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A Connection Between V/R and Polarization in Be Stars

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Abstract. Okazaki (1991) and Papaloizou, Savonije, & Henrichs (1992) suggested that the quasi-cyclic V/R variability observed in the emission line profiles of many Be stars is caused by a precessing one-armed density wave in the circumstellar disk. It seems likely that the changing aspect of such a non-axisymmetric density pattern might also lead to a related variation of the continuum polarization. We have searched for such an effect in two well-studied Be shell stars, ζ Tau and 48 Lib, based on data compiled from several groups of observers from 1984 to 1998. Using the Monte Carlo radiation transfer code of Wood, Bjorkman, Whitney, & Code (1996), we have calculated the polarization due to electron scattering in Be disks in the presence of one-armed density perturbations. Although the notorious long and short term deviations from strict periodicity present in Be stars make it difficult to rigorously demonstrate the connection between the V/R variability and the polarization variations, we have been able to find specific modes that are consistent with the observed V/R line profile variations together with the suspected polarization cycles.

1. ζ Tau

The collected B-band polarization and Hα V/R data on ζ Tau were searched for periodicities using the Scargle periodogram method, and no statistically significant results were found. However, based on some prominent periodogram peaks and the symmetry involved, we chose a period of 2.2 yr for p and 4.4 yr (twice the polarization period) for V/R, as shown in the left panel of Figure 1. The theoretical results shown in the right panel of Figure 1 were obtained using the kidney-shaped neutral one-armed density perturbation illustrated in Figure 2 to calculate the line profiles and the polarization. This model successfully

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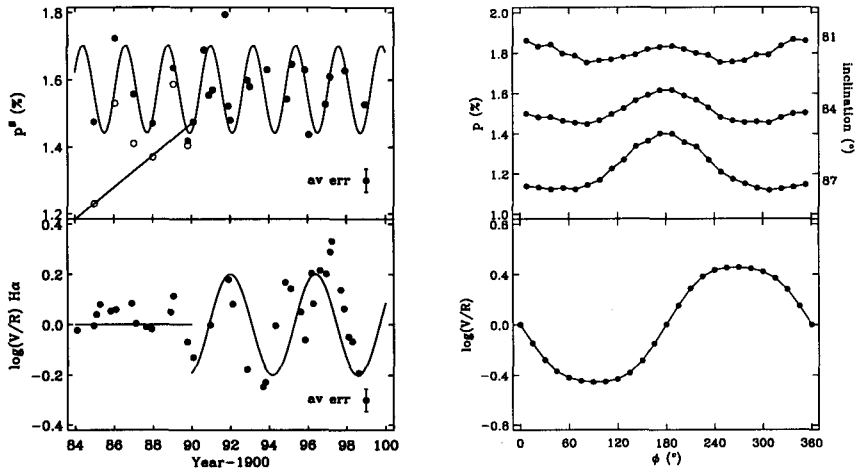

Figure 1. Left: Observations of ζ Tau. Right: Model fit to the observations for 3 different inclinations (one cycle shown).

reproduces both the 2:1 period ratio and the phase relationship between p and V/R (note that polarization minima correspond to extrema of V/R).

2. 48 Lib

Our investigation of 48 Lib followed the same general procedure outlined above for ζ Tau, with the extra step of removing a non-negligible interstellar polarization. We chose periods of 4.2 yr and 8.4 yr for p and V/R, again based on prominent peaks in the Scargle periodograms and on symmetry. The data and the model fit are shown in Figure 3. An additional complication in this case was the relative phase of p and V/R, which required a spiral-shaped unstable density perturbation for the fit (see Figure 4).

3. Conclusions

An unfortunate limitation to this study is that the variability of Be stars includes multiple modes and is rarely, if ever, strictly periodic. This makes any analysis of long-term periodicities especially difficult due to the effect of other variations occurring on shorter time scales. We have, however, found specific modes consistent with the observed V/R line profile variations together with the suspected polarization cycles.

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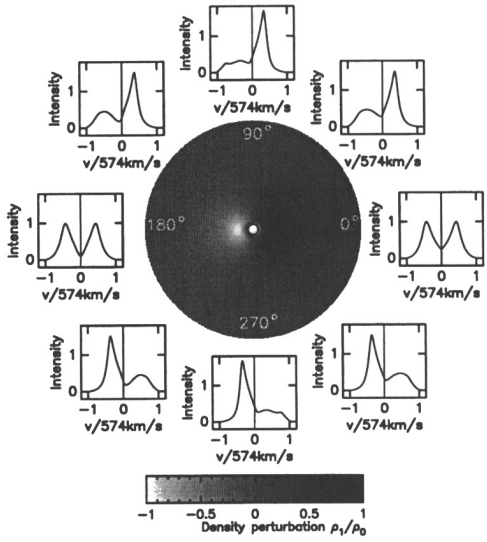

Figure 2. Disk perturbation model for ζ Tau.

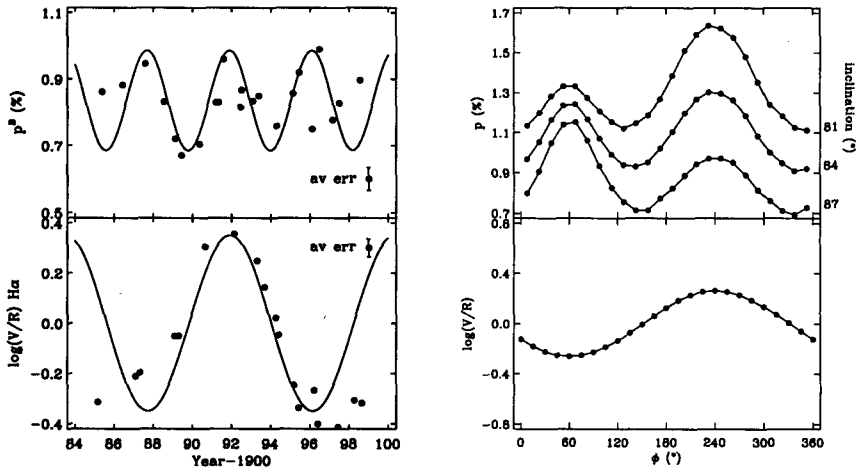

Figure 3. Left: Observations of 48 Lib. Right: Model fit to the observations for 3 different inclinations (one cycle shown).

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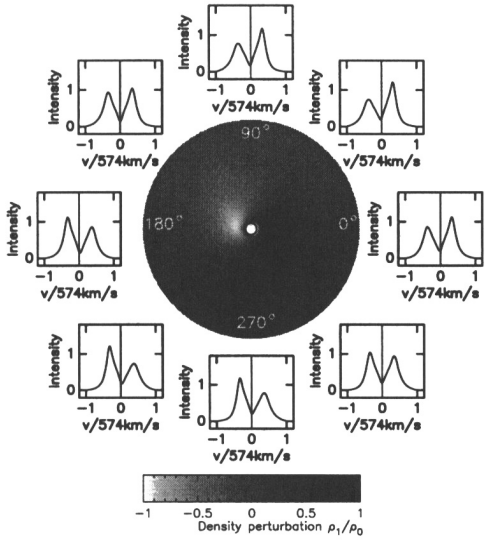

Figure 4. Disk perturbation model for 48 Lib.

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