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INVESTIGATING THE SPECTROSCOPIC, MAGNETIC AND CIRCUMSTELLAR VARIABILITY OF HD 57682

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Abstract. The O9IV star HD 57682, discovered to be magnetic within the context of the MiMeS survey in 2009, is one of only eight convincingly detected magnetic O-type stars. Spectropolarimetric observations were combined with Hα spectroscopy data mainly coming from amateurs observations. This dataset was used to determine the rotational period, refine the longitudinal magnetic field variation and magnetic geometry.

Keywords: stars: individual HD 57682, stars: magnetic fields, stars: circumstellar matter, stars: rotation, stars: winds, outflows, techniques: polarimetric, professional-amateur collaboration

1 Introduction

In 2010, the O9IV star HD 57682 was one of only eight convincingly detected magnetic O-type stars. These small numbers are both a reflection of the rarity of O-type stars with detectable magnetic fields, and the challenge of detecting such fields when present. The present study seeks to refine and elaborate the preliminary results reported by Grunhut et al. (2009).

Since 2007, a long-term French campain for Be stars (including O-type candidates) has been initiated with the launch of the BeSS database (Bouvier et al. 2007). In this context, in February 2010, Coralie Neiner (GEPI, Paris-Meudon obsevatory) sent a request to amateurs for spectroscopic monitoring of HD 57682 on the Hα line during a MOST satellite run. However, abrupt changes in the line studied prompted us to contact J. Grunhut*, lead author of HD 57682 magnetism discovery paper (Grunhut et al. 2009). It was then the beginning of a survey of nearly a year that resulted in an article that appeared in 2012 in MNRAS (Grunhut et al. 2012).

2 Data and observations

Spectropolarimetric observations were mainly collected with the high-resolution ($R \sim 68\,000$) ESPaDOnS spectropolarimeter from which mean average profiles were extracted. Additional spectroscopic data come from the ESO CES and mostly from amateur LHIRES3 ($R \sim 15\,000$) spectra stored in BeSS database. Dynamic spectra (Fig 1) show signs of periodicity.

In order to characterize such periodic behaviour and its origin, surface line-of-sight component B_ℓ of the magnetic field values were obtained by measuring the first-order moment of the Stokes V profile from spectropolarimetric observations, normalized by the intensity profile. The dipole magnetic field strength B_d was then determined from comparing the B_ℓ curve to a grid of models as described in the results section.

On the other hand, period analysis of Hα EW and B_ℓ enable an accurate rotation period measurement. Hα EW and V_{radial} measurements were primarily coming from BeSS observations of HD 57682 fed by amateurs (51 out of 67 spectra). Thus an ephemeris was computed. It was based on rotation period computed from periodogram and $HJD0$ corresponds to B_ℓ maximum: $\mathrm{HJD}_{B_\ell}^{max} = 2453347.71(35) + 63.5708(57) \cdot E$

All Hα EW and B_ℓ measurements are reported in Fig. 1 as well as Hipparcos photometry where amateurs contribution, 51 out of 67 spectra, are green down-facing triangles.

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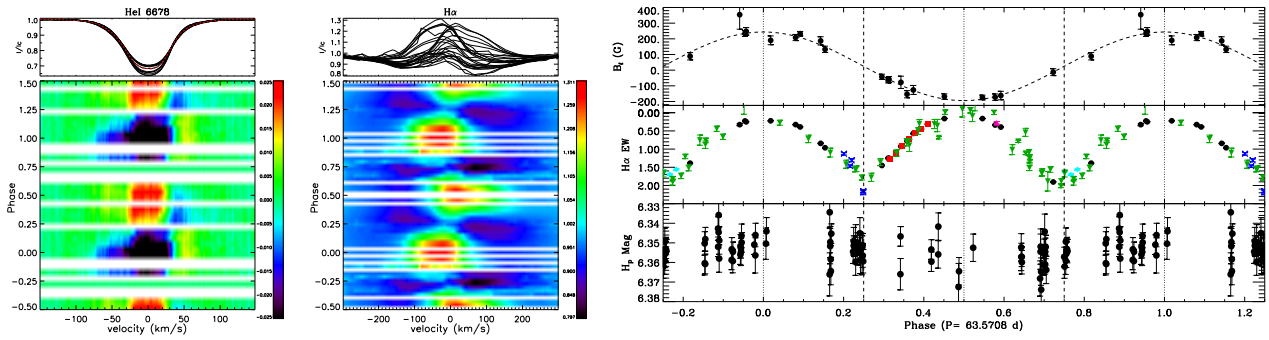

Fig. 1. Left panel: Phased variations in selected spectral lines with sinusoidal equivalent width variations. **Center panel:** Same as left panel but for Hα line here that show evidence of two emission features per rotation cycle. Red spots highlight the circumstellar emission. Phased observational data using the computed ephemeris.
Right panel: *Upper:* Longitudinal magnetic field variations measured from mean average profiles of the ESPaDOnS spectra. *Middle:* Hα EW variations measured from ESPaDOnS (black circles), CES (red squares), FEROS (blue Xs), Las Campanas Observatory (turquoise diamonds), UVES (pink up-facing triangles), and BeSS (green down-facing triangles) datasets. *Lower:* Hipparcos photometry. The dashed curve in the upper frame represents a least-squares sinusoidal fit to the data.

3 Results

From this new data set, it was possible to constrain the rotation period to 63.5708 ± 0.0057 d, to examine the variations of several lines and to refine the geometry of the longitudinal magnetic field coming from a dipole almost perpendicular ($79 \pm 4°$) to the axis of rotation and intensity 900 ± 60 G. Moreover, the modeling of the variations of the Hα line shows that its emissions are generated by an equatorial ring of optically thick plasma and confined by the stellar magnetic field.

Hα emission variation is often attributed to the variable projection of a flattened distribution of magnetospheric plasma. To this end, we explored the potential of using a "Toy" model to fit the observed Hα EW variations. This model lead us to confirm Hα EW behaviour by an equatorial disc (Fig. 2).

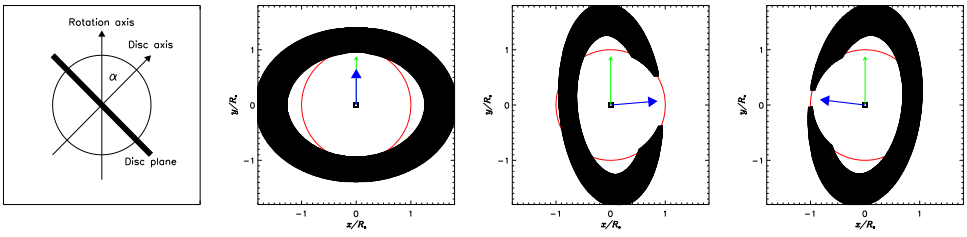

Fig. 2. Illustration of our "Toy" model for the Hα emission disc. The left panel provides an example schematic diagram showing the orientation of the plane of the disc for a given disc inclination α relative to the rotation axis. The other panels represent projections of the disc (solid black) and central star (solid red) onto our line-of-sight during phases 0.0, 0.33, and 0.66.

4 Conclusion

Our investigation have allowed us to study HD 57682's magnetic and magnetospheric properties at a level of detail not currently achievable for any other magnetic O-type star. Our analysis indicate a highly complex behaviour that can be used as a testbed for future 3D MHD simulations to better understand non-rotationally supported magnetospheres.

References

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