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ACCURATE STELLAR MASSES FOR SB2 COMPONENTS: INTERFEROMETRIC OBSERVATIONS FOR GAIA VALIDATION*

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Abstract. A sample of about 70 double-lined spectroscopic binaries (SB2) is followed with radial velocity (RV) measurements, in order to derive the masses of their components when the astrometric measurements of Gaia will be available. A subset of 6 SB2 was observed in interferometry with VLTI/PIONIER, and the components were separated for each binary. The RV measurements already obtained were combined with the interferometric observations and the masses of the components were derived. The accuracies of the 12 masses are presently between 0.4 and 7 %, but they will still be improved in the future. These masses will be used to validate the masses which will be obtained from Gaia.

In addition, the parallaxes derived from the combined visual+spectroscopic orbits are compared to that of Hipparcos, and a mass-luminosity relation is derived in the infrared H band.

Keywords: binaries: spectroscopic, binaries: visual, stars: fundamental parameters, stars: individual:HIP 12272, HIP 14124, HIP 14157, HIP 20601, HIP 104987, HIP 117186

1 Introduction

An observation program is on going since 2010 at the OHP observatory with the T193/Sophie, in order to improve the orbital elements of a selection of 200 known spectroscopic binaries (SBs) (Halbwachs & Arenou 2009; Halbwachs et al 2014). Our long-term goal is the derivation of accurate stellar masses from the orbital elements of the double-lined spectroscopic binaries (SB2s), taking into account the astrometric measurement of the Gaia satellite. The diagram in Fig. 1 illustrates the progress of the programme. As explained in Halbwachs et al (2014), a reliable SB2 orbit may be obtained when the number of RV measurements of each component is at least 11, and when the period was enterily covered by the observation. A third condition is not visible on this diagramme, however: the measurements must be adequately distributed in orbital phase.

During the second semester of last year, interferometric measurements were performed at ESO, with the VLTI and the PIONIER instrument. Our purpose was to derive masses in order to check the reliability of those that will be obtained from Gaia. Six binaries were observed, which are HIP 12272, HIP 14124, HIP 14157, HIP 20601, HIP 104987 and HIP 117186. Four of them are taken from our sample, but two (HIP 14124 and HIP 14157) are southern stars which are not observable from Haute-Provence. They are included in a programme which is carried on from the Roque de los Muchachos Observatory, with the Hermes instrument.

* BASED ON OBSERVATIONS PERFORMED AT ESO AND AT THE HAUTE-PROVENCE OBSERVATORY

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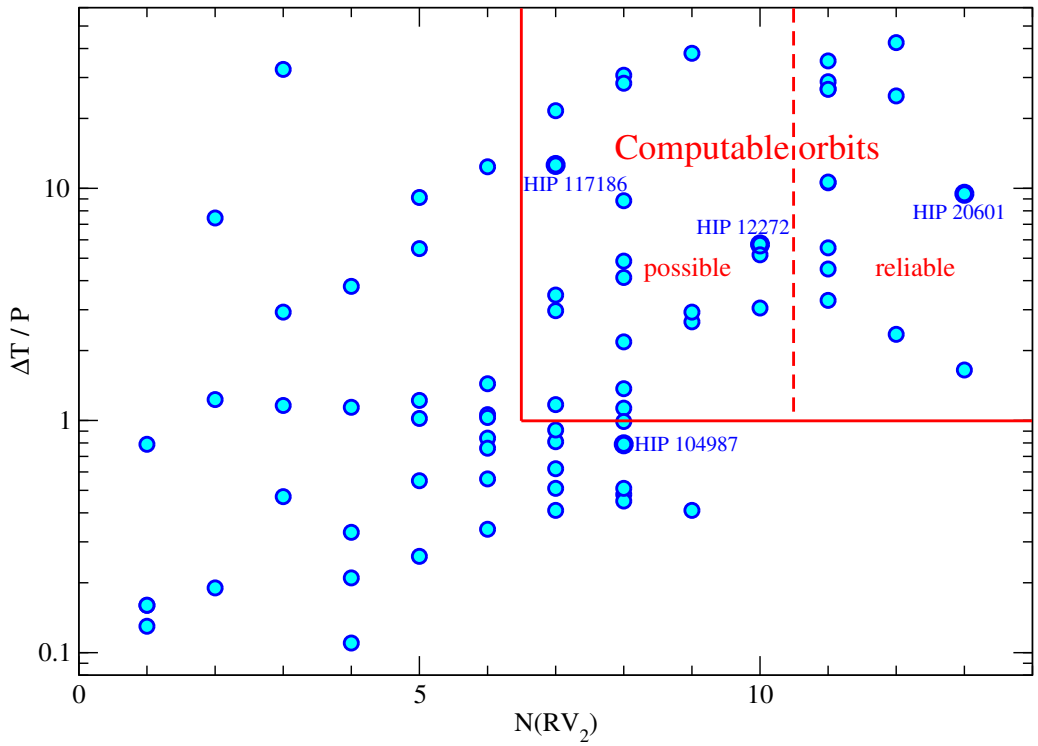

Fig. 1. The number of covered periods vs the number of detections of the secondary dip of the SB2, after semester 2014B. The HIP numbers of the stars observed with the VLTI are indicated.

2 Derivation of the masses, parallaxes and H IR magnitudes

None of the stars observed with PIONIER is fulfilling the conditions to obtain a reliable and definitive orbit. Nevertheless, the stars observed at OHP have all enough measurements to derive a preliminary SB2 orbit. Moreover, the ancient measurements are taken into account, in addition to the RV coming from our own observations.

Between four and nine interferometric measurements were obtained for each star, covering at least 25 % of the period. This sufficient to derive a visual orbit, but we consider that 6 observations covering half of the period are a minimum to compute reliable elements: a visual orbit consists in 7 elements (e, P, T_0, a, i, ω, Ω), and 6 2-dimension measurements lead to a solution with 6 degrees of freedom. This is just enough for the verification and for the correction of the uncertainties. As a consequence, the results hereafter must also be considered as preliminary for unsufficient interferometric measurements, for three of the six stars: HIP 12272, HIP 14124, and HIP 104987.

The RV and the interferometric measurements are used to derive simultaneously the orbital elements of the binaries, and therefore the masses of the components and the parallaxes of the systems. In addition, the flux ratios in the infrared H band are also obtained. Since the total H magnitudes are known thanks to Cutri et al. (2003), the indidual magnitudes of the stars were also computed, and therefore the absolute H magnitudes. The results are presented in Table 1.

3 The mass-luminosity diagram

The positions of our stars in the mass-luminosity diagram are directly taken from Tab. 1 and plotted in the left panel of Fig. 2. The four stars lighter than the Sun have masses which are compatible with the relation of Henry & McCarthy (1993), although they all are a few percent larger.

Table 1. The orbital elements of the 6 binaries, and the masses and absolute magnitudes of the 12 components.

HIP	P (d)	T_0(JD) 2400000+	e	ω_1 (°)	Ω_1 (°)	i (°)	a (mas)	$\mathcal{M}_{1,2}$ ($\mathcal{M}_\odot$)	ϖ mas	$H_{abs\ 1,2}$ (mag)	n_{VLTI} $\Delta T/P$
12272	269.344	53352.65	0.1347	62.5	351.11	35.6	17.4	1.64	15.50	1.497	4
	±0.0049	±1.33	±0.0041	±1.8	±0.53	±1.0		±0.12	±0.49	±0.083	0.27
								1.076		3.373	
								±0.077		±0.087	
14124	362.996	43069.06	0.6841	301.77	151.48	84.82	39.3	1.390	29.17	2.725	7
	±0.052	±0.20	±0.0053	±0.88	±0.15	±0.12		±0.066	±0.61	±0.061	0.28
								1.084		3.482	
								±0.037		±0.067	
14157	43.32031	51487.5000	0.7595	174.67	19.141	92.24	5.8	0.981	19.558	3.645	10
	±0.00013	±0.0081	±0.0010	±0.18	±0.082	±0.18		±0.0.10	±0.078	±0.031	> 1
								0.8819		4.073	
								±0.0089		±0.032	
20601	156.38023	56636.6695	0.85142	201.943	340.513	103.163	11.3	0.9763	16.714	3.688	6
	±0.00027	±0.0018	±0.00016	±0.061	±0.056	±0.074		±0.0031	±0.035	±0.047	0.72
								0.7250		4.687	
								±0.0015		±0.049	
104987	98.8026	52719.7	0.0049	55.	216.7	151.56	12.2	2.14	18.46	-1.08	5
	±0.0062	±6.1	±0.0040	±22.	±1.2	±0.51		±0.12	±0.35	±0.20	0.25
								1.796		1.05	
								±0.092		±0.20	
117186	85.8238	56402.540	0.32728	175.90	16.930	88.054	4.7	1.673	8.450	1.282	7
	±0.0013	±0.081	±0.00077	±0.37	±0.047	±0.043		±0.031	±0.083	±0.038	0.68
								1.399		2.173	
								±0.038		±0.040	

4 Comparison of the parallaxes with Hipparcos

Since Fekel (2015) have found a stellar system with a parallax significantly different from that provided by Hipparcos 2, it is relevant to compare our parallaxes to that coming from this catalogue. This is done on the right panel of Fig. 2. Although the individual stars have all parallaxes with errors smaller than 2 σ, this figure suggests that the small parallaxes of Hipparcos 2 could be systematically underestimated. However, this impression must still be confirmed on the basis on more data.

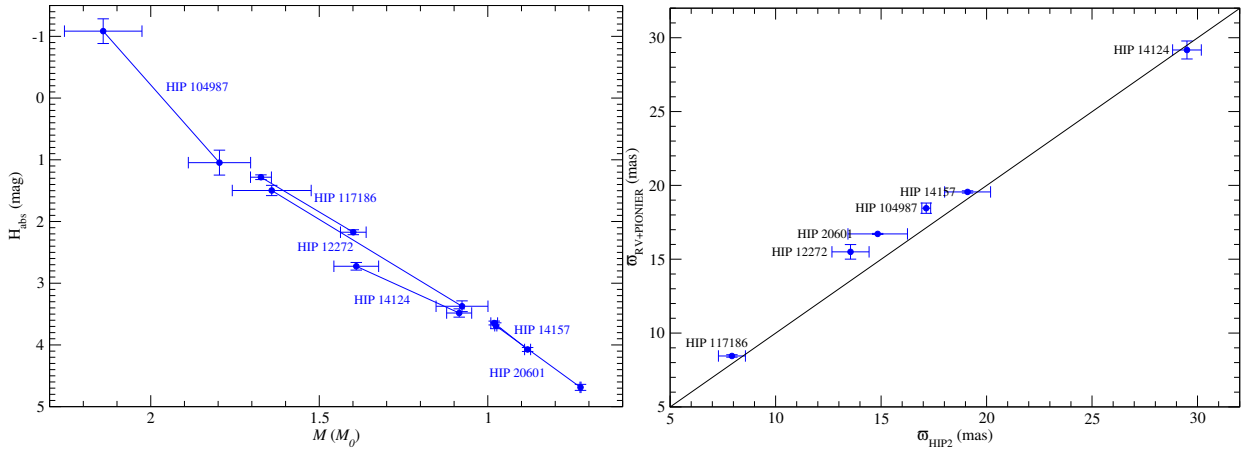

Fig. 2. Left: The twelve binary components in the masse-luminosity diagramme; H_{abs} is the absolute magnitude in the infrared 2-Mass H band. **Right:** Comparison of our parallaxes to that of Hipparcos 2. The Hipparcos 2 parallaxes were corrected for the orbital motion only for the three binaries well-observed with the VLTI (HIP 14157, HIP 20601 and HIP 117186).

5 Conclusions

We have obtained relevant masses and parallaxes for 6 binaries and their components.The results presented here are preliminary, but a study of the three binaries well observed with the VLTI will be detailled in a forthcoming refereed paper (Halbwachs et al 2016)

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