COMMISSION 26: DOUBLE AND MULTIPLE STARS

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Preface:

In the recent years new techniques are expanding visual binary star astronomy into previously inaccessible regimes of angular resolution and accuracy of measurements regarding the astrometric and astrophysical parameters of their components. New techniques and algorithms are providing enhanced sensitivity to low mass companions and the determination of photometric properties of the components of close visual binaries. The potential now exists for significantly narrowing, if not eliminating entirely, the historic gap separating spectroscopic from visual binaries. Advances in closely related fields as in precision radial velocity measurement and enhanced accuracy of parallax determination from ground and space based observatories will place demands upon double star astronomy that have been absent for half a century. Today double and multiple star astronomy is perhaps closer to fulfilling its true potential than it has ever been, entering a fundamentally important area of modern astrophysics.

Visual and photographic methods are rapidly being replaced by more powerful electronic methods of measurement by astronomers from all over the world. Access for double star observers using modern techniques is finally being routinely granted at the largest telescopes located at the best observing sites, an often quoted dream of such leading figures in our field as van den Bos and Finsen. Groups in the U.S., France, Australia and Germany are constructing or planning long baseline interferometers that will turn systems of stars having orbital periods of a few days into "visual" doubles. Other interferometric techniques using single aperture telescopes in the visible and infrared spectral regions are currently being used by French, German, British, Soviet, U.S. and other astronomers to obtain diffraction-limited measurements of double star geometry and to measure magnitudes and colors of the individual components of these objects. This most classic of all subfields in astronomy, the last to which direct measurement with the eye has made a major contribution, is truly in the midst of a revolution.

I. The Hubble Space Telescope - Double and Multiple Stars:

Research in binary star astronomy is the principal activity of the Center for High Angular Resolution Astronomy at Georgia State University. Research activities center around the capabilities of a speckle camera developed and operated by CHARA. The camera system incorporates a microchannel plate intensified CCD array, which is read-out at standard video rates and supplies speckle pictures for video recording and subsequent processing or for real time processing by means of a hardwired vector-autocorrelator. The camera has been used an average of 15 nights per year on the 4-meter telescope on Kitt Peak and for 50 nights per year on the 1.8-meter Shane telescope at Lick Observatory,

the 2.5-meter Hooker telescope at Mt. Wilson and the 3.8-meter CHF telescope on Mauna Kea. These last three telescopes were used in a survey for duplicity on Hubble Space Telescope guide stars.

The primary program, as carried out on Kitt Peak, involves the attempted resulution of spectroscopic binaries, close visual binaries and other stars. Limiting resolution and magnitude for the routine program is 0.030 arc-second and V = +11.0. The ICCD speckle camera has produced some 2700 measurements published in early 1987. Numerous revisions of orbits are underway at CHARA. Observations taken at the Perkins telescope (Lowell Observatory) are aimed at detecting low mass companions, including Jupiter-sized objects, by means of submotions revealed through the high accuracy of speckle interferometry. A concerted effort toward the recovery of intensity ratios of the components of close binaries is underway. The feasibility of an optical array of telescopes capable of sub-milliarcsecond resolution and applicable to the direct angular resolution of short period spectroscopic binaries is currently under discussion. Participants in these efforts include or have included: H.A. McAlister, D.J. Hutter, J.R. Sowell and W.G. Bagnuolo, Jr. of CHARA, O.G. Franz of Lowell Observatory and M.M. Shara of Space Telescope Science Institute.

The second large and very productive team working in the field of speckle interferometry using the 2m telescope at Pic du Midi, Canada-France-Hawaii telescope at Mauna Kea and 1.93m telescope at Haute-Provence is guided by A. Labeyrie, D. Bonneau, A. Blazit, R. Foy, L. Koechlin, R.V. Stachnik, D.Y. Gezari, Y.Y. Balega, J.M. Carquillat, J.L. Vidal, F. Vakili and M. Faucherre. Beside the Observation of very close binary stars, the measurements of star diameters, color dependent limb darkening, determinations of inclination and masses for the system Algol AB-C, high resolution of Pluto-Charon system, Uranus and Neptune and 3C273 have been published.

The third large groupe using speckle technique and ESO telescopes at La Silla is working on similar observations. There are G. Weigelt, K.H. Hofmann, T. Reinheimer, G. Baier, R. Ladebeck, U. Bastian, E. Keller, R. Mundt, J. Ebersberger, M. Walter, M. Mueller, R.B. Orellana and others.

II. Hipparcos - Double and Multiple Stars

During the last three years J. Dommanget, with the collaboration of O. Nys, has carried on his contribution to the ESA Hipparchos Astrometric Mission preparation as a member of the Input Catalog Consortium, where he is in charge since 1981 of problems concerning double and multiple stars.

In order to solve these problems it appeared essential to establish a specific "Catalogue of the Components of Double and Multiple Stars (CCDM)" giving accurate astrometric and photometric data on each component. To collect the necessary information, an international working group was established. Its activity has mainly been directed to accurate astrometric observations and identifications. The members are presently: J.P.Anosova (Leningrad), A.N. Argue (Cambridge), P. Bacchus (Lille), P. Brosche (Bonn), U. Bastian (Heidelberg), P. Candy (Perth), J. Guibert (Paris), L. Louys (Uccle), E. Oblac (Besancon), V.V. Orlov (Leningrad), R. Pannunzio (Torino), R. Perdomo (La PLata), F. Schmeidler (München), D. Sinachopoulos (Bonn), J. Torra (Barcelona) and G. Soulie (Bordeaux). The work of this group may be considered from the following points of view:

a) The Catalog of the Components of Double and Multiple Stars:

The basic reference of this catalogue is the Index (1976.5) whose format has been fundamentaly modified in such a way, that each component is described by one record. This enables primarily the introduction of information missing

in the Index as: DM numbers for the secondary components or other identifications. It presently consits of 62.300 systems split into four files of 56.600 double stars, 4.400 triple stars and 1.000 quadruple stars and 300 multiple stars of more than four components.

More than 2.000 newely published AGK2/3 and SAO identifications of components have been introduced in the CCDM. Hundreds of double stars having separations less than 3", that cannot be identified on photographic plates, are observed by amateur astronomers in West Germany and in France using finding charts, under leadership of U. Bastian and P. Bacchus. Simultaneously, this work has led to the discovery of hundreds of errors in the Index: a manuscript is being prepared for publication.

The format of the CCDM also permits the introduction of accurate astrometric data. Today, the completion of this catalogue is under way. Some 20.000 accurate positions of components of systems have been extracted from a new general astrometric catalogue prepared at Heidelberg especially for the Hipparcos mission and have already been introduced in the CCDM. A few hundreds of meridians observations made at Berlin-Babelsberg, more than three thousand photographic positions obtained at Leningrad, Perth, Uccle, Torino, La Plata, and Bordeaux, nearly two thousand relative positions of secondary components computed at Bonn and some 2.500 CCD photometric and astrometric data of double stars recently obtained at La Palma (Cambridge group) as well as micrometric observations made at München, are being introduced in the CCDM. Also some 800 "semiaccurate" positions (+- 0.1 arc-minute) published by P. Bacchus and useful for identifications have also been considered.

b) The double and multiple stars in the Hipparcos Input Catalogue:

The intercomparison of the CCDM with the INCA DATA BASE (210.000 stars) has allowed the identification of some 20.000 systems. One may thus estimate by 10.000 the presently identified known double and multiple systems in the HIPPARCUS INPUT CATALOGUE that will consist of some 100.000 stars.

In view of their possible observation by Hipparcos, all these systems had to be studied from the point of view of the number of entries to consider in the Input Catalogue as a function of their components separation and their differences in magnitudes. Research has also been made on the observability problems of astrometric and spectroscopic pairs and on the possibility of orbit computations based on the sole Hipparcos observations.

As a by-product of the identification work done for the CCDM and for the Hipparcos Input Catalogue, a full list of the BD stars having a suffix "a" or "b" has been established for publication in view to bring the attention to the fact that these suffixes do not mean anything concerning components A or B.

Research has been made on Schmidt plate reduction taking into account the curvature introduced in the plate exposed to the sky.

In connection with a program called "Contribution of the Stars of Various Masses and Compositions to the Chemical Evolution of the Galaxy", a new study has been started on the orientation of the orbital planes of visual double stars in the surrounding of the sun.

In the course of preparation of Hipparcos data analysis, members of the Fundamental Astronomy by Space Techniques Consortium (FAST) and of the Northern Data Analyses Consortium (NDAC) have studied algorithms and worked out s/w programs in order to detect astrometric binaries and multiple stars among Hipparcos program stars and to derive their astrometric parameters. The state of the art of these studies is represented by several papers. Detection should occure for binaries brighter than 13 magnitudes with separation larger than 0.07 arc-second and magnitude difference between the components smaller than three. These studies have been carried out by J. Kovalevsky, P.L. Bernacca, W. Delaney, L. Borriello, A. Farilla, M. Froeschle, J.L. Falin, F. Mignard,

S. Soederhjelm, F. D'Alessandro, L. Lindegren, G. Prezioso, E. Canuto, B. Fassino and H.G. Walter.

III. Visual and Photographic Observations:

Visual and photographic observations have been continued at different observatories. U.S. Naval Observatory, Observatoire de Nice, Bosscha Observatory, Osservatorio Astronomico di Torino, Observatorio Astronomico Universidad de Santiago de Compostella and other observatories have published a large number of observations of double stars.

Beside the classical visual and photographic methods, modern measuring techniques as CCD cameras, solid state area scanner, speckle cameras, interferometric methods, multicolor photometry, radial velocity measurements, have been used on regular basis. Here we have to mentione the strong trend toward the complete analysis of physical parameters of selected double stars instead of compilation of large number single observations of orbital parameters only. Also the increasing collaboration between different observatories and individual astronomers in the double star research should be pointed out.

IV. IAU Colloquium No.97 :

The colloquium "Wide components in double and multiple stars" was held at the Brussels Congress Center, Belgium, June 8-13, 1987. It was co-sponsored by comissiones 26 and 24 with the collaboration of comissions 30, 33 and 42. The colloquium was organized by the Royal Observatory of Belgium and dedicated to W.J. Luyten. The meeting was devided into seven sessions including one poster session that were devoted to the following specific subjects: Cataloguing wide pairs; Wide nearby binaries; Wide components in multiple systems; Observation of wide pairs and their results; Statistical studies on wide pairs and origin and evolution of wide pairs. Sixty astronomers from 17 countries registered and delivered 48 papers and posters including 6 introductory lectures. The aim of this colloquium was to show how much double star research may be important for better knowledge in many astronomical domains including star formation and evolution as well as galactic structure and dynamics. It drew attention on wide pairs when so much is done today in the field of close binaries. It has shown that astrometric, spectroscopic and photometric investigation of wide pairs appear today as an indispensible counterpart to observation of close systems. This was the second colloquium organized on double stars by the Royal Observatory of Belgium and the seventh by IAU Comission 26. The proceedings of the colloquium will be published in Astrophysics and Space Science.

I am most grateful to those who have supplied information for this report.

Karl D. Rakos
President of the Commission