In Table III we give the values of M_s and $B–V$ for "ambiguous" orbits arising from uncertainty of quadrant interpretation. It will be noticed that in the classical type of ambiguity (e.g., B 1909) where the period of one orbit is approximately double that of the other and the eccentricities are small and large respectively, the values of M_s do not differ greatly and therefore cannot be used as a discriminant. In some other cases, however, the values of M_s may differ sufficiently to enable a choice to be made.

Note added: Worley has pointed out that the $B–V$ values for the components of β 513, OΣ 149 and β 648 (Table II) quoted from the catalogue of Blanco *et al.* were not observed directly but derived from the combined values of + 0.17, + 0.64 and + 0.59, respectively.

References

Alexander, J. B. 1970, *Mon. Notes astr. Soc. South Africa*, **29**, 44.

Blanco, V. M., Demers, S., Douglass, G. G. and FitzGerald, M. P. 1968, *Pub. U.S. Nav. Obs.*, 2nd ser., **21**.

Finsen, W. S. and Worley, C. E. 1970, *Republ. Obs. Johannesburg Circ.*, **7**, 203.

Harris, D. L., Strand, K. Aa. and Worley, C. E. 1963, Empirical Data on Stellar Masses, Luminosities, and Radii in *Basic Astronomical Data*, ed. K. Aa. Strand, Univ. of Chicago Press, p. 285.

Hertzsprung, E. 1964, *J. des Obs.*, **47**, 31.

Knipe, G. F. G. 1969, *Republ. Obs. Johannesburg Circ.*, **7**, 197. 1970, *ibid.*, **7**, 260.

Smak, J. 1967, *Acta astr.*, **17**, 213.

Discussion

Strand remarked that this idea of Hertzsprung's had first appeared in the second of his first two professional papers, published in the Zeitschrift für wissenschaftliche Photographie in 1905 and 1907. In that paper he used this method to discuss the luminosities of the components of Capella. Hertzsprung apparently had forgotten this in his 1964 paper where he referred to a paper published in 1911.

Session 3. Multiple Systems

In his introductory talk, A. Poveda divided the subject into its morphological, dynamical, and cosmological aspects. The idea that runaway stars originate from binaries, due to an explosive mass loss of the primary liberating the secondary, was so difficult to understand that another explanation should be found.

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Some morphological features are the following: there appears to be a decrease in number by a factor of 3 from double to triple systems and again by this factor from triple to quadruple stars. Furthermore, there is a real increase in the concentration toward the galactic plane with increasing multiplicity. Triple systems are classified in two groups: (a) doubles with a distant companion at more than three times the separation of the inner pair, including very close eclipsing or spectroscopic pairs with a visually separated companion and (b) systems with a separation ratio of less than three to one. Similarly, the types of quadruple systems are: (a) a close triple with a distant companion; (b) a close double with two distant companions, including the double-doubles, and (c) the cluster type in which all components have nearly equal separations, such as the Trapezium. It was not until the work of Ambartsumian, Markarian, and Sharpless that the trapezia were recognized as a distinct type. The chance that a trapezium is merely a double with nearby field stars is quite small if the stars are brighter than 12^m and the separations are less than $80''$, as Ambartsumian concluded.

The components of multiple stars differ, in a dynamical sense, from the members of normal galactic clusters in their stronger mutual interactions. Trapezium systems are distinguished from ordinary multiple systems which are composed of a close two-body system within a wider unit which behaves again as a two-body system. In the trapezia there is a continuous interference of a third or fourth component with the system of the other stars. The crossing time is of the order of 3×10^4 years, and 15 of these crossings would probably dissolve the system. A model computation to derive a better estimate of this quantity yielded an age of the order of 2×10^5 years. Parenago's result of 10^4 years for the Trapezium expansion age was based on micrometer observations. Poveda's re-examination showed marginal or no motion for all separations in the system except AE (confirmed by Franz). In particular, the observed motions must be a full order of magnitude smaller than would be required for escapes, given any reasonable estimate for the distance. The energies cannot be made negative by assuming large radial separations unless it is supposed that the cluster is a very prolate system, extended in the line of sight.

The ADS catalogue contains 110 trapezia of which only 33 have more than four observations on record. Motions appear to be indicated in not more than 12 systems and expansion in only one. Poveda then discussed a few particular systems (to be published later) and concluded that there was no evidence for expansion of the systems but rather for ejection of individual components. The cosmogonical inference is that these must be very young systems. The results are limited, however, by the paucity of observations, not only positional data but also magnitudes, spectral features and radial velocities. Typical escape velocities are estimated at about 1 km/s, hence a dispersion of this order should be detectable spectroscopically.

Strand recalled his derivation of an expansion age of 14,000 ± 2,000 years for the Orion Trapezium from comparison of W. Struve's micrometer observations in 1836 and modern multiple-exposure plates of the ABCD group. Harrington mentioned a numerical study of the same object, including the potential of the surrounding cluster, by a Soviet research group, which indicated that the system might not possess positive energy but may be bound in an oscillating mode of motion.

Many wide systems, with separations of the order of 1 minute of arc (and hence neglected by visual observers) are interesting, nevertheless, because they contain stars of particular interest and luminosity criteria for the stars may be derived from such systems. For instance, γ Vel (the nearest Wolf-Rayet star) seems to have a small group of stars surrounding it as does β Lyr. (Abt).

A long-focus survey for fainter trapezia was suggested although, as Franz remarked, good use could be made already of the Palomar Survey. In the Nice double-star survey, third components at separations of 5″ to 10″ were seen in 5 per cent of the pairs discovered (Muller). Walker confirmed the fairly high incidence of additional components; almost all cases are of the AB-C type (with the distant body being the faintest). Worley has examined the suspected trapezium system containing VY CMa at Cerro Tololo but failed to see objects of star-like appearance. Probably there are merely knots of nebulosity in the vicinity and the apparent motions reported were spurious.

The inclusion of trapezia in double-star catalogues is subject to selection under a rather artificial criterion, viz. the separation of the closest pair (Heintz). The question was raised whether the radial location of stars relative to an embedding nebula could be inferred from some spectroscopic or photometric feature, but these effects appear to be below the detectable level.

For a concluding report, Harrington was asked to summarize his numerical work on triple-star stability. He rejected the idea that trapezium-type associations could have evolved from clusters. Nor is there a way from a trapezium triple to a normal one (distant-companion type) although it may temporarily appear that way when one component moves outward on a highly eccentric orbit. Many energy exchanges can take place, with a possible lifetime up to 10^9 years, before an escape occurs. The current state of knowledge on stellar three-body systems with sufficiently large separation ratios is:

(a) The semi-major axis a is shown by the integration to be a constant plus a small perturbing function composed of periodic terms. Hence a is stable.

(b) The eccentricity e_2 of the large orbit varies but slowly while more important changes take place in e_1 (for the inner orbit), and in the angle ϕ between the orbit planes. If ϕ is near 90° an instability results as e_1 periodically increases almost to unity. Since the variations are not purely in sine/cosine terms the averaged angle ϕ is slightly less, and the average eccentricity e_1 somewhat larger, than expected from a random distribution.

(c) The crucial parameter for the stability problem appears to be, not the ratio a_2/a_1 of the semi-major axes, but q_2/a_1, where q is the periastron distance. This value must exceed 3.5 for co-revolving systems and 2.75 for counter-revolving systems. But the observed limit (> 5) is still higher – a fact which may turn out to be cosmogonically significant.

Session 4. Photometric and Spectroscopic Data

THE PHOTOMETRY OF VISUAL BINARIES

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A substantial part of our understanding of the physical nature of stars rests upon observations of visual binaries. In order to secure a complete interpretation of a binary system we require these data: semi-major axis, parallax, period, magnitudes, colours, spectral types and velocities. It goes without saying that for very few systems are all these desiderata available, largely through technical difficulties of observing two images in close proximity to one another – and these difficulties are particularly serious in carrying out photometry. Nevertheless, the usefulness of photometry of binaries is so great that no effort should be spared in resolving the observational and technical problems.

Although the fundamental need for magnitudes is obvious in the case of establishing and improving the mass-luminosity relationship, there are other useful applications of photometry even among binaries of unknown period, orbital separation or parallax. For example, some visual binaries provide unique means of luminosity calibration through relating a star of unknown luminosity to another star having a well-established luminosity. In other

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