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The mass-ratio distribution of spectroscopic binaries along the main-sequence

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Abstract. Binarity is now a well-established quality affecting a large fraction of stars, and recent studies have shown that the fraction of binaries is a function of the spectral type of the primary star, with most massive stars being member of a close binary system. By cross-matching TGAS with S_{B^9}, we went one step further and derived the mass ratio distribution of binary systems as a function of the spectral type of the primary star. This, combined with the binary fraction, provides very strong constraints on star formation and critical input for stellar population models.

Keywords. stars: binaries, stars: evolution, Hertzsprung-Russell diagram

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The distribution of the masses of the two components of a binary system, M_1 and M_2 are clues to critical questions related to the formation and evolution of binaries. We aim here to derive the distribution of the mass ratio, $q = M_2/M_1$, as a function of the primary mass, M_1, thanks to the Tycho-Gaia Astrometic Solution (TGAS; Lindegren *et al.* 2016).We use the Oct. 2016 version of the S_{B^9} catalogue (Pourbaix *et al.* 2004) that contains a large set of spectroscopic binaries gathered from the literature. Our systems are divided into single-lined spectroscopic binaries (SB1), for which we only have the spectroscopic mass function, and double-lined spectroscopic binaries (SB2), for which we already have the mass ratio.

TGAS and S_{B^9} are cross-matched to select all binary systems containing a main sequence primary, for which the relative error on the parallax was below 16%. This provided us with a catalogue of 142 K, 340 G, 421 F, 369 A, and 153 B stars, i.e. 1425 stars in total. Using their B- and V-magnitudes, combined to an estimate of the extinction, A_V, enabled us to put all our objects in the colour-magnitude diagram, $B - V$ vs. M_V.

For the SB1 systems, their position in the Hertzsprung–Russell diagram was used to determine their mass from a comparison with the PARSEC stellar evolutionary tracks (Bressan *et al.* 2012). This was done with a weighting scheme that takes into account the error bars as well as the time a star of a given mass spends at a certain location of the colour-magnitude diagram. The mode's mass of our samples is, resp., 0.85 $M_\odot$ (K stars), 1.05 $M_\odot$ (G), 1.2 $M_\odot$ (F), 1.8 $M_\odot$ (A), and 4.0 $M_\odot$ (B). Using a different metallicity would imply a different mass, but this has negligible impact on the mass ratios we determine.

To determine the mass-ratio distribution (MRD) of our SB1, we make use of their spectroscopic mass function and the primary mass derived above and apply the Richardson-Lucy deconvolution technique (Boffin 2010). This can be done for our 5 samples and the result is shown in Fig. 1. The final MRD is then obtained by summing up the MRD coming from the SB1 with that of the SB2 (obtained directly). The main issue is whether we are suffering from observational biases, i.e. if the S_{B^9} catalogue contains relatively

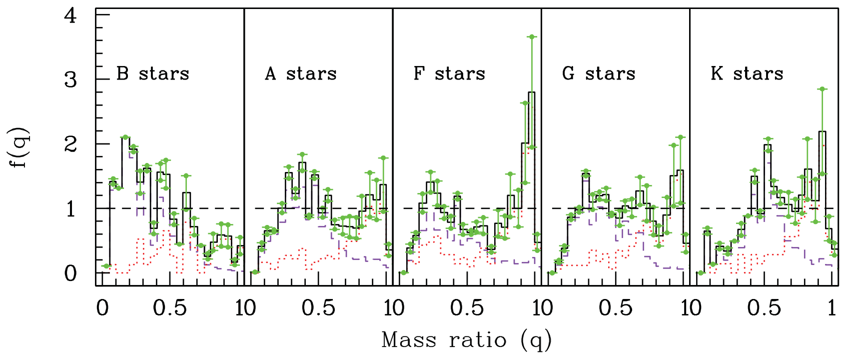

Figure 1. Mass-ratio distributions for the stars in the S_{B^9} catalogue per their spectral type. The purple (dashed) histogram is the MRD obtained for SB1 by deconvolution, while the red, dotted line shows the MRD for the SB2. The final, heavy black line, MRD is the sum of both, with the green dots showing the variations if we count only half of the SB2 or twice the SB2. For illustration purpose, the dashed line shows the uniform distribution.

too few or too many SB2 compared to SB1. Our large samples and the fact that the data come from various, independent sources, should ensure that any bias, if present, is quite small. For illustration purpose, we show in Fig. 1 what we would have if we added only half (resp. twice) the distribution of SB2.

Our results clearly indicate that the MRD is a function of the spectral type of the primary, and thus of its mass, although (except for B stars) the general trend is to have a MRD that is relatively flat, with the *K*-stars lacking smaller companions and the *F*-stars showing an excess of twins.

Using our primary mass distribution as well as our MRD, we can further obtain the distribution of the companion's mass as a function of the primary's spectral type. It appears that up to a given value, around 0.4 $M_{\odot}$, the distributions are peaked towards lower masses, but in a much less steep way than would be expected from the Salpeter or Chabrier IMF.

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