ON THE SEPARATIONS OF COMMON PROPER MOTION BINARIES CONTAINING WHITE DWARFS

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Luyten [1,2] and Giclas et al. [3,4] list over 500 known common proper motion binaries (CPMBs) which, on the basis of proper motion and estimated colors, are expected to contain at least one white dwarf (WD) component, usually paired with a late type main sequence (MS) star. Preliminary assessments of the CPMBs suggest that nearly all are physical pairs [5,6]. In this paper we address the issue of whether significant orbital expansion has occurred as a consequence of the post-MS mass loss expected to accompany the formation of the WDs in CPMBs.

Though the CPMB sample remains largely unobserved, a spectroscopic survey of over three dozen CPMBs by Oswalt [5] found that nearly all faint components of Luyten and Giclas color class "a-f" and "+1", respectively, or bluer were a WD. This tendency was also evident in a smaller sample studied by Greenstein [7]. Conversely, nearly all CPMBs having two components of color class "g-k" and "+3" or redder were MS+MS pairs. With the caveat that such criteria discriminate against CPMBs containing cool (but rare) WDs, they nonetheless provide a crude means of obtaining statistically significant samples for the comparison of orbital separations: 209 highly probable WD+MS pairs and 109 MS+MS pairs.

As a statistical measure of physical separation we define a separation index, $\log s/\mu$, where s is the angular separation (in ") of the pair and μ is its proper motion (in "/y). Frequency histograms for $\log s/\mu$ are compared in Figure 1 for the WD+MS and MS+MS pairs. Evidently the mean separation indices of WD+MS systems are significantly larger than MS+MS pairs (labelled L+G in Table 1), implying nearly a factor of two difference in projected semimajor axis. The histograms also suggest that the dispersion in separations does not change much during post-MS mass loss; selection effects favoring the detection of one type of CPMB over the other would most likely result in different dispersions.

The lower half of Figure 1 displays F(ms), the fraction of CPMBs likely to be MS+MS pairs (expressed in logarithmic form for convenience), as a function of separation index, $\log s/\mu$ (bins containing fewer than five CPMBs have been omitted). This plot suggests a monotonic decrease in the

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fraction of MS+MS pairs with increasing separation-- contrary to the expectation that close pairs of contrasting colors (WD+MS) are more easily distinguished from those of similar color. There is also no discontinuity in either diagram which might be construed as the result of binary disruption dynamically induced by perturbations from the Galactic disk [8]. Curiously, $F(ms) \sim (s/\mu)^{-1/3}$ is consistent with the scatter in this plot; the physical significance, if any, has not yet been established.

Is the apparent difference in separation between WD+MS and MS+MS pairs an artifact of the criteria used by Luyten and Giclas in searching for WD binaries? We tested this hypothesis by selecting a random spatial distribution of CPMBs from the LDS catalog [9]. This sample yielded 210 probable MS+MS CPMBs and 26 probable WD+MS pairs. Since Luyten's criterion

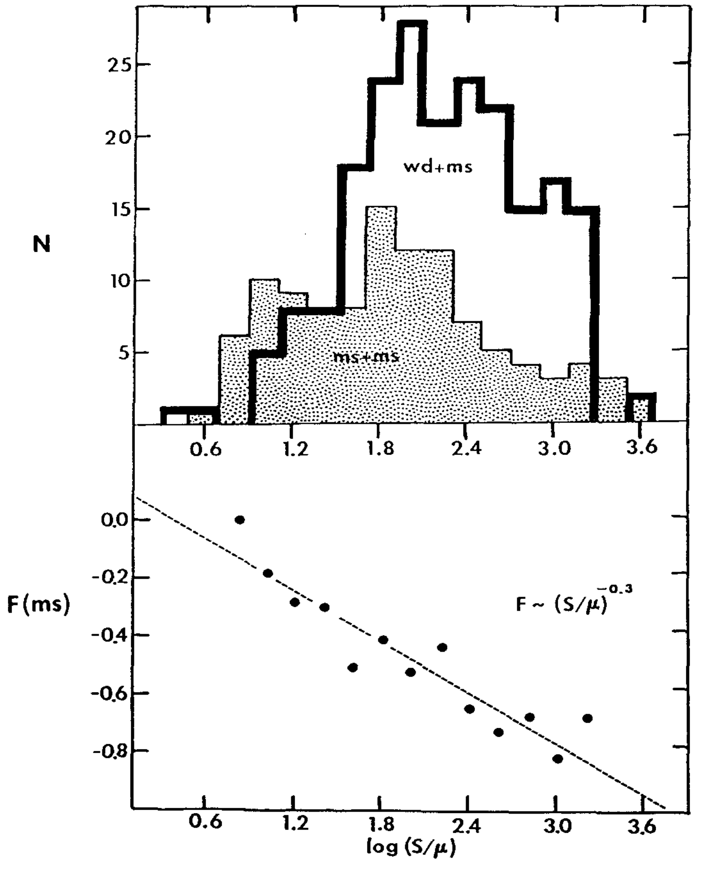

Figure 1. Top: Separation index log s/μ histograms of Luyten and Giclas CPMBs. Bottom: Fraction F(ms) of the sample likely to be MS+MS pairs plotted as a function of separation index.

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Table 1.

Comparison of Binary Separation Indices

Sample	WD+MS pairs n	WD+MS pairs <log s/μ>	WD+MS pairs m.e.	MS+MS pairs n	MS+MS pairs <log s/μ>	MS+MS pairs m.e.
L+G	209	2.22	0.04	109	1.91	0.07
LDS	26	2.34	0.10	210	2.09	0.04
DA	52	2.11	0.07	-	-	-
nonDA	46	1.95	0.08	-	-	-
DQ	8	1.54	0.17	-	-	-

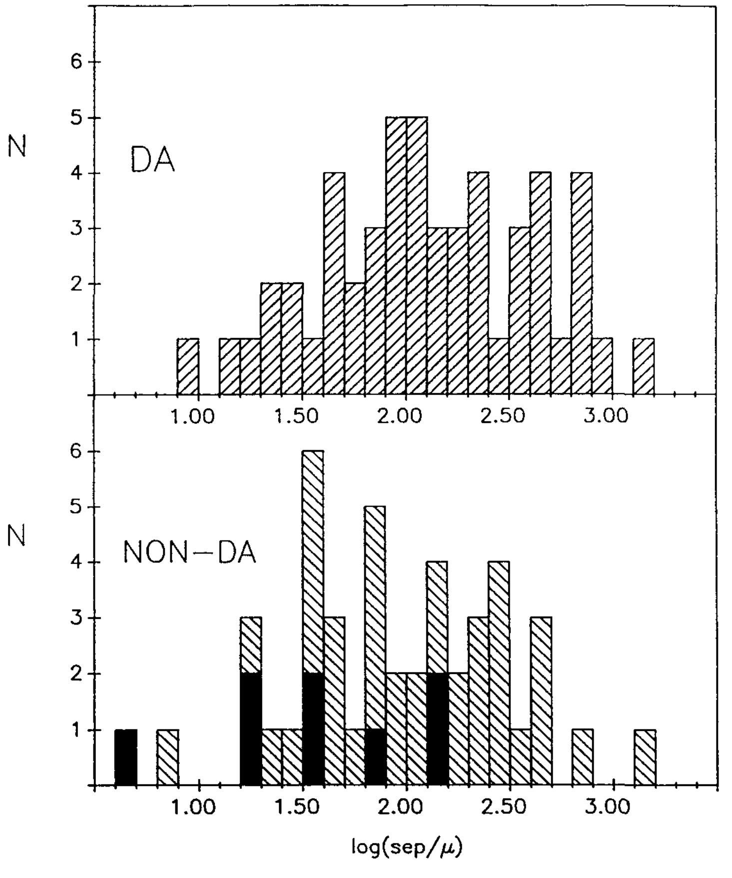

Figure 2. Comparison of separation index log s/μ histograms for CPMBs containing known DA (top) and nonDA (bottom) WDs. Both groups have MS companions. CPMBs with a DQ WD have been shaded in the nonDA histogram.

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for inclusion in the LDS was solely identical proper motion, these samples should be fairly representative of the general distribution of CPMB transverse velocities. The mean separation indices derived for the LDS WD+MS and MS+MS pairs are given in Table 1. We again find that WD+MS pairs are nearly twice the physical separation of MS+MS pairs; however both LDS groups have separation indices larger than their counterparts in the Luyten and Giclas suspect WD binary lists. We tentatively ascribe this to the lower transverse velocities of the LDS pairs [10].

The frequency of helium-rich (i.e. nonDA) WDs is higher among CPMBs than among single stars [11]. Plausible explanations are that WDs found in CPMBs have different parent masses, angular momentum histories, and/or mass-loss compared to those of single WDs. Do the physical separations typical of DA and nonDA CPMBs differ? We culled a sample of 98 CPMBs containing spectroscopically identified WDs from the literature [12]. Figure 2 compares the separation index histograms for these DA and nonDA CPMBs. Although they may be marginally different (see Table 1), the heterogeneous nature of the sources of spectroscopic identifications admits the possibility that misclassified weak-lined WDs contaminate the sample. Possibly significant is the fact that the eight known CPMBs containing DQ WDs which are included in the "nonDA" histogram (shaded) have a mean separation one third that of most WD+MS pairs (see Table 1).

Clearly the potential of the Luyten and Giclas CPMBs as probes of post MS mass loss and orbital evolution has barely been tapped. Nevertheless, our preliminary results corroborate Greenstein´s [7] assertion that significant orbital expansion is likely to have occurred among WD+MS pairs.

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