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Investigating the continuum linear polarization of Be stars

Robbie J. Halonen[1], **Frances E. Mackay**[1], **Carol E. Jones**[1], **and T. A. Aaron Sigut**[1]

[1]Dept. of Physics and Astronomy
The University of Western Ontario
London, ON, Canada
email: rhalonen@uwo.ca

Abstract. In order to understand the mechanisms that govern the development of circumstellar disks surrounding classical Be stars, we use computational codes to create theoretical models of these particular objects with their gaseous environments and we compare the predicted observables to astronomical observations. In this study, we present the use of the non-LTE radiative transfer code of Sigut & Jones (2007) to examine the effect of a self-consistent thermal structure and realistic chemical composition on the polarization of the classical Be star γ Cassiopeia. Primarily, we investigate the effect of several improvements on the pioneering work of Poeckert & Marlborough (1978) in calculating the polarization levels of γ Cas. We establish best-fit models for the same observations and analyze the implications of the differences between our results and those obtained by Poeckert & Marlborough.

Keywords. stars: emission-line, Be, methods: numerical, radiative transfer, polarization

1. Introduction

Observations of Be stars, through techniques such as photometry or spectroscopy, can be used to place important constraints on the geometry and density structure of their circumstellar disks. Non-zero polarization levels constitute a key observable for investigating the nature of Be stars, particularly for probing the geometric properties of the circumstellar environment. Along with observations, detailed modeling can be used to theoretically ascertain fundamental disk parameters. Computational modeling efforts began with the work of Poeckert & Marlborough (1978), hereafter PM. PM used a radiative transfer code to predict the polarization of γ Cas. Although their models were more or less ad hoc due to the complexity of the problem and the computational limitations at the time, PM's model was remarkably successful in predicting the polarization and other observables for the star.

2. Overview

Our calculations use the output level populations, temperature structure, and radiation field of the non-LTE radiative transfer code BEDISK developed by Sigut & Jones (2007) for the underlying model of the Be star disk. This computational code formally solves the coupled problems of radiative transfer, statistical equilibrium and radiative equilibrium to provide a self-consistent calculation of the thermal structure of the disk. The constructed disk is assumed to be axisymmetric about the stellar rotation axis and symmetric about the midplane and to have an initial density structure of the form $\rho = \rho_0(R/R_{star})^{-n}$ in

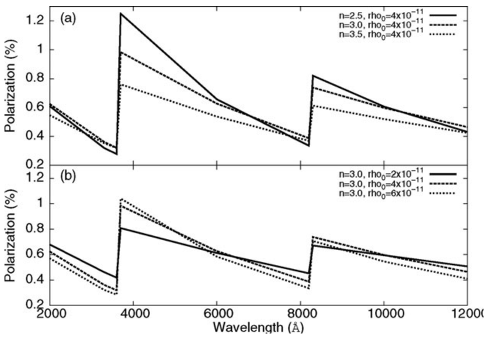

Figure 1. The effect of varying n and ρ_0 from the density equation are illustrated in the top and bottom graphs, respectively. These models include a self-consistent calculation of the thermal structure of the disk and the use of a realistic chemical composition.

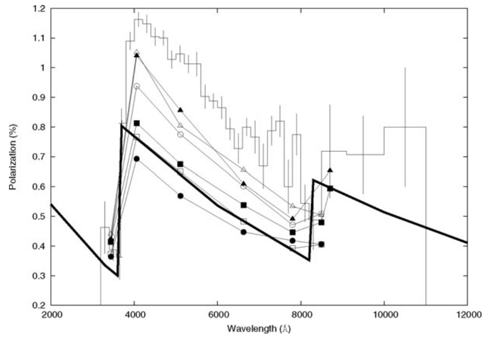

Figure 2. The thick line represents the best fit to the 1976 observations (open squares) modeled by PM. The fit is an improvement over that of PM whose model predicted consistently higher levels than measured. See Mackay *et al.* (2010) for further discussion.

the equatorial plane. The gas is taken to be in vertical, hydrostatic, isothermal equilibrium perpendicular to the plane of the disk. The net polarization of the disk is determined by integrating the Stokes parameters at individual grid points along lines of sight through the disk, with the results summed over the projected area of the disk. The use of the BEDISK code in providing the necessary inputs into the polarization computation allows us to significantly improve PM's method with regards to both the state of the gas and the extent of computational sampling used throughout the disk.

3. Results and Future Work

The most notable improvements of the BEDISK code are the inclusion of self-consistent calculation of the thermal structure of the disk and the use of a realistic chemical composition for the enveloping gas. The profound effect that these improvements have on the thermal structure of the disk significantly affect the level populations and the number of scatterers present in the disk and, therefore, influence the predicted polarization. Furthermore, the BEDISK code uses an increased number of grid points, both in the disk and on the star, in order to improve the accuracy of the solution. Our access to PM's code provides us with the unique opportunity to investigate the effect that various computational parameters have on the polarization result published by PM. For a full discussion of the results of our study, see Mackay *et al.* (2010).

We are currently investigating the influence of line effects and line blanketing on the continuum polarization. Furthermore, we hope to include the process of multiple scattering into our calculations. Lastly, we are preparing an extensive study of the correlations between the continuum linear polarization and other principal observational features of Be stars.

References

Mackay, F. E., Halonen, R. J., Jones, C. E., Bjorkman, K. S., Sigut, T.A.A. & Meade, M. R. 2010, *ApJ*, submitted

Poeckert, R. & Marlborough, J. M. 1978, *ApJ*, 220, 940

Sigut, T. A. A. & Jones, C. E. 2007, *ApJ*, 668, 481

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