

26. DOUBLE STARS (ETOILES DOUBLES)

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1. Visual Observations

Since the summer of 1979, more than 17 000 visual measures were made and have either been published or are being prepared for publication.

Couteau, using the 50- and 76-cm telescopes at Nice, obtained 984 measures and also discovered 207 pairs. Of these, 13% are closer than $0''.25$, and 33% have separations smaller than $0''.5$. Also at Nice, Morel made 300 measures with the 76-cm refractor and discovered 6 pairs.

At Torino, Ferreri initiated a program of visual double-star observations.

Heintz, using the 91- and 100-cm (Yale) reflectors at Cerro Tololo and the Sproul 61-cm refractor, carried out measures at the rate of 2000 per year and discovered 56 pairs.

Muller used the 50-cm refractor at Nice to carry out 1247 measures and to discover 53 pairs among 3900 stars examined. His search extends from $+53^\circ$ to the north pole and is virtually complete above 60° , while exploration below $+60^\circ$ has progressed from 32% to 69% during the three-year report interval.

At Belgrade, Popović and Zulević used the 65-cm Zeiss refractor to obtain 564 and 710 measures, respectively. Popović examined BD stars in the declination zones $+34^\circ$ to $+44^\circ$ and discovered 21 pairs.

At Moscow, Starikova continued the use of a polarizing micrometer for measurement of close binaries.

Valbousquet used the 65-cm refractor at Merida for visual double-star observations.

Walker has submitted for publication a list of 3053 measures obtained during 1972-1979. Since 1979, he has made 1124 observations with the 150- and the 100-cm reflectors at the U. S. Naval Observatory Flagstaff Station and with the 90-cm refractor at Mount Hamilton.

At Copenhagen, Wieth-Knudsen used a modified Muller-type double-image micrometer for measuring positions and magnitude differences of 20 pairs.

Wilson, during two 45-day visits to Johannesburg, used the 67-cm refractor to obtain micrometer measures of about 100 pairs, most of which have rapid orbital motion and are beyond the reach of northern hemisphere observers.

Worley made 2600 measures with the 26-inch refractor at Washington and 1400 measures with the Cerro Tololo 36- and 60-inch reflectors.

2. Photographic Observations

Kiselev reports that photographic observations of visual double stars were continued at Pulkovo with the 26-inch refractor and the Carte du Ciel astrograph. Of 200 stars observed, 50 show appreciable orbital motion, 7 of them changes of position angle equal to or greater than 0.4° per year. Detailed results of this work will be published in *Trudy Glavn. Astron. Obs. Pulkovo* in 1983. Future programs at Pulkovo will involve

(i) A continuation of survey observations of "forgotten" binaries with preference given to those in the north circumpolar area.

(ii) Determination of trigonometric parallaxes of selected double stars with appreciable orbital motion.

(iii) Accumulation of observational data needed for the determination of orbits by the method of apparent motion parameters of the binaries discussed by Kiselev and Kiyeva (28.118.035). For these objects, photometry, spectroscopy, and radial velocity determinations are greatly desired.

From the Sproul Observatory, Hershey and Lippincott report that astrometric plates continue to be taken with the 61-cm refractor at an average rate of 4750 plates per year. During the years 1978-1981, results for 80 long-interval series have been published, including a detailed analysis of the nearby photographically resolved system $\Sigma 2398$. Sufficient orbital coverage with significant photocentric amplitudes yielded independent orbital elements for ζ Her, 85 Peg, and Ho 296. Orbits for five unseen companions, revealed by photocentric amplitudes of from 1 to 40 microns, were published. Substellar mass is indicated for the companion to CC 1228; continued studies on BD+43°4305 indicate a low-mass unseen companion. Long-interval series on 40 unresolved visual doubles are ready or will soon be ready for measurement of parallax and for mass-ratio analysis.

At Torino, Pannunzio (27.118.026) completed an investigation of the parallax, proper motion, and mass ratio of Stein 2051. He also carried on a program of double-star observation by traditional photographic methods and by an experimental technique involving image trailing.

At Allegheny Observatory, Russell and Gatewood (28.118.015) have completed an astrometric study of the triple system Gliese 815 (Furuhjelm 54).

At Belgrade, Zulević plans to initiate a program of photographic double-star measurement with the Zeiss refractor.

3. Interferometric Observations

During the interval 1979-1982, 1800 measures of approximately 350 binary systems were obtained by McAlister and his collaborators in the Georgia State University speckle interferometry program carried out with the 2.1- and the 4-m Kitt Peak telescopes. This program has now resulted in the direct resolution of 90 bright binary systems. Combined spectroscopic and speckle-interferometric studies have been completed during this period for the systems τ Per, γ Per, 51 Tau, α Aur, η Vir, β CrB, χ Dra, and ϕ Cyg. A new intensified CCD speckle camera- and analysis system has been completed. This system increases the limiting magnitude from approximately $V = 7.5$ for the KPNO photographic system to approximately $V = 17$ and will be used to continue the Kitt Peak work and to initiate new programs both at Kitt Peak and at Lowell Observatory. The new camera is capable of performing accurate differential photometry of systems with separations down to the diffraction limit.

Bonneau and Foy (27.118.028) carried out speckle interferometric observations of binary systems with the Haute Provence 1.93-m telescope and, in collaboration with Blazit and Labeyrie (28.118.016), obtained speckle interferometric measures of 104 binaries or suspected binaries with the 3.6-m ESO and the 1.93-m Haute Provence telescopes.

Morgan *et al.* (27.118.045) continued their observations of binary stars by speckle interferometry with the 2.5-m Isaac Newton and the 1-m telescopes of the Royal Greenwich Observatory and with the 1.9-m telescope of the South African Astronomical Observatory.

At CERGA, Blazit, Bonneau, Koechlin, Labeyrie, and their collaborators are engaged in work on binary stars with both a digital speckle interferometer and the two-telescope interferometer.

At the Physikalisches Institut in Erlangen, Baier, Ebersberger, Lohman, and Weigelt are engaged in double-star research involving the reconstruction of high-resolution images by speckle techniques.

In Moscow, Tokovinin has started a program of measurement of very close binaries by means of a phase-grating interferometer.

4. Occultation Observations

Observations of occultations have played an increasingly important role in the detection and resolution of close binary stars. While numerous observers participate in this work regularly or occasionally, particularly active, systematic programs were carried on by Eitter and Beavers at the E. W. Fick Observatory, by White at the Lowell Observatory, and by Evans and his collaborators at the McDonald Observatory, where Evans also has compiled a *Catalog of Occultation Double Star Observations*.

A list of *New Double Stars* compiled and updated on the basis of occultation observations is also published periodically by Dunham (27.118.037; 28.118.100).

5. Photometric Observations

Since 1979, the program of photoelectric area-scanner observations coordinated by Rakos at Vienna has led to the reduction of a large volume of photometric and astrometric data on visual binaries. A first compilation of these results will appear in *Astron. Astrophys. Suppl. Ser.*

At the Lowell Observatory, Franz has continued his area-scanner observations of selected double stars with particular emphasis on pairs containing an evolved component.

At La Plata, Ferrer (27.118.010) used a focal-grating photometer on the 43-cm refractor to measure magnitude differences in 90 southern double stars.

At the Instituto de Astronomia, UNAM, México, Echevarría, Roth, and Warman (27.118.018) carried out and analyzed UBVRI photometric observations of 68 trapezium-type systems.

6. Spectral Classification and Radial Velocity Programs

At the Kitt Peak National Observatory, Abt is in the process of obtaining MK spectral types of all multiple-star components brighter than $B = 8.0$ in the *Aitken Catalog* and the *Catalogue of Bright Stars*. The first segment of 865 types was published in *Astrophys. J. Suppl.* 45, 437, 1981.

Spectral types on the MK system for 30 visual double stars with separations mostly between 1" and 3" were published by Corbally and Garrison (28.118.023).

Culver and Ianna continued their spectroscopic and photometric studies of barium-star binaries.

Radial velocities of 173 visual systems with known visual orbital elements were published by Abt, Sanwal, and Levy (28.118.019) and by Roemer and Sanwal (28.118.018).

Heintz (*Astrophys. J. Suppl.* 46, 247, 1981) has obtained coudé plates at Kitt Peak National Observatory to determine radial velocities of 127 binary and proper motion stars.

At Victoria, spectroscopic investigations of visual double stars were continued principally by Batten, Fletcher, McClure, and Scarfe. Some preliminary high-dispersion plates have been obtained with the Canada-France-Hawaii 3.4-m telescope on Mauna Kea. Use of the radial velocity scanner has permitted more rapid observation of several systems of appropriate spectral type, as well as extension of the program to fainter magnitudes. The reliability of the scanner as a substitute for photographic plates for accurate radial velocity observations is still being assessed. Objects having received particular observational attention have included δ Equ, π Cep, 70 Oph, ζ Her, ADS 11579, ADS 14893, ADS 3588, 64 Ori, and Kui 114.

Continuing the program of radial velocity determinations of the components of visual double stars at the Royal Observatory of Belgium, van Dessel has used telescopes at ESO and Haute Provence to obtain 250 spectrograms of 30 pairs.

7. Experimental Equipment, Space Techniques

Dommanget has continued his work on the use of a television technique for astrometric observations of visual pairs. Results of initial tests of image analysis were presented at IAU Colloquium No. 62 at Flagstaff in May 1981.

From the University of Sydney, Davis reports that a prototype study is now underway for the development of a major long-baseline interferometer.

At Allegheny Observatory, Gatewood *et al.* (27.118.002) have developed and tested a prototype photoelectric detector for astrometry. They have concluded that an improved, space-borne instrument of this type may be capable of detecting any Earthlike planet orbiting any of several hundred stars nearest to the Sun.

Dommanget has investigated many aspects of the expected impact of space astrometry upon double-star research. In collaboration with Bacchus and Nys, he is examining in particular the role of double stars in the HIPPARCOS astrometric satellite project, and the problems that may be associated with the inclusion of double stars in the HIPPARCOS observing program.

Franz, as a member of the Space Telescope Astrometry Team, continued to investigate the use of the ST Fine Guidance System for double-star research.

8. Orbital Analyses

More than 250 first or revised orbits were published, largely in *Circulaire d'Information* Nos. 79-85. Investigators most active in orbit computations were Baize, Heintz, and Starikova who, together, accounted for nearly 75% of the orbital elements published during the report interval.

An investigation concerning the nature of a double-star orbit calculated from three fundamental points and the apparent areal constant was carried out by Dommaget (*Astron. Astrophys.* 95, 45, 1981). A corresponding computer program has been written by Nys.

Zulević (27.118.030) has examined the reliability of the computation of the orbital elements of visual binaries with components of equal brightness.

Kiselev and Kiyaveva (28.118.035) have investigated the determination of visual double-star orbits by the method of apparent-motion parameters from short-arc observations.

The orbital evolution of close triple systems was examined theoretically by Mazei and Shaham (26.118.009).

9. Statistical Analyses

In order to produce a relatively uniform and homogeneous group of double and multiple stars free of optical and spurious systems and suited for statistical studies, Poveda, Allen, and Parrao applied a "filter" to the about 70 000 entries of the IDSII. The resulting "filtered" IDS (FIDS), containing 51 201 entries, was subjected to extensive statistical analysis with the following principal results:

(i) The FIDS contains the great majority of binaries with primaries brighter than magnitude 10 and with magnitude differences less than 1 mag; these represent 3% of the intrinsic visual binary population.

(ii) The true fraction of visual binaries and multiples to field stars is found to be about 0.9; most companions remain undetected.

(iii) Examination of 968 multiple systems of trapezium type confirms the existence of such systems among all spectral types.

Detailed results of this work have been submitted for publication in the *Astrophysical Journal*.

Abt (26.118.005) has studied the frequency of binaries on the main sequence on the basis of available observational data.

Salukvadze (26.118.002; 26.118.036) has carried out statistical investigations based upon the Abastumani catalog of trapezium-type multiple systems.

Starikova (*Astron. Zh.* 58, No. 2, 1981) has studied the kinematic properties of double stars and has shown that they differ systematically from those of single stars of the same spectral class, except for B-stars. This result suggests that many "single" B-stars may in fact be very close binaries.

Dommaget, as part of his extensive statistical studies of double stars, has examined the problem of the evolution of binary star orbits due to mass loss (*Proceedings of IAU Colloquium No. 59*) and the mass-eccentricity correlation in spectroscopic and visual binary orbits (*Proceedings of IAU Colloquium No. 69*).

Based upon a study of the 2500 binaries discovered by Couteau and Muller, Couteau (*Astron. Astrophys.*, in press) has developed a statistical method for calculating parallaxes and masses of binaries with unknown orbits.

10. Catalogs; Data and Information Management

During the report interval, 2387 additions have been made to the Index Catalog of double stars, maintained by Worley at the U. S. Naval Observatory, while 10 527 new measures have been added to the Observation Catalog. The project to complete the observation catalog through the accession of the older observations continues. As of November 1981, 129 000 such observations (means) are present in the catalog, and an additional 18 000 have been punched. Aside from the major series by O. Struve (65% completed) and Mädler, only relatively minor lists remain to be done.

A system for on-line use of the catalogs, allowing data to be added and corrections to be made from a terminal, is expected to be operational in a few months.

A copy of the USNO catalog is maintained at Nice by Fulconis.

Walker is developing a data-base management system to handle his double-star observations, program-star selection, program updating, and photocopy production of results. Publication of his *Catalog of Visual Binaries with Variable Components* is being delayed due to printer changes in Washington, D. C.

The second catalog of ephemerides of the radial velocities of visual double stars with known orbits has been completed by Dommanget and Nys and is now in press (*Comm. Obs. Roy. Belgique*, Ser. B).

Dommanget has maintained up-to-date his catalogs of the orbits and rectilinear trajectories of visual binaries. A magnetic tape version is available.

Muller has continued to edit the *Circulaire d'Information* of Commission 26 published in February, June, and October of each year.

11. Colloquia

IAU Colloquium No. 62 on "Current Techniques in Double and Multiple Star Research" was held at Flagstaff, Arizona, in May 1981. Proceedings are being prepared for publication as a *Lowell Observatory Bulletin*.

12. Acknowledgements

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President of the Commission