Disk Time Evolution of the Be star HD 45725

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Introduction

Classical Be stars are B-type main sequence stars holding a geometrically thin equatorial quasi-Keplerian disk with a rotational velocity between 30% and 95% of their critical rotational velocity (Zorec et al. 2016). It's still under debate how the star transfers not only angular momentum, but also mass to the disk, but when the material is on the circumstellar orbit it is governed by viscosity (Lee et al. 1991).

HDUST

The code HDUST (Carciofi & Bjorkman 2006) is a NLTE Monte Carlo radiative transfer code capable of predicting observables from 3D circumstellar disk models. We use HDUST to model the disk of *HD 45725* using an ad-hoc volumetric density distribution as follows:

$$\rho(r,z) = \rho_0 \left(\frac{R_*}{r}\right)^m \exp\left(-\frac{z^2}{2H^2}\right) \quad ; \quad H(r) = H_0\left(\frac{r}{R_*}\right)^\beta \quad ; \quad H_0 = \frac{a}{v_{crit}} R_*$$

with r and z respectively being the radial and vertical positions within the disk, R_* as the equatorial radius of the star, ρ_0 as the density where $r = R_*$ and $z = 0$, m being a parameter which defines how quickly the density decreases with the increasing r, a being the sound speed of the disk, which is determined within the code from the temperature structure, and v_{crit} is the critical rotational velocity of the star.

Method used for modelling

In order to obtain an accurate model for the observed spectra, we fixed (the most part of) the stellar parameters based on previous works (Chauville et al. 2001, Arcos et al. 2018), and calculate a grid of models varying the disk parameters (ρ_0, R_{env}, m). This star have several observations, so in order to obtain better results we chose the most symmetrical spectra. Selected observations can be seen in Table 2.

HDUST models do not consider broadening due to electron scattering ocurring in the disk, then to quantify this effect, we implemented the same procedure than Marr et al. (2021) as follows: we assume a fraction f from $H\alpha$ flux to be affected by electron scattering with velocities ranging between 300 and 800 [km s^{-1}]. The scattered flux is modeled with a Gaussian profile. Therefore, a new line profile F_{new} is obtained by:

$$F_{new}(\lambda) = (1-f)F_{nc}\lambda + f \times F_c(\lambda) \tag{1}$$

where F_{nc} is the nonconvolved line profile predicted by HDUST and F_c is the convolution of F_{nc} with a Gaussian with FWHM of ν_e.

Fixed	
T_{pole}	20.9 $[kK]$
R_{pole}	4.32 $[R_\odot]$
M	6.62 $[M_\odot]$

Table 1. Adopted stellar parameters for the star HD45725

Disk parameters					
Date	m	$\rho\ [g\ cm^{-3}]$	$R_{env}\ [R_*]$	f	ν_e
2008-01-08	3.9	$1.38 \cdot 10^{-11}$	80	0.6	450
2008-02-02	3.0	$1.55 \cdot 10^{-11}$	80	0.6	450
2009-12-12	3.0	$1.38 \cdot 10^{-11}$	80	0.6	450
2011-01-15	3.0	$1.00 \cdot 10^{-11}$	120	0.6	380

Table 2. Best models for each observation date. Synthetic line profiles can be visualized in Figure 1.

Results

Figure 1 shows the best models from HDUST (blue solid line) in comparison with four observations of the Be star HD45725. The disk parameters are shown in Table 2. The disk maintains almost stable between 2008 and 2011, and the density slowly decays close to the stellar equator.

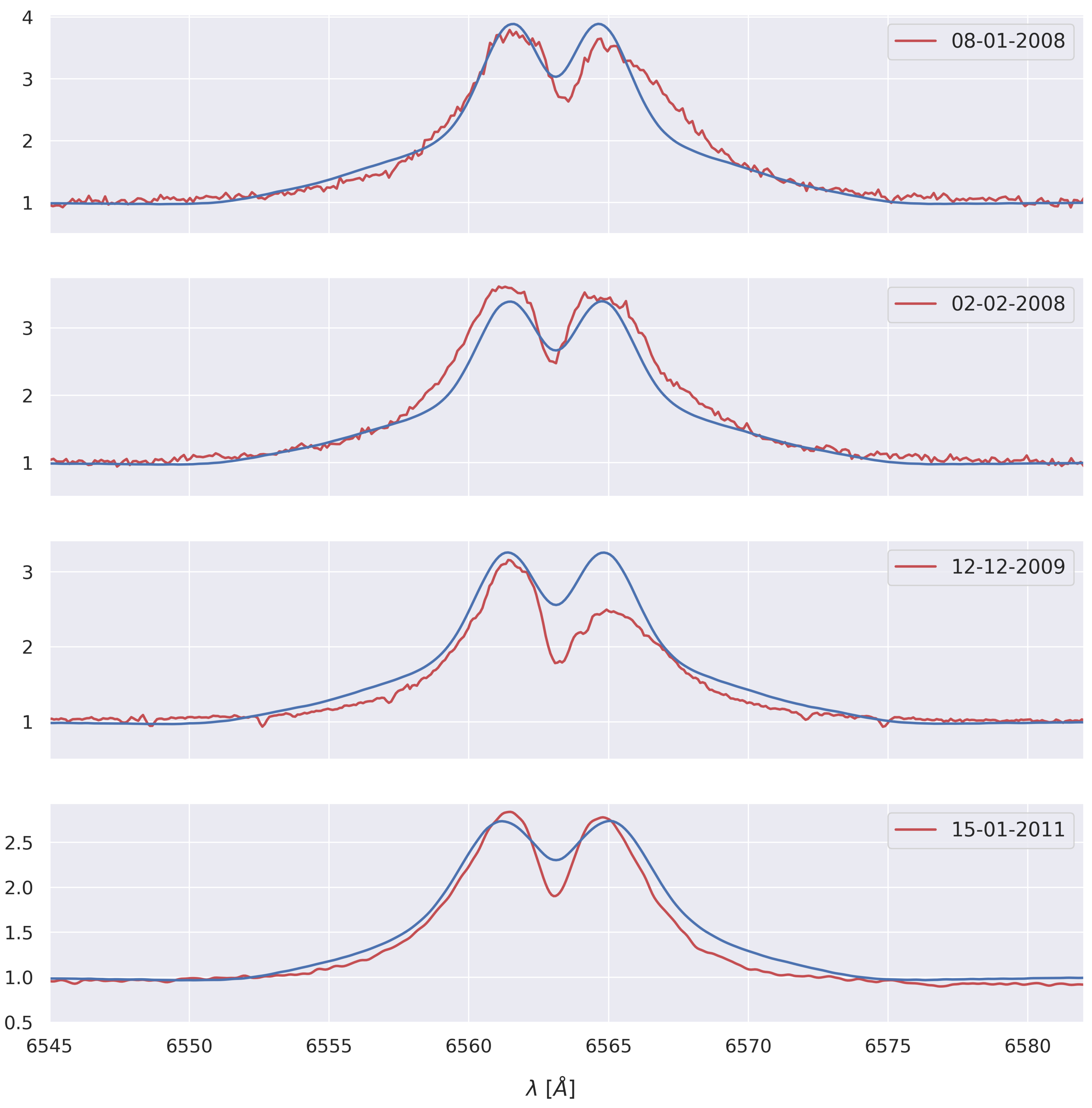

Figure 1. $H\alpha$ line-emission of different epochs (red solid line) and their corresponding best model from HDUST (blue solid line).

Future work

More models have to be done in order to improve these results. Also, we are currently working on the implementation of hydrodynamical solutions to describe the density contribution for fast-rotation stars with decretion disks in the code HDUST.

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