DRAWING THE TREASURE MAP: DISENTANGLING THE STRUCTURE OF THE MAGNETIC FIELD OF THE SYSTEM BD+20 1790

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ABSTRACT

In this contribution we present the preliminary results of the study of the structure of the magnetic field of the system BD+20 1790 and its close-in gigant planet.
Previous results show a high level of stellar activity, with the presence of prominence-like structures, spots on the surface and strong flare events, despite the moderate rotational velocity of the star.
The presence of the planet could be an interpretation for these, in terms of stellar-planet interactions (SPI) theory.
To study the stellar activity we have carried out both echelle spectroscopic and photometric monitoring over the past few years.

The aim of this work is to map the active regions at different atmospheric levels. The simultaneous study of photospheric and chromospheric active regions is a powerful tool that allows us to trace, reconstruct and model the puzzle of the magnetic field topology since the structure of a magnetic flux tube breaking into the stellar atmosphere is traced by the configuration of these active regions at the different levels.

In short, studying and drawing the map of the magnetic field of this system will enlarge our understanding of SPI, as well as stellar magnetism and activity.

Stellar prominences provide unique probe of stellar magnetic fields out to distances of several radii into the corona and can therefore be compared to other tracers of coronal extent like X-rays observations. Also their spatial distribution provides us with a valuable diagnostic of the complexity of the coronal field topology.

Through studying the profile line asymmetries of Hα and Hβ lines, prominences-like structures were detected in the chromosphere of the star (Hernán-Obispo 2005, 2007). These can be observationally detected as transients migrating across the emission line profile, that are interpreted as cool material embedded in the surrounding hotter corona and co-rotating with the star (Cameron & Robinson 1989 a,b, Byrne et al. 1996).

Modelling these chromospheric phenomenae is an important challenge in this case, because of the detection of these prominence-like structures in unstable positions, far from equatorial regions (Jadine 2001).
Prominences could be supported considerably above the stellar equator if the field had a strong quadrupole component .Due to the low vsini, and the strong dynamo that one might expect to generate this component, we explore the relation between SPI and the presence of prominences.

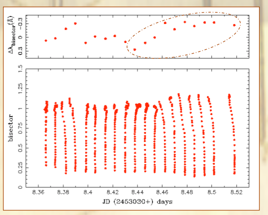
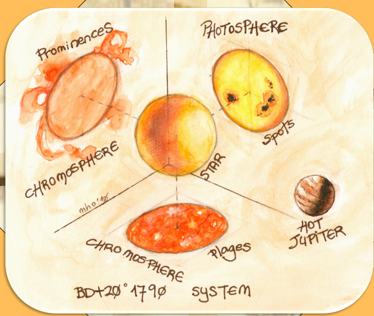


Fig.1 . Bisector of the subtracted spectra of Hα line. The dashed ellipse marks the prominence transit. The time of the transit was about 2h.



Strong chromospheric activity was detected in several observing runs (Hernán-Obispo 2005, 2007, 2010). All these activity indicators are in emission above continuum, from Ca II H&K to Ca II IRT lines. The wide wavelength range of the spectra, from the near UV to the nIR, allowed us to study the structure of the chromosphere by using lines which carry information on different atmospheric levels, from the region of T_{min} to upper chromosphere.

The emission flux in active stars usually shows a periodic modulation which is most likely caused by rotational modulation of plage-like structure emission. We investigate the variation of stellar activity indicators ascribed to plage-like structures, such Balmer lines, mainly Hα.
To avoid the photospheric contribution to the spectral profiles, we applied the spectral subtraction technique (Montes et al. 1995). No modulation were observed, although it is possible hidden by the flares, which affect significantly the Hα emission.

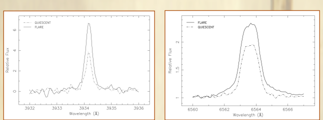


Fig 4. Chromospheric activity indicators. Left. Ca II K. Right. H . The dashed line indicates quiescent state, while solid line indicates flare state.

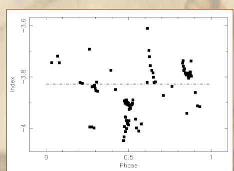


Fig 5. Spectrospcic index for Hα, phased folded orbital period. The dashed line is indicating the quiescent state. Error bars for indeces are about 0.001.

Acknowledgements
This work was supported by the Spanish Ministerio de Educación y Ciencia (MEC) under grant AYA2005-02750, by Ministerio de Ciencia e Innovación (MICINN) under grant AYA2008-06423-C03-03 The Comunidad de Madrid under PRICIT project S-0505/ESP-0237 (ASTROCAM), and financial support from the European Commission in the form of a Marie Curie Intra European Fellowship (PIEF-GA-2008-220679).
We thank Calar Alto Observatory for allocation of DDT to this programme. Based on observations made with TNG and LT at La Palma, Spain.

Due to the high level of chromospheric activity detected a high photospheric activity was expected. The photometric observations yielded a light curve with evidence of rotational modulation, the semi-amplitude of which approaches $\Delta V \approx 0.^{m}06$ and indicates the presence of spots on the surface.
The period analysis of the entire set of observations reveals a photometric period of 2.8 days.
The amplitude in each band is consistent with large spot or spot group covering at least 4% of the surface.
ASAS-3 (All Sky Automated Survey) observations were carried out during 2002-2009 years, obtained in V band. Sample light curve folded to rotational period is shown on Fig 3.
Quasi-coherence over seven years shows that spots could be regenerated at about the same longitude.

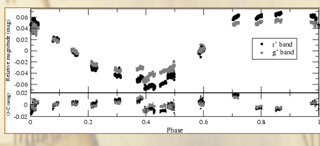


Fig 2. Photometry phased to the 2.801 days period. A linear trend and a zero point have been subtracted to both bands. The residuals with respect to a simple sine-wave model are show in the lower panel.

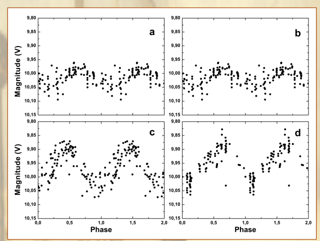


Fig.3. Sample light curves from ASAS data, folded with rotaional period. a) 2002-2003 data; b) 2003-2004 data; c) 2004-2005 data; d) 2007-2008 data. Note the scale constancy.

Stellar magnetic activity may be influenced by the presence of a close-in giant planet, as proposed by Cuntz et al (2000), in the form of enhanced stellar activity of the star's outer atmosphere. Thus the planetary companion reported by Hernán-Obispo et al. (2010a), a massive close-in planet, could explain the high level of stellar activity detected.

Also, the large flares with energy releases in the superflare regime and the high rate of flare occurrence could find a source in addition to stellar activity in the reconnection of the stellar coronal field as the planet is moving inside the Alfvén radius of the star. (Ip 2004).

The mere presence of the planet and its magnetic field embedded in the corona may affect stellar wind formation and coronal densities. In a recent paper, Lanza (2008) proposes a new model that predicts the formation of prominence-like structures in very highly active stars with close-in giant planets.

Modelling such features can allow us to obtain information on the magnetic field of the planet although in an indirect way.

In a forthcoming paper (Hernán-Obispo et al. 2010b, in prep.) we explore in detail these possible SPI (see Fig. 6).

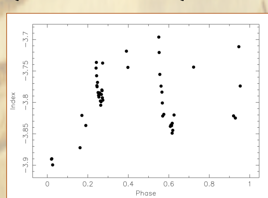


Fig. 6. Spectroscopic index for Hα phased folded sinodic period. It can be seen a clear modulation.

Further details soon in Hernán-Obispo et al. 2010b and in Hernán-Obispo et al. 2010c (in preparation)