DUPLICITY ON THE MAIN SEQUENCE*

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(Received 3 October, 1983)

Abstract. A review paper or a lecture like the following one, will best serve 'its' conference by giving an overview of the basic facts, and an impartial review of current debates, also by trying to point out some apparently crucial questions whose solutions, we hope, will determine the line of future research.

Because these stars are essentially unevolved, beyond the topic of multiplicity on the Main Sequence looms the fundamental problem of the formation of binary star systems. Thus we are going to concentrate on the following questions: the fraction of stars that are formed in binary and multiple systems, the distribution of mass ratios for unevolved systems, the role of very wide pairs and the smallest known stellar or substellar masses. We will pay special attention to nearby binary stars. On the other hand, we do not have the space to discuss in any detail the binaries in extragalactic systems, in the upper regions of the HR-diagram; they are practically all evolved systems.

1. The Percentage of Multiplicity

It is a commonplace in double star astronomy that about half of the stars in galaxy are in double or multiple systems, that is, if we study three stars closer, we may expect that one of them turns out to be double. The true figure of duplicity might be even higher, but more accurate statements about the percentages of multiplicity are much harder to come by. The problem is the great difficulty of carrying out reliable statistical surveys based upon reasonably complete and homogeneous samples. Setting, for instance, a suitable magnitude limit for a survey means completeness up to a certain distance only if we restrict the survey to a narrow range of absolute magnitudes. This is the case with Abt's and Levy's well known study of nearby solar type stars but not with Aitken's important surveys of visual duplicity. Even if the survey is more or less complete to a given space limit, there is an inhomogeneity introduced by a 'magnitude equation': spectroscopic data are usually less accurate for fainter objects and visual detection will miss, with increasing distance, closer companions which remain unresolved.

Studies about the distribution of mass ratios, eccentricities, angular momenta and similar data are equally or probably more exposed to observational bias than the question of mere duplicity of multiplicity. As to this latter point, we can say that several independent studies suggest, quite concordantly, a fraction of duplicity around 60–65%, if one makes an allowance for 'missed objects'. Heintz even arrives at a multiplicity of 80–85% (1969). In this context, the multiplicity ratio is taken as

$$\frac{\text{no. of components in double or multiple systems}}{\text{no. of all stars considered}}.$$

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* Paper presented at the Lembang–Bamberg IAU Colloquium No. 80 on 'Double Stars: Physical Properties and Generic Relations', held at Bandung, Indonesia, 3–7 June, 1983.

Astrophysics and Space Science **99** (1984) 29–39. 0004–640X/84/0991–0029$01.65.

This means asking the question: how many stars, in general, are formed as members of a multiple system? Sometimes a different question is asked: given a certain class of stars, such as WR-stars, Am-stars, novae, what is the percentage of these objects in doubles or multiples: is perhaps duplicity an important, possibly characteristic feature of the class? In such cases the duplicity ratio is modified to

$$\frac{\text{no. of systems with at least one component of the specified type}}{\text{no. of all stars of this type}}\,.$$

In the following table, percentages based on this ratio are indicated by an asterisk.

A selected list of recent (more or less so) statistical studies of stellar duplicity present itself as follows:

nearby stars:	$r \leq 5$ pc	multiplicity: 59%	
	$r \leq 10$ pc	55%	Woolley *et al.* (1970) and
	$r \leq 20$ pc	45%	Gliese's Catalogue (1980)
Main Sequence,	B-M	50%	Jaschek and Gomez (1970)
O-type stars		36%*	Garmany *et al.* (1980)
early B-type stars	(B2–B5, IV–V)	50%	Abt and Levy (1978)
late B-type stars	(B7–B9)	45%	Wolff (1978)
A–F star around N galactic pole		40–45%	Hill *et al.* (1976)
solar type stars	(F3–G2, IV–V)	53%	Abt and Levy (1976)
M-type dwarfs		39%	Worley (1969)
B2–F5 (Fehrenbach prism study)		'well above 50%'	Gieseking (1980)
Among evolved stars:			
Giants (K III)		30%*	Jaschek and Gomez (1970)
WR stars		53%*	Lamontagne and Moffat (1982)

We may add two counts of multiplicity among the brightest and the brighter stars in the sky. These samples are very far from being homogeneous but refer to objects which, on the whole, should be the best studied ones:

brightest stars ($V \leq 1.65$)	multiplicity 60%	
Catalogue of Bright Stars	55%	(Hoffleit and Jaschek, 1982)

In the same catalogue we also find a tabulation of the frequencies of increasingly large multiple systems, starting with

$N = 2$, $n = 1715$ systems, then
$N = 3$, $n = 675$,
$N = 4$, $n = 237$, etc.

The highest multiplicities are: $N = 15$, $n = 1$ and $N = 17$, $n = 1$. It is quite obvious that these unusually high multiplicities still need a specific study of confirmation.

Gieseking's investigation, mentioned in the tables of statistical studies above, is remarkable as it represents the first large scale application, with the aim of binary star statistics, of a promising modern technique: the basis of his statistical analysis was essentially improved by the addition of 900 stars observed with the Fehrenbach prism. In this way large bodies of homogeneous observational material can be gained although the accuracy is somewhat inferior to that of slit spectroscopy and the detection of double-lined binaries is not favorable. A potentially even more powerful method is Fellgett's photoelectric radial-velocity spectrometer, capable of an accuracy of $\pm 0.5 \text{ km s}^{-1}$ and thus comparable with the best high dispersion determinations. The gain in observation and reduction time is enormous; there is a limitation to later spectral types but in this respect the Fehrenbach prism complements the spectrometer very well. On the 'other end' of the distribution, among the visual binaries, separations $\leq 0\overset{''}{.}1$ are in the range of interferometric methods and even the lunar occultations could be used for statistical purposes although this needs a sustained and well organized effort: during the 18.6 year period of the revolution of the nodal line, some 9% of the stars in the BD or SAO catalogues could be checked by this method.

Returning to various attempts to distill a definitive ratio of stellar multiplicity out of these statistics, we may summarize the outcome by the qualitative statement: it is generally assumed that a single ratio exists for all unevolved, Main-Sequence stars (see, for instance, Jaschek and Gomez, 1970) and this percentage may be rather high, substantially above the often quoted 50%. Even the reversed question seems not to be far-fetched: are there, after all, single stars? – although the answer to this question is almost certainly affirmative. A further question can be added: are planets around many, perhaps most, of these single stars? There is very little objective ground for an answer to this question as yet, although occasionally the attempt has been made to extrapolate the mass distribution of the secondary components to values as small as 1/1000 solar mass. All this is, however, very uncertain since the planetary system is a markedly different structure from binary and multiple stars, also star clusters, and may have been formed in its own very specific way. It is by no means certain that the maxim: "A planetary system can be considered to be a binary (or multiple) system in which the mass ratio is very large" alone will help us much in understanding the cosmogony of our solar system.

2. Mass-Ratios and Double Star Formation

Statistics of the mass ratios in binary systems as well as the distribution according to angular momentum (usually expressed by linear separations or periods) are at least as important as the multiplcity percentages. We do hope to obtain information concerning the formation mechanisms of binary stars. Thus we are going to consider here, however briefly, four studies representing this area of current research. Their results are not in very good agreement, to say the least, illustrating how far we are from the answer to the problem of binary formation.

In his already cited 1980 paper, Gieseking also discusses the mass ratios in binaries of the spectral range B2–F5. This was a review article and a detailed publication of the data is expected to follow. Yet it is obvious that the material, augmented by a large number of objective prism observations, is far more homogeneous than that of a traditional catalogue study. Gieseking's result, that mass ratios around $q = 1$ are virtually non-existent and the mass ratios peak near 0.25 (see his Figure 7), is unexpected and surprising in the extreme. One's immediate reaction is that the method of observation must very strongly discriminate against double-lined binaries and with it against mass ratios higher than 0.65 or 0.7; a remark in a similar sense has been made in the paper. Nevertheless, Gieseking does interpret this distribution as supporting Lucy's earlier views that binary origins by fission should favor low mass ratios.

Lucy himself found, if not in direct contradiction, certainly in no agreement with these results, that double-lined spectroscopic binaries (SB2's) show a remarkably sharp peak at $q = 0.97$, making nearly identical components quite common (Lucy and Ricco, 1979).

Lucy and Ricco based their work on Batten's 6th catalogue of spectroscopic binary orbits (1967). Unlike Virginia Trimble in an earlier 'more ambitious investigation', they considered only double-lined binaries, about 180 systems. This restriction has the advantage that no assumption is necessary concerning the unknown inclinations and the selection of unevolved systems is more reliable, since we may expect that evolutionary effects lead preferably to lower mass ratios. On the other hand, this restriction is *ab initio* strongly biassed toward high mass ratios, as the secondary spectrum tends to remain invisible if $q < 0.7$. Lucy and Ricco's claim is, essentially, that even in the limited interval $0.6 < q < 1.0$, there exists a conspicuous peak between $q = 0.95$ and $q = 1.0$ (occasional values of $q > 1.0$ are considered observational errors). Since the material in the catalogue offers a statistically rather poor sample, no effort was spared to show that the peak so near $q = 1$ is not a consequence of selection effects nor close binary evolution. (The latter is actually not too surprising.)

But what exactly is meant when the authors say that: "many close binaries ... with intermediate and small total masses ... are formed by a mechanism, that, in its ideal form, would create binaries with identical components"? Many, but not all? What if the form of the mechanism is "not ideal"? Are they in favor of several different processes of binary formation? If we add namely the grey mass of some 800 single-lined binaries (SB1's), the picture would almost certainly change considerably. We then may expect a more bimodal distribution with a second maximum perhaps around $q = 0.3$ or $q = 0.4$, even if one could eliminate all the evolved pairs – not an easy problem if we have a good number of single-lined non-eclipsing systems. Thus we see two careful and extensive studies coming up with conclusions that do not seem well compatible with each other. If we turn to a third investigation we find another, different result yet we see that the final picture still not at hand.

3. The Solar Type Stars and Nearby Binaries

The best available information about mass ratios is still the already mentioned investigation by Abt and Levy (1976) of nearby solar type stars (F3–G2, IV–V). The main advantages of this study are: (1) it is 'objective', to use the authors' word, covering all objects within a certain magnitude limit in a homogeneous treatment; (2) we may hope that for these nearby stars spectroscopic and visual detections complement each other, making the sample virtually complete; (3) evolutionary effects play no significant role due to the relatively late spectral types.

There was some criticism raised about this statistic; the critics seem to have their so-called valid points but I do not think these would bring down the whole study. To mention one example: the homogeneous treatment could be improved by standardizing the exposure times, photographic densities, even waiting for similar seeing conditions, but it does not seem necessary to adhere to such strict rules in order to detect radial velocity variations of the order of 2–3 km s^{-1}. There certainly are weak points: the whole material is relatively small, 123 stars, leaving important 'bins' of the mass ratio and orbital period represented by only 2–4, even 1–2 objects; the time coverage of some systems is insufficient; finally, the estimate of the minimum detectable velocity is perhaps somewhat optimistic – thus influencing the 'completeness corrections' applied by the authors.

The main results of this investigation still deserve our full attention. Concerning the mass ratios, they are twofold:

(1) For the primary mass, $M_1 = 1.2 M_\odot$, the maximum frequency is at $M_2 = 1.2 M_\odot$ ($q = 1$), then the frequency of mass ratios show a slow decline, approximately with $M_2^{0.4}$. This is valid for 'short' periods, $P \leq 100$ years.

(2) For $P \geq 100$ years, the frequency of secondaries increases rapidly as one goes to smaller mass ratios, following the van Rhijn distribution.

The difference between these two groups is interpreted as a consequence of their entirely different history of formation: fission of fast rotating protostars (1) vs separate formation from contracting protostars (2). This part of the discussion illustrated again the importance of these statistics for the theories of binary star formation.

Corrections for 'missed' objects is an essential part of this study. For most mass ratios and periods, visual or spectroscopic detection is, indeed, possible. There are, however, some very difficult combinations. If we consider the smallest mass ratio used by Abt and Levy, $M_1 = 1.2 M_\odot$, $M_2 = 0.0075 M_\odot$, we have to deal with the following possibilities:

Period	Max. angular sep. ($0''.08 < p < 0''.12$)	Max. V for primary
10^{-2} yr		8.8 km s^{-1}
10^{-1} yr	$\sim 0''.02$	4.1 km s^{-1}
1 yr	$0''.09$–$0''.13$	1.9 km s^{-1}
10 yr	$0''.4$–$0''.6$	0.8 km s^{-1}
100 yr	$1''.9$–$2''.8$	0.4 km s^{-1}

Abt and Levy assume that 2 km^{-1} amplitude in the radial component of V_1 can be detected. Considering a magnitude difference of 8 or 9 between components of such a disparity of masses, we may conclude that the cases:

with $P = 10^{-2}$ yr and $P = 100$ yr are certainly,
with $P = 10^{-1}$ yr and $P = 10$ yr marginally detectable,

while a system with $P = 1$ year will almost certainly escape detection. Corrections for incompleteness at this mass ratio are a difficult matter and the low mass end of the distribution remains correspondingly uncertain.

A point-by-point discussion of Abt and Levy's distribution of the mass ratios, summarized in their diagram, see Figure 6 of the paper cited, does indeed suggest that cases with $M_1 = M_2 = 1.2M_\odot$ are most frequent, forming a shallow maximum at $q = 1$. For the rest of the q-values the distribution *could be* considered – for 'short period' systems – as having a constant frequency, independent of M_2. This is, interestingly enough, the distribution shown by nearby visual binaries, as it will be presented immediately. The low-mass end of this distribution remains an open question. It is difficult to dispute the markedly different behavior of 'long period' pairs in Abt and Levy's data; the dividing point seems, however, somewhat arbitrary and it can be placed closer to $P \sim 10$ yr. It should be noted, on the other hand, that there is hardly even a

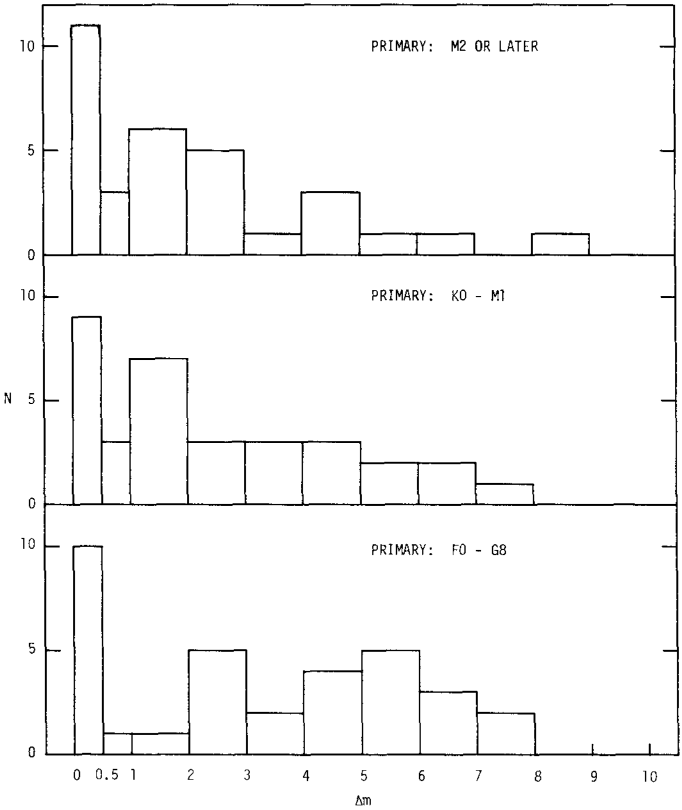

Fig. 1. Distribution of the magnitude differences among 98 visual pairs, based on a 15 hr A.R. interval of the *Catalogue of Nearby Stars*. For all systems, $r < 20$ pc.

hint of a van Rhijn distribution among the secondaries of nearby visual binaries – the more remarkable since for these long periods Abt and Levy, too, have to rely on visual pairs.

It is worth noting that the distribution of periods (or semi-major axes) for this sample is, as Abt and Levy found, not bimodal. Similar distributions with a single maximum around $P = 5$ to 10 yr was found also by Kuiper, Heintz, and others. How is this distribution compatible with two different mechanisms of the binary star formation?

The question seems justified whether we can find out more about the distribution of mass ratios by looking at the nearby binaries, $r < 20$ pc. The material is condensed in two important catalogues but this does not make a number of follow-up studies and checks in the literature unnecessary. A common investigation of nearby double and multiple stars is underway between the present author and Michael Gainer (St. Vincent College, Latrobe, Pennsylvania); as of now, the A.R. intervals 0^h–3^h and 12^h–24^h are covered and the following remarks are based on this partial study, encompassing about 60% of the available material.

Since these double stars are almost exclusively Main-Sequence pairs, the mass ratios can be translated into Δm-values between the components. The histograms of Figure 1 show a similarity of Abt and Levy's diagrams, with the modifications proposed above. There is a distinct maximum at $\Delta m = 0$, followed by a distribution down to $\Delta m = 10$, which can be best characterized by a constant value. (Both our Figure 1 and the Abt–Levy distributions are plotted with a logarithmic scale along the abscissa.) The maximum at $\Delta m = 0$ to 0.5, corresponding to about $q = 1.0$ to 0.85 is unlikely to be result of observational selection: these are relatively bright pairs of $3''$–$5''$ separation, on the average, and a magnitude difference of 0.5 can hardly affect the chances of a discovery to such a marked extent. One has to bear in mind, of course, that the two samples are not identical: ours corresponds rather to the 'long period' group of Abt and Levy's.

4. Very Wide Binaries (cpm Pairs)

It is certainly not without importance for the theory of binary star formation that the distribution curve of the semi-major axes (actually: the observed separations) has a long, pronounced tail, reaching from a few hundreds or perhaps thousands AU to up to 5×10^4 AU or more, a substantial fraction of a parsec. In many cases the common origin is not immediately visible in the telescope and proper motion studies contribute strongly to the discoveries. It is well known, for instance, that the visual pair α Centauri AB has a companion at a distance of 2° – Proxima – which shares the parallax and the space motion of the visual pair and undoubtedly forms a triple system with it. The projected separation is about 9500 AU, the orbital period may be of the order of half a million years (as compared with the 80-year period of the close pair).

The dividing line between 'ordinary' visual binaries and cpm pairs is, of course, a matter of convenience. Abt and Levy, quite consistently, call visual binaries those pairs for which an orbit can already be calculated and all the other physical pairs cpm binaries. (Most double-star astronomers would probably not call a system like, for instance, the spectacular pair β Cygni a cpm binary, in spite of a separation over 30″ and a period which might be in the range of ten thousands of years; yet it is the unchanged configuration, the common proper motion, that indicates the binary nature of the pair.)

The number of cpm components in triple and multiple systems is surprisingly high. So for instance among 16 triple stars in the surveyed section of Gliese's *Catalogue*, no less than 7 are discovered by common proper motion. Luyten (1971) estimated that the space density of wide pairs may be as high as 0.003 pc^{-3}.

Among them the widest known pairs are:

36 UMa and BD 57° 1266, and
α PsA and HD 216803;

in both cases the projected separations amount to about 5×10^4 AU. The orbital periods are of the order of 10 million years, the (average) orbital velocities around 200 m s^{-1}. The existence and 'life expectancy' of such wide systems, in view of stellar perturbations, poses interesting problems. Yet there can be little doubt that these wide pairs do exist, although the observed common proper motion should be confirmed by parallax and radial velocity information – not always available. As illustration of a strong case of two components belonging to the same system, in spite of nearly 2° distance between them in the sky, we may quote the data of the Formalhaut system:

	α PsA	HD 216803
Parallax	0″.149 ± 0″.008	0″.128 ± 0″.008
μ_α	0″.386	0″.326
μ_δ	−0″.161	−0″.158
Radial vel.	+ 6 km s^{-1} (class A)	+ 10 km s^{-1} (class C)

This seems to be a definitive case of a very wide double system. It is tempting to link the existence of these wide pairs to capture processes having occurred in the denser part of a star cluster – now completely dispersed – where these stars were originally formed. We know from numerical treatment of the n-body problem that this process of double star formation is possible and the pairs formed in this way have characteristic separations of several hundreds or thousands of AUs.

5. Unseen Companions

Among nearby stars we hope to find the lowest luminosities and lowest masses on the Main Sequence. The study of nearby stars can also supply the information about a whole new class of objects of possibly very low mass: black dwarfs or objects with 'substellar masses' and – conceivably – even members of other planetary systems.

The lowest known luminosity is ascribed to Gliese 752 = BD 4° 4084B; this component of a visual binary, classified M5e ±, has $M_V = 18.6$; for comparison, the A-component, classified M3.5e, has $M_V = 10.31$. (The parallax is 0″.173 and therefore this absolute magnitude is well determined.) This luminosity is still unquestionably 'stellar': Jupiter, at full phase, would appear 7.8 mag. fainter than Gliese 752, at the same distance.

The lowest masses for observed ('seen') stars, as known today, are in the visual systems:

Ross 614: $0.11 M_\odot + 0.007 M_\odot$ (Probst, 1979), and
Wolf 424: $0.067 M_\odot + 0.064 M_\odot$ (Heintz, 1977);

the uncertainty of the masses in Wolf 424 is given $\pm 0.015 M_\odot$. The absolute visual magnitudes are 16.6 (Ross 614B) and 15.1 (Wolf 424). For possibly even smaller masses we have to turn to the so-called unseen companions.

This group of objects is set apart by the very special observing technique they require; they are more properly called, as part of a wider family, astrometric binaries. Our best hopes to find 'substellar' masses and perhaps even planets around other stars, rest with this way of investigation. The planets are a controversial question we do not want to touch upon here: it mainly concerns the nearby Barnard's star and its possible planetary companions. This particular field is something almost a monopoly of a handful of specialists among positional astronomers and a colleague from the wider fields of binary star astronomy, paying a visit to this *hortus conclusus*, can only register with some astonishment the conspicuous divergence of opinion among the specalists. Perhaps we may accept David C. Black's judgement (1980), himself a visitor to this topic that "any perturbations to the motion of Barnard's star are at or below the level of present astrometric observational accuracy".

Substellar masses or black dwarfs, however, may be a different type of evidence. Following Kumar's work, they are generally expected in the range of $0.01 M_\odot$ to 0.06–$0.07 M_\odot$, that is, from 10 to about 60–70 Jupiter masses. If frequent enough, they may, indeed represent a new class of galactic objects. They may be quite numerous, as products of fragmentation in the contracting prestellar cloud, near the lower end of the mass spectrum (which we do not know with sufficient accuracy). Their possible discovery is linked to membership in binary or multiple systems and we have to add, that present astrometric evidence is rather meager, hardly supporting the idea of a wide class of new objects. Most of the prospective candidates listed in an earlier paper by Kumar (1966) are not be found in more recent lists, and the evidence for substellar masses narrowed down to four cases, none of them completely unambiguous.

We may consider, as basis of a discussion, van de Kamp's compilation in his review article (1975), some of the data seem, however, far from being definitive. It is somewhat discouraging, for instance, to learn that in the case of Gliese 873 = EV Lac, the period was recently revised from 28.9 yr to 45 yr (Van de Kamp, 1981). There are only four stars which may possibly have a 'black dwarf' companion in the system:

ε Eri, BD 68° 946, BD 43° 4305 and Stein 2051.

In case of ε Eri, even the existence of a perturbation is questioned, see Heintz (1978). The triple system Stein 2051 exhibits the perturbation beyond doubt, even spectaculary, but the range of possible masses turns out to be $0.02 M_\odot$ to $0.17 M_\odot$, depending also on the mass of the C-component, a white dwarf. Thus the unseen companion of the M-type component can be itself a late type M-dwarf. Difficulties of this type of a study are particularly well shown in the case of BD 68° 946 = Ci 18,2354. Here a recent rediscussion of the system by Lippincott (1977) resulted in a marked modification of the important orbital element α, the semi-major axis of the photocentric orbit: α went from $0''.102$ to $0''.033 \pm 0''.002$. Heintz is ready to exclude the case at the time being, before more reliable data can be secured. On the other hand, Miss Lippincott points out that the observational basis was substantially increased before this revision and the entire material was remeasured with a Grant-type machine, that is, it was done more objectively than earlier. The change in the masses was strongly downward; the minimum mass of the unseen companion stands now at $0.009 M_\odot$, although this value corresponds – as usual – to the hypothesis of a magnitude difference $\Delta m \rightarrow \infty$ between the components, meaning a dark companion.

We mentioned these cases as illustrations to the point that, owing to the difficulty of the measurements, their interpretation is by no means straightforward. It seems fair to say that not a single case of unquestionably substellar masses have been found yet, but we may have one or two good candidates. The frequent view of popular works and even textbooks that unseen astrometric companions refer to 'black dwarfs' (expressed, for instance, by the unfortunate phrase in German literature: *planetenaehnliche Sternbegleiter*) is simply not correct. They refer in most cases to late Main Sequence companions.

This fact is also expressed by the value of the mean mass, $0.3 M_\odot$, for unseen companions, used by van de Kamp (1981) in an attempt to estimate the mass density of these objects. Revising an earlier figure, he proposed $N = 0.07 \text{ pc}^{-3}$ for the number density, and $0.021 M_\odot \text{ pc}^{-3}$ for the mass density of the unseen companions. This is a small number statistic and the number density is still comparable with the number density of stars, thus a figure that at first glance appears unexpectedly high.

6. Notes on Particular Objects Around the Lower Main Sequence

Concluding this survey, we are going to add, at least in the form of a few time (and space) restricted remarks, some interesting finds about binaries 'around' the Main Sequence (subgiants and subdwarfs) and about a particular class of binaries on the Main Sequence: the low mass contact systems (W Ursae Majoris type). All these remarks are based on unpublished work.

The study of nearby binaries, mentioned earlier, provides us almost exclusively with unevolved systems on the Main Sequence. Near the spectral types F and early G, however, we find a few evolved binaries of the combination subgiant + Main-Sequence star. Among the nearby *subgiants*, we expect to find some very old field stars and in fact, most of the subgiants in binary systems in Gliese's catalogue follow the M67 evolutionary track. Subgiants can be found, of course, among the single stars as well but membership in binary systems can help us to define the position in the HR diagram more accurately.

There are about ten *subdwarf* binaries within 20 pc, mostly marked by high space velocities, 100 km s^{-1} s to 250 km s^{-1} s. Not surprisingly, in typical cases both components are subdwarfs and pairs with nearly identical components are frequent. Their 'vertical' distance from the Main Sequence can reach 6–7 mag.

On the Main Sequence itself there are a few very close detached binaries among nearby stars; they are 'on the verge' of interaction between the components. Castor C = YY Geminorum is the best known example with $P = 19.5$ hr: it is not interacting in the form of any substantial mass exchange but both components show enhanced stellar activity. On the other hand, the number of W UMa type contact systems is surprisingly low: one in Gliese's catalogue (44i Bootis), none in Abt and Levy's sample. Their space density is certainly not the highest among eclipsing binaries and it may be as low as $1\text{–}2 \times 10^{-5}$ pc^{-3}. One of them, the binary i Bootis is member in a triple system and this enables us to obtain a good determination of the mass of the contact pair. This turns out unexpectedly low: not much larger than $1.2 M_{\odot}$. A somewhat similar case, at a greater distance is VW Cephei. Here the system data are less well determined but they, too, suggest an undermassive contact pair of $1.3\text{–}1.5 M_{\odot}$. The spectral types are G2 + G2 resp. G5 + K0. It would be very interesting to see other binary masses of this group derived from triple and multiple systems.

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