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THE "BINARITY AND MAGNETIC INTERACTIONS IN VARIOUS CLASSES OF STARS" (BINAMICS) PROJECT

C. Neiner[1], J. Morin[2], E. Alecian[1,3] and the BinaMIcS collaboration

Abstract. The "Binarity and Magnetic Interactions in various classes of stars" (BinaMIcS) project is based on two large programs of spectropolarimetric observations with ESPaDOnS at CFHT and Narval at TBL. Three samples of spectroscopic binaries with two spectra (SB2) are observed: known cool magnetic binaries, the few known hot magnetic binaries, and a survey sample of hot binaries to search for additional hot magnetic binaries. The goal of BinaMIcS is to understand the complex interplay between stellar magnetism and binarity. To this aim, we will characterise and model the magnetic fields, magnetospheric structure and coupling of both components of hot and cool close binary systems over a significant range of evolutionary stages, to confront current theories and trigger new ones. First results already provided interesting clues, e.g. about the origin of magnetism in hot stars.

Keywords: stars: magnetic field, binaries: spectroscopic, binaries: close, techniques: polarimetric

1 Introduction

The goals of the "Binarity and Magnetic Interactions in various classes of stars" (BinaMIcS) project are to understand the impact of magnetic fields on stellar formation and evolution, of tidal effects on fossil and dynamo magnetic fields, of magnetism on angular momemtum and mass transfers between binary components, as well as magnetospheric interactions. To address these questions, we are missing observational information on the magnetic field strengths and topologies of a statistically large sample of magnetic close binary systems, in which we expect significant interaction via tidal or magnetospheric interactions. Therefore, BinaMIcS is based on two large programs of spectropolarimetric observations with ESPaDOnS at CFHT (Hawaii) and Narval at TBL (Pic du Midi, France), in addition to theoretical developments and modelling efforts.

Three samples of short-period spectroscopic binaries with two spectra (SB2) are observed:

- known selected cool ($<$ F5) magnetic binaries, to characterise their magnetic properties in details and compare them to single magnetic cool stars
- the few known hot ($>$ F5) magnetic binaries, to characterise their magnetic properties in details and compare them to single magnetic hot stars
- a survey sample of hot binaries, to discover new hot magnetic binaries and compare the occurence of magnetic fields in hot binaries versus single hot stars.

[1] LESIA, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, Univ. Paris Diderot, Sorbonne Paris Cité, 5 place Jules Janssen, 92195 Meudon, France
[2] LUPM-UMR 5299, CNRS & Université Montpellier, Place Eugène Bataillon, 34095, Montpellier Cedex 05, France
[3] Univ. Grenoble Alpes, CNRS, IPAG, F-38000 Grenoble, France

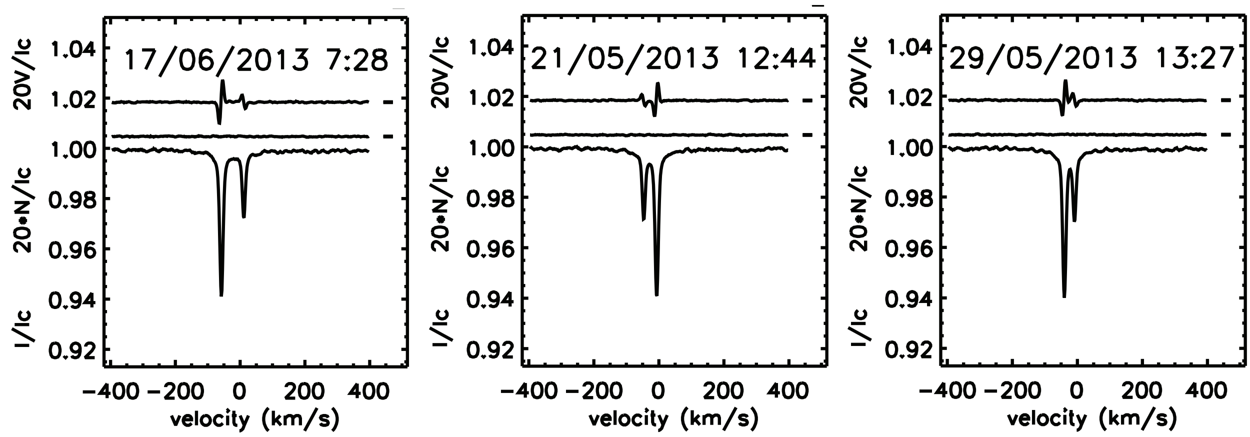

Fig. 1. Three examples of LSD Stokes V (top), null (middle), and intensity profiles (bottom) of the cool binary system BY Dra, taken at various orbital phases. The V and N profiles have been shifted upwards for display purposes. The Stokes V profiles clearly show that both binary components are magnetic.

2 Magnetic hot SB2 systems

Six magnetic SB2 systems with at least one O, B, or A component were known to exist and are currently being characterized in the frame of BinaMIcS. These are HD 37017 (V1046 Ori, Bohlender et al. 1987), HD 37061 (NU Ori, Petit et al. 2011), HD 136504 (ϵ Lup, Hubrig et al. 2011; Shultz et al. 2012), HD 47129 (Plaskett's star, Grunhut et al. 2013), HD 98088 (Folsom et al. 2013), and HD 5550 (Neiner et al., these proceedings, Alecian et al., submitted). Among them, only one is known to host two magnetic stars: ϵ Lup (Shultz et al. 2015). In addition, two newly discovered magnetic SB2 systems with early F stars are being characterized within BinaMIcS: HD 160922 (Neiner & Alecian 2013) and HD 210027 (ι Peg, Neiner & Lèbre 2014).

No other magnetic OBA SB2 system was discovered among the ∼200 systems (∼400 stars) observed within the survey sample. Among single hot stars, ∼7% are found to host a magnetic field, with a typical strength of a few hundreds to a few thousands gauss (Grunhut & Neiner 2015). These fields are of simple configuration and stable over decades. Moreover, they are of fossil origin, i.e. remnants from the field present in the molecular cloud at the time of stellar formation, possibly enhanced by a dynamo action during the early phases of the life of the star (Borra et al. 1982; Neiner et al. 2015). If similar magnetic fields were present with the same occurence in hot binaries as in single hot stars, we should have detected 20 to 30 magnetic stars in the survey sample. There is thus a clear and strong deficit of magnetic stars in hot short-period spectroscopic binaries.

A possible explanation for this dearth of magnetic fields in hot SB2 systems is provided by stellar formation processes. Stellar formation simulations (e.g. Commerçon et al. 2011) showed that fragmentation of dense stellar cores is inhibited when the medium is magnetic. Therefore, it seems that it is more difficult to form a binary system in the presence of a fossil field and, thus, magnetic hot binaries are rarer.

3 Magnetic cool SB2 systems

The BinaMIcS sample of magnetic cool SB2 systems includes cool main sequence stars, evolved RS CVn objects, and young T Tauri stars. Several of these systems show signatures of magnetic fields in both components. This is the case, for example, of the K4Ve+K7.5Ve system BY Dra (see Fig. 1) or σ^2 CrB (see Neiner & Alecian 2013).

Single magnetic cool stars show various types of magnetic fields, with various levels of complexity, axisymmetry, and strength. Fig. 2 shows known single magnetic cool stars (filled symbols) in a mass versus rotation period diagram. Stars with the strongest fields are the lower mass stars, the slowest rotators, and often have simple poloidal fields. Weak complex fields are found in two regions of the diagram: slowly rotating very low-mass stars, and rapidly rotating higher mass stars. Open symbols in Fig. 2 indicate the position of the cool magnetic binary targets of BinaMIcS. Magnetic maps of these binaries will be compared to the maps of single stars to assess the effect of binarity on stellar dynamo processes.

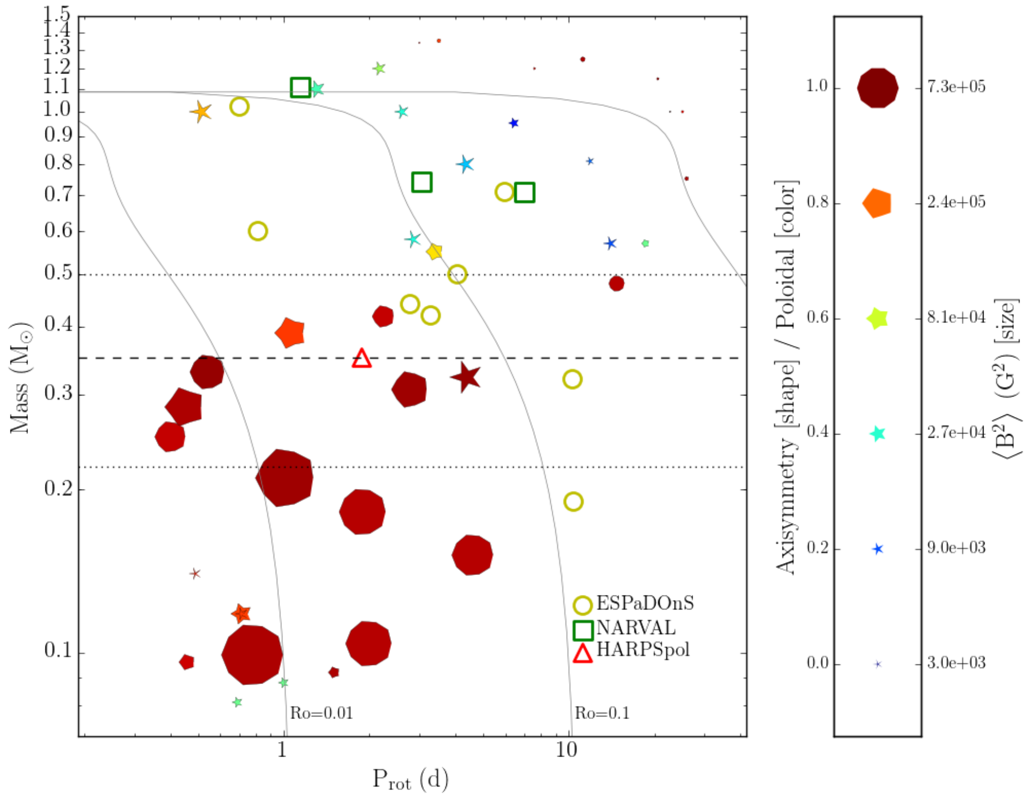

Fig. 2. Mass versus rotation period diagram for single magnetic stars (filled symbols) and cool binaries of the BinaMIcS sample (open symbols). For single stars, the shape of the symbol indicates the axisymmetry of the magnetic field configuration, its color indicates how poloidal the field is, and its size indicates the strength of the field.

4 Conclusions

BinaMIcS aims at studying the effect of magnetism on binary formation and evolution. Individual hot and cool short-period spectroscopic binary (SB2) systems are being studied in great details to infer their magnetic properties. These results will be compared to those obtained for single stars. In addition, the magnetic survey of hot binaries already provided an important result: hot stars in short-period binaries are less often magnetic than when they are single.

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