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THE MAGNETIC FIELD OF THE HOT SPECTROSCOPIC BINARY HD 5550

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Abstract. HD 5550 is a spectroscopic binary composed of two A stars observed with Narval at TBL in the frame of the BinaMIcS (Binarity and Magnetic Interactions in various classes of Stars) Large Program. One component of the system is found to be an Ap star with a surprisingly weak dipolar field of ∼65 G. The companion is an Am star for which no magnetic field is detected, with a detection threshold on the dipolar field of ∼40 G. The system is tidally locked, the primary component is synchronised with the orbit, but the system is probably not completely circularised yet. This work is only the second detailed study of magnetic fields in a hot short-period spectroscopic binary. More systems are currently being observed with both Narval at TBL and ESPaDOnS at CFHT within the BinaMIcS project, with the goal of understanding how magnetism can impact binary evolution and vice versa.

Keywords: stars: individual: HD 5550, stars: early-type, stars: magnetic field, binaries: spectroscopic, stars: chemically peculiar

1 Observations of HD 5550

HD 5550 is a spectroscopic double-line (SB2) binary system composed of two A-type components (Carrier et al. 2002). HD 5550 was previously reported to be an Ap SrCrEu star (Renson et al. 1991). Carrier et al. (2002) also reported that the secondary has chemical peculiarities, but they could not distinguish more precisely the peculiar type of this component.

We observed HD 5550 in the frame of the BinaMIcS (Binarity and Magnetic Interactions in various classes of Stars) project, with the goal to understand the interplay between magnetism and binarity (see Neiner et al., these proceedings). Twenty-five high-resolution spectropolarimetric observations were obtained with Narval at the Bernard Lyot Telescope (TBL, Pic du Midi, France) and were used to check for the presence of a magnetic field in both components.

We first disentangled the spectra of the two components to be able to analyse them separately. The binary orbit has a period $P_{\rm orb} = 6.82054$ d (Carrier et al. 2002) and is almost circularised with an eccentricity e=0.005. We then used Zeeman and Atlas9 LTE models on the disentangled spectra to derive the stellar parameters of both components: we confirmed that the primary component is an Ap star and found that the secondary is an Am star, with overabundance of the iron-peak elements, extreme overabundance of Ba, and underabundance of Ca. Finally, we applied the Least-Square Deconvolution (LSD) technique to produce averaged Stokes I and V spectra of each component and we measured the magnetic field in both stars.

2 Magnetic results

2.1 Primary Ap star

We found that the primary Ap star is magnetic with clear Zeeman signatures (see Fig. 1). The longitudinal field B_l values are systematically negative and vary from -26 to -12 G, with typical error bars of 4 G.

From the variations of the Stokes V profiles, and the corresponding B_l values, we found that the field is modulated by the rotation period $P_{\rm rot} \sim 6.84$ d. This period is compatible with the orbital period $P_{\rm orb} \sim 6.82$ d, i.e. the rotation of the star is synchronised with the binary orbit.

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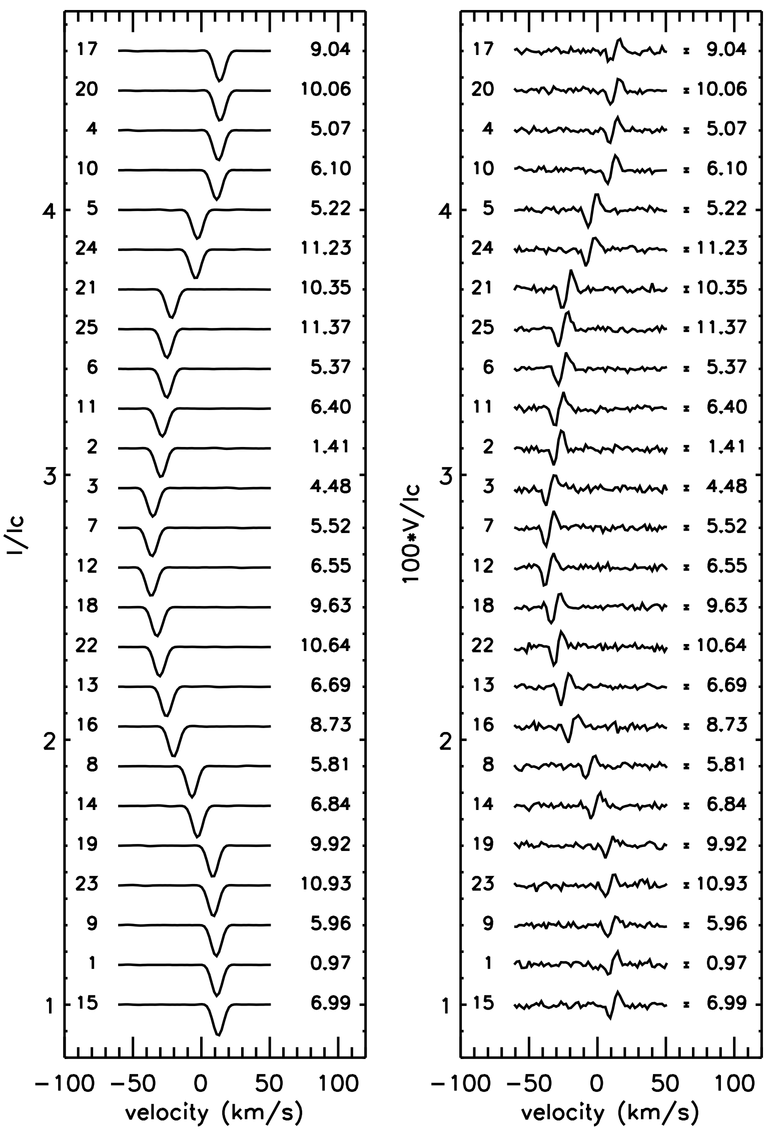

Fig. 1. LSD I/Ic (left) and V/Ic (right) profiles of the primary component of HD 5550, ordered by increasing orbital phase. Taken from Alecian et al., submitted to A&A.

An oblique dipole model of the Zeeman signatures shows that the polar field strength is only $B_{\rm pol} = 65 \pm 20$ G, with an inclination $i \sim 32°$ and an obliquity $\beta \sim 156°$. This is the weakest magnetic field known in an Ap star. Indeed, typical magnetic field strengths in Ap/Bp stars are of the order of 1 kG, with a range between 300 G and 30 kG (e.g. Borra & Landstreet 1980; Landstreet 1992; Bagnulo et al. 2006). The dipolar field value of HD 5550 falls in the dichotomy desert proposed by Aurière et al. (2007) between strong and ultra-weak fields.

2.2 Seconday Am star

We did not detect a magnetic field in the secondary Am star. The longitudinal field values we measured by integrating the LSD I and V profiles are all consistent with 0 G, with uncertainties of 3-4 G.

To determine the upper limit on the possible undetected magnetic field of the secondary star, we first fitted the LSD I profiles with Gaussian profiles. We then computed 1000 synthetic Stokes V profiles for various values of the polar magnetic field $B_{\rm pol}$. Each of these models uses a random inclination angle i, obliquity angle β, and rotational phase. We added a white Gaussian noise to each modeled profile with a null average and a variance corresponding to the signal-to-noise of the observed profile. We then computed the detection probability of a magnetic field as a function of $B_{\rm pol}$ for each observation, and combined them to obtain the detection probability function for the full dataset. Above a 90% detection probability, we consider that we would have detected the field in our dataset. We therefore established that the upper limit of the magnetic field of the secondary Am component, which could have remained hidden in our observations, is ∼40 G.

Only a few Am stars are known to host a magnetic field so far and all of them have ultra-weak fields, with longitudinal components of less than 1 G (Petit et al. 2011; Blazère et al. 2015). If such an ultra-weak field were present in the Am component of HD 5550, it would have remained undetected in our observations.

3 Conclusions

Spectropolarimetric Narval observations of HD 5550 showed that it is a binary system composed of a weakly magnetic Ap star and an Am star found to be non-magnetic with the achieved precision. With HD 98088 (Folsom et al. 2013), this is the second hot magnetic spectroscopic binary studied in details. Studying more hot magnetic binaries, which is one of the goals of the BinaMIcS project, will allow us to understand the interplay between magnetism and binarity in hot systems.

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