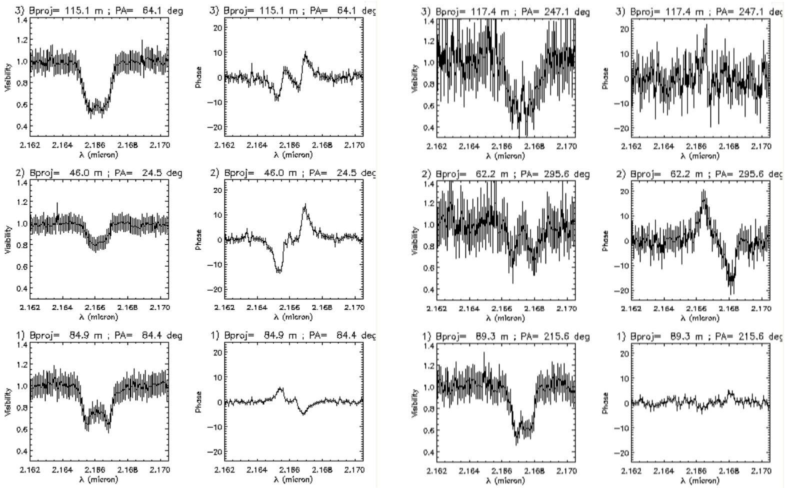
Observations used

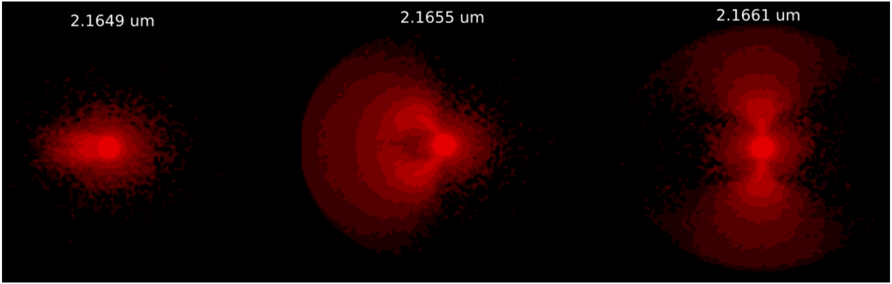
- Photometry and radio fluxes up to cm wavelengths - APEX, CARMA
- Spectroscopy - IUE, Ondřejov, UVES, FEROS + additional amateur spectra from the BeSS database
- Polarimetry - HPOL, Pico dos Dias Observatory
- **Near-Infrared Spectro-interferometry - VLTI/AMBER, (VLTI/MIDI, VLTI/PIONIER) CHARA/MIRC, (CHARA/CLIMB)**

HR AMBER spectro-interferometry in Brγ

2009-12-31 - 3 UTs 2010-04-02 - 3 ATs

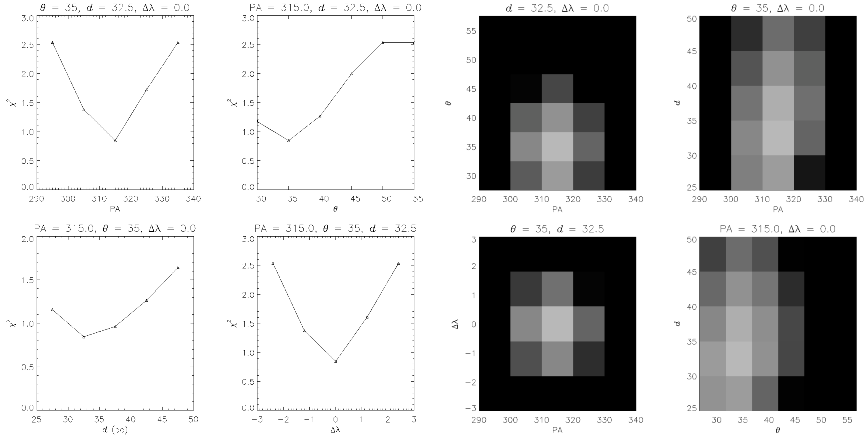


Synthetic image in Brγ produced by HDUST)



Fitting spectro-interferometry

4 free parameters - distance, i, PA, $\Delta\lambda$



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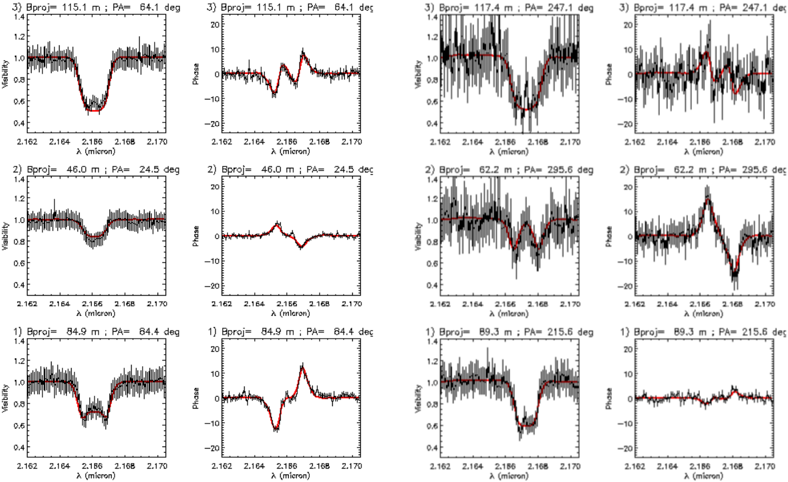
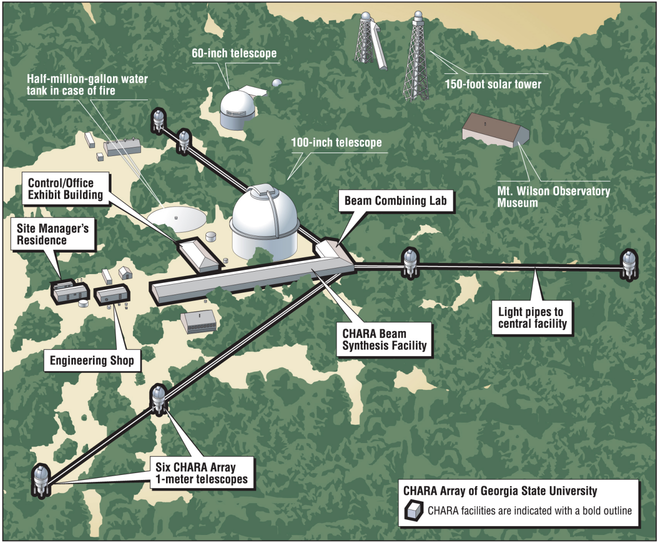


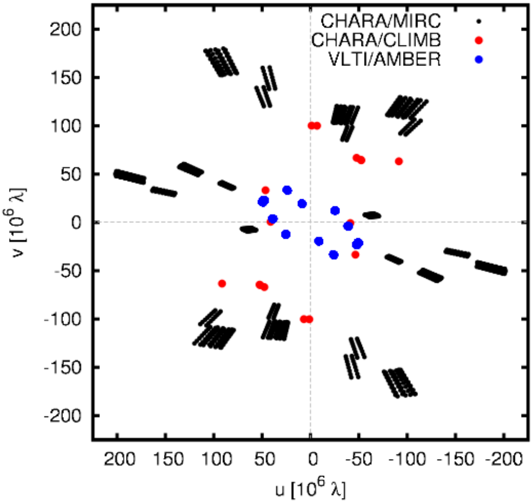
Center for High Angular Resolution Astronomy



Center for High Angular Resolution Astronomy

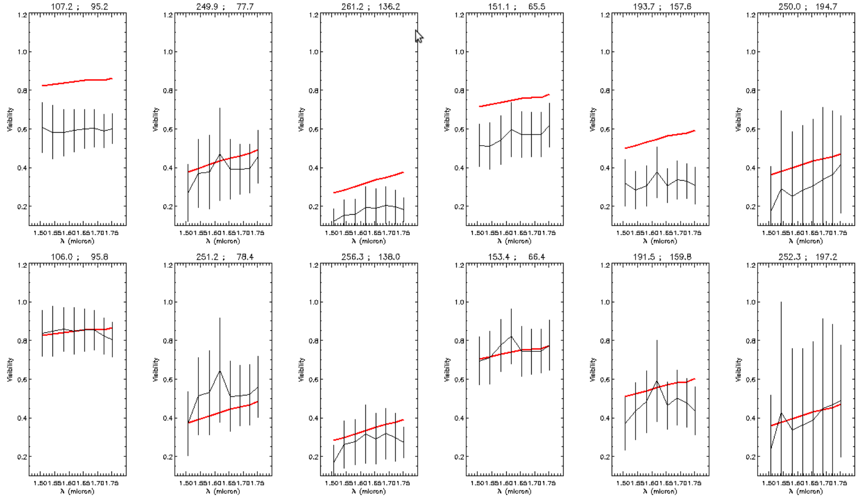
Mode	Telescopes	Band	Typical limit Mag=	Best performance Mag=	At Spectral Resolution R=
Acquisition	2	V-R	10.0	12.0	Broad band
Tilt tracking	2	V-R	10.0	12.0	Broad band
CLASSIC	2	H or K band	7.0	8.5	Broad band
CLIMB	3	H or K band	6.0	7.0	Broad band
VEGA (hi-res)	2 or 3	2 bands of 7nm (separation 30nm) in 480-850nm	4.0	5.0	30000
VEGA (med-res)	2 or 3	2 bands of 35nm (separation 160nm) in 480-850nm	6.5	7.5	6000
MIRC	6	H (K)	4.5 (3.0)	5.5 (4.0)	40
PAVO	2	630-900 nm	7.0	8.0	30

uv coverage of AMBER, MIRC and CLIMB observations



Kraus et al. 2012, ApJ 744, 19

LR CHARA/MIRC spectro-interferometry in H-band



Things to do...

- Include all data - APEX, CARMA, VLTI/PIONIER, VLTI/MIDI,...
- Obtain a perfect self-consistent model matching all the observations
- Use far-IR and radio fluxes to obtain the physical size of the disk

Thank you for your attention!