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Hα spectropolarimetry of GG Car

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Abstract. We present spectropolarimetric observations of the B[e] supergiant star GG Car at two epochs. Polarization line effects along Hα are analysed using the Q–U diagram. In particular, the polarization position angle (PA) obtained using the line effect allows to constrain the symmetry axis of the disk/envelope. The depolarization line effect around Hα is evident in the Q–U diagram for both epochs, confirming that light from the system is intrinsically polarized. A rotation of the PA along Hα is also observed, indicating a counter-clockwise rotating disk. The intrinsic PA calculated using the line effect ($\sim$85°) is consistent between our two epochs, suggesting a clearly defined symmetry axis of the disk.

Keywords. polarization, stars: individual (GG Car), circumstellar matter

1. Introduction

Early studies of GG Car (Pickering 1896, Pickering & Fleming 1896) showed that it displayed a peculiar spectrum with strong emission lines. McGregor *et al.* (1988) identified CO absorption bands along with characteristics of the B[e] phenomenon, which include strong Balmer lines in emission, low excitation permitted emission lines (e.g. FeII), forbidden emission lines (e.g. [FeII] and [OI]), and strong infrared excess (Zickgraf 1998). Lamers et al. (1998) classified this object as a Galactic B[e] supergiant (sgB[e]) based on estimates of its effective temperature and luminosity. Previous optical broadband long-term polarization variability (e.g. Gnedin et al. 1992) indicates that GG Car does have intrinsic polarization, which probably originated in light scattering off one of the binary components or a variable circumstellar disk/wind. Spectropolarimetry is a powerful tool because it provides insight into stellar envelopes where scattering opacities exist without the need to resolve the envelope (Magalhães *et al.* 2006). In this sense, it yields additional information about the envelope geometry and the structure of the line formation region.

2. Observations and results

The observations were performed during 2 runs in 2006 April and May using the 1.6m telescope at the Observatório do Pico dos Dias (OPD-LNA), Brazil. We used IAGPOL, the IAG imaging polarimeter (Magalhães *et al.* 1996), installed in the Eucalyptus-IFU spectrograph. This setup provides a spectral range of $\sim$600 Å around Hα and a resolution R=4000, or $\sim$0.3 Å/pixel.

Our Hα spectropolarimetry is shown in Fig. 1 for our 2 epochs. Significant changes in the polarization level and its PA, indicative of a detected line effect, are observed across the Hα emission for both dates, which suggests that intrinsic polarization in GG Car is present. The $Q-U$ diagrams show the line effect evident around the emission line. In 2006 Apr., the line effect is consistent with depolarization showing a linear excursion that points approximately to the (Q,U) coordinates origin. On the other hand, the 2006 May

† In memoriam

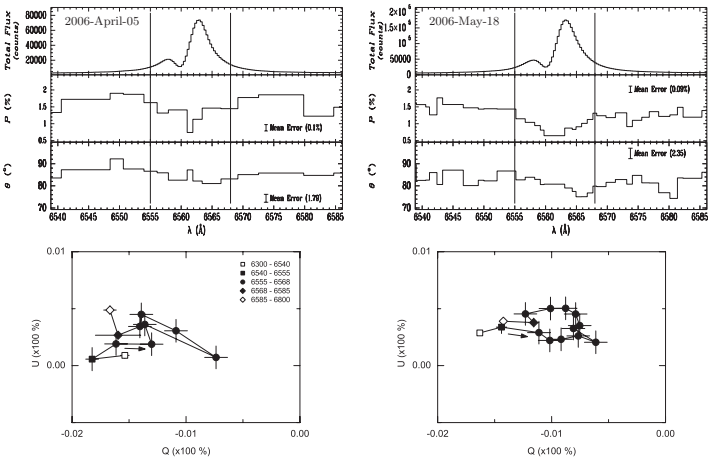

Figure 1. Spectropolarimetry of GG Car around Hα at 2 epochs. *Top*: The vertical lines indicate the region where the line effect is evident. The spectra show the total flux (top), polarization (middle), and polarization PA (bottom) binned using a variable bin size with a constant polarization error (per bin) of 0.1%. *Bottom.*: $Q-U$ diagram showing the line effect (black dots). Arrows indicate the direction in which the wavelength increases. Mean values before and after the line effect are also shown (see symbols).

data also exhibit depolarization but with a clearly defined PA rotation, which resembles a mix between a loop and a linear excursion. The non-detection of the loop in the 2006 Apr. data may be due to the lower signal-to-noise ratio in this measurement. Interestingly, the direction in which the wavelength increases around the line effect has the same sense in our 2 epochs. This direction is such that if a disk exists around GG Car it must rotate counter-clockwise as seen by an observer on Earth (Poeckert & Marlborough 1977).

To determine the intrinsic PA (PA_{int}), we completed a linear fit to the points that display the line effect in the $Q-U$ diagram. The PA_{int} values are practically identical ($\sim 85°$) during our 2 epochs considering the individual errors and represents a clearly defined symmetry axis for the disk. If this is true, the PA_{int} will be perpendicular or parallel to the disk plane depending on whether we have an optically thin or optically thick disk, respectively (Vink *et al.* 2005). Consistent with this issue, VLTI/MIDI interferometry (Domiciano de Souza 2009, priv. comm.) also detects a disk plane close to being perpendicular to our PA_{int} indicative of an optically thin disk.

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