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WHAT CAN THE S_{B^9} DATABASE DO FOR YOU?

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RESUMEN

En este trabajo se ilustran los problemas que pueden abordarse con S_{B^9}, el Noveno Catálogo de Órbitas de Binarias Espectroscópicas.

ABSTRACT

This paper illustrates different kinds of problems that can be tackled with S_{B^9}, the 9th catalogue of spectroscopic binary orbits.

Key Words: **BINARIES: SPECTROSCOPIC**

1. OVERVIEW

In 2000, IAU Commission 30 initiated the preparation and release of the 9th catalogue of spectroscopic binary orbits [5] (hereafter S_{B^9}, Pourbaix et al. (2004)) to supersede the former catalogue of Batten, Fletcher & McCarthy (1989). The aim was to provide electronic access to all spectroscopic orbits together with the radial velocities used to derive them.

2. ORBITAL PERIOD VS. EVOLUTION STAGE

Unlike Hipparcos, GAIA – the next ESA astrometry mission – will measure radial velocities using its on-board Radial Velocity Spectrometer (RVS). Owing to the extreme regularity of the scanning law, a periodogram used to derive the orbital period of a spectroscopic binary exhibits tons of aliases at $\nu > 4\mathrm{d}^{-1}$. In order to make the processing of the GAIA data more efficient and robust, can one limit the range of periods investigated? About 1 500 systems from S_{B^9} belong to the Hipparcos catalogue (ESA 1997), thus making their position in the HR diagram available (left panel of Fig. 1).

What is the shortest period for 0.1mag large bins in (observed) $B-V$? The shortest periods of MS (respectively off-MS) stars are plotted in the right panel of Fig. 1 as filled triangles (pentagons). As a dispersion indicator, the second next to shortest periods are plotted as open symbols. The two squares represent systems absent from the Hipparcos catalogue but known to be off-MS stars. The behavior of the two sets is consistent with the theoretical period derived assuming that one component fills its Roche lobe (Mermilliod 2001), with $B-V$ vs. T_{eff} after Schmidt-Kaler (1982).

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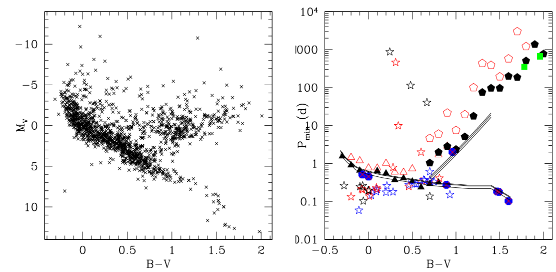

Fig. 1. **Left panel:** Position in the HR diagram of the S_{B^9} system after Hipparcos. **Right panel:** Shortest orbital period versus $B-V$ color index

* 'Main-Sequence' stars: the lines correspond to mass ratios (m_2/m_1) of 0.2, 0.6, and 0.9. The mass of the primary was set according to Popper (1980).
* 'Giants' stars ($B-V > 0.7$, $M_V < 4$): tracks for $m_1 = 1.0$, 1.2, and 1.5$\mathrm{M}_\odot$ with $m_2 = 0.6\mathrm{M}_\odot$. The relation between M_{Hp} (assumed to correspond to M_V) and $B-V$ is based on Fig. 3.5.5 (ESA 1997).

Besides those *regular* systems, S_{B^9} also contains close binaries (with a white dwarf or sub-dwarf component), with periods essentially shorter than 0.3d and whose location in the $(B-V, P)$ is rather unclear because of the composite color index. Those systems are plotted with the observed $B-V$ as stars. For a small subset of them, the spectral type of the secondary was derived. The corresponding $B-V$ was adopted and the system duplicated and plotted as a filled circle. The rightmost of them is a detached binary so it cannot lie **below** the MS line.

Regardless of $B-V$, most of the latter systems will be tough cases for GAIA. Indeed, even if variations of the radial velocities are noticed by the GAIA RVS, identifying the right period among the many aliases will remain unlikely. However, such short period systems represent less than 5% of S_{B^9}.

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3. ECCENTRICITY-PERIOD DIAGRAMS

The eccentricity versus the logarithm of the period (in days) diagram proves to be an essential tool in understanding the tidal evolution of the binary systems. The S_{B^9} catalogue allows to perform a comparison between several subsamples of this diagram. Figure 2 shows the e-log P diagram for all systems with a well-defined main-sequence primary. It is clear from this, but not necessary easy to understand, that there is a different behavior between, say, systems with a B main-sequence primary and systems with a G or K V primary. The latter for example, show only circular or quasi-circular orbits for periods below about 10 days. Clearly the cut-off period is dependent on the spectral type of the primary. This must be related to the stellar structure of the components of the system and/or to the formation history of the system.

4. MASS RATIO DISTRIBUTION

Mass ratio distributions (MRD) among binaries are most certainly predictable outcomes of binary star formation theories and, hence, deserve to be studied in detail. The S_{B^9} catalogue allows again to perform an analysis of the MRD as a function of several parameters, for example the spectral type of the primary. For single-lined spectroscopic binaries (SB1), the mass ratio is not directly available. For systems with a main-sequence primary, it is possible to infer the value of m_1 from the mass-spectral type relation. One can then study the distribution of the reduced mass function, Y, given by:

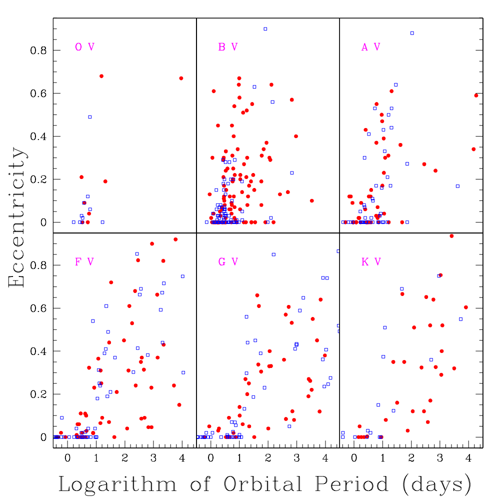

Fig. 2. Eccentricity-Period diagrams for systems having a well-defined MS primary. The heavy dots are the SB1 systems while the open squares are for SB2s.

$Y = f(m)/m_1 = q^3 z^3/(1+q)^2$, which depends only on the mass ratio, q, and on the inclination angle, i, through the variable $z = \sin^3 i$.

The distribution of $\log Y$ is shown in Fig. 3 for the different subgroups of SB1 with a well-defined main sequence primary. Again, it is obvious that the several distributions are different. There is clearly a continuous trend going from the most massive stars to the less massive ones.

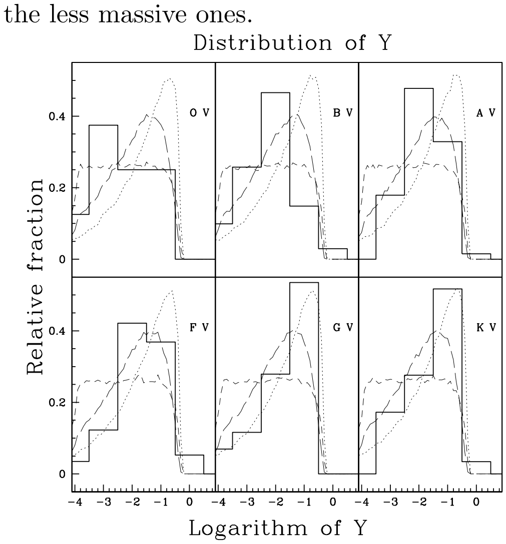

Fig. 3. Distribution of $\log Y$ for the different subgroups of SB1 with a well-defined MS primary. The observed distribution is shown with the black solid histogram, while the different lines correspond to different models of m_2/m_1 distribution: uniform over 0–1 (dotted), linear over 0.05–1 (long dash) and $f(q) \propto q^{-1}$ in the same range (short dash). It can be seen that O V stars have a Y-distribution more compatible with a $1/q$ distribution, while K V stars agree with a uniform distribution of q.

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REFERENCES

Batten, A. H., Fletcher, J. M., & McCarthy, D. G. 1989, Publ. Dom. Ap. Obs., 17, 1

ESA. 1997, The Hipparcos and Tycho Catalogues (ESA SP-1200)

Mermilliod, J.-C. 2001, in The influence of binaries on stellar population studies, ed. D. Vanbeveren (Dordrecht: Kluwer Academic Publishers), 3

Popper, D. M. 1980, ARA&A, 18, 115

Pourbaix, D., Tokovinin, A. A., Batten, A. H., Fekel, F. C., Hartkopf, W. I., Levato, H., Morrell, N. I., Torres, G., & Udry, S. 2004, A&A (submitted)

Schmidt-Kaler, T. 1982, in Landolt-Börnstein new series VI, ed. K. Schaifers & H. H. Voigt, Vol. 2b (New York: Springer-Verlag), 15