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PROCEEDINGS OF IAU SYMPOSIUM NO. 17 VISUAL DOUBLE STARS

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INTRODUCTION

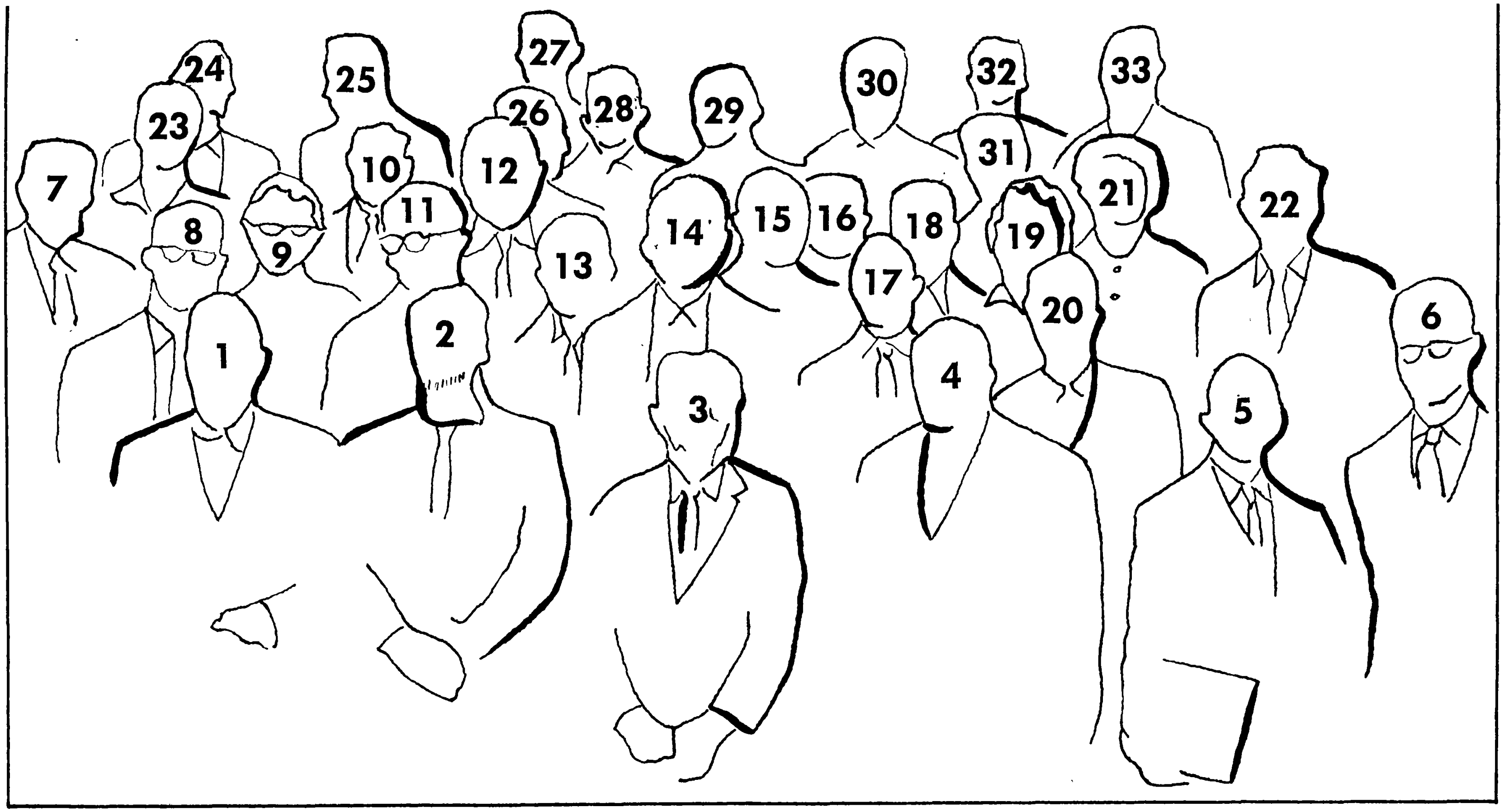
The symposium was opened by Chairman PETER VAN DE KAMP as follows:

"I am happy to welcome you here. The idea of this symposium was suggested at the time of the tenth general assembly of the International Astronomical Union in Moscow in 1958, and this is the result. The organizing committee was guided by the desire to include veteran observers, some of the young double-star astronomers, and some astrophysicists. This is not an occasion for long papers, but rather, I hope, for a soul-searching conference approaching our subject with directness and with the strong desire and feeling to define and redirect our aims. We shall concentrate on visual double stars—more appropriately called astrometric, resolved and unresolved, binaries."*

I. AIMS AND NEEDS

A. Observations and Elements. EGGEN opened the discussion with a few comments on the immediate aims of double-star astronomy which perhaps are so well known that they often are

* Symposium editor's note: No stated papers were read. A number of participants were asked in advance to start a discussion of the various topics. Everyone was urged to contribute. In the synthesis of the discussion that follows, names are appended primarily when the ideas expressed are those of the participants speaking. Any lack of individual credit of statements should not be taken personally, and the ideas stated herein are in general a composite from all the contributing participants.



KEY TO PARTICIPANTS IN IAU SYMPOSIUM NO. 17 VISUAL DOUBLE STARS

1. E. Hertzsprung, Denmark
2. W. H. van den Bos, South Africa
3. G. Van Biesbroeck, U.S.A.
4. S. Arend, Belgium
5. L. M. Barreto, Brazil
6. J. Dommanget, Belgium
7. H. M. Jeffers, U.S.A.
8. W. S. Finsen, South Africa*
9. M. Williams, (N.S.F.), U.S.A.
10. C. Worley, U.S.A.
11. O. J. Eggen, U.K. (now U.S.A.)*
12. D. H. P. Jones, U.K.
13. K. Aa. Strand, U.S.A.
14. W. J. Luyten, U.S.A.
15. J. S. Hall, U.S.A.
16. Su-Shu Huang, U.S.A.
17. U. Güntzel-Lingner, Germany
18. W. P. Bidelman, U.S.A.
19. D. Allen (secretary), U.S.A.
20. R. R. de Freitas Mourao, Brazil
21. S. L. Lippincott, U.S.A.
22. P. van de Kamp, U.S.A., *Chairman*
23. B. V. Kukarkin, U.S.S.R.
24. R. M. Petrie, Canada*
25. O. Franz, U.S.A.
26. P. Muller, France*
27. A. J. Deutsch, U.S.A.
28. P. Couteau, France
29. A. Danjon, France*
30. W. D. Heintz, Germany
31. J. Rösch, France
32. P. G. Kulikovsky, U.S.S.R.
33. P. Herget, U.S.A.
—. A. N. Deutsch, U.S.S.R.

* Members of organizing committee.

taken for granted. Astrophysicists who are dependent upon the results of double-star astronomy for the determination of stellar masses are often unaware of the difficulties facing this subject. Consequently, they cannot properly evaluate the mass determinations they adopt. There is little doubt that the major aim, from the astrometric point of view, is the derivation of stellar masses, and in fulfilling this aim there are two matters that need careful attention: (1) the analysis of available measures, especially those of angular separation, to permit a reduction of all orbits to a uniform system of values for the semi-axis major a, and therefore to a uniform system of masses; and (2) to make certain that not only pairs that can now yield masses are adequately observed but that those pairs which later generations can use for this purpose are also cared for.

VAN DEN BOS recalled that the masses of binaries depend on three quantities: the period, the semi-axis major of the orbit, and the parallax in the form

$$m_A + m_B = \frac{a^3}{p^3 P^2}.$$

The probable error of the parallax plays a vital role; in almost all cases the limit of the accuracy of the masses is primarily set by the uncertainty of the parallax. Therefore the most accurate masses are derived only from the nearby stars—that is, stars with parallaxes, say, greater than 0.″05. Only when the scale of the orbit is very small does its error play a greater role than that of the parallax in the accuracy of the mass determination. The accuracy of the determination of the period increases with time.

Looking for means other than trigonometric parallax for the distance determination of double stars, DOMMANGET mentioned the importance of obtaining radial velocities for both components. As a guide to the best times for spectroscopic observation, ephemerides are being computed at Uccle from the orbital elements derived from the apparent orbit; these will be published in graph form. HERTZSPRUNG called attention to accurate distance determinations for individual members of extended clusters with common proper motion, such as the Ursa Major and the Hyades groups; the accuracy for the distance values improves with time.

The possibility of deriving very accurate parallaxes from spectroscopic and photometric methods will increase in the future.

The accuracy of the mass determination, currently limited by that of the parallax, should not in any way keep us from striving toward the best possible value for the semi-axis major, and to place the measurements of the angular separations on one system free from systematic errors which reach extreme values when the separations are close to the resolving power of the telescope. It is, therefore, essential to use a telescope with as large an aperture as possible for close doubles. The closer pairs have on the average a shorter period, offering a better chance of obtaining results in a reasonable time. This should give impetus to attempts at discovering new close pairs. Unfortunately, the close pairs are inaccessible to direct photography and require visual measurements with refracting or reflecting telescopes of large aperture.

The work accomplished with the 82-inch reflector of the McDonald Observatory has shown that reflectors (in the Cassegrain form) are just as effective as refractors. From his experience VAN DEN BOS finds that the reflector must have 50% larger aperture than the refractor to be comparable, i.e., any good 60-inch reflector will equal or be better than the 40-inch refractor.

STRAND reiterated the necessity for using telescopes with large light-gathering power and resolution for the visual study of double stars. In the northern hemisphere, instruments like the 60-, 100-, 120-, and even the 200-inch telescope should be made available for critical programs in double-star astronomy. Observatory directors should recognize these important needs. For the southern hemisphere, an extremely critical situation exists because there are very few large reflectors available. It would be highly desirable to have a large reflector placed in South Africa which could be used for double-star astronomy. Beyond this, FINSEN pointed out the extremely promising unexplored field of the application of the interferometer with large telescopes.

Large apertures are required especially for following pairs entering critical phases in their motions—i.e., periastron or closest apparent separation. Large apertures are also obviously needed where the companions are faint. As an example, VAN BIESBROECK cited the case of the companion of Mira, which has been followed for some 30 years. After lingering at apastron for ten years the companion is now closing in and becoming very difficult to measure, especially due to its own peculiar fluctuations in brightness aside from the enormous range in brightness of Mira itself. Is the companion going to describe a long ellipse or is it going to turn quickly around the main star in a highly eccentric orbit? The coming years will tell unless the present generation of astronomers is so engrossed in other fields that the opportunity for solving the case is missed, thereby also missing a chance to obtain the mass of this very important star (see Sec. III, *E*). Here again results can be expected only from the use of good-sized telescopes by experienced observers. This type of work can be done around the period of full moon, when many other types of investigations are hampered. Now that the 82-inch McDonald reflector is no longer available for double-star work, VAN BIESBROECK appeals to other observatories equipped with large telescopes for the continuation of double-star observations. The large telescopes are crowded with programs of astrophysical interest. It might be said, however, that the astrophysicist depends much more on the double-star astronomer than vice versa.

It is important for an observer to know when and how often a particular star should be measured. How much should be published concerning the elements and ephemerides? The period, periastron passage, and an approximate ephemeris are guides; however, in order not to be misled, one must know the accuracy of the ephemeris. Care must be exercised so that the observations are not prejudiced by pre-knowledge. The accuracy of an orbit may be generally indicated by FINSEN's classifications "definitive," "reliable," "preliminary," and "premature." There is a great preponderance of the last class.

B. Statistics. It is tempting to use the statistics of the various parameters of the elements of double-star orbits and the apparent physical characteristics of double stars in order to learn something of the frequency and the nature of the origin of stellar systems. Statistics, however, must be handled with extreme caution since selection effects dominate all aspects of double-star parameters. Selection of discovery, selection of observation, selection of computation, all result in spurious correlations, VAN DEN BOS warned.

FINSEN felt that no certain correlation among the orbital elements has been established and that the apparent period-eccentricity relation was an end-effect which tended to disappear with time. He showed a recent graph of period plotted against eccentricity for approximately 500 orbital pairs where little dependence of eccentricity on period is apparent. DOMMANGET cautioned that we must not overlook any real correlation of period and eccentricity that might exist. It would appear to be preferable to have any correlations of orbital elements established within the framework of statistical theoretical studies of the evolution of binaries. A clue to the evolution of stars might be revealed through evidence of mass loss in visual binaries. Theoretically, the mass loss, due to corpuscular and electromagnetic radiation, does not affect the invariance of the areal velocity. Considering, then, all systems (visual and spectroscopic) as having the same areal velocity, DOMMANGET found a period-eccentricity correlation for each class of areal velocity. Selection effects according to DOMMANGET can explain only the absence of orbits of large period and small eccentricity, as shown by Barbier, but not at all the absence of short periods and large eccentricities for each of these classes.

FINSEN said that in 1961 the poles of 67 binary orbits are known without ambiguity (including those with inclinations near 0, 90, or 180°). This is a deplorably small increase over the 28 systems known in 1933. We must be aware that different populations may be included in the above 67 binaries, and we do not know if any correlations are dependent on population characteristics. AREND has found a random distribution of the orbital planes. Up to the present, data are available for only a very small region of the Galaxy limited to the vicinity of the sun. To be significant, the study must include a larger number of orbits and a greater volume of space. HERTZSPRUNG believes that any marked deviation from an arbitrary distribution of the orientation of double-star orbits should show in the distribution of the present position angles of known physical pairs.

C. Spectroscopic Aspects. PETRIE emphasized some of the broader aspects of double-star astronomy from the point of view of the spectroscopist: it should first be clear that only relatively wide pairs can be observed spectroscopically if the spectrum of each star is to be recorded separately. Effective spectroscopic observations have to be restricted to double stars with separations greater than 2″, except for the brighter components of quite unequal pairs. It should be understood also that the velocity differences between components in almost every case are too small to be recorded as double lines by the spectrograph. The remarks made here, then, must refer chiefly to wide pairs, although it is recognized that spectroscopic observations of the brighter component of close pairs may sometimes be desirable.

PETRIE pointed out that out of 32 wide pairs followed spectroscopically at Victoria, 18 show variable velocity for one of the components, indicating that the system has at least three components. From the inspection of various catalogs at least 20% of wide doubles with orbits give spectroscopic or astrometric evidence of a third member. The true percentage of triple or multiple systems probably is much greater.

A fundamental problem of radial-velocity work is the determination of the wavelengths of the spectral features to be measured. The adopted wavelengths should be such that measured radial velocities of all spectral types are on a common system that will reproduce the known velocities of members of the solar system. Observations of the sun, moon, and planets give us wavelengths appropriate to spectral type G. The extension to earlier, and later, spectral types can best be controlled by observations of visual binaries in which the components have different spectra. For example, one may extend the wavelengths to class A through observations of stars like μ Bootis (4.5, A7; 6.7, G0; separation 108″) and to class B from doubles like ADS 2559 (7.4, B3; 8.5, G5; separation 3″.7). Wavelength standards have been studied extensively at Victoria. Some 20 visual binaries have been observed with various dispersions and the wavelength system has been determined for spectral types B0 to K8, inclusive. Much work remains to be done: the O stars and the M stars remain to be placed into the system, while the important matter of luminosity effects upon the effective wavelengths in F, G, and K spectra has scarcely been touched.

Radial-velocity controls are of far-reaching importance. They are necessary if we are to investigate with confidence membership of star clusters, K-term and relativity shift in radial velocities of early-type stars, and motions in the Galaxy. We can scarcely arrive at a completely satisfactory radial-velocity system without continued and detailed spectroscopic observations of visual binaries. EGGEN also stressed the important use of systems that contain a dwarf and a giant component in untangling the giant-dwarf difference in the system of radial velocities. Observations of clusters like the Hyades and Praesepe indicate a systematic difference between the velocities of the giants and dwarfs; but the trend of the difference with spectral type—or perhaps luminosity—of the giants is not clear.

The calibration of spectroscopic absolute-magnitude criteria is particularly difficult and uncertain for stars of class B and for giants and supergiants of all spectral types. This is a consequence, of course, of the generally great distances at which we find these objects and the inability to make direct distance measures of an adequate number of standard stars, PETRIE continued. When an early-type, highly luminous star coexists in a visual binary with a main sequence star of solar type which will fix the distance modulus, the absolute magnitude of the luminous star may be found. The use of visual binaries for absolute-magnitude calibrations has important advantages, for we thereby avoid uncertainties caused by the errors in mean parallaxes, galactic rotation parallaxes, and in the allowance for interstellar absorption. Finally, it is up to the double-star astronomer to determine which stars are physical pairs.

STRAND pointed out that most of these A- and B-type stars have extremely small proper motions. The observations made by W. Struve in 1830 must be used for first-epoch observations in order to obtain a long enough time-base to establish common proper motion or orbital motion.

MULLER noted that for many of the close pairs, where the spectra cannot be determined separately, the colors can be determined visually. These give good indications of spectral type.

D. Astrophysical Aspects. It is very important for the analysis of star clusters to know which stars are double so that the color-magnitude diagrams are not distorted by unknown companions. This was emphasized by BIDELMAN and FRANZ. The latter illustrated the problem by citing investigations of galactic clusters where radial velocities of a selected number of cluster members have been obtained. A large percentage of cluster stars shows variable radial velocity, indicating that a significant fraction of the cluster members are binary stars. For these cases it may be very difficult to derive a reliable distance and age for the cluster by fitting the zero-age main sequence to the observed main sequence in the color-magnitude diagram of a cluster.

EGGEN pointed out that although visual double-star observers are mainly concerned with the close pairs which will yield orbital elements, there is a growing, perhaps even larger, astrophysical interest in the wider pairs which show little relative motion. Each of these systems is a miniature cluster for which photometric and/or spectroscopic observations can give valuable information for evolutionary studies. A catalog of all systems known to be physical with the components separated by more than say 3″ would be a valuable aid, especially to the astrophysicists. Many of these systems have small proper motions so that observations of the relative position of the components alone cannot always determine whether they are connected physically; radial velocity observations are also necessary.

BIDELMAN recalled the appropriate statement made over 50 years ago by Miss Clerke to justify the study of spectra of double stars: "The members of binary systems may fairly be regarded as contemporaneous. Their origin was in common; their destinies are indissoluble; they are identically circumstanced; they must be similarly composed. They should then be exceptionally trustworthy guides to the unravelment of evolutionary time relations." This has proved to be correct. Magnitude-spectrum studies of systems with giant and dwarf components also provide a check on spectroscopic parallax calibration and information on the dispersion in luminosity for a given spectral type. In these studies the orbital elements play no role, our knowledge of the star's physical connection being primarily based on common proper motion and/or common radial velocity. Extensive spectroscopic observations of both wide (BIDELMAN, Stephenson) and close (D. Williams) binaries having giant primaries have recently been made with the Lick 36-inch refractor.

According to WORLEY there are some 700 wide pairs of large Δm whose primary appears in the Yale *Bright Star Catalogue.* These require attention to determine whether or not they are physical pairs. He has measured some 300 of these; further observations remain to be made with large telescopes.

HUANG enumerated three aspects in which the study of visual binaries can help astrophysicists. First, it helps to understand the structure and evolution of a normal star through the determination of stellar masses. Only from the study of visual binaries whose separations are great enough to insure non-interference from one or the other component are we able to correlate the structure and evolution of a normal star with its mass determined by observers of visual binaries. Because of observational selection, an eclipsing or a spectroscopic binary is apt to be a close pair, in which case the components may interact physically. Therefore, their evolution will be different from the evolution of a single star, because some additional parameter, such as the interchange of mass, could change the course of normal evolution, or even the structure itself (as in W Ursae Majoris stars). Second, the study of visual binaries throws light on the structure and evolution of star systems, such as our own galaxy. Here the statistics of double stars play an important role. For example, the existence of many double stars in our galaxy must be related to the mode of star formation. Were they formed as binaries or are they the remnants of star clusters or associations? The results of statistical studies of binaries in different sub-systems of our galaxy give us a clue concerning the mode of star formation, and consequently the structure and evolution of our galaxy. The third aspect of the application of double-star astronomy to astrophysics concerns the search for planets around stars other than the sun. So far, no adequate theory has been advanced to predict the limiting mass below which an astronomical object will become a dark planet instead of a shining star. Therefore, detection of planetary companions of stars is an important problem for visual-binary observers.

KUKARKIN stressed the astrophysical importance of double stars from the point of view of population and evolution: e.g., the study of the characteristics of doubles in the spherical component (Population II) of our galaxy, in globular clusters (close systems of W Ursae Majoris type), in associations (visual double and multiple stars), and, in particular, the study of doubles where one component is unstable. Special attention should be given to very young stars of the T Tauri or RW Aurigae types. Many of them are doubles and should be observed systematically.

There appears to be a lower percentage of binaries among the disk or halo stars when velocity is used as a population criterion. It is difficult to say at the moment how selective this criterion is. We need a comprehensive catalog of physical pairs for which spectra are available. This would provide a start for the study of double stars in Population II. LUYTEN's catalog with over 1,000 stars of common proper motion would be valuable in this respect since the high-proper-motion criteria used would insure the inclusion of many high-velocity stars. This catalog does not, of course, include doubles of small proper motion, so that a supplementary study of slow-moving pairs would also be necessary.

II. TECHNIQUES

MULLER presided over the discussion of the various techniques in double-star measurements. They are few and they are well known; three are well established—visual, photographic, interferometric; the fourth of more recent origin employs an image tube to amplify the intensity of the telescopic image. The essential objectives were to define the potentialities of each method with particular attention to separation, magnitude, and precision.

A. Visual. COUTEAU compared the accuracy of the various visual methods. The major part of double-star observations are made with the filar micrometer. Except for FINSEN's work with the interferometer, all great surveys have been made with the filar micrometer.

Numerous measures based on other methods have yielded significant results. Those are the micrometer with artificial double stars (Duruy), the half-wave interferometric micrometer (DANJON), the Iceland Spar micrometer (Lyot), the double-image prism micrometer (MULLER). All these instruments have given good results in the hands of their designers. Only the micrometer of MULLER, however, is currently used in addition to the filar micrometer in France—at Meudon and Nice. A total of 7,000 measures has been obtained with the double-image micrometer, allowing comparison with the classical method.

Measurements made with the double-image micrometer show an internal agreement of the same order for $\overline{\Delta\rho}$ and for $\overline{\rho\Delta\theta}$ namely $\pm 0\overset{''}{.}012$ for $\rho \geqq 1''$. For the filar-micrometer measurements, the internal error is twice as large for $\overline{\Delta\rho}$ as for $\overline{\rho\Delta\theta}$ and reaches $\pm 0\overset{''}{.}050$ for $\rho \geqq 1''$. The internal error for either method decreases as the aperture becomes larger.

To study the external agreement between observers, COUTEAU divided the material into two groups: (a) For distances under $0\overset{''}{.}3$,the comparison of similar-epoch measurements by different observers yields deviations of as much as 10%, although they are small in absolute value. Comparison with ephemerides shows that most observers using the filar micrometer measure distances too large. The Lick double-image measurements appear to be 1% too small. (b) For distances around $0\overset{''}{.}5$ most observers with either kind of micrometer measure distances 3 to 4% too large, except for two observers whose measures are too small. The errors with the filar micrometer increase with increasing ρ, but in a different manner for each observer. In the interval $0\overset{''}{.}5$ to $2\overset{''}{.}6$ there is a range of $0\overset{''}{.}04$ in the residuals—observed *minus* ephemeris—for the prism method. For the filar method the mean error among experienced observers is $\pm 0\overset{''}{.}054$ for a distance of $0\overset{''}{.}5$, and $\pm 0\overset{''}{.}060$ for a distance of $2\overset{''}{.}6$. Since these comparisons are made with ephemerides based on the measures themselves, they are not necessarily free from systematic errors.

From COUTEAU's study it appears that the gain in accuracy of the double-image micrometer warrants its use in place of the filar micrometer whenever possible. There are two drawbacks: the loss of light in the double-image micrometer is serious; for example, with the 38-cm refractor at Nice the magnitude limit is 8.5. Secondly, there is great difficulty in measuring very close pairs.

KULIKOVSKY reported that a Muller-type, double-image micrometer has been constructed in Leningrad for the Sternberg Astronomical Institute (Moscow). He showed a photograph of the instrument. The first tests yield favorable results.

B. Photographic. STRAND called attention to the photographic technique established by Prof. HERTZSPRUNG 47 years ago. Provided necessary precautions are taken as prescribed by HERTZSPRUNG, an internal accuracy of $\pm0''.01$ (m.e.) is obtained in both coordinates for a multiple-exposure plate with 40 to 60 images. STRAND then described how the photographic methods of observing double stars can be speeded up and simplified for the observer. One of the drawbacks in the past has been the lengthy task of photographing and reducing the measurements. Since 1951, cameras with automatic plate transports and automatic timing have been used. Exposure times are usually short enough to rely entirely upon the right-ascension drive of the telescope for guiding. However, the U.S. Naval Observatory (Washington) camera is furnished with a photoelectric guider which can be used for long exposures. STRAND and his colleagues reduced the time for plate measurement by a factor of two by using digitizers and a keypunch for recording data directly on an IBM card, while at the same time lessening the fatigue of the measurer. The greatest time saving has occurred in the reduction of the data to a mean position, with the necessary information in regard to mean errors of the single images and of the means. With the data on IBM cards the reductions are carried out in four minutes with the IBM 650 computer, while reductions made with an electric desk calculator take 3½ hours on the average.

The accuracy of the results depends very little on the separation when the pairs are well separated. By means of a grating Δm is kept under $0^{m}.5$ so that there is no magnitude effect. The lower limit of separation depends primarily on Δm. At the Naval Observatory the smallest feasible separation is $2''.5$ or $3''$.

HERTZSPRUNG recalled that good photographic position angles may still be obtained for pairs closer than those for which the distance begins to show systematic errors. Although a comparison of visual and photographic measurements of a number of doubles may be helpful in determining systematic errors for wider visual pairs, one cannot assume the same errors for the very close pairs measurable by visual means only. Nevertheless, it was agreed that it is worthwhile to carry out both photographic and visual observations for a small number of stars, in order to evaluate personal errors.

Plates taken with gratings for astrometric measurement can also be used photometrically. According to STRAND Δm can be estimated with an internal accuracy of $\pm0^{m}07$. These estimates show no systematic error when compared with Wallenquist's photometric catalog, or with pairs measured visually by MULLER. HERTZSPRUNG pointed out the advantage of the grating method for bridging large intervals of magnitude.

In 1937 HERTZSPRUNG initiated a photographic double-star program at the Lick Observatory. Since 1939 an automatic device has been in use for making the exposures. Two thousand plates have accumulated, almost one-third of which have been measured by HERTZSPRUNG.

C. Interferometric. FINSEN gave his views on the interferometric method. When Michelson, Anderson, and Merrill made their first experimental interferometer observations of double stars more than forty years ago, they were hoping to be able to resolve double stars, in Michelson's words, "beyond the powers of the largest telescopes." One would have expected, therefore, that their brilliant success in resolving the spectroscopic binary Capella with the 100-inch reflector would have been energetically followed up, with the promise of reducing and perhaps even closing the gap between spectroscopic and visual binaries. But this has not come about, and instead of exploiting the method to its fullest with the largest reflectors, we find it relegated to comparatively small telescopes—a use for which it was not intended and for which there is little or no justification. In the northern hemisphere, a few interferometer measures have been made with the 36-inch Lick refractor, and the only other application of the method has been with apertures as small as 18 inches and even 13 inches. In the south only one telescope has been used for interferometer observations, namely, the 26½-inch refractor of the Union Observatory (now Republic Observatory).

The intensive interferometer program carried out at the Union Observatory was profitable only because it was exploring new ground. It would be completely pointless to continue it with the present telescope should southern double-star observers ever gain access to a large reflector for interferometer measurements. In that event, the interferometer itself would not become outmoded; the largest telescope is never large enough.

The application of the method to small telescopes might be justified if it compared favorably with the micrometer in productivity and reliability. But this is far from being the case, for the interferometer has several quite serious drawbacks which we are justified in accepting only if its resolving power can be achieved in no other way. The chief drawback is a consequence of the fact that the gain in resolving power is uni-directional and is achieved at the expense of a serious loss in the perpendicular direction. Duplicity is therefore no longer directly visible but must be inferred from the variation in fringe visibility as the instrument is rotated. Even if we assume that spurious variations have been excluded or compensated for (and this is no easy matter but requires continual vigilance), we are still faced with a very real danger of misinterpretation. As an inevitable result, the process of measuring a double star with the interferometer is far more exacting and time-consuming than it is with the micrometer and there is also much more risk of gross error. Another serious disadvantage is its limitation to stars brighter than the seventh magnitude, or perhaps a little fainter. This limiting magnitude seems to be nearly independent of the size of the telescope if full advantage is taken of the potential resolving power. The accuracy of the separation is of the order of 10%, except for the brighter pairs, where it may be as little as 5%. There is also a limitation on the difference in magnitude, which should not exceed $0^{m}5$ or at the most $1^{m}0$, although the micrometer is perhaps not much better in this respect for very close pairs. FINSEN's interferometer slits formed by two movable segments are easily withdrawn for examination of the star with full aperture.

From the point of view of resolving power, the interferometer has the advantage over the micrometer. However, when the seeing is too bad for effective micrometer measurement, it is also usually too bad for interferometer work, according to FINSEN.

The application of the beam interferometer to double-star measurements was mentioned, but it is doubtful if this would be feasible. The over-riding disadvantage is that the beam interferometer cannot be rotated.

DANJON described the half-wave interference micrometer that he designed; from his experience it takes no longer to make measurements with it than with the filar micrometer, and the two coordinates can be measured with the same precision.

D. Image Tube. Recently, photoelectric image tubes have been used to amplify the intensity of the telescopic images of close doubles. HALL described the work being carried out at the Lowell Observatory. It is well known that close pairs with components of equal brightness can be measured by the best visual observers under good conditions even when the separation is slightly below the Rayleigh limit. Calculation shows that for pairs separated at the Rayleigh limit the central minimum is approximately 20% below the intensity of the two equal maxima. Most photographic work is confined to pairs separated by more than five times the Rayleigh limit, because of seeing effects and emulsion distortions of close images. With the aid of a Barlow lens and image tubes, however, stars separated by only twice the Rayleigh limit have been photographed. In this case the first minima coincide and there is a point of zero intensity between the two maxima. The Barlow lens provides the necessary scale, and the image tube reduces exposure time by a factor of about 100 so that the effects of changes in seeing are considerably reduced.

In experiments carried out by Fredrick, HALL, and Baum at the Lowell Observatory, a scale of about 4″/mm was used at the focus of the 24-inch refractor and its compound visually-corrected Barlow lens. The images were focused on the cathode of a cascaded image tube followed by an $f/1.5$ relay-lens that formed an image of the output phosphor of the tube on the film of a 16-mm motion-picture camera. Star images as faint as 7.5 magnitudes were recorded through a green filter exposing at the rate of 16 frames per second. Pairs with equally bright components 0″.5 apart showed separate images. Two stars with a magnitude difference of 3^m0 and 0″.8 apart were easily separated.

HALL indicated that it now appears possible to stabilize the motion of the center of light of the two images by the method developed by DeWitt, Seyfert, and Hardie at the Dyer Observatory with the use of a cascaded image tube instead of the more complicated image orthicon. The intensity gradient in the direction of the position angle can then be measured by means of a slow scan, a photomultiplier, and a recorder. This should allow the measurement of close double stars by a method that does not involve photographic techniques.

HALL also suggested that the problem of measuring magnitude and color differences of close binary stars should be thoroughly investigated with the basic image-tube techniques described above.

Double-star photography employing the image-tube techniques of Lallemand is also being carried out under the direction of RÖSCH with Wlérick at the Pic du Midi Observatory with the 60-cm refractor. Distortions introduced by the image tube in producing a focal image on the photographic plate are controlled by having at the focus of the refractor a reseau which is also impressed on the photographic plate. The images from exposure times of $1/16$ second show distinct distortions common to both components due to atmospheric effects. RÖSCH has taken advantage of these distortions in the method of measuring the separation of the two components. An optical measuring device superposes the images of the two components and the separation can then be read directly. A sequence of images of a close double obtained cinematically was shown.

III. PROGRAMS

A. Catalogs and Tables. VAN DEN BOS presided over this discussion. A very important part of any program is making pertinent data available in the most usable way. The vast accumulation of double-star measurements up to 1927 appears in the Aitken *Double Star Catalogue.* Since then the work of cataloging has been carried on by JEFFERS and VAN DEN BOS in the northern and southern hemispheres, respectively. JEFFERS described the *Catalogue of Observations* which is virtually completed to date on punched cards. Because there was little agreement among astronomers on the limits of magnitude and separation, very few pairs have been excluded from the *Catalogue.* In 30 years of observation, 110,000 measurements have been cataloged. JEFFERS and VAN DEN BOS have also compiled an *Index Catalogue,* giving name, position for the years 1900 and 2000, number of observations, total number of complete sets of measures, ρ and θ of first and last measurements, magnitude, proper motion, spectrum, and notes. There are about 40,000 pairs listed north of $-20°$ and about 19,000 pairs south of $-20°$ including all wide pairs discovered photographically. The importance of these two catalogs cannot be overestimated and a great debt is owed to JEFFERS and VAN DEN BOS for the arduous task of compiling the data.

Concern on the part of the participants was expressed by STRAND for adequate preservation of these data. A number of card copies of the *Catalogue of Observations* and also of the *Index Catalogue* should be made and deposited at selected observatories throughout the world. (See recommendation at end of symposium.) JEFFERS said that publication of the *Index Catalogue* was intended when the work of both catalogs was completed. MULLER and others strongly urged that any changes or corrections necessary in the future be made simultaneously in all copies in order to preserve uniformity. Attention was called to the auxiliary information given (magnitude, Δm, spectrum, etc.), which in general has been taken from standard sources and is only intended as a guide. For precise information one should consult specialized catalogs.

BIDELMAN announced that he has compiled a catalog of all stars for which spectroscopic absolute magnitudes have been determined; many binaries are included in this compilation. There are no present plans for publication of this catalog, but requests for information will be freely honored. KULIKOVSKY said that a catalog of double stars in which one of the components is a nonstable star is being compiled at the Sternberg Institute in Moscow. The total number of pairs is in the neighborhood of 200.

The catalog of predicted radial velocities computed from the visual orbits has already been mentioned by DOMMANGET in Section I, *A*. It was stressed that radial velocities should be measured not only at the times predicted to be most advantageous from the visual orbit, but at other times also, since prediction of the third coordinate from observations of the other two is frequently unreliable.

HERTZSPRUNG described his catalog of photographic double-star measures with 6000 entries. The results of each plate are listed on an addressograph plate giving the details of the measures. In this way copies can conveniently be made.

FRANZ called attention to the new edition being printed of the Union Observatory X, Y tables of elliptic rectangular coordinates. Suggestions regarding presentation details were asked for.

WORLEY has compiled a new catalog of orbits and he questions whether it should be published, and if so in what form. It was suggested that some indication of the accuracy of the elements should be given. Care should be taken to use the definitions of the elements adopted at the IAU General Assembly in 1935. The participants were divided on the desirability of including dynamical parallax. An orbit catalog becomes out of date in several years, after which a new edition should be printed.

GÜNTZEL-LINGNER described the Potsdam catalog of wide double stars—from 1″.8 to 60″. So far, a partial catalog has been completed comprising 400 pairs. The purpose of compiling this catalog is: (1) to give a basis for decision whether the pair is optical; (2) to supply a basis for dynamical parallax; (3) to furnish a basis for later orbit computation of wide pairs; (4) to give indication of relative motion from accompanying diagrams; and (5) to aid in selecting stars for further observations. HERTZSPRUNG and others urged the use of diagrams of Δx and Δy, plotted against the time, the best known datum.

B. Surveys. VAN DEN BOS spoke about the repetition of surveys. No systematic survey, such as those carried out at Lick, Johannesburg and Bloemfontein, can be exhaustive; later discoveries have been added. Moreover, the work involved in a survey of the whole sky down to magnitude 9.0 as given in the *Durchmusterung* is so great that in the opinion of VAN DEN BOS a repetition of these surveys would be uneconomical. If, for statistical reasons, it should be desirable to determine the degree of completeness, repetition of a few regions might be considered. The surveyor should then obviously be unaware of known double stars in these regions. The only surveys for which repetition after a suitable interval—or even more than one repetition—would be practical, are those dealing with a much more limited number of stars than is the case for the general surveys. As examples one could mention: (1) naked-eye stars, (2) stars with large parallaxes or proper motions, (3) stars in selected areas, and (4) stars of particular astrophysical interest.

COUTEAU supported his belief that a repetition in the northern hemisphere would be desirable, by recalling the results from the southern hemisphere survey just completed by Rossiter who found 1200 systems fainter than 8.8 magnitude; in the northern hemisphere similar systems number around 500. LUYTEN added that special programs are very important, such as the survey at high galactic latitude with Haro's three-image method of color determination, which will throw some light on the frequency of doubles in high galactic latitudes. Down to magnitude 19 many pairs have already been found in which the components are white or red dwarfs with separations from 5″ to 10″.

FINSEN described his interferometer program for stars between declinations +20° and −75° down to magnitude 6.5, and between 6.5 and 7.5 for stars with proper motions exceeding 0″.05 in either coordinate. Approximately 10,000 examinations have been made of some 6000 stars, and 64 new pairs have been found. Orbits for two short-period systems have already been determined. This program should be extended with a large reflector to the northern hemisphere.

C. Selected Areas. VAN DEN BOS discussed the program of selected areas. The general surveys have been restricted to stars not fainter than the *Durchmusterung* magnitude 9.0—a little fainter in the case of the Bloemfontein survey. As the magnitude scales of the *Durchmusterungs* tend to be compressed near their fainter limits, the number of stars contained therein increases rapidly when one goes beyond 9.0. Sample counts in the Cape *Photographic Durchmusterung* indicate that it contains just about as many 9.1 − 9.5 stars as stars brighter than 9.1. Obviously, then, if it should be thought desirable to obtain information of statistical value for stars fainter than 9.0, it must be done by sampling; Kapteyn's Selected Areas would be appropriate because they have been catalogued.

VAN DEN BOS counted the stars down to photographic magnitude 12.99 in the −30° zone of the Harvard–Groningen *Durchmusterung* in areas of 1° × 1°. To keep the number of stars per area manageable, it was obviously necessary to change to areas 1/2° × 1/2° for galactic latitudes between $\beta = -20°$ and $\beta = +20°$. If we leave out the two polar caps and the ±75° zones, the total number of stars to be inspected is near 12,000. This is, of course, a far smaller number than the number dealt with in the general surveys of all BD stars and it is quite manageable, even if one should wish to repeat the survey after a lapse of, say, 10 to 20 years to obtain an idea of the coefficient of perception.

From a comparison with the Union Observatory *Card Catalogue,* VAN DEN BOS found that the number of known pairs in the areas of the −30° zone was very small, only about a dozen or so, of which only two were fainter than magnitude 9.0. Such a survey of faint stars would, in VAN DEN BOS's opinion, be of little value unless it were undertaken with adequate optical power—reflectors of at least 60-inch aperture and preferably larger. The difficulty of discovery and measurement increases greatly with increasing magnitude. If a plan of this nature should be deemed advisable, VAN DEN BOS suggested that a start could be made with only two declination zones, say +30° from a northern observatory and −30° from a southern observatory. This would enable us to judge whether or not the results obtained are commensurate with the effort and telescope time needed before continuing with other zones. A further point to be considered: whether the pairs found should be micrometrically measured at discovery or soon after, or whether it would be sufficient merely to announce the duplicity. VAN DEN BOS favored measurement, even if only on a single night.

FINSEN felt that the selected areas plan has the advantage of not committing us to a specific problem—we cannot predict what kind of data future astronomers will require. It was doubtful, however, whether it would prove to be the most direct and economical approach to some of the more pressing problems of double-star astronomy. Consider, for example, the population of single, double, and multiple stars in a unit volume of space centered on the sun. If we rely on existing duplicity data augmented by a one percent Selected Area survey, we will in effect overlook 99% of the nearby stars that are fainter than magnitude 9.0. Gliese's list of stars nearer than 20 parsecs contains only 915 entries, of which 447 are fainter than 9.0. We will, therefore, find our sample reduced from 915 to about one half; even more serious would be the resulting discrimination against absolutely faint stars. But it would not take long to make a special survey of all the stars in Gliese's list, and this would be the simplest solution of the problem. It would obviously be wasteful and inefficient to attempt such surveys with the relatively modest apertures used in the past.

VAN DE KAMP was in favor of having the Selected Areas serve as a pilot study. He recalled that Kapteyn was aware of the need of having a special plan of selected areas to cover the Milky Way. He suggested taking photographs of the Selected Areas which could be repeated in several years for proper motion determination. VAN DEN BOS commented that there were first-epoch plates of the Selected Areas. Perhaps an extensive study in all other aspects should be made in these areas. The astrophysicists present felt that the returns on a program of selected areas would not warrant the time involved. There was much interest in observations of stars of special interest in other astronomical disciplines. LUYTEN suggested that if a selected area program is to be carried out it might be well to augment it with the stars in Gliese's catalog. LUYTEN added that he has listed 10,000 stars with proper motions greater than $0\rlap{.}''2$; they go beyond magnitudes accessible to double-star observers. One difficulty is to supply identification charts for double-star observers; photostatic copies could be made. Stars in LUYTEN's catalogs are subject to more selective effects because of the high proper motion, whereas Vyssotsky's survey does not contain this bias.

WORLEY, at the suggestion of BIDELMAN, has been making a survey of M dwarfs with the Lick 36-inch refractor. Out of the 800 known M dwarfs, he has examined about 700 and found 27 new pairs; 9 have separations of less than 1″ and a few show rapid motion. Many of these stars had already been examined earlier by Kuiper.

HERTZSPRUNG has long advocated examining variable stars at minimum for duplicity.

FINSEN suggested that there should be liaison between the observers and the users; perhaps a small sub-committee or commission could act in this capacity.

D. White Dwarfs. LUYTEN discussed the white dwarfs which constitute one of the most important classes of stars for which masses need to be determined; yet at the present time the mass of only one normal white dwarf is known. The companion to Sirius seems to be somewhat anomalous, and it has even been suggested that it may itself be a binary, while the companion to Procyon is so difficult to observe that its magnitude, color, and spectral class are not accurately known, thus leaving only o^2 Eridani B with well-determined data. No other white dwarfs belong to binaries with short periods and known orbits, but some 40 wide pairs with common proper motion which contain one white dwarf component, and at least two double white dwarfs are now known. While the periods of most of these systems are very long, it should be possible to find some indications of orbital motion from observations extending over a few decades, and from these we should be able to obtain at least some statistical information concerning the masses. It is evident that observations of highest precision are needed; this is obviously a task for long-focus refractors, used in parallax work, or large Cassegrain reflectors. In addition, since the information obtained will have only statistical meaning, it seems essential that a number of control pairs containing two red dwarfs as components and with roughly the same separations, magnitudes, and proper motions should be observed with the same equipment. LUYTEN has started this investigation and has already determined provisional orbital motions for 17 pairs containing at least one white dwarf component, and for 15 control pairs. However, the only material now available consists of miscellaneous plates taken with a variety of refractors and reflectors, with different focal lengths, and situated in widely different latitudes. As such, the program has a built-in guarantee of serious troubles, if not failure. Yet the results attained thus far indicate that the masses of white dwarfs seem to be definitely larger than those of red dwarfs of the same luminosity.

E. Stars of Individual Importance. A. J. DEUTSCH mentioned the motion of the companion of Mira, which has been so slow for a long time that it must lie near apastron in a highly eccentric orbit viewed at high inclination (see Sec. I, *A*). The sum of the masses is probably less than two solar masses. There are some reasons for believing that, besides the Mira variables, many red giants have masses of only one sun or less. In the first place, we have clear spectroscopic evidence of substantial massflows from most M-type giants and supergiants. In the second place, we have a clear theoretical requirement that a massive star must lose most of its mass before it exhausts its nuclear fuel and becomes a white dwarf. From the paucity of stars intermediate between the red-giant stage and the white-dwarf stage, we may infer that stars make this transition rapidly. But the observations appear to exclude the possibility of sufficient mass loss during this short transition. Accordingly, we may conclude that a massive star will already have dwindled to one solar mass or less while it is still in the red-giant stage. If this is so, we should find evidence for it in the motions of the visual companions of red giants. Since it is often possible to assign parallaxes to these stars with considerable accuracy (e.g., by the spectroscopic method of O. C. Wilson), the study of a group of these pairs should yield "hypothetical masses" that are statistically significant. The prediction is that these masses will be substantially less than those of the stars in that part of the main sequence from which the observed giants have evolved.

F. Relation to Spectroscopic Observations. Spectroscopic observations accompanying the visual observations are of great importance. This leads to spectral classification and also to the observation of the third dimension of the apparent orbit.

PETRIE gave a few words of caution about radial velocities. The expected radial-velocity changes in visual binary observations are small and require moderately powerful spectrographs, careful control of the velocity system, and the repetition of equally accurate observations during a period of time stretching into tens of years. Sporadic observations are of little value. We should rather emulate the well-conceived series of radial velocities of 48 double stars, recently published by Struve and Zebergs, and support its repetition some years hence. The probable error of a mean velocity from three spectrograms at a dispersion of 10 Å/mm is ± 0.4 km/sec for solar-type stars, ± 0.8 km/sec for A stars, and ± 1.7 km/sec for B stars. It is obvious that spectroscopists must put forth a major effort if we are to exploit the great wealth of material represented by a century of visual measurements of double stars.

Spectroscopic observations of wide pairs suggest a number of problems of importance that were briefly described by PETRIE.

G. Triple and Multiple Stars. An inspection of the literature confirms in a general way the high incidence of spectroscopic binaries, although it is not known in all cases that the wide pair is physical. It is highly desirable to establish by a more extensive survey the frequency of triple and multiple systems.

H. Variable Stars. A number of representative periodic variables, for example, δ Cephei, 16 Lacertae, β Cephei, etc., are accompanied by fainter companions. Here is perhaps an excellent opportunity to improve our knowledge of the absolute magnitudes of variable stars (and nonvariable stars of special importance) by astrometric and spectroscopic observations.

I. Composite Spectra. Radial-velocity observations of 21 unresolved systems show a definite velocity difference between the two spectra in 10 cases. Presumably the others will ultimately show orbital motion differences. Some of these systems may be expected to be interferometric doubles. Their investigation may well provide absolute magnitudes and masses of giant red stars.

J. Special Systems. Some systems of unusual interest are found in a spectroscopic survey. The star ADS 14864 has a brighter component which is composite, being composed of a supergiant K star and a B3 star; the fainter component is a B3 star and is somewhat underluminous. The B-type component of the composite pair is itself a spectroscopic binary. Here is a system of at least four stars exhibiting large variations in mass, luminosity, and temperature, and the mass of the system is at least 20 solar masses.

LUYTEN suggested checking old Carte du Ciel plates to see if some of the wide pairs measured by PETRIE appear separated; if so, one new plate might determine whether they are physical or optical.

Uncontaminated separate spectra have been obtained at Mount Wilson according to DEUTSCH for doubles as close as 1″ under favorable conditions. At the Haute Provence Observatory spectra of separations as small as 0″.7 have been obtained. RÖSCH mentioned that individual spectra of close doubles, down to 0″.5, are being obtained by a method he described in 1958, whereby the times of exposure are controlled electronically.

The full exploitation of double-star studies requires the careful and earnest coordination of visual and spectroscopic observations. A possible solution suggested by MULLER and DOMMANGET is to form a small working group composed of astrometric and spectroscopic observers. The group could compile and collate the data now available and suggest the necessary observations to be undertaken, even approaching interested observatories with definite requests.

K. Miscellaneous. DOMMANGET drew attention to the orbital motion criteria that distinguish between elliptical, parabolic, and hyperbolic orbits for short arcs showing little or no curvature. HEINTZ described the photographic observations with a magnifying eye-piece being made at the Munich Observatory. With the 11-inch refractor, separations of 1″ can be measured on good nights. With highest magnification the scale is 1″.3/mm and 7th magnitude is reached in 60 seconds with fast film.

There is need for proper motions of double stars, and meridian astronomers should not avoid observing them.

VAN DEN BOS read a letter by HERTZSPRUNG intended for circulation among institutions where astronomy is taught:

Tølløse, July 10, 1961

At the occasion of the Eleventh General Assembly of the International Astronomical Union a symposium on Visual Double Stars was held.

The lack of young observers is a serious menace to the future of double-star astronomy.

We have had men like Dembowski, Burnham, Aitken, Rabe, and others, not to mention the few still-living astronomers of this indispensable character. The question is only how to find them at an early stage of life.

It is, therefore, proposed to make acquaintance with the measurement of double stars compulsory for every student of practical astronomy, in the hope that the right man can thus be found. He will not need any encouragement—he is born to it as a mission of life.

But to be admitted at a large telescope it is necessary to have shown talent for this very special branch of observation.

That ability can be demonstrated with an instrument of modest size, such as found at many university observatories.

The primary consideration should, of course, be the promotion of the inclination of the student—rather than of the personal interests of the professor astronomiae.

The debt to our ancestors for the observations they made to our benefit, we can pay only by doing the same to the advantage of our successors.

E.H.

IV. SUMMING UP

VAN DE KAMP, the symposium chairman, summarized the two-day discussion as follows:

"Certainly we are all agreed that double stars are important simply because they exist, and may well represent the major portion of the stellar population. An increasing number of stars are found to be double from visual surveys, astrometric, and spectroscopic studies.

One of their most useful contributions to astronomical knowledge is that they provide the one direct method of determining stellar masses. Other aims are the statistics of double stars and their orbital elements, and the significance of double stars to astrophysics and theories of stellar evolution. The temptation of seeking correlations within the various elements is very great, especially as it could throw light on the general problem of the origin of double stars and evolution, but extreme caution must be exercised because of the selection effects which, at present, may mask any true correlations.

The importance of combining visual and spectroscopic data was emphasized. Closer liaison and cooperation between the astrometric and spectroscopic branches of double-star astronomy must be aimed for.

In the discussion of techniques, the potentialities and advantages of the double-image micrometer were emphasized. Visual observers continue for the present to hold the sole responsibility for the measurement of close pairs; they should not measure pairs wide enough to be measured by the more accurate photographic method. In order to measure the close pairs, which so often are the short-period binaries yielding masses in relatively short times, telescopes of large apertures must be used; also, only large telescopes should be used for interferometer measurements. The need for young double-star astronomers and for adequate time with large telescopes was stressed. A large proportion of large-aperture telescope time is devoted to astrophysical problems; yet the astrophysicist is dependent on the double-star astronomer for one of his most fundamental working parameters—namely mass.

The exploitation of image-tube techniques for double-star astronomy is just starting and we may hope for future aid by this method for the surveillance of close doubles.

In the session devoted to programs, there was discussion on the double-star catalogs of Jeffers and van den Bos, which are nearing completion and which represent a monumental piece of compilation of double-star data. Programs devoted to various kinds of surveys were discussed. These included (a) naked eye stars, (b) stars with large parallaxes or large proper motion, including wide pairs, (c) pairs containing variable stars, (d) stars in small selected areas, and (e) stars of particular astrophysical interest. There were some differences of opinion as to the relative values of studying selected areas versus individual stars.

The rapport and communication between the various types of double-star observers and the workers in other branches of astronomical research should be maintained and strengthened; a better coordination of supply and demand of information concerning double stars should be provided."

V. RECOMMENDATIONS

1. IAU Symposium No. 17 (Visual Double Stars) considering the fundamental importance of double-star observations to our science and recognizing the growing scarcity of qualified observers, stresses the necessity of encouraging young astronomers to take up double-star astronomy.

   The symposium expresses the wish that the IAU facilitate by all means at its disposal the sending of young observers to those observatories where this research is actively pursued. (Unanimously adopted.)

   Le Symposium No. 17 de l'UAI, considérant l'importance fondamentale des observations d'étoiles doubles pour toutes les branches de l'astronomie et la pénurie actuellement croissante d'observateurs qualifiés, insiste sur la nécessité d'encourager les jeunes astronomes à s'orienter vers l'étude des étoiles doubles. Le Symposium exprime le souhait que l'Union Astronomique Internationale facilite par tous les moyens en son pouvoir l'envoi des jeunes observateurs dans les observatoires où cette étude est poursuivie activement. (Unanimité.)

2. The Symposium recommends that experienced double-star observers be given increased opportunity to use reflectors of large aperture. (Unanimously adopted.)

   Le Symposium recommande que les observateurs d'étoiles doubles confirmés se voient offrir davantage d'occasions d'utiliser les grands réflecteurs. (Unanimité.)

3. The Symposium notes with satisfaction that it is the wish of the Republic Observatory, South Africa, to continue its traditional specialization in the field of visual double stars and expresses the hope that the acquisition of a large reflector for this purpose will not be long delayed. (Adopted with one abstention.)

   Le Symposium enregistre avec satisfaction l'intention de l'Observatoire de la République d'Afrique du Sud de maintenir sa spécialisation traditionnelle dans le domaine des étoiles doubles visuelles, et exprime l'espoir que l'acquisition d'un grand réflecteur pour ces travaux puisse intervenir prochainement. (Adopté avec une abstention.)

4. The Symposium expresses its gratitude to Dr. Jeffers and Dr. van den Bos for their monumental work in creating the *Catalogue of Observations* and the *Index Catalogue* of double stars.

   To insure the preservation of these catalogs, now available only at the Lick Observatory, the Symposium recommends that copies be deposited at a few selected observatories. (Adopted by acclamation.)

   Le Symposium exprime sa gratitude à MM. H. M. Jeffers et W. H. van den Bos pour l'oeuvre considérable qu'ils ont accomplie en créant le *Catalogue of Observations* et l'*Index Catalogue* d'étoiles doubles.

   Pour assurer la conservation de ces catalogues, qui n'existent actuellement qu'à l'Observatoire Lick, le Symposium recommande que des copies soit déposées dans un petit nombre d'observatoires choisis. (Par acclamation.)

5. We wish to express our thanks to the IAU for sponsoring

this Symposium, to the National Science Foundation for financial support, to the University of California for its hospitality, to Mrs. Shane for arrangement of housing facilities, and to Dr. van de Kamp and his associates for arranging the Symposium.

Nous désirons exprimer notre reconnaissance à l'Union Astronomique Internationale pour avoir patronné ce symposium, à la National Science Foundation pour son aide financière, à l'Université de Californie pour son hospitalité, à Mme. Shane pour les facilités de logement et à M. van de Kamp ainsi qu'à ses seconds pour l'organisation du Symposium.

SARAH LEE LIPPINCOTT, EDITOR
Sproul Observatory
Swarthmore College
Swarthmore, Pa., U.S.A.