HD 195965: Voigt-Profile Broadening Analysis

Observed Hα spectral line

Fit the observed line with a Voigt profile

Gaussian component

σ_λ

Lorentzian component

γ_λ

Gaussian width in velocity units

$$\sigma_{v,\mathrm{obs}} = c\frac{\sigma_\lambda}{\lambda_0} = 128.3\ \mathrm{km\,s^{-1}}$$

Separate known broadening contributions

$$\sigma^2_{v,\mathrm{obs}} = \sigma^2_{\mathrm{th}} + \sigma^2_{\mathrm{rot}} + \sigma^2_{\mathrm{res}}$$

Thermal broadening

$$\sigma_{\mathrm{th}} = \sqrt{k_B T/m_H}$$

$14.7\ \mathrm{km\,s^{-1}}$

Rotational broadening

$$\sigma_{\mathrm{rot}} = K(\epsilon) v \sin i$$

$116.3\ \mathrm{km\,s^{-1}}$

Residual Gaussian broadening

$$\sigma_{\mathrm{res}} = \sqrt{\sigma^2_{v,\mathrm{obs}} - \sigma^2_{\mathrm{th}} - \sigma^2_{\mathrm{rot}}} = 52.4\ \mathrm{km\,s^{-1}}$$

HD 195965: Interpretation of the Residual Broadening

Residual Gaussian broadening

$$\sigma_{\rm res} = 52.4\ {\rm km\,s^{-1}}$$

Possible residual sources

$$\sigma^2_{\rm res} = \sigma^2_{\rm micro} + \sigma^2_{\rm macro} + \sigma^2_{\rm inst} + \sigma^2_{\rm puls} + \sigma^2_{\rm other}$$

Turbulence: micro / macro

B-star microturbulence: $\sigma_{\rm micro} \sim$ few ${\rm km\,s^{-1}}$

Macroturbulent / large-scale broadening can be tens of ${\rm km\,s^{-1}}$

Turbulence and decorrelation

$$C(\tau) \sim e^{-|\tau|/\tau_{\rm turb}} \Longrightarrow \text{Lorentzian-like spectral broadening}$$

Macroturbulent Mach number

$$c_s \simeq 24\ {\rm km\,s^{-1}}, \quad \mathcal{M}_{\rm macro} \simeq \frac{\sigma_{\rm macro}}{c_s}$$

If $\sigma_{\rm macro} \simeq \sigma_{\rm res}$: $\mathcal{M}_{\rm macro} \simeq 2.2$