Active OB stars: structure, evolution, mass loss, and critical limits
Proceedings IAU Symposium No. 272, 2010
C. Neiner, G. Wade, G. Meynet & G. Peters, eds.

doi:10.1017/S1743921311010350

Discovery of a strong magnetic field in the rapidly rotating B2Vn star HR 7355

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Abstract. We report on the detection of a strong, organized magnetic field in the helium-variable early B-type star HR 7355 using spectropolarimetric data obtained with ESPaDOnS on CFHT by the MiMeS large program. We also present results from new V-band differential photometry obtained with the CTIO 0.9m telescope. We investigate the longitudinal field, using a technique called Least-Squares Deconvolution (LSD), and the rotational period of HR 7355. These new observations strongly support the proposal that HR 7355 harbors a structured magnetosphere similar to that in the prototypical helium-strong star, σ Ori E.

Keywords. stars: magnetic fields, stars: rotation, stars: early-type, stars: circumstellar matter, stars: individual (HR 7355), techniques: polarimetric

1. Introduction

HR 7355 (HD 182180) is a bright B2Vn helium-strong star originally classified as a Be star due to Hα emission present in its spectrum (Abt & Cardona 1984). Previous studies of this star show a $v \sin i \sim 300$ km s^{-1} (Abt *et al.* 2002) with a $P_{\rm rot} \sim 0.52$ d (Koen & Eyer 2002), as well as variation in helium, Hα, and brightness, suggesting the presence of a magnetosphere (Rivinius *et al.* 2008). HR 7355 is the most rapidly rotating helium-strong star, rotating near its critical velocity, providing an excellent testbed for magnetospheres under the effects of rapid rotation.

2. Method

Least-Squares Deconvolution (LSD) describes the stellar spectrum as the convolution of a mean Stokes I or V profile, representative of the average shape of the line profile, and a line mask, describing the position, strength and magnetic sensitivity of all lines in the spectrum. From the LSD mean Stokes I and V profiles, we calculate the longitudinal magnetic field, B_ℓ:

$$B_\ell = -2.14 \times 10^{11} \frac{\int vV(v)dv}{\lambda gc \int [1 - I(v)]dv} \tag{2.1}$$

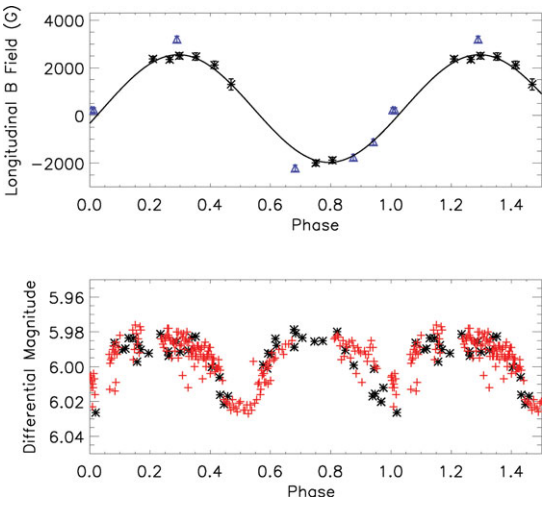

Figure 1. Top: Longitudinal magnetic field measurements for HR 7355 and the best-fit first order sine curve. Oksala *et al.* (2010) (asterisks) and Rivinius *et al.* (2010) (diamonds) with 1 σ error bars. Bottom: The V-band photometric light curve for HR 7355 including both HIPPARCOS photometry (asterisks) and new CTIO data (plus signs).

(Wade *et al.* 2000), where λ is the average wavelength and g is the average Landé factor in the mask. I_c is the continuum value of the intensity profile. The integral is evaluated over the full velocity range of the mean profile.

3. Results

We detect a strong magnetic field on HR 7355, the most rapidly rotating helium-strong star discovered thus far. A simultaneous independent confirmation of the field detection has been obtained with FORS at the VLT by Rivinius *et al.* 2010. The longitudinal magnetic field varies sinusoidally with the rotation period, with extrema -2 to 2.5 kG. Assuming a dipole magnetic field, the polar value of the magnetic field is $\sim$ 13-17 kG. The photometric (brightness) light curve constructed from HIPPARCOS archival data and new CTIO measurements shows two minima separated by 0.5 in rotational phase and occurring 0.25 cycles before/after the magnetic extrema. Using the Scargle periodogram, eclipse-like photometric variations give a highly precise P_{rot} = 0.5214404(6) days. We confirm spectral variability of helium and metal lines, as well as variability of Hα emission. Hα emission indicates circumstellar material extending out to 5 $R_\star$ from the star, rotating rigidly with the stellar surface. We conclude that HR 7355 is a magnetic oblique rotator with a magnetosphere, mirroring the physical picture for σ Ori E (Townsend *et al.* 2005).

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https://doi.org/10.1017/S1743921311010350 Published online by Cambridge University Press