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HD 156324: A Tidally Locked Magnetic SB3 With an Orbitally Disrupted Centrifugal Magnetosphere

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Abstract. Period analysis of radial velocity, equivalent width, and magnetic measurements of the SB3 system HD 156324 yield identical results in all cases, indicating the system is tidally locked with orbital and rotational periods of 1.58 d. Its Hα emission profile exhibits marked morphological departures from the usual pattern observed amongst magnetic B-type stars, which can plausibly be ascribed to tidal disruption of the gravitocentrifugal potential.

Key words: stars: individual: HD 156324 – stars: magnetic field – binaries: spectroscopic – binaries (including multiple): close – stars: massive

HD 156324 is a triple Spectroscopic Binary (SB3) system (Alecian et al., 2014) in the Sco OB4 association (Kharchenko et al., 2005), consisting of a He-strong B2V primary, a B6V secondary, and a PGa B6V tertiary; since the system is a hierarchical triple we designate these components Aa, Ab, and B, respectively. The primary (Aa) has a strong magnetic field, and displays Hα emission indicative of a Centrifugal Magnetosphere (CM; Petit et al. 2013). We have obtained a large dataset of high-resolution ESPaDOnS spectropolarimetry and FEROS spectroscopy with which to determine the system's orbital, rotational, and magnetic properties.

Radial velocities (RVs) were measured from the Mg II 448.1 nm line, in which all three components are clearly detected, using a parametric fitting algorithm described by Grunhut et al. (2017). The RVs of the He-strong star and the secondary vary in antiphase, as expected. Frequency analysis of the Aab RVs using Lomb-Scargle statistics yields a period of 1.5805(10) d, which we take to be the orbital period $P_{\rm orb}$. The same analysis of the B component's RVs yields two significant periods: one around 2 years, and the second of 6.67(2) d. We interpret the short-term variation as orbital motion with an undetected, lowmass fourth star, and the long-term variation as the orbit of the B sub-system around the more massive A sub-system.

The longitudinal magnetic field $\langle B_z \rangle$ of the Aa component was evaluated from Least-Squares Deconvolution (LSD; Kochukhov et al. 2010) profiles which we disentangled using the iterative process described by González & Levato (2006) so as to remove the contributions of Ab and B from the Stokes I profiles. $\langle B_z \rangle$ varies between 0 and 3 kG, with a typical uncertainty of ∼300 G. Period analysis of $\langle B_z \rangle$ yields a rotational period $P_{\rm rot} = 1.5804(3)$ d, identical within uncertainty to $P_{\rm orb}$.

Since the magnetospheric Hα emission should also be modulated with $P_{\rm rot}$, we measured the Hα equivalent width, and found $P_{\rm rot} = 1.5806(3)$ d, again identical within uncertainty to $P_{\rm orb}$. We infer that Aab is tidally locked. Consistent with this, the eccentricity $e \sim 0$, the rotational and orbital inclination angles are both about 25°, and the semi-major axis and Kepler corotation radius are both at about 3 R_*.

The Hα emission is notable in that it shows only a single emission bump, i.e. there is evidence for only one plasma cloud, whereas two are expected theoretically (Townsend & Owocki, 2005), and invariably observed in CM-host stars (Petit et al., 2013). Maximum RV separation of the Aab components occurs at the same phase as maximum Hα emission, indicating that the plasma cloud and the Ab component are directly opposite one another, i.e. Ab occupies the expected position of the missing cloud. This suggests that modification of the gravitocentrifugal potential by the presence of a close companion may explain the missing emission cloud.

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