

## 26. DOUBLE STARS (ÉTOILES DOUBLES)

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### 1. VISUAL OBSERVATIONS AND PROGRAMS

Couteau at Nice reports that between July 1973 and 1 Oct. 1975, 1150 measures have been made and 301 doubles found from the examination of 15 000 stars. Since 1967, of the doubles discovered, 85% have separations less than  $2''$ , 12% less than  $0.''2$ . This program for discovery of new doubles extends from declination  $+17^\circ$  north; about 40% of this zone has been completed with the result that the number of couples with separations less than  $0.''3$  has been tripled in the observed region. A number of these doubles are of special astrophysical interest.

At the end of July 1974 Muller terminated his work with the 83-cm refractor at Meudon and is now active with CERGA at Grasse. The third and last series of measurements at Meudon include 451 measures of 259 objects. Muller's association in Grasse permits the continuation of his polar survey started in 1969 at the Nice Observatory. In addition he has started a routine program with the 50-cm refractor including couples not measured for 60 years or more.

Worley has made 3309 measures (1 Sept. 1972–30 Sept. 1975) with the USNO 26-in. refractor. Behall, using the same equipment and the 24-in. reflector at Washington, has made 1090 measures. Worley made measures of 934 pairs with the 24, 36, or 60-in. reflectors of the Cerro Tololo Inter-American Observatory.

Walker at the Flagstaff station of the USNO has made 1085 measurements in addition to 824 measurements at the Lick Observatory.

Holden made 1100 measures of southern pairs at Cerro Tololo and Las Campanas. Approximately 1400 measures were made with the refractors at Lick and a small number with the 152-cm reflector at Mt. Wilson.

Measurements with a micrometer, modified as described later, on the Copenhagen 30-cm refractor are carried out by Wieth-Knudsen.

1660 measures made by Popović, Olević, and Zulević with the Belgrade Zeiss 65-cm refractor have been published in BAOB No. 125, 126. In zone  $+34^\circ$  to  $+35^\circ$  Popović has discovered 71 new pairs, 29 of which have separations under  $3''$ . Double stars observations are becoming increasingly difficult in the city of Belgrade and sites in the mountains are being investigated. The 5th series of measurements is in preparation.

Heintz has made micrometer measurements of 935 pairs with the Sproul 24-in. refractor between 1971.8 and 1975.0, which have been recently published.

Freitas-Mourão has made 410 measurements of southern doubles with the 18-in. Cooke refractor at Rio de Janeiro.

### 2. PHOTOGRAPHIC OBSERVATIONS AND PROGRAMS

Results of 170 pairs measured with the 60-cm double refractor of the Bosscha Observatory 1954–1964 were recently published by P. S. The (now at the Astronomical Institute, University of Amsterdam). Hidajat reports that photographic program is being continued; 541 plates on 266 pairs have been taken in a one-year period commencing 1974, Oct. 1. Elsa van Albada is preparing for publication measures of southern doubles observed from 1953–60. Observations of Sirius with a special grating designed by the late G. van Albada have been made by E. van

Albada and Hidajat in 1974–75 which will be analyzed along with those taken in the 1960's.

The USNO photographic program included 1200 multiple exposure plates of 250 double star systems, obtained with the 26-in. refractor. In the current 3-year interval 1530 plates were measured.

The Sproul 24-in. refractor program with emphasis on nearby stars continues with determination of parallax, orbital motion, mass-ratio, and perturbations which reveal unresolved binaries.

The photographic program with the Pulkovo 26-in. Zeiss refractor started in 1968 includes some 200 double and triple systems, most of which have not been observed since 1910–30. The program is limited to those systems brighter than  $11.0 m_v$ ,  $\Delta m < 1.0$ ,  $\rho > 3''$  and  $\delta > 40^\circ$ . Observations are being accumulated at an annual rate of 300 plates with 10–20 exposures each. It is anticipated that the first results will be published in 1978, from which Kiselev and his group hope to find stars with orbital motion where  $\Delta\theta \geq 10^\circ$  per century so that dynamical along with trigonometrical parallaxes can be determined in addition to their masses.

At the National Observatory in Rio de Janeiro a program continues with the 46-cm refractor under the direction of Freitas-Mourão.

Luyten continues his work on double stars with common proper motion and has published another 2000 pairs in this report period. This brings the total of such pairs found in the Bruce and Palomar Proper Motion Surveys to well over 5000, more than any other double star observer has found. Among these are 330 pairs of which one component appears to be degenerate and a few dozen where both components appear to be degenerate.

The Allegheny Observatory continues its photographic program on double stars with the Thaw refractor.

The 41-in. astrometric reflector of the Torino Observatory was dedicated in May 1974. It is designed after the U.S. Naval Observatory 61-in. telescope. Fracastoro has started a photographic astrometric program which includes photographically resolved visual binaries.

### 3. PHOTOMETRY

Franz has used a photoelectric scanner on the 72-in. Perkins Telescope at the Lowell Observatory for *UBV* measures with particular emphasis on pairs containing at least one variable component.

Determination of  $\Delta m$  with a polarization filter are made by Wieth-Knudsen in Copenhagen.

Walker, USNO, has obtained over 600 *UBV* measures of the integrated light of binary components. Included are those pairs with orbits and those suspected of containing at least one variable star. ADS 1693A was discovered to be a W UMa type binary (*IAU Info. Bull. Variable Stars* #855, 1973).

The National Observatory at Rio de Janeiro is organizing a program of photoelectric photometry of doubles.

### 4. RADIAL VELOCITY PROGRAMS

The program of radial velocity determinations of selected visual binaries was continued with the 1.2-m. telescope at the Dominion Astrophysical Observatory by Batten, Fletcher and Scarfe. High-dispersion observations of 70 Oph A obtained in 1966–74 have been reduced by Van Dessel and Batten; the observed velocities agree well with the predictions of the Sproul results by Heintz and Worth. Fletcher is analyzing spectra of Procyon for a determination of the orbit. Also 61 Cyg is being observed. Scarfe has continued his program of observation of systems listed in a previous Report. Observations of two triple systems ADS 8189 and 11060 have been continued by Batten and Morbey, respectively.

Spectrograms taken at the Haute Provence Observatory by Van Dessel, Couteau and Morel in 1970–71 are being reduced at the Utrecht Observatory with the digital microphotometer.

An inventory of the most interesting binaries suitable for radial velocity observations has been established and presented by Van Dessel at the Colloquium in Coimbra.

## 5. ORBITAL ANALYSIS

More than 10 orbits have been determined from observations made with the 74-cm Nice refractor by Couteau.

15 Orbits have been determined at Belgrade. Protitch is redetermining the orbit of L726-8 and the preliminary results show pronounced apsidal motion.

Worley and Behall have published a new orbit and mass ratio of L726-8.

Heintz has computed over 40 new or revised orbits which include his measurements made at the Sproul Observatory since 1971.8. A reference list to his orbits is given in *Astrophys. J. Suppl.* 29, p. 288, 1975.

Orbits have been determined at Uccle for ADS 7044, ADS 8446 and ADS 10723.

Finsen has made a thorough revision of the spectroscopic and interferometric orbits of Capella while Heintz has made an astrometric study of the components from photographs taken with the Sproul 24-in. refractor.

S. Siregar at the Bosscha Observatory has determined the orbit of ADS 1733.

Baize, though retired from observational work, continues orbital analyses and theoretical studies.

Orbits computed by Freitas-Mourão at the National Observatory in Rio de Janeiro appear in the *Anais de Academia Brasileira de Ciencias* and in their observatory publications.

New or revised orbital elements appear in the *Information Circular* of IAU Commission 26.

## 6. STATISTICS OF DOUBLES

Baize presents some statistics concerning frequency of spectral types in various catalogues. Also there is a discussion of the distribution of the various orbital elements. These and a third paper on the mass-luminosity relation appear in *L'Astronomie* 89.

Finsen continues to do statistics based on Finsen-Worley Catalogue.

Muller has presented statistics on double stars indicating the influence of various selection effects (Colloquium in Coimbra and IAU Colloquium No. 33 in Mexico, October 1975).

## 7. MASSES, PARALLAXES, PROPER MOTIONS, PERTURBATIONS

Masses and mass ratios have been determined for seven systems, and orbits for seven unseen astrometric companions have been published from observations made with the Sproul 24-inch refractor. A summary article by van de Kamp on unseen astrometric companions has appeared in the *Ann. Rev. Astron. Astrophys.* 13, 295, 1975. A study of the mass density of unseen companions was presented by van de Kamp at the Tercentenary Symposium on the Galaxy and the Local Group at Herstmonceux Castle in 1975.

Research on the perturbation on the motion of ADS 14826 is being carried out by Dommanget.

The McCormick Observatory USNO, Van Vleck Observatory and the Allegheny Observatory continue to publish masses, mass ratios, and analyses of proper motions for perturbation.

## 8. METHODS, THEORETICAL WORK, RESULTS

Wierzbinski is engaged in a new method of corrections to orbital elements.

Baize is preparing a paper on new methods of orbital element determination.

Harrington, USNO, has continued investigation on the dynamics of triple stars by several series of computer numerical experiments to study stability and dynamical evolution of unstable systems. The decay of unstable quadruple and quintuple systems produces the observed proportion of triples and binaries.

Popović has made a study of the relation between the integrated magnitude, epoch of

observation, and separation of components (*Proc. Astr. Obs. Beograd* 20, 1975). Djurković has reviewed the problem of the origin of binary systems (Proceedings of the National Conference of Yugoslav Astronomers 1973).

Morbey at the Dominion Astrophysical Observatory has investigated the problem of determining orbital elements of a visual binary through simultaneous visual and spectroscopic observations. Hershey at the Sproul Observatory developed a program and used it to make simultaneous orbital determinations combining astrometric, photometric time of minimum, and spectroscopic data in single solution for Algol AB, C.

Van de Wiele, Uccle, has made a theoretical study of the possibility of massive invisible companions in double star systems from doubles listed in the Index Catalogue.

## 9. SPECIAL EQUIPMENT AND TECHNIQUES

The Carl Zeiss firm at the request of Wieth-Knudsen has developed under the name of 'Zwischenoptik' an optical system which has replaced the microscope of the Muller-micrometer with a system which allows use of the same eye pieces used with the filar micrometer, and yields the same magnification.

In use at the Nice Observatory are the 74-cm and the 50-cm refractors; the latter is equipped with a digitized micrometer which records the name of the star and the P.A. and  $\rho$ .

Franz continued his program of positional and photometric observations with the photoelectric scanner on the 72-in. Perkins reflector at the Lowell Observatory.

Dommanget continues with investigations of the use of television techniques with the 45-cm Cooke-Zeiss equatorial in Belgium.

Lunar occultations continue to be fruitful in discovery of duplicity for separations of the order of  $0''.01$ . D. S. Evans and his colleagues have timed 397 occultations from February 1973 to 1975 with 36 cases of duplicity, the majority of which are new discoveries.

White is engaged in the study of stellar duplicity from occultations at the Lowell Observatory.

Rakos in Vienna continues a double star program using area scanning techniques. Similar equipment has been installed in the Torino Observatory in 1974 used on the 41-in. astrometric reflector.

Achromatic double-star interferometry as developed by Wickes and Dicke of Princeton shows promise with separations around  $0''.5$ . The work of Labeyrie with speckle interferometry continues to hold promise for measurement of close doubles.

A new 1.87-m fixed baseline interferometer designed for binary star observation is operated in Italy by the Royal Observatory of Edinburgh. It has a resolving power of  $0''.015$  and will eventually have a limiting magnitude of 7.8.

## 10. CATALOGUES AND ATLASES

The main Double Star Catalogue of Measures and The Index Catalogue of double stars is kept up to date by Worley with help from Miranian and Douglass at the U.S. Naval Observatory. 3684 cards listing new doubles and 18108 cards listing corrections, additions, and replacements were mailed to the three participating depositories (Lick, Greenwich, Meudon). In addition 6000 cards listing corrections and/or changes in format were prepared for distribution: 31 requests were received. The Index Catalogue double star tape was sent to six institutions.

In 1974 the Meudon copies of the Index Catalogue and Catalogue of Measures were transferred to Nice. They have been copied on discs so that the entries may be consulted immediately without removing the perforated card. The Catalogues are now under the personal supervision of Cousteau.

In preparation at the Royal Observatory of Belgium is the second Catalogue of the Ephemerides of the relative radial velocities of components of visual doubles in which the orbital elements are known.

The first general Catalogue of Double Stars made in Belgrade from 1951–1971 was published in 1974 under the direction of Popović.

The Nice Atlas of Orbits of visual doubles continues to grow and is made up-to-date twice a year. The supplementary sheets are sent to all those who have bought the Atlas. The Atlas may be procured directly from the Observatory at Nice.

Walker is revising a Catalogue of double stars with one or more variable components.

Finsen continues to maintain his orbit catalogue (with Worley) up-to-date and edited.

The *Information Circular* of the IAU Commission 26 continues to be drawn up and published three times a year by Muller. Included are new and revised orbits and other appropriate information and announcements. Normal deadlines for inclusion are the 1st of March, July, and November.

## 11. PUBLICATIONS

Few references are given within the body of the report. The majority of the European double star observations appear in the *Astronomy and Astrophysics Supplements* and the publications of the observatories where the observations were made. In the U.S.A., the *Astrophys. J. Suppl.* and the USNO Publications publish observations when appropriate. The majority of results: orbits, mass, mass ratios and results from astrometric studies of unseen companions from the U.S.A. – appear in *Astron. J.*, *Astrophys. J.* and *Publ. Astron. Soc. Pacific*.

## 12. COLLOQUIA

In 1974 October a European Double Star Colloquium was held in Coimbra, Portugal, with A. Simões da Silva as host. European observing programs, techniques, special observational problems, and the future of observational programs concerning visual double stars were discussed. It is hoped that the proceedings, dedicated to Arend and edited by Da Silva and Dommanget, President of the Colloquium, will be published in Portugal in the near future.

IAU Colloquium No. 33, 'Observational Parameters and Dynamical Evolution of Multiple Stars' was held in Oaxtepec, Mexico, October 1975. Papers and discussion dealt with trapezium-type and hierarchical systems. Both observational and theoretical studies were presented. The Proceedings are dedicated to W. S. Finsen and will be published in *Revista Mexicana de Astronomia y Astrofísica*.

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*President of the Commission*