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A Mass Estimate in a Sample of Double Stars

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Abstract. The total masses of binaries are calculated on the basis of their orbital elements from the *Sixth Catalog of Orbits of Visual Binary Stars*. They are then compared with the values resulted from the mass-luminosity relation for the Main Sequence where as the input data are used: trigonometric parallax, total apparent magnitude of the pair (source *Hipparcos Catalogue*) and magnitude difference (source *Hipparcos Catalogue* and *Photometric Magnitude Difference Catalog*). It seems that for the pairs indicated as having qualitative orbital elements the agreement between the total-mass values obtained in these two ways is satisfactory.

Keywords. binaries: visual, stars: fundamental parameters (masses, parallaxes, magnitude difference).

1. Introduction

The total masses $M_{\rm dyn}$ of binaries are calculated on the basis of their orbital elements from the *Sixth Catalog of Orbits of Visual Binary Stars* (Hartkopf & Mason 2003) and of the Hipparcos parallaxes. They are then compared with the values of the astrophysical masses obtained by means of the mass–luminosity relation for the Main Sequence (MS) where two approaches are applied. In the first one (referred to as I) we take the total apparent magnitude m_J (Johnson) of the pair from Hipparcos (ESA 1997) and the magnitude difference Δm from Hipparcos or from the *Photometric Magnitude Difference Catalog* (Worley, Mason & Wycoff 2001), then we find the individual magnitudes by using the corresponding formula (Heintz 1978, p.28) and with them calculate absolute magnitudes. In the second approach (referred to as II) we take the individual apparent magnitudes from the *Washington Double Star Catalog* (WDS) to obtain the absolute ones in the same way. In both cases we use Hipparcos parallaxes. Since all the stars are close enough to the Sun, interstellar absorption is neglected. Spectral types are taken from the WDS. In some cases the spectral type is given for both components. The corresponding bolometric corrections are applied following Kulikovskij (1985, p.246). The astrophysical masses of the components are obtained according to Angelov (1993). Our sample contains 451 binaries for which all the data mentioned above are available. Out of them there are 68 with spectral types given for both components. In the case of the other 383 ones only one spectral type is given and we assume it for both components. Therefore, we form two subsamples corresponding to these two cases.

2. Results

The masses of the components for the subsample of 68 binaries are presented as function of the spectral type for both approaches in Figures 1*a* and 1*b*. As seen, there is practically no difference between the two approaches and the obtained mass values follow closely the theoretical curve.

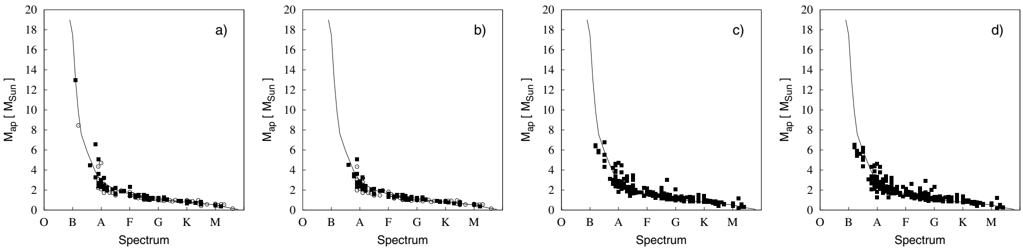

Figure 1. Astrophysical mass versus spectral type for a subsample of 68 binaries (a) approach I, (b) approach II, for subsample of 383 binaries (c) approach I, (d) approach II; the lines are theoretical fits, the squares correspond to the primary, the circles to the secondary.

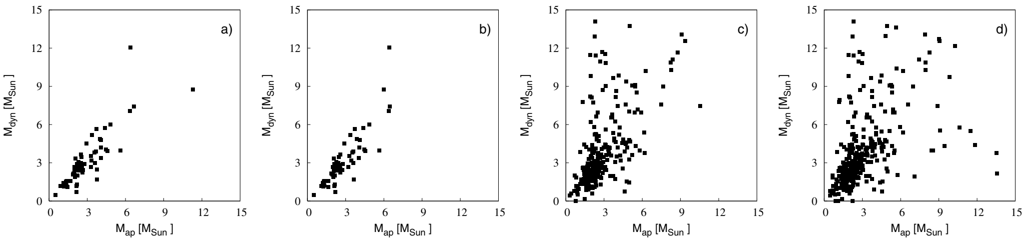

Figure 2. Dynamical mass versus astrophysical mass for a subsample of 68 binaries (a) approach I, (b) approach II and for a subsample of 383 binaries (c) approach I, (d) approach II.

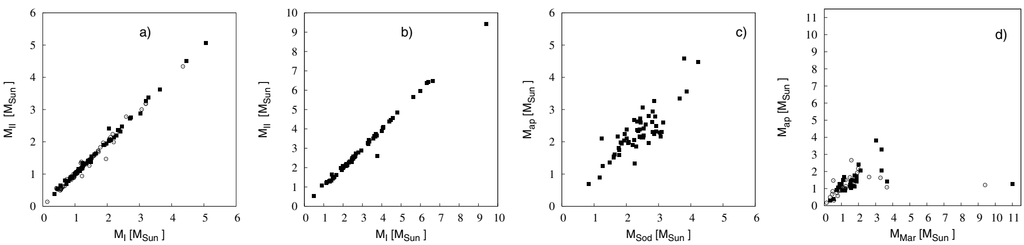

Figure 3. Astrophysical mass from approach II versus that from approach I for a subsample of 68 binaries: (a) for components - the squares the primary, the circles the secondary; (b) total mass. Our astrophysical total mass versus total mass by Söderhjelm (1999) for common stars (c). Our astrophysical mass for components versus mass by Martin and coworkers; the squares the primary, the circles the secondary (d).

In the case of the other subsample again there is no difference between the two approaches (Figures 1c and 1d), but the obtained mass values do not follow the curve so closely because we do not have spectral types for both components.

The comparison of the total masses obtained astrophysically and dynamically (Kepler's third law) is seen in Figure 2. In the case of the subsample of 68 binaries (Figures 2a and 2b) we have almost a straight line with very few outliers, whereas in the case of the other subsample (Figures 2c and 2d) the scatter is apparently larger which is more contributed by dynamical masses. Note that for approach I (used Δm) the scatter is smaller.

The agreement between the component masses obtained by using the two approaches for the subsample of 68 binaries can be seen in Figure 3a, the same for the total masses in Figure 3b. In both cases we see a straight line with almost no scatter. Thus no matter whether we use magnitude differences or individual magnitudes given in the catalog, we obtain practically the same mass values.

For some of the stars from our sample the masses have been determined by other authors and because of this we want to make comparisons. Figure 3*c* shows a comparison with the results of Söderhjelm (1999). We have 57 stars in common with him where for a vast majority of them he determined the total mass only. For this reason in Figure 3*c* our astrophysical total masses are compared to Söderhjelm's ones. As seen, the agreement is satisfactory. Besides, we find 30 stars in common with Martin and coworkers (Martin & Mignard 1998; Martin et al. 1998). They determined individual masses and, therefore, we compare our astrophysical individual masses. The comparison is seen in Figure 3*d*. It is seen that in most cases the agreement is satisfactory, but there are a few cases where their masses are significantly higher than our ones for both components.

3. Conclusion

The comparison of the two approaches shows no essential difference as to whether the individual magnitudes are taken from a catalogue or they are obtained from the magnitude difference.

The scatter in the dependence of the dynamical mass on astrophysical one is inevitable due to the observational errors and it is well known that the dynamical masses are especially sensitive to inaccuracy of parallaxes. If the components of binaries are MS stars, then their masses are related to their spectral types. Therefore, one should pay attention to the agreement between the obtained mass values and the spectral types of the components because we find very often disagreements between these two quantities in the literature.

Acknowledgements

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