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DERIVATION OF THE MASS RATIOS OF 20 NEW DOUBLE-LINED SPECTROSCOPIC BINARIES*

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Abstract. The secondary component was detected in the spectra of 20 systems which were previously single-lined spectroscopic binaries (SB1s) with known orbital elements. The mass ratio of each new double-lined spectroscopic binary (SB2) was derived through two methods: (1) computation of an SB2 orbit using the old measurements of the radial velocity in addition to the new ones, and, (2) direct computation of the mass ratio from the variations of the radial velocities of the components. Some results are presented here.

Keywords: binaries: spectroscopic

1 Introduction

The double-lined spectroscopic binaries (SB2s) are at the root of the less model–dependent methods used to derive the stellar masses. Their orbital elements are used to derive the products $\mathcal{M}_* \sin^3 i$, where $\mathcal{M}_*$ is the mass of a component and i is the inclination of the orbital plane. The astrometric measurements obtained with the Gaia satellite will make possible the derivation of i for a lot of astrometric binaries. In order to obtain accurate masses with Gaia, an observational program is on going since 2010 at the OHP observatory with the T193/Sophie instrument, in order to improve the orbital elements of a selection of known SBs (Halbwachs & Arenou 2009; Halbwachs et al 2014a,b). The selection included 152 SB1s, but an additional component was found for 25 of them, including 5 multiple systems. A preliminary list of SB2s newly discovered, including a rough estimation of the mass ratios, $q = \mathcal{M}_2/\mathcal{M}_1$, was presented in Halbwachs et al. (2011). Three years later, it is now possible to derive accurately q for all of the new SB2s. This is done hereafter, using two different methods: (a) the derivation of the spectroscopic orbital parameters, combining the newly obtained radial velocities (RVs) with old measurements of the primary components, and (b) derivation of q from the variations of the new RVs of the components.

2 Derivation of the spectroscopic orbital parameters

The number of radial velocity measurements obtained with Sophie is usually not sufficient to derive accurately the semi-amplitudes of the RV variations for both components. However, when the old measurements of the primary component are taken from the on–line SB9 catalogue (`http://sb9.astro.ulb.ac.be//`, Pourbaix et al. 2004), only three additional observations of the secondary component, taken at different phases, are required. The semi-amplitude of the RV of the secondary component was thus derived for 19 new SB2s. The calculation was not possible for one SB2, since the old measurements were never published. For the others, the mass ratio was derived from $q = K_1/K_2$.

* BASED ON OBSERVATIONS PERFORMED AT THE HAUTE-PROVENCE OBSERVATORY

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3 Derivation of q from the RV variations of both components

Wilson (1941) has pointed out that the mass ratio may be directly obtained from a few measurements of the RVs of both components. It is given by the equation:

$$q = \Delta V_1 / \Delta V_2 \tag{3.1}$$

where ΔV is a variation of the RV of a component, in absolute value. Again, three RV measurements of both components are sufficient to derive q and its uncertainty, but the old measurements are not used. The results are presented in Halbwachs et al (2014a).

4 Comparison between the two methods

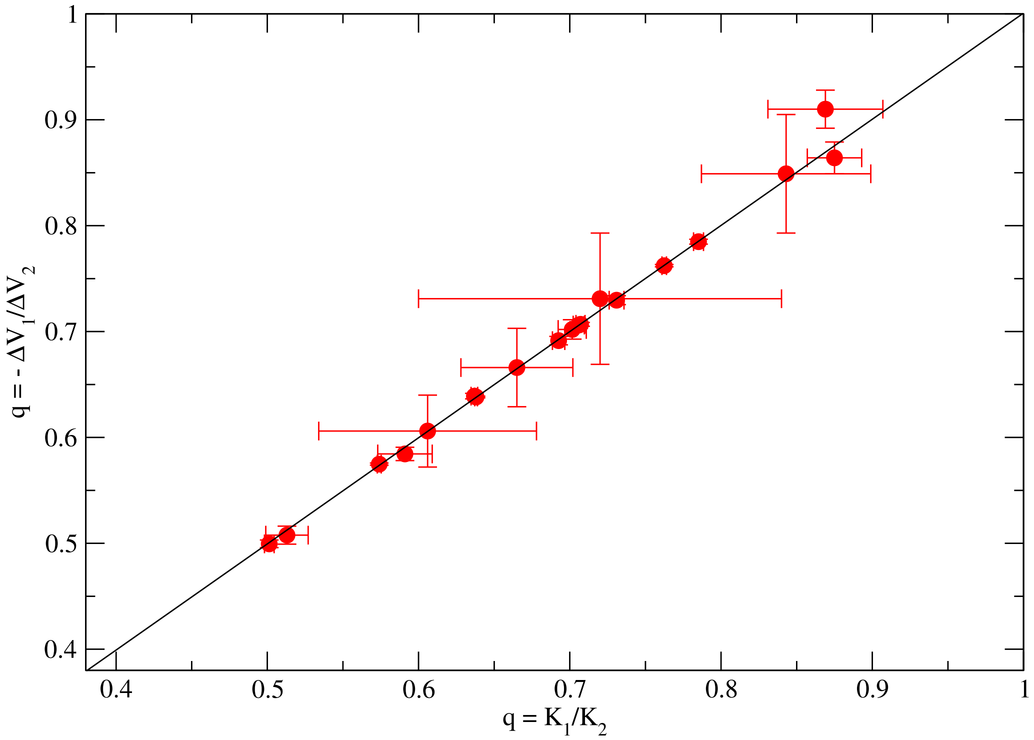

Fig. 1. The mass ratios derived from the variations of RV vs those coming from the semi-amplitudes K_1 and K_2.

The mass ratios obtained in Sect. 2 and 3 are compared in Fig. 1. As expected, they are quite similar, but the error bars of the latter method are a bit smaller than those of the former. The values of the mass ratios are between around 0.5 and around 0.9.

5 Properties of the new secondary components

In this section, we discuss why the secondary components of the 20 new SB2s were not detected before, when the old SB1 orbit were obtained with a spectrograph or with a spectrovelocimeter less efficient than Sophie. An examination of the cross-correlation function (CCF) of the spectra shows that the new SB2s may be classified in two categories:

- Systems with a small secondary dip (Fig. 2, left panel). The depth of the secondary dip is around 10 % of that of the primary, indicating that the secondary component is significantly fainter than the primary star. The mass ratio is then small (i.e. around 0.7 or less) when both components are on the main sequence, but it is large when the primary star is evolved.

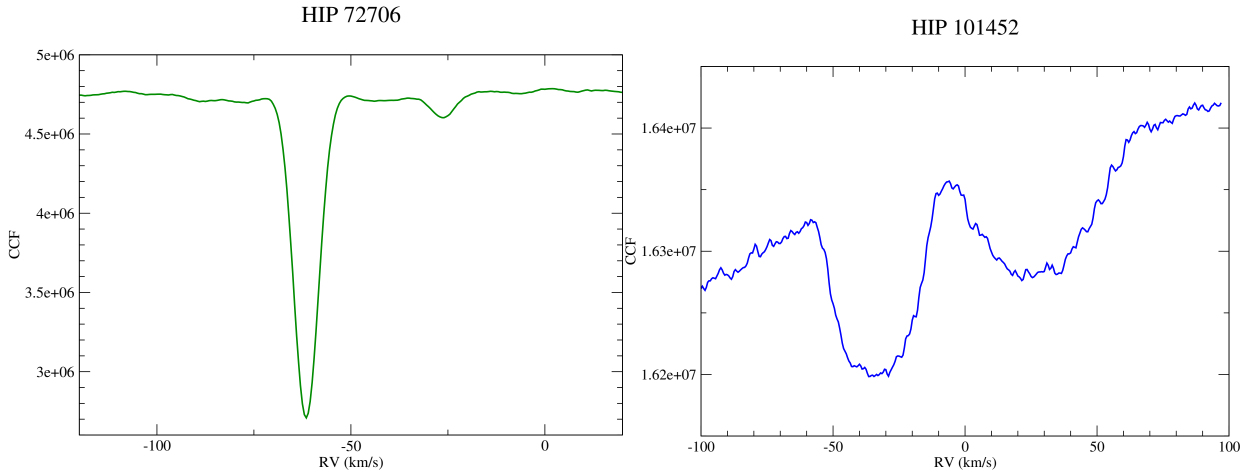

Fig. 2. Left: CCF of a newly discovered SB2 with a small secondary dip. **Right:** CCF of a new SB2 with very wide dips.

- Systems with very wide secondary dip (Fig. 2, right panel). The dips of both components of these systems are enlarged by a fast rotation. The lines of the secondary spectrum were too wide to be detected with an old spectrograph, or the secondary dip was too wide to be visible with a spectrovelocimeter like Coravel.

6 Conclusions

These 20 new SB2s illustrate the excellent capacity to find faint secondary components with the Sophie spectrograph. The methods used to derive the mass ratios and the results obtained for each star are fully developed in Halbwachs et al (2014a).

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