SF2A 2023
M. N'Diaye, A. Siebert, N. Lagarde, O. Venot, K. Baillié, M. Béthermin, E. Lagadec, J. Malzac, J. Richard (eds)

MASSES AND LUMINOSITIES OF SB2 COMPONENTS DEDUCED FROM OHP SPECTROSCOPIC OBSERVATIONS AND GAIA-DR3 ASTROMETRIC ORBITS

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Abstract. The masses and luminosities of 10 binary components are derived from accurate SB2 orbital elements and from Gaia DR3 astrometric orbits.

Keywords: binaries:spectroscopic, Astrometry, stars: fundamental parameters

1 Introduction

A selection of double-lined spectroscopic binaries (SB2s) have been observed since 2010 with the 193 cm-telescope and the "Spectrographe pour l'Observation des PHénomènes des Intérieurs Stellaires et des Exoplanètes" (Sophie) at the Observatoire de Haute-Provence (OHP), in order to obtain precise orbital elements (see Halbwachs et al. 2020, and references therein). The third Data Release of the Gaia satellite (Gaia-DR3) includes the elements of nearly 165500 astrometric orbits (Gaia Collaboration et al. 2016; Halbwachs et al. 2023; Holl et al. 2023), including 10 SB2s of the OHP programme, out of 34 whose orbits we have already published: HIP 20601, 21946, 61100, 61732, 62935, 95575, 100046, 101382, 116160 and HD 98031. The combination of the SB2 and astrometric orbital elements is used here to estimate the masses and luminosities of the components of these binaries, where possible.

2 Selection of binaries of compatible orbital elements

It is not possible to calculate a joint solution for our spectroscopic measurements and the astrometric measurements of the DR3, as the latter have not been included in Gaia-DR3. We therefore must ensure that the spectroscopic and astrometric orbital elements are compatible, and exclude stars for which they are not. We checked the compatibility of the periods, eccentricities, arguments and epochs of periastron at the 2 σ threshold, and finally retained HIP 20601, 21946, 61732, 95575 and 101382.

3 Calculation of the masses and luminosities

The calculation of the masses is trivial, since we have already calculated and published the quantities $\mathcal{M}_1 \sin^3 i$ and $\mathcal{M}_2 \sin^3 i$ and their uncertainties (see references in Table 1; $\mathcal{M}_1$ and $\mathcal{M}_2$ are the primary mass and the

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Table 1. Masses and absolute magnitudes derived from our SB2 orbits and from Gaia-DR3.

Ident. HIP	SB2 orbit reference	$\mathcal{M}_1$ ($\mathcal{M}_\odot$)	$\sigma_{\mathcal{M}_1}$ ($\mathcal{M}_\odot$)	$\mathcal{M}_2$ ($\mathcal{M}_\odot$)	$\sigma_{\mathcal{M}2}$ ($\mathcal{M}_\odot$)	$M_{G\ 1}$ (mag)	$\sigma_{M_{G\ 1}}$ (mag)	$M_{G\ 2}$ (mag)	$\sigma_{M_{G\ 2}}$ (mag)
20601	Halbwachs et al. (2020)	1.015	0.019	0.753	0.014	4.964	0.033	7.09	0.23
21946	Kiefer et al. (2018)	0.792	0.016	0.560	0.010	6.4739	0.0057	8.796	0.031
61732	Halbwachs et al. (2020)	1.414	0.086	0.995	0.060	3.485	0.012	5.506	0.052
95575	Kiefer et al. (2016)	0.773	0.028	0.690	0.025	6.1876	0.0051	7.0225	0.0094
101382	Kiefer et al. (2018)	0.8374	0.0024	0.6584	0.0017	5.3276	0.0036	7.189	0.012

secondary mass, respectively, and i is the inclination of the orbital plane). So all we have to do is calculate i and its uncertainty from the Thiele-Innès elements given in DR3, applying the relations given by Halbwachs et al. (2023), and deduce the masses. The uncertainties of the masses are calculated by a simple quadratic sum, since the elements of the astrometric orbits are not correlated with those of the spectroscopic orbits.

To calculate luminosities, we consider the quantities $a_1 \sin i$ and $a_2 \sin i$ from the spectroscopic orbits, where a_1 and a_2 are the semi-major axes of the orbits of the components around the barycentre. The luminosity ratio is derived from the formula:

$$\frac{\mathcal{F}_1}{\mathcal{F}_1 + \mathcal{F}_2} = \frac{a_1 - a_0}{a_1 + a_2} \tag{3.1}$$

where $\mathcal{F}$ refers to a flux and where a_0 is the semi-major axis of the photocentre orbit, converted into km using the trigonometric parallax. Knowing the magnitude of the binary in Gaia's G band, we can deduce the absolute magnitudes of the components. Uncertainties are calculated by simulation to take into account the different correlation coefficients. The results are presented in Table 1.

4 Comparison with previous results

The masses of the components of 3 binaries have already been calculated from our spectrocopic observations and interferometric orbits. These are HIP 20601 (Halbwachs et al. 2020), 95575 (Docobo et al. 2018) and 101382 (Kiefer et al. 2018). The results are all compatible within 2 σ with those from Gaia-DR3.

The masses and absolute magnitudes of the stars considered here were all derived from the same data in Chevalier et al. (2023), but with different results, since they have re-evaluated the elements of the astrometric orbit by assigning elements from the spectroscopic orbit with the Template Model Builder code.

5 Discussion and conclusion

We used the Gaia-DR3 to calculate the masses and absolute magnitudes of the components of 5 binaries that we had observed spectroscopically at the Haute-Provence Observatory with the T193/Sophie. The Gaia-DR4 will include the astrometric transits, allowing the calculation of combined astrometric and spectroscopic solutions. The 34 binaries that we had already monitored at the T193/Sophie should then all obtain more accurate results.

We made use of the Vizier database, operated at CDS, Strasbourg, France.

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