Part II

Evolutionary Trends in Wide Binary Systems

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EVOLUTIONARY TRENDS IN WIDE BINARIES

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1. INTRODUCTION

Zdeněk Kopal has kindly invited me, and I have accepted, to "instruct the theoreticians on known facts". He also asked me to express my opinion on the relative evolutionary stages of components.

I am essentially an observing astronomer, occupied with stars in our immediate neighborhood, say within 10 or at most some 25 parsec, i.e., the lower main sequence and the white dwarf degenerate branch.

I hope that I may perhaps contribute by surveying and reporting some relevant data. I shall touch on a number of topics, limited because of selection and lack of knowledge. My contributions to binary stars lie in the realm of parallaxes, mass-ratios and masses, - and for the past half century, perturbations, interpreted as unseen companions, stellar and otherwise. I shall briefly report on some results, and I shall be wondering and hoping that some trace of stellar evolution may possibly be present in these results. After having witnessed for more than half a century my own astronomical evolution, the time has come for me to become more aware of theoretical, evolutionary and cosmological aspects of the cosmic material, I have been playing with so long.

I dare say that basically I deal with wide binaries, i.e., systems with sufficient separations which make mass-exchange unlikely. Thus far, I have not been particularly concerned with evolutionary aspects, but I welcome the occasion to learn more about them.

The word evolution refers to individual components of binary and multiple stars, but also, as a consequence, to the changing frequency of the numerical distribution of the objects. In the cases of stars, evolution cannot be followed over the required long intervals, except through theoretical considerations. And the results of these may be tested through the momentary situation, i.e., the various stages of evolution, reached by different components, as observed at this time.

Z. Kopal and J. Rahe (eds.), Binary and Multiple Stars as Tracers of Stellar Evolution, 81–103.

Time-probes in the past, attainable for bright very distant objects such as galaxies and quasars, cannot be used in the study of the binary and multiple structures, which can hardly be studied beyond a distance, or past, of a few thousand lightyears at the very most.

My presentation is bound to incomplete, very limited and based on personal experience and preference. May the choice of the scattered subjects be helpful in our soul-searching attempts, suggested by the title of this Colloquium.

2. "WIDE" BINARIES, ORBITAL MOTION, COMMON PROPER MOTION

How do we define a wide binary? Traditionally visual binaries are discovered from "resolving" apparently single stars, with adequate telescopic power. With the exception of Mizar and Alcor, ε 1 and ε 2 Lyrae, possibly a few others, double stars are not evident to the naked-eye , and play a minor role in low-optical surveys. But with larger, even medium-size telescopes, double stars prove to be a major, possibly the major portion, of the stellar population. To separate true physical., i.e., gravitationally bound, from optical binaries, i.e., chance alignments of stars, at widely different distances, orbital motion ultimately will tell the story. But common proper motion, if desired, followed by parallax determination furnishes an infallible proof for physical connection. For example, the wide pair G 175-34, proved to have been observed long ago as a double: Stein 2051. Its large proper motion (μ = 2".37) and large parallax (p = 0".192) make this a most interesting object.

Most well determined orbits of visual binaries have semi-axes major a between 15 and 30 a.u.; hardly any orbits are known with a $>$ 100 a.u. Provisional orbits have been derived for a number of visual binaries with a between 50 and 100 a.u., and periods between 350 and 700 years. Van Biesbroeck (1957) compares large double star orbits, on the average, with planetary orbits in the solar system. For a total of 163 orbits with sufficiently reliable parallaxes he finds that the greatest numer have sizes of something like 30 a.u. Selection effects are obvious of course, but there is a marked decrease beyond 100 a.u. The question arises naturally to what separation binaries do exist. Using the common proper motion criterion, Van Biesbroeck lists 9 nearby wide binaries with reliable parallaxes and with projected linear separations ranging from 7500 to 44000 a.u., the latter value being 0.21 parsec or 0.7 lightyear; the corresponding periods would be of the order of ten million years. Williams and Vyssotsky (1942) have found separations ranging from 1.000 to 50.000 a.u. Tolbert finds an upper limit of about 40.000 a.u. for the intrinsic separations; two systems ADS 1073 and ADS 15434 were found with exceptionally large separations 140.000 a.u. (0.68 pc) and 220.000 a.u. (1.06 pc).

For these very wide binaries the question arises whether the binding energy is sufficiently large to protect the binary against dissolution, i.e., whether the relative orbit is not, or could become, hyperbolic. Observational orbital tests have been proposed by the author (1961).

The extreme spacings could not be a large fraction of the average observed spacing between stellar systems of about 2 parsec in our immediate neighborhood (within 5 parsec). Huang has remarked that the binding energy of a very wide binary system is so small that the system can easily be disrupted by a stellar encounter. Hence, such a system may prove to be unstable and dissociate before completing a few revolutions. A rough estimate for instability would be a separation larger than about one parsec, i.e., one half of the average spacing of stellar systems. The fact that wide binaries exist, suggests that these may have been created comparatively recently.

The spacings of the above mentioned extreme two cases are still below the range of stability given by Huang. Moreover, these two systems have very massive components, about 15 M_{o}, which would render them more resistant to disruption.

4. PROPER MOTION BINARIES

Already referred to in Van Biesbroeck's studies, a simple efficient, infallible method for discovering binaries, and automatically excluding any optical ones, is furnished by the obvious fact that for binary components, the proper motions are virtually the same, save for the generally small, relative orbital motion. Their proper motions may be measured, "absolute", or relative, on a background of "fixed" stars. This leads us to the large and fruitful field of <u>common proper motion</u> stars (historically sometimes referred to as 61-Cygni binaries): <u>visual</u> binaries often with large angular (and linear) separation between the two components, and correspondingly large periods.

The foremost discoverer of these common proper motion binaries is W.J. Luyten, who has stressed that the classical visual double star is not representative of the typical binary in space (Luyten, 1969). The vast majority of stars in space are probably main sequence stars, less luminous than the Sun, but the majority of doubles listed in general catalogues, are more luminous than the Sun, and include substantial numbers of red, yellow and blue giants.

The classical discovery surveys based on apparent magnitude have not, or only the weakest criterion, for parallax. The common proper motion surveys have the <u>strongest</u> possible criterion for parallax, and are likely therefore to be more representative of the true spatial situation. The common proper motion approach is easily extended by means of photography to very faint stars, say <u>21 pg.</u>, down to a common proper motion of 0″.2 and a minimum separation <u>of 1″.5</u> or less. Hence the importance of the Luyten surveys and analyses. Statistical considerations yield a (geometric) mean value for the semi-axis major in a.u., ($a = \frac{12s}{\mu}$) where s is the angular separation, μ the (common) annual proper motion in arcseconds. For s = 1", $\mu = 0''.2m$ we find a = 60 a.u. The wide doubles thus discovered have semi-major axes from 50 to 100 a.u., and periods from 300 years upward.

To quote Luyten, there is a frightening amount of observational selection in the finding of these proper-motion wide pairs. While all the selection effects resulting from these observational restrictions can be easily recognized, it is very difficult, if not impossible, to make quantitative allowance for them. For this reason Luyten emphasizes that all conclusions must be considered as extremely provisional.

From his proper motion survey with the 48-inch Schmidt telescope, Luyten ultimately expects up to 100.000 wide common binaries, down to annual proper motion of 0".05 (statistically nearer than 200 parsec) separations down to 1" and faint companions down to 23 mag. This number exceeds by a wide margin the total number of visually discovered double stars nearer than 200 parsec. These relatively wide common proper motion pairs constitute observationally the <u>most common type of binaries</u> in space. No spectra are known for these faint stars, but color estimates b a f g k m have been made from photographic plates, white dwarfs corresponding to color range b to f, red dwarfs to color range k to m.

5. LONG FOCUS PHOTOGRAPHIC ASTROMETRY

For a detailed presentation of this subject the reader may consult the author's "Stellar Paths" (van de Kamp, 1981).

It is now time to first say something about the technique and possibilities of photographic astrometry applied to individual stars and stellar systems with long-focus optical instruments, the real hero's of high accuracy astrometric investigations, to quote my late friend and colleague Joe Ashbrook. First employed in the beginning of the current century for measuring accurate stellar <u>parallaxes</u>, the same technique provides the geometric and dynamical properties of double and multiple stellar systems (and of associations and star clusters) and thus plays an obvious role in the study of origin and evolution of these systems. The high accuracy results from the large scale portrayal of a small portion of the sky, usually less than one degree across, the high quality of photographic emulsions and of measuring machine, and the <u>differential</u> nature of measurements made relative to a number of reference stars within small angular distance of the central "parallax" star. The ultimate limiting accuracy appears to be something like 0".002 (about 0.1 micron for a representative instrument). Parallax determinations yield absolute <u>magnitude</u>; <u>mass-ratio</u> determinations, together with the space-time dimension of visual binaries, yield <u>masses.</u> And presently the same photographic technique leads to the discovery and subsequent study of <u>perturbations</u> in stellar paths.

The absolute magnitude

$$M = m + 5 + 5 \log p$$

plotted against spectral class furnishes the well-known H-R diagram. Of particular interest for low luminosity stars, whose spectra may not be known, is the color-absolute magnitude relation. The illustration for stars nearer than 22 parsec (figure 1) clearly reveals the lower main sequences and the white dwarf or degenerate section of the diagram. Were it not for scatter due to observational errors, the main sequence - especially - would be rather narrower than the diagram indicates.

For a binary the combined mass, expressed in terms of the Sun's mass, is given by the harmonic relation:

$$M_A + M_B = \frac{a^3}{P^2}$$

where the semi-major axis a is expressed in astronomical units of distance, and P in years. Or, since the parallax p is a required datum, we write

$$M_A + M_B = \frac{a^3}{p^3} \cdot \frac{1}{P^2}$$

where a and p are expressed in arcseconds. The cube power of p puts a severe limitation on the attainable accuracy for the combined mass, even for relatively nearby systems. The separate masses may be found from the observed orbital motion of the two components relative to the uniform motion of the center of mass.

Stellar masses thus found faced with absolute magnitude yield the mass-luminosity relation for the lower main sequence and a number of white dwarfs. An illustration (Fig. 2) is given for the components of visual binaries nearer than ten parsec with well-determined orbits; the degenerate components of Sirius and Procyon, to a lesser extent o_2 Eridani B, form striking exceptions to the general mass-luminosity relation which represents the main sequence. Minor deviations are indicated for a few binaries, such as Zeta Herculis and for 85 Pegasi.

6. WIDE ECLIPSING BINARIES

At this stage we mention two wide binaries with very massive components that have received special intensive observational attention (van de Kamp, 1978). They are the two long-period eclipsing

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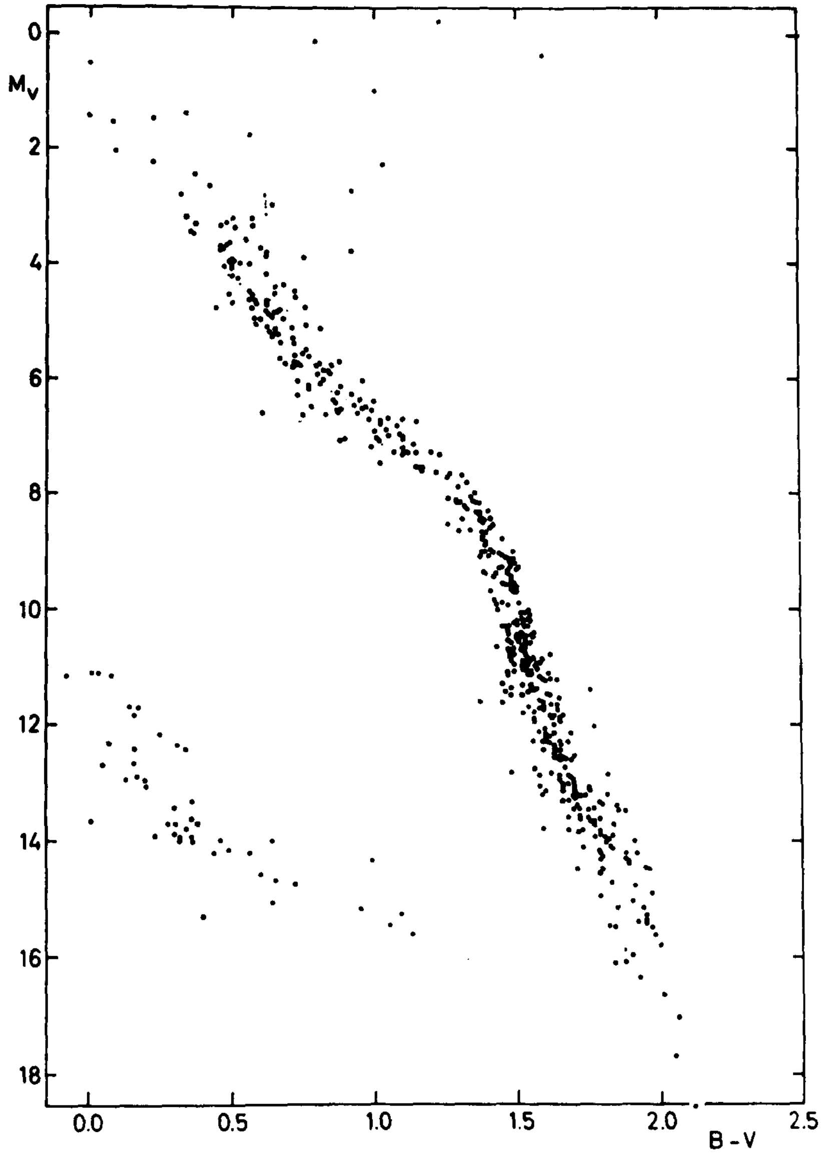

Fig. 1. Color (B-V)-luminosity (M_V) diagram for stars nearer than 22 parsec (Gliese).

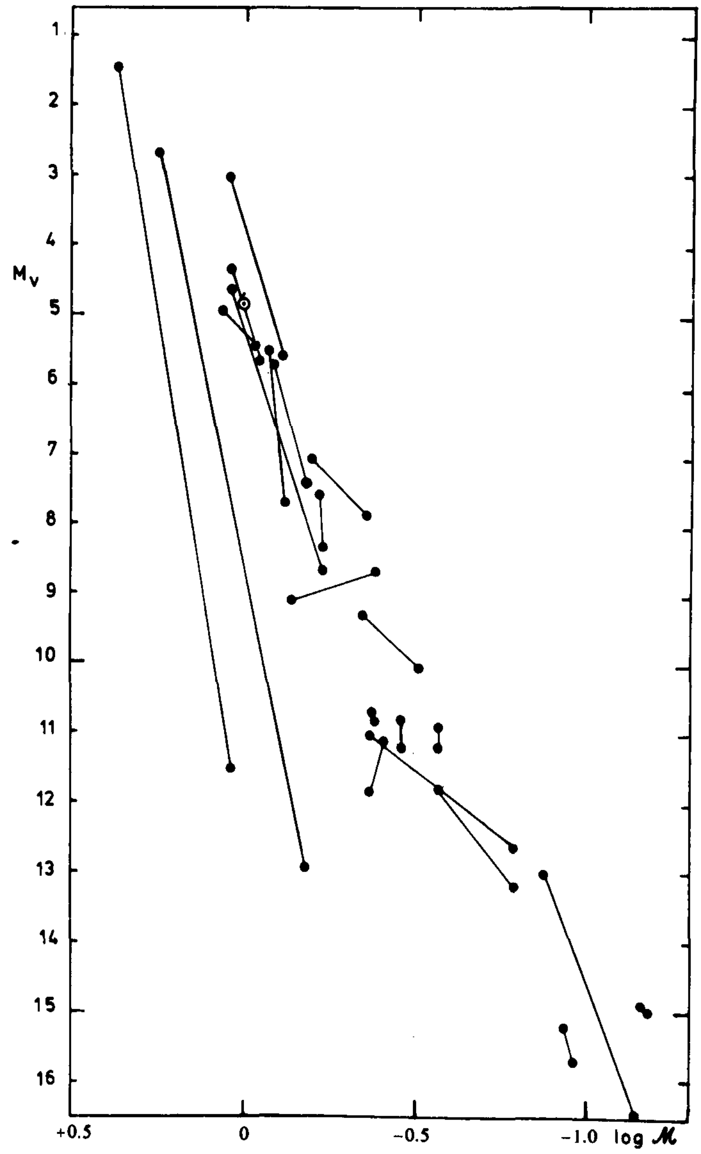

Fig. 2. Mass-luminosity relation for binary components nearer than 10 parsec. The Sun is indicated by ⊙ .

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binaries VV Cephei and Epsilon Aurigae. The relevant data for these objects are

	Period	Semi-major axis of relative orbit	Parallax	
VV Cephei	20.4 yr	25 a.u.	0".0014	± 0".0002
Epsilon Aurigae	27.08	27 a.u.	0.00172	0.00018

The very accurate parallaxes are "orbital" parallaxes obtained by equating the observed astrometric orbit with its linear dimension obtained spectroscopically which exceeds the astronomical unit, the base of annual parallax determinations, by a factor of about ten.

VV Cephei consists of a super giant M Star and a B9 companion, with masses 18.3 and 19.7 M_o and absolute visual magnitudes - 4.3 and - 2.6, respectively, after correcting for 0.3 mag. interstellar absorption. Epsilon Aurigae consists of a supergiant F Star, and a mysterious companion, with masses 15.5 and 13.7 M_o and an absolute visual magnitude of - 6.7 for the bright component, after correcting for 0.84 mag. interstellar absorption.

7. CLASSICAL BINARIES WITH ONE DEGENERATE COMPONENT

In anticipation of reviewing Luyten's studies of wide binaries with one degenerate component, we list the classical cases of such binaries:

These, the only measured masses of white dwarfs, range from 0.42 M_o to 0.94 M_o, well below the Chandrasekhar limit. We also record the case of an <u>unseen</u> white dwarf:

			Parallax	Inferred Mass
Zeta Cancri D	17 yr	α = 0".191	0".042	0.9 M_o

A recent study at USNO of the most interesting, by now, quadruple system G 107 - 69/70 (parallax 0".091 reveals the secondary G 107-70 to be a partially resolved binary consisting of <u>two low-mass white dwarfs</u>, each with masses of approximately 0.5 M_o.

8. PROPER-MOTION BINARIES WITH ONE DEGENERATE COMPONENT: STATISTICAL STUDIES

The Luyten proper-motion binaries include particularly interesting pairs. Six percent of the total studied contain a white dwarf or degenerate component. Sixty percent of these pairs are similar to the classical pair o_2 Eridani BC, a white dwarf plus a late main sequence K or M dwarf. Luyten considers these as "normal" pairs

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Classical Examples of Binaries with One White Dwarf Component

	Period	Semi-major axis	Parallax	M_V		Sp		Masses 1	Masses 2
Sirius	50.09 yr	19.9 a.u.	0".377	1.4	11.2	A1	DA	2.20 $M_\odot$	0.94 $M_\odot$
Procyon	40.65	15.9	287	2.6	13.1	F5	...	1.78	0.65
o^2 Eridani BC	247.9	33.6	205	11.1	12.8	DA	M4e	0.42	0.20
Stein 2051	$>$300	$\sim$40	183	12.4	13.7	M5	DC	0.22	0.48

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with a white dwarf component. For only one pair, LP 129 - 620/621, is the white component bolometrically definitely brighter than the red component: 16.6 pg, f; 20.8 pg, m .

Since virtually no parallaxes are known for any of these proper motion pairs, Luyten employs the reduced proper motion $H = m + 5 + 5 \log \mu$, which has a close relationship to and averages about 6 units higher than the absolute magnitude $M = m + 5 + 5 \log p$. For the average of the components Luyten finds

red stars :	H =	17.5 pg mag,	average color	m (k - m)
white stars :	H =	17.5 "	" "	a3 (b - f)
o^2 Eridani B:	H =	17.8		a3

A plot of H against color (fig. 3) shows the above average for the red stars very close to the main sequence, for the white stars well within the white dwarf area, both established from a study of proper motion stars in the North Polar Cap.

A similar plot for pairs where either the degenerate component is later than color f, or the main sequence component earlier than k, or both, shows that for the great majority, one component is definitely in the white dwarf area of the diagram. A plot for the dozen or so pairs for which both components are degenerate (which includes LDS 275, the first double white dwarf discovered) shows that with one exception the whiter star is always the brighter of the two, exactly what one would expect if a single degenerate branch exists. Four m- components could be degenerate, or because of the crude color estimates, could be actually very faint main sequence stars.

Common proper motion binaries containing a white dwarf and a non-degenerate star exist therefore in large numbers. Altogether, 24 of these objects were studied by Wegner (1981); comparative kinematical youth is indicated. Wegner concludes that some white dwarfs are remnants of fairly massive evolved stars that were originally above the Chandrasekhar limit of 1,4 $M_\odot$ for white dwarfs. Studies by others have also indicated the existence of relatively massive white dwarf progenitors.

9. SOME THOUGHTS OF EVOLUTION

Cecilia Payne-Gaposchkin and Sergei Gaposchkin (1946) have studied the spectrum-luminosity relation between components of binaries. They draw attention to the well-known fact, that associations between components of practically all physical types are observed, witness for example the above mentioned VV Cephei and Epsilon Aurigae. They suggest that the components of one and the same binary may have different constitutions, and they do not exclude the formation of one star in the neighborhood of a pre-existing star.

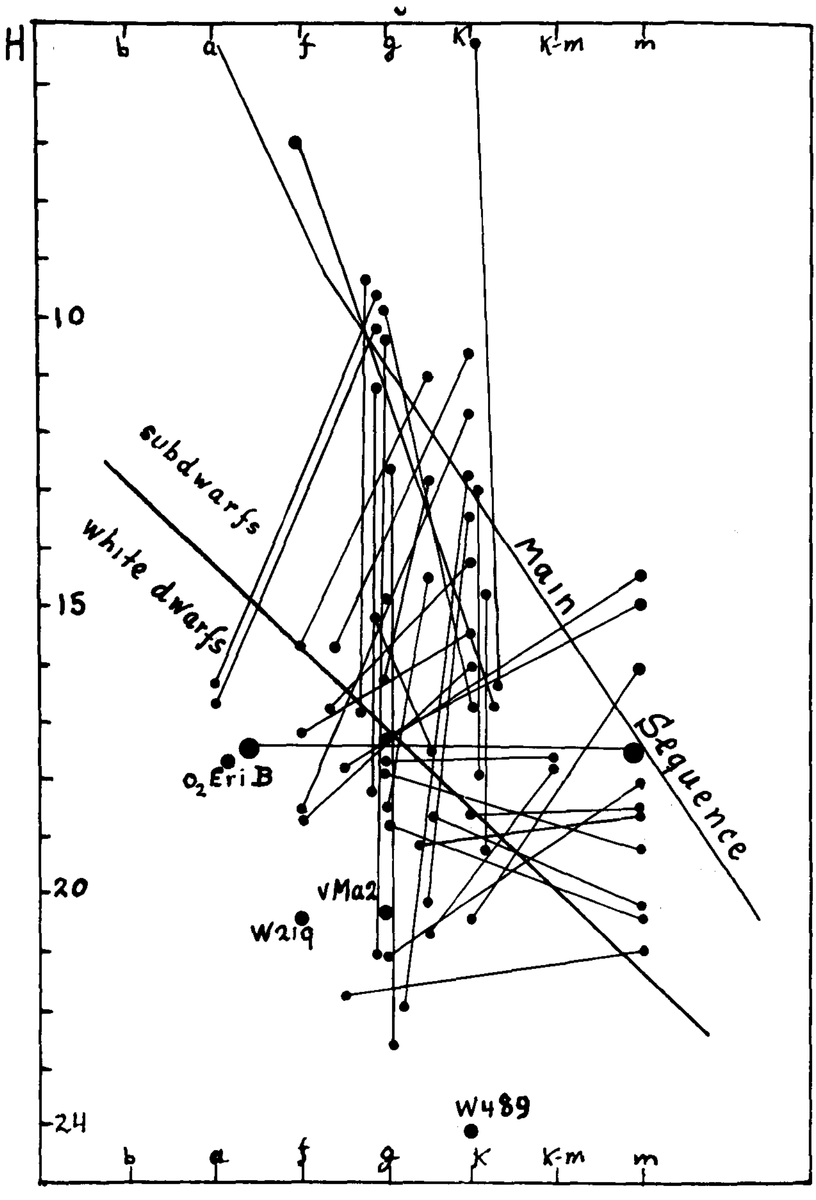

Fig. 3. Reduced proper motion vs color for proper-motion binaries with one degenerate component.

From a study of 94 wide visual binaries Tolbert (1964) finds confirmation for the theories of common origin and evolution. Each component apparently evolved as a single star without close-binary-type interactions. He assumed that all secondaries of luminosity class V (IV, III or A m) had absolute magnitudes on the main sequence; differential colors and magnitudes were used for the primaries. The diagram for the V-primaries is in agreement with evolution, upward and to the right in the H-R diagram with minor exceptions of no consequence. Clearly, these binaries cover a wide range of ages, up to binaries with early-type primaries and late-type secondaries.

We review briefly a recent study on wide binaries in the solar neighborhood and the statistical effect of encounters, by John M. Retterer and Ivan R. King (1981). They recall that single stars may be rare (Abt and Levy, 273). High frequency of duplicity exists in the solar neighborhood, up to 1.3 (i.e., 100 "stars" contain 230 components; Abt, 1978).

The observed distribution of a, one of the most important binary characteristics, is found to be a smooth, single-peaked function from spectroscopic binaries with a = 0.1 a.u. to wide visual and common-proper-motion binaries with a $\sim 10^4$ a.u. Up to a $= 2 \times 10^4$ a.u. = o.1 parsec, the distribution of semi-axes major is the original distribution, undisturbed, but beyond that separation the distribution is determined completely by a steady-state decay process due to stellar encounters. This seems to agree with the observational results of Bahcall and Soneira (1981) from their study of the distribution of stars brighter than V = 16 mag. near the North Galactic Pole. The clustering properties of these stars reveal that a significant fraction ($\sim$ 14%) of the stars appear to be in binaries or triples with a typical separation of the order of 0.1 parsec. Very few binaries have separations of more than 0.1 parsec. Compare this with the separation for the overwhelming majority of visual binaries, which is less than 0.001 parsec or 200 a.u.

10. PERTURBATIONS AND UNSEEN ASTROMETRIC COMPANIONS

The study of perturbations in stellar paths, systematically begun half a century ago has yielded over a score of well determined perturbation orbits. All of these announce the existence of a new hitherto unknown binary system.

For some of these, the unseen companions have been detected visually on the basis of prediction and for many more it is clear that the systems are "normal", i.e., that the companions not seen yet, will not yield any new, shocking information. But a limited number of discoveries made thus far, appear to reveal companions with masses below 0.06 $M_{\odot}$, i.e., of a sub-stellar nature; even Jupiter-like companions are indicated in one case.

Perturbations therefore should increasingly contribute to our knowledge of binary systems and unavoidably, this additional information will have bearing on stellar evolution.

The principal orbital data for dynamical interpretation are the semi-axis major (scale) α expressed in astronomical units and the period of revolution P expressed in years. The harmonic relation for the now unresolved astrometric binary is replaced by the <u>mass-function</u>

$$\frac{\alpha^3}{P^2} = (M_A + M_B)(B - \beta)^3$$

where B and β are the fractional values mass and luminosity respectively of the companion, relative to the total system.

Or, we may write

$$M_B = \alpha P^{-\frac{2}{3}} (M_A + M_B)^{\frac{2}{3}} + \beta (M_A + M_B)$$

Interpretation of this formula requires adopted values for M_A and for β .

For details, the reader is referred to "Stellar Paths", Chapters 13ff.

For the case of a small value of the <u>orbital constant</u> $\alpha P^{-\frac{2}{3}}$, and of no visual evidence for the companion, we may write to a high degree of approximation : $M_B = \alpha P^{-2/3} M_A^{2/3}$.

The first pre-photographic discoveries of the perturbations in the proper motions of Sirius and of Procyon, announced by Bessel in 1844 were followed by visual detection of the faint companions in 1862 and 1896, respectively. The first photographic discovery of a perturbation of the red dwarf Ross 614 (1936) was followed by the visual detection of its companion in 1955. The fainter component of Ross 614 has the smallest known well-determined mass of a visible star, namely 0.06 M_o. The second visual detection of an unseen companion followed the photographic study of the perturbation of the G 5 main sequence star VW Cephei (1975).

As long as the companion ascribed to a perturbation is not seen, no final value for its mass can be established; however, generally its mass can be evaluated within fairly narrow limits. Likely locations in the mass-luminosity diagram (Lippincott) are not at all inconsistent with the lower part of the main sequence for components of visual binaries. Exceptions are the white dwarf component of Zeta Cancri C and half a dozen <u>substellar</u> objects. Four of these have masses ranging from about 0.00 5 to 0.02 M_o; two appear to be of planetary

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nature with masses somewhat below that of Jupiter. Whether these substellar and planetary companions lie on an extension of zero-age main sequence toward very low luminosities and very low masses, is not excluded but remains to be "seen".

A few illustrations of well-established perturbations are given on Figure 4. For details, consult "Stellar Paths" (van de Kamp, 1981).

A special example of a multiple (in fact double) perturbation is that of the nearly red dwarf Barnard star, at a distance of 6 light-years. The pattern of yearly mean residuals may be attributed to two component perturbations with circular orbits, (Fig. 5) periods of 13.5 and 19.0 years and radii of about 0".01 each. The reality of these small perturbations is supported by the (Fig. 6) instrumental profile of the Sproul refractor based on measurements of several stars without detectable perturbations. An instrumental stability within 0.1 micron or 0".002 in the focal plane is found over the past three decades.

Interpretation of the perturbation of Barnard's star leads to masses of about 2/3 that of Jupiter for each component. The orbits of the components are not far from being co-planar, and could be co-revolving.

11. MULTIPLICITY AMONG BINARIES

The degree of multiplicity beyond binary is high. Finsen and Worley find that 18% of visual binaries with calculated orbits have third components while 6% contain four to six components. Similar results are found from spectroscopic studies by Petrie, by Batten, and from other samples of binaries. In several of the wide binaries, one or two of the components are found to be double, and the resulting system may be quadruple or even more (Sigma Coronae Borealis, Castor, Zeta Cancri, Xi Ursae Majoris, G 107-69/70).

In the mass-luminosity diagram, no marked difference is shown within the available accuracy in the behaviour of components of binaries, whether these are members of multiple systems or not (Fig. 7).

Note that our present knowledge of individual masses and luminosities of white dwarfs is furnished by two binaries (Sirius and Procyon), by one binary which is part of a triple system (o^2 Eridani) and three binaries which are part of a quadruple system (Zeta Cancri, Stein 2051, G 107 - 69,70).

A further note: The several papers on triple near collisions, which I heard recently at Cortina d'Ampezzo, referring among others to my old friend Carl Siegel, and remarks and discussions with others, revived and renewed my interest in the general subject of the origin of binary stars and their evolution. A near collision of two stars might not result in the formation of a binary; the chances

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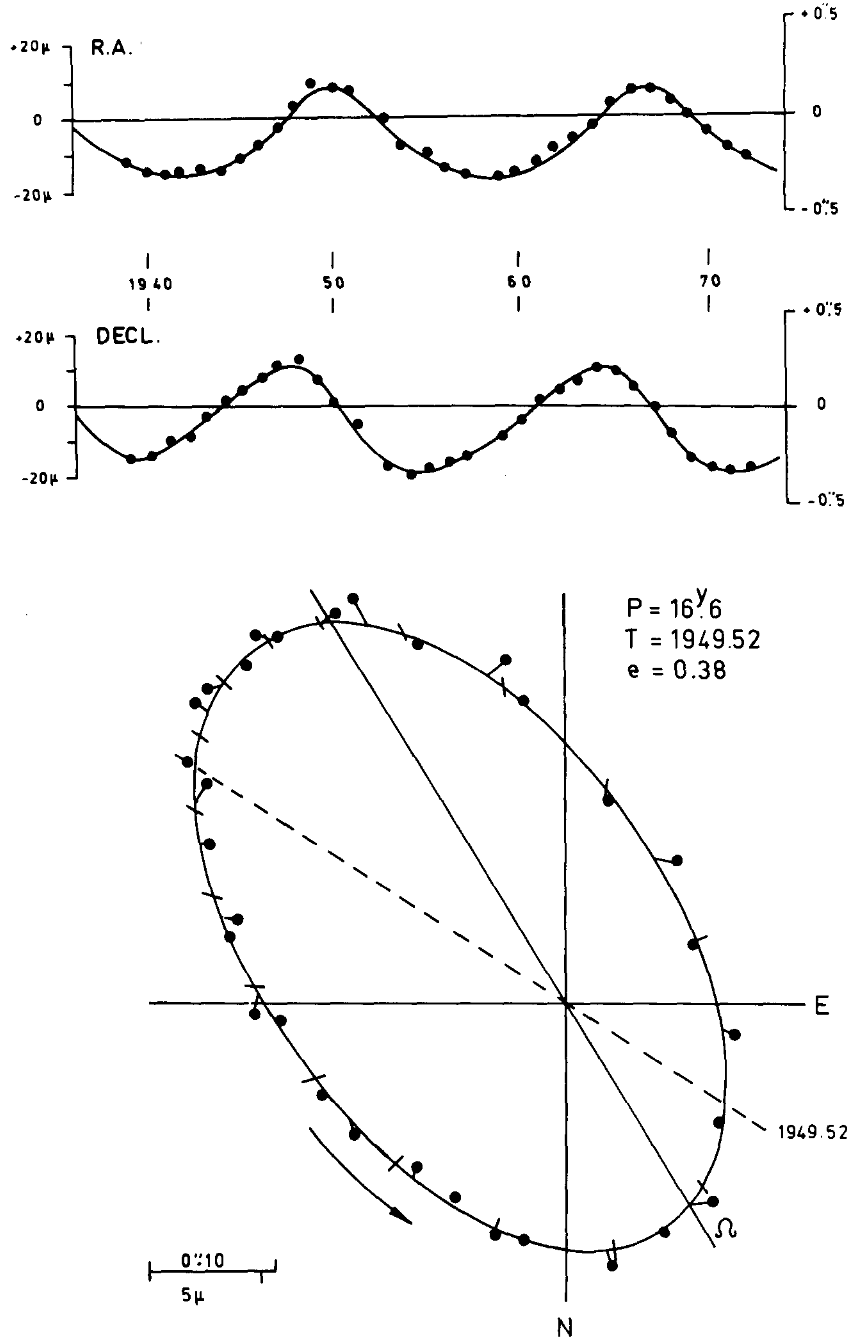

Fig. 4. Ross 614. Normal points, calculated displacement curves and photocentric orbit. Sproul Observatory.

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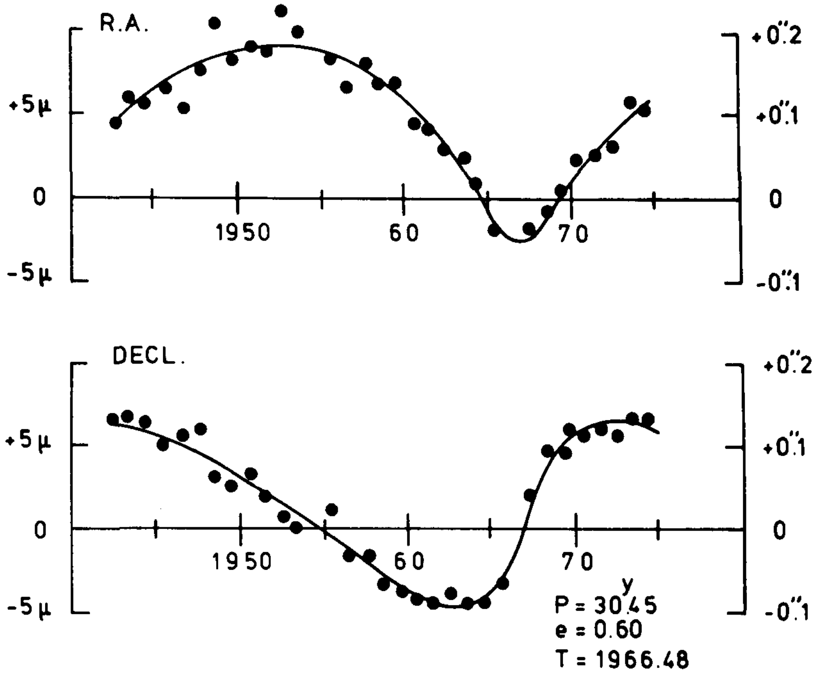

Fig. 4 (cont.). VW Cephei. Normal points and calculated displacement curves.

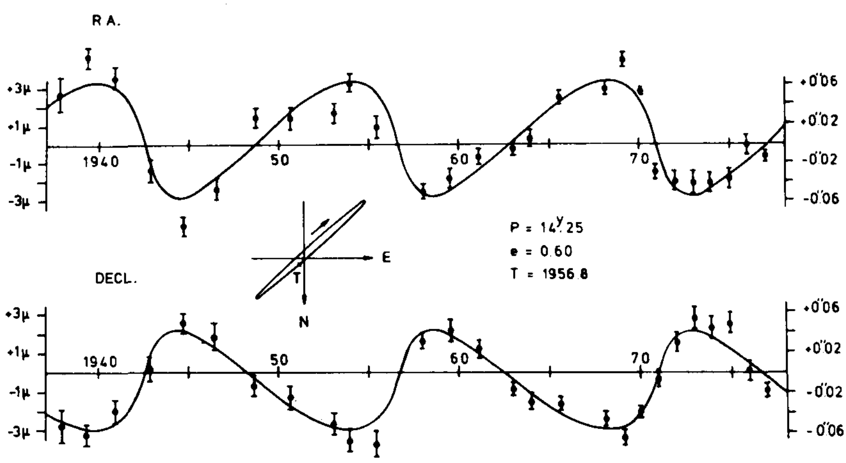

Fig. 4 (cont.). χ^2 Orionis. Normal points. Calculated displacement curves. Photocentric orbit. Sproul Observatory.

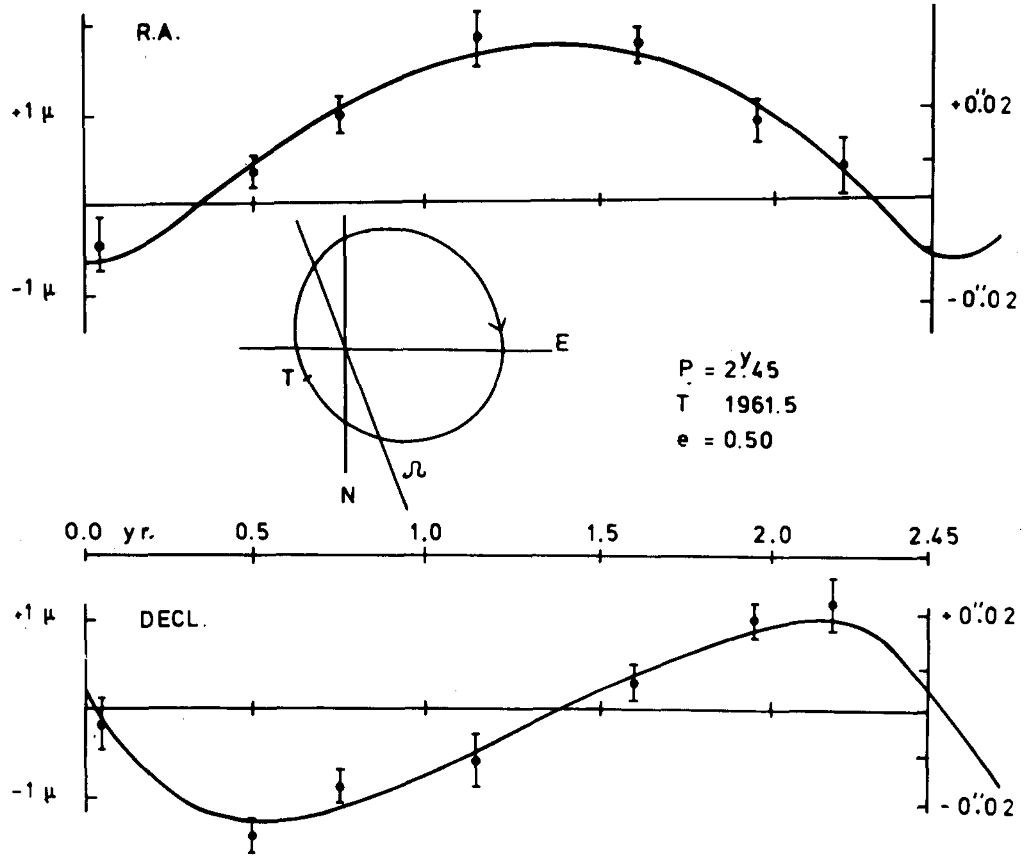

Fig. 4 (cont.). Wolf 1062. Normal points. Calculated displacement curves. Photocentric orbit. Sproul Observatory.

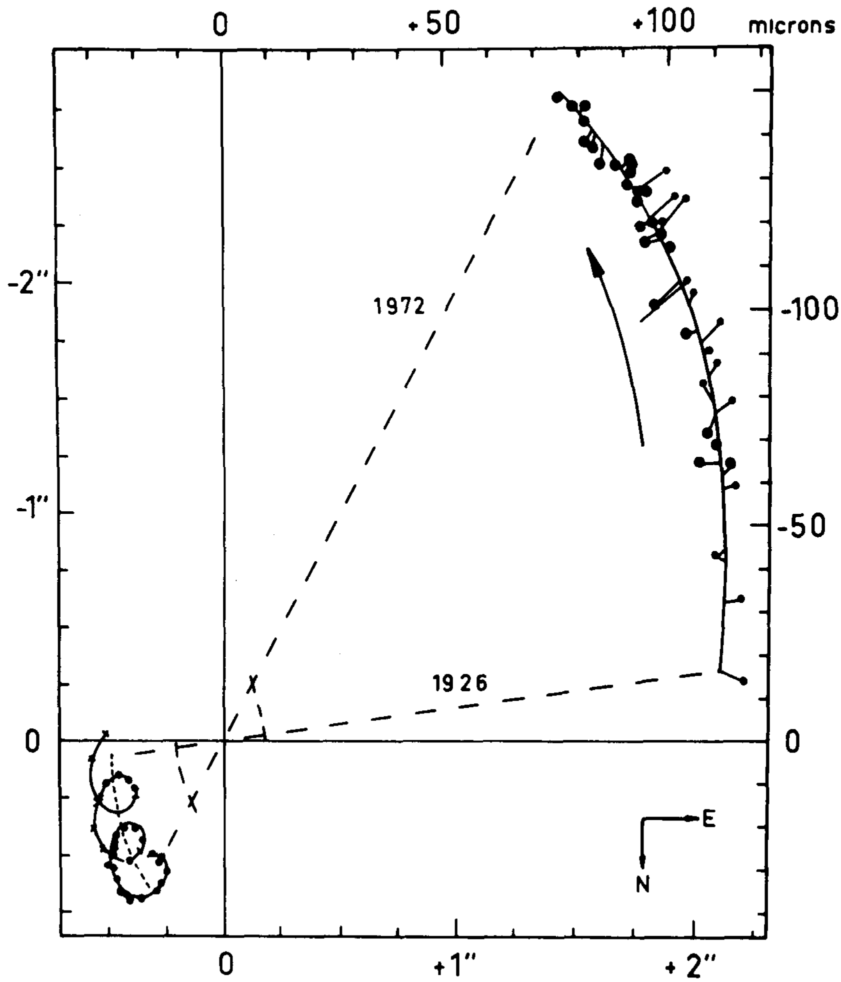

Fig. 4 (cont.). BD +66°34 A. Normal points. Perturbed orbital motion of A with respect to center of mass of A and B. Sproul Observatory.

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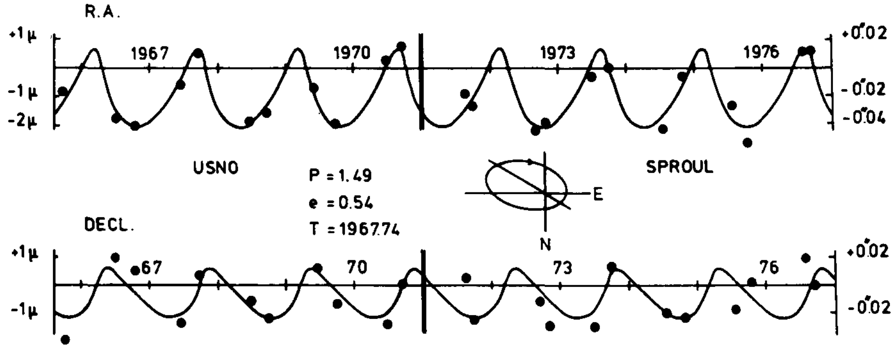

Fig. 4 (cont.). G 24-16. Normal points, calculated displacement curves and photocentric orbit. USNO and Sproul Observatory.

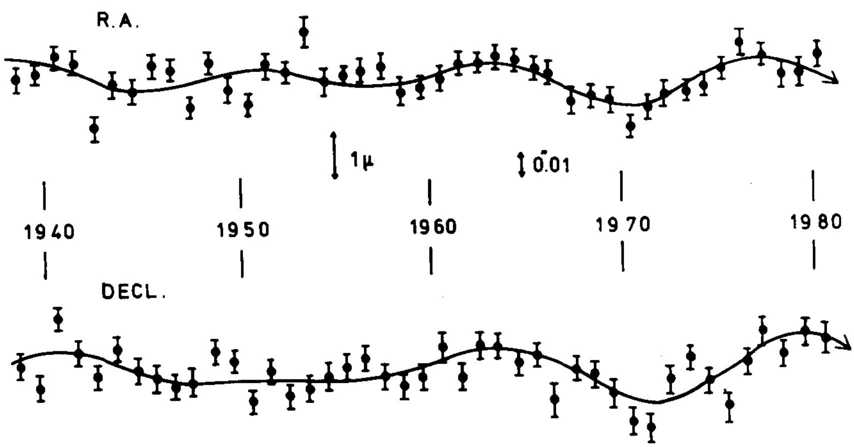

Fig. 5. Barnard's star. Yearly normal points and calculated orbital displacement curves in RA and Decl over the interval 1938-1980 from Sproul photographs obtained on 1165 nights.

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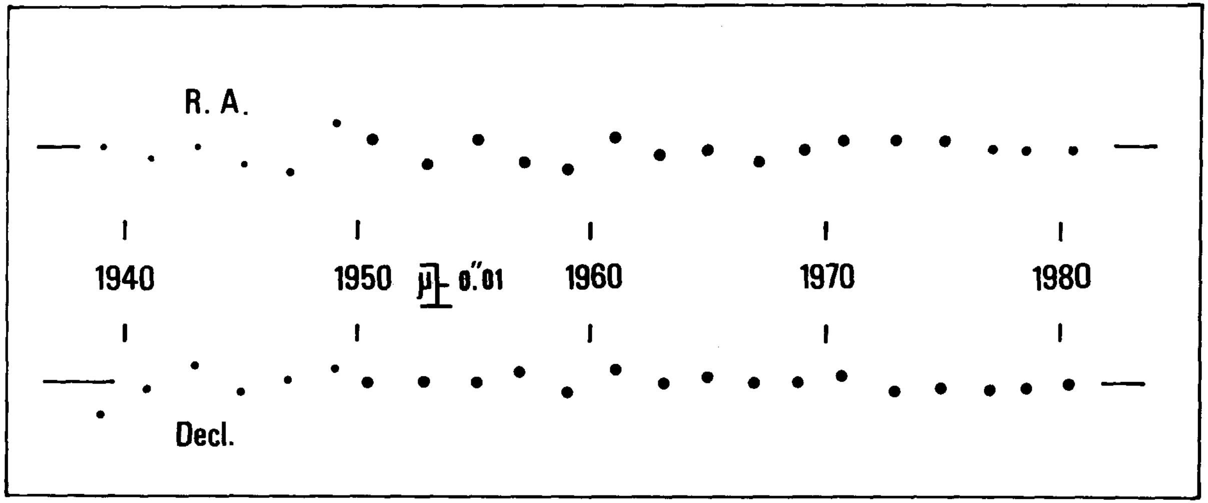

Fig. 6. Instrumental profile of the Sproul 61 cm refractor, based on 8 photographic series. The average deviation amounts to 0.1 μ = 0.″002.

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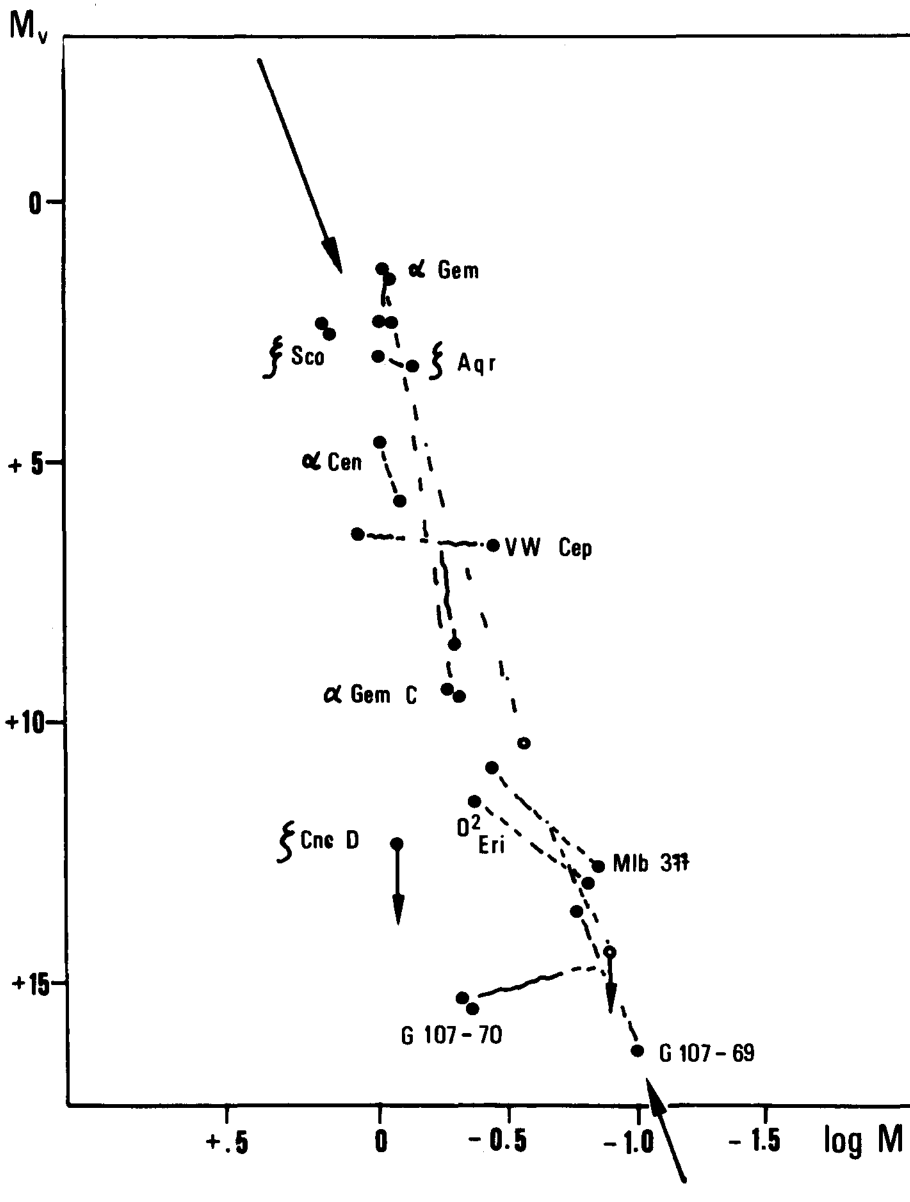

Fig. 7. Masses in multiple stars. The full drawn arrows indicate the general mass-luminosity relation.

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would seem to be better for a binary being left after a near triple collision. And what about near quadruple etc. collisions and how scarce they likely would be.

Embroidering a little further on this subject. Could a near triple collision of a binary with two single stars result in a triple star or in two double stars? And so on.

12. DOES THE SUN HAVE A DISTANT STELLAR COMPANION?

From the observational standpoint the possible existence of a distant stellar companion of the Sun is not excluded. Calculations were carried out twenty years ago by the author (1973) for circular orbits with radii ranging from 1.000 to 100.000 a.u. and a range in absolute magnitude of + 15 to +30 for such a companion.

For a companion of small mass, say a faint M star or substellar object, the corresponding range for period, annual proper motion, annual parallax, and apparent magnitude would be as follows:

Orbital Radius		Period	Annual Proper Motion	Annual Parallax	Apparent Magnitude for	
a.u.	Parsecs	in yrs			abs.mg + 15	abs.mg + 30
1.000	0.005	30.000	41"	210"	- 1.6	+ 13.4
100.000	0.5	30.000.000	0".041	2".1	+ 8.4	+ 23.4

The annual proper motion decreases rapidly, with the 3/2 power of the distance. The object would be characterized by a large parallax but at greater distance by a "small" proper motion. Parallax measurements of large proper motion stars, say with $\mu > 0''.5$ have not yielded yet an abnormally large parallax of say 10" or more; the largest known parallax is still below 1". Who knows what the future still may bring. We might narrow down the search for such a companion, by preconceived notions of coplanarity and corevolution with the planetary system, but this might prejudice the search.

For a white-dwarf companion the above figures would be slightly different, depending on the adopted mass for the companion; at the same distance the proper motion would increase somewhat.

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