Mem. S.A.It. Vol. 90, 424

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A very rare hierarchical SB4 system detected in the Gaia-ESO Survey?

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Abstract. The *Gaia*-ESO survey (GES) is a ground-based large spectroscopic survey targeting a hundred thousand stars for which radial velocities, atmospheric parameters and detailed chemical abundances are released. The bright A2V star HD 74438 has been detected with four radial velocity components in its cross-correlation function. This star belongs to the young open cluster IC 2391 and was already suspected to be a triple system because lying 0.9 mag above the main-sequence in the colour-magnitude diagram of this cluster. The GES spectra have revealed the physical nature of two pairs but the time coverage was insufficient to derive the orbital parameters. On-going follow-up of this star with the HRS/SALT and HERCULES/MJUO allows us to derive an orbital solution of the faintest SB2 (P = 4.4 d, e = 0.16). The orbital elements of the brightest SB2 are more difficult to assess possibly due to the interaction of the faintest SB2 and preliminary solution gives P = 20.5 d and e = 0.36. The long-term variation seems to show that the two SB2 are gravitationally bound.

Key words. stars: individual: HD 74438 – binaries: close – binaries: spectroscopic – techniques: radial velocities

1. Introduction

HD 74438 is a spectroscopic binary with four visible components candidate (SB4, Merle et al. 2017) initially discovered in one of the closest young open cluster IC 2391 observed by the ground-based large spectroscopic *Gaia*-ESO Survey (Gilmore et al. 2012; Randich et al. 2013). We want to characterise the orbits and the atmospheric parameters of the SB4 candidate and determine if it truly belongs to a gravitationally bound quadruple system (Fig. 1). We obtain follow-up spectroscopic observations of this interesting target with high resolution spectroscopy on HRS/SALT[1] in South Africa

[1] Southern Africa Large Telescope

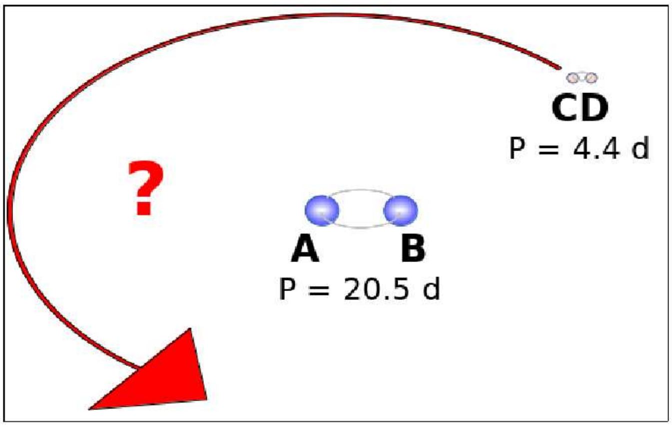

Fig. 1. Is the SB4 HD74438 system a gravitationally bound system?

(Crause et al. 2014) and HERCULES/MJUO[2] in New Zealand (Hearnshaw et al. 2002, 2003). Radial velocities (RV) of the time series spectra are analysed to find orbital solutions of the two SB pairs.

2. The orbital solution of the AB pair

The AB pair is made of the two brightest components in the cross-correlation functions and shows the lowest RV amplitude. Only the data from HERCULES/MJUO are used to compute the orbital solution because they sample well the orbit over five periods. Doing this will allow to see if any drift is present when compared with data taken years ago. The measured RV (plusses) and the orbital solution obtained are shown for component A (blue) and component B (yellow) in Fig. 3. The period and eccentricity of the AB pair are 20.5 d and 0.36 with RV amplitudes of 45.8 and 51.3 km $s^{-1}$for A and B components respectively. The systemic RV is 8.2 km s^{-1}. The complete set of the RV orbital solution parameters will be published in a forthcoming paper (Merle et al., in prep.).

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3. The orbital solution of the CD pair

The CD pair is made of the two faintest components in the cross-correlation functions and shows the largest RV amplitude. Similarly to the AB pair, only the data from the HERCULES/MJUO are used to compute the orbital solution of the CD pair. The period and eccentricity of the CD pair are 4.4 d and 0.16 with RV amplitudes of 83.6 and 85.6 km $s^{-1}$for C and D components respectively. The systemic RV is 23.8 km s^{-1}.

4. Radial velocities and orbital solutions of the four components over… 5 years

Orbital solutions obtained with HERCULES/MJUO data are shown for the ensemble of available data from 2014 with GES data (Fig. 4) to April 2019 with HRS/SALT data (Fig. 2). The bright pair with a low amplitude is displayed in blue (component A) and yellow (component B), whereas the faint pair with a high amplitude is displayed in green (component C) and in red (component D).Dots, plusses and diamonds represent UVES/GES, HERCULES/MJUO and HRS/SALT measured RV, respectively.

In Fig. 4, we notice a shift of the radial velocities of each pair in the opposite direction:

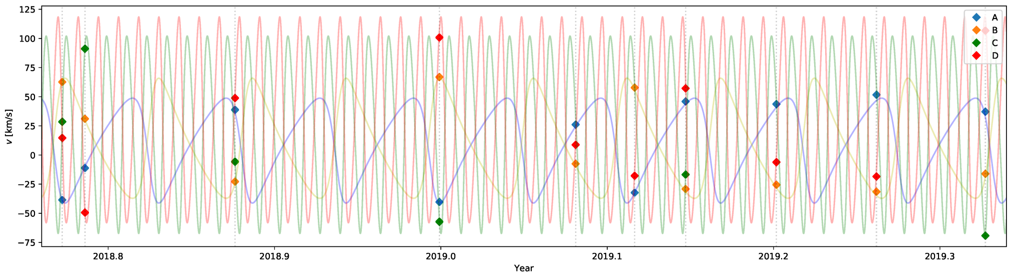

Fig. 2. Measured RV for HRS/SALT (diamonds) and computed orbital solution (lines) for the 4 components, from October 2018 to April 2019.

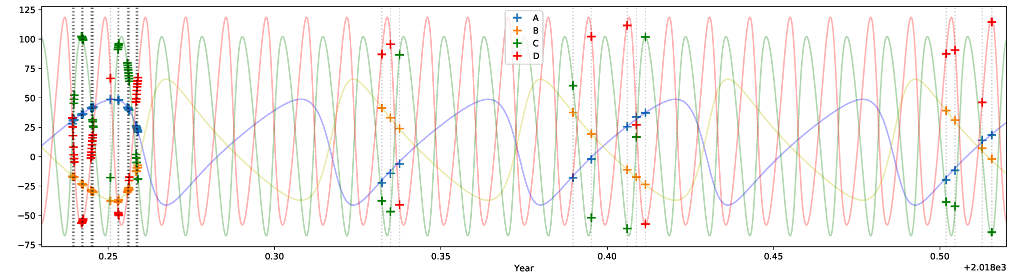

Fig. 3. Measured RV for HERCULES/MJUO (diamonds) and computed orbital solution (lines) for the 4 components, first semester of 2018.

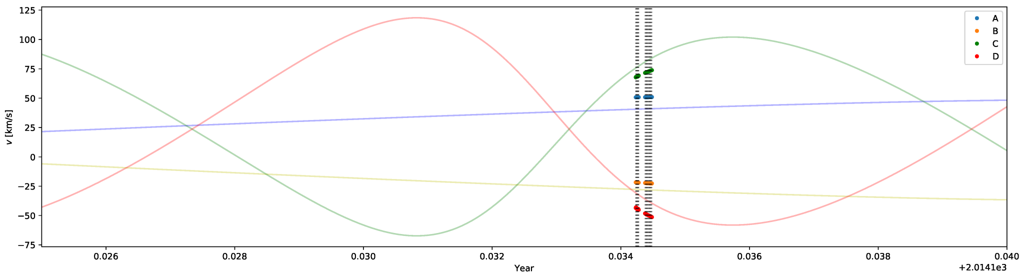

Fig. 4. Measured RV for UVES/GES (diamonds) and computed orbital solution (lines) for the 4 components, 2.5 h in 2014.

the pair AB shows radial velocities about 10 km/s higher than the orbital solution whereas the pair CD shows similar negative offset with respect to the orbital solution.These offsets are the sign that the two SB2 pairs are indeed gravitationally bound but it requires a long term monitoring to obtain the orbital solution. Indeed, we expect the period of the two pairs to be at least one order of magnitude larger than the period of the AB pair since the system is hierarchical.

5. Conclusions

The follow-up of the HD 74438 system with three different spectrographs has allowed to determine the orbits of the two SB pairs. Signs showing that these two SB pairs are gravitationally bound emerge when comparing the 2014 GES data with the recent monitoring on HERCULES/MJUO and SALT/HRS: a derive of 10 km/s is indeed measured and cannot be due to the inter-spectrograph offsets only. The next steps are to characterise the astrophysical parameters of each component and compare this system with the very few other SB4 known so far (Shkolnik et al. 2008; Lehmann et al. 2012; Rappaport et al. 2017).

Acknowledgements. T.M. and S.V.E. are supported by a grant from the Fondation ULB.

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