THE BINAMICS PROJECT: BINARITY AND MAGNETISM

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Abstract. We present the BinaMIcS project, its goals and the first BinaMIcS spectropolarimetric observations obtained with Narval at TBL and ESPaDOnS at CFHT: dedicated time-series for targeted hot and cool close double-line spectroscopic (SB2) binaries and a survey of hot close SB2 binaries. The very first results are also presented. In particular, our first survey observations seem to show a lack of magnetic fields in hot close binaries compared to single stars.

1 The BinaMIcS project

BinaMIcS (Binarity and Magnetic Interactions in various classes of Stars) is an international project led by France (PI E. Alecian), which includes over 90 observers, modellers and theoreticians from 13 countries (see \url{http://lesia.obspm.fr/BinaMIcS}). The goal of the BinaMIcS project is to exploit binarity to yield new constraints on the physical processes at work in hot and cool magnetic stars. In particular, BinaMIcS aims at studying (1) the role of magnetism during stellar formation, (2) magnetospheric star-star (and star-planet) interactions, (3) the impact of tidal flows on fossil and dynamo magnetic fields, and (4) the impact of magnetism on mass and angular momentum transfer.

Studying binaries rather than single magnetic stars allows to better constrain the fundamental parameters of the targets. Moreover, binaries are an ideal laboratory to study physical processes related to star-star interactions, such as tidal deformation, wind-wind collisions, magnetospheric coupling, tidally excited pulsations,... Finally, they are important to understand the origin of magnetic fields. For example, in cool stars, they allow to test the synchronisation of the binary versus the dynamo interaction; in intermediate-mass stars, magnetic fields are known to be anomalously rare in binaries and this needs to be understood; and in massive stars, some theories propose that a field could be generated in stellar mergers.

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DOI: (will be inserted later)
However, spectropolarimetric studies of binary stars are particularly challenging. First, one needs to obtain spectropolarimetric measurements over the rotation periods of both stars and over the orbital period. Second, one needs to disentangle the intensity spectra of both components as well as the Zeeman signatures in the polarised light to be able to characterize the magnetic field of both stars.

2 The BinaMiS observing program

The BinaMiS project has been allocated two Large Programs (LP) of observations: one LP of 604 hours for 4 years (February 2013 to January 2017) with ESPaDOnS at CFHT (PIs E. Alecian and G. Wade), and one LP of 128 hours for 2 years (March 2013 to February 2015) with Narval at TBL (PI C. Neiner). This Narval LP is renewable for another 2 years.

BinaMiS observes 3 samples of targets:

(1) The cool Targeted Component (cTC): this sample consists of selected cool magnetic SB2 dwarfs, RS CVn, BY Dra, W UMa and pre-main sequence stars, with various fundamental and orbital parameters. These targets will be observed with a great coverage to perform a detailed characterisation of their magnetic field as well as detailed modelling. The results will be compared with those obtained for single stars. We will also study the variations and correlation with eccentricity.

(2) The hot Targeted Component (hTC): this sample consists of all 13 known magnetic SB2 systems of O, B or A spectral type visible from CFHT or TBL. This includes 1, 6 and 6 systems for which the hottest star is an O, B and A star, respectively. These targets will be observed with a great coverage to perform a detailed characterisation of their magnetic field as well as detailed modelling. The results will be compared with those obtained for single stars. We will also study the wind and magnetospheric interactions between the 2 components.

(3) The hot Survey Component (SC): this sample consists of over 200 close SB2 binaries, including eclipsing ones, with at least one component of O, B, A or early F spectral type and a secondary component not later than F. The goal is to search for a magnetic field in these targets. Those systems that will be discovered to be magnetic will be transferred to the hTC sample. We will derive the statistical occurrence of magnetic fields in this sample and compare it with the results obtained by the MiMeS collaboration for single stars (Wade et al. 2013).

3 First targeted observations

The BinaMiS observations started in February 2013. A complete dataset has already been obtained for several TC stars. For the cTC, we observed BH CVn, a RS CVn (F2IV+K2IV) system for which only one of the 2 components is magnetic, and BY Dra (K6Ve+...) for which both components are found to be magnetic. Snapshots have also been obtained for a number of other cool systems (UZ Tau E, \(\sigma^2\) CrB, V1379 Aql, ER Vul, HD 216489, HD 28, HD 34029,...) to allow the selection of the best cTC targets. \(\sigma^2\) CrB has been selected for follow-up as a
Fig. 1. Examples of 3 spectropolarimetric observations of the cool system $\sigma^2$ CrB. Top: LSD Stokes V profiles showing the magnetic signatures in both stars. Bottom: Corresponding LSD intensity profiles.

cTC target since the first spectropolarimetric observations show clear magnetic detections in both components (see Fig. 1). For the hTC, we already observed the Plaskett star, a system discovered to be magnetic by the MiMeS collaboration (Grunhut et al., these proceedings), as well as HD 5550, an Ap+A system. These TC datasets are currently being analysed and a full characterisation of the magnetic fields of each system will be published in 2014.

4 Preliminary survey results

At the time of writing, 93 close SB2 systems including at least one O, B, A or early F star have been observed. Among these systems, a magnetic field has been detected in one system: HD 160922. This is a F4+F5 system with an orbital period of 5.28 days. Only one of the two stars in the system shows a magnetic signature. This target has been transferred to the hTC sample and we have acquired 15 measurements. The simple magnetic signature does not seem to vary much from one observation to another. Therefore this star could host a fossil field rather than a dynamo field (see Fig. 2).

The detection of only one magnetic system among the 93 systems observed so far raises many questions. If we consider only the 79 systems including at least one O, B or A star, we can compare the occurrence of a magnetic field in these systems with the occurrence established by the MiMeS collaboration for single massive stars. In single stars, the occurrence is 7% (Wade et al. 2013). If the occurrence was the same in binaries, we should have detected between 5 and 11 magnetic systems. Instead we found none. Although the statistics of our current sample is
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Fig. 2. Examples of spectropolarimetric observations of the F4+F5 system HD 160922. Left: LSD intensity profiles. Right: Corresponding LSD Stokes V profiles showing the magnetic signatures in one star.

not sufficient to draw firm conclusions, the lack of detections in this sample may be an important result for stellar formation and the origin of magnetism in massive stars. The observations of the complete SC sample will provide firmer conclusions and cast new light on these issues.

5 Conclusions

BinaMicS is an ambitious project to study magnetic interactions in hot and cool close binary systems, understand the role of magnetism during stellar formation and the origin of magnetic field in massive stars. The first BinaMicS observations already provide very interesting results.

Acknowledgements

Based on observations obtained at the Telescope Bernard Lyot (TBL) operated by the Observatoire Midi-Pyrénées, Université de Toulouse, Centre National de la Recherche Scientifique (CNRS) of France, and at the Canada-France-Hawaii Telescope (CFHT) operated by the National Research Council of Canada, the Institut National des Sciences de l’Univers of CNRS, and the University of Hawaii.

References

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