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An Impression from Programmes Performed at ESO about the Interest of European Astronomers in Visual Double and Multiple Star Research

E. L. VAN DESSEL
Royal Belgian Observatory, Uccle, Belgium

ABSTRACT: The European Southern Observatory gives opportunity to the European astronomical community to use a large variety of instruments. In this paper we try to make an assessment about the proposals that show an interest in visual binary and multiple star research. The material is based on projects proposed and performed in the last 3 years. Main streams of research are: speckle measurements, radial velocities, photometry (completion of catalogues), and astrometric positions.

1. INTRODUCTION

The aim of the present paper is summarized in the abstract. We have taken the liberty, for the purpose of this Colloquium, and because of the perhaps remote chance that not all participants are aware of the possibilities offered by ESO (European Southern Observatory, observation site mountain La Silla at an altitude of about 2400m), to remind about the available telescopes and auxiliary equipment: see Table 1. The facilities on La Silla consist of 14 telescopes, headquarters are in Garching–bei–Munchen, computing facilities at La Silla comprise an HP1000 system with full image processing capabilities (IHAP), a VAX 11/750 and several SUN workstations for image processing (MIDAS). More information about operational utilities are to be found in the ESO Users Manual (Schwarz & Melnick 1989).

We intend to give an idea about the interest that is shown from the European astronomical community about visual double and multiple star research, in terms of numbers of proposals, instruments requested, topics. Data basis: applications that have been introduced in periods 45 to 49, which covers the years April 1990 to September 1992 (applications can be made twice a year, after which the Observing Programmes Committee (OPC) will meet).

The OPC consists of representatives of the 8 member states, one or more ESO delegates, and one or more external experts.

We shall restrict ourselves to give an overview of the proposals that have been introduced without commenting on the number of nights that have been attributed.

2. TELESCOPES AND INSTRUMENTS ASKED FOR

This section is purely about statistics. The scientific contents will be discussed in section 3. During periods 45 to 49 there have been applications for:

- The NTT 3.5-m with the EMMI spectrograph: twice asked for by Anasova and Orlov: "Dynamical evolution of triple stars".

- The NTT for EFOSC/DIFA/SUSI photometry: asked for by Reipurth and Zinnecker (2 periods): "Component colors of pre-main–sequence binaries".
- The 3.6-m, I.R. speckle: twice asked for by Leinert *et al.*: "Search for low–mass companions to nearby M-dwarfs".
- 3.6-m: also I.R.speckle: Perrier *et al.*, twice asked for: "Interferometric imaging of very low mass binaries".
- 3.6-m, AIT-MCP speckle instrumentation (cf. Barnstedt *et al.* 1987, Neri 1988): Neri *et al.*: "Speckle imaging of close binaries" (and of planetary nebulae). Twice asked for.
- 3.6-m, own instrumentation (adaptive optics camera "Come-on"): Mariotti *et al.*: "Search for southern brown dwarfs in binary systems". Period 46.
- 3.6-m, I.R.photometer: Stecklum and Henning: "Lunar occultation measurements of young stellar objects". Period 48.
- 3.6-m, CASPEC: Ardeberg and Lindgren, from period 46 onwards: "Masses and orbital elements for double stars of extreme population II".
- 2.2-m: none.
- 1.52-m: high–resolution spectroscopy: Bues and Loos: "Spectrophotometry of cpm–binaries with at least one white dwarf component". Period 47.
- 1.52-m: Echelec spectrograph: Drechsel, Lorenz, Mayer: "Absolute dimensions of OB-type binaries". Periods 48 and 49.
- 1.54-m Danish telescope: several programmes with spectroscopic/visual binaries on the list, using CORAVEL:
  - ⋆ The Geneva team (Mermilliod, Mayor, Duquennoy): 2 programmes, periods 46 to 49: "Constraints on stellar formation derived from orbital elements of cluster binaries", and "Stellar duplicity of very low mass stars".
  - ⋆ The Ardeberg and Lindgren team: 2 programmes, from period 45 onwards: "Masses and orbital elements for double stars of extreme population II" (cf. 3.6-m telescope), and "Very low–mass companions of stars of the Halo population".
  - ⋆ The Nordström–Andersen team: "Membership, duplicity, age, and isochrone fitting for open clusters" (periods 45, 47 and 49).
  - ⋆ Tagliaferri *et al.*: "Coravel studies of cool stars serendipitously discovered by EXOSAT". Period 48.
- 1.54-m Danish, photometry:
  - ⋆ Oblak *et al.*: cf. 90-cm Dutch. Periods 47/48, also key programme (discussed in section 3): "CCD photometry of close visual double stars".
  - ⋆ Sinachopoulos: "CCD photometry for the interpretation of the main sequence". Period 45.
- 1.54-m Danish, direct imaging: Gry and Maucherat: "Search for other companions to Sirius (possible brown dwarfs?)".

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- 1.4-m CAT (Coudé Auxiliary Telescope), with CES: none.
- 1-m, with I.R. photometer: Stecklum and Henning: "Lunar occultation measurements of young stellar objects". Period 48.
- 90-cm Dutch: CCD photometry:
  - ⋆ Oblak *et al.*: cf. 1.5-m Danish. Period 48, prior to key programme.
  - ⋆ Van Dessel and Sinachopoulos: "CCD photometry for the interpretation of the main sequence" (twice asked for).
- 50-cm Danish, photometry uvby:
  - ⋆ Ardeberg and Lindgren: cf. 3.6-m, 1.54-m Danish ; on the 50-cm: approximately 155 nights so far obtained.
  - ⋆ Sinachopoulos: "Photometry of wide pairs". Periods 46 and 47.
  - ⋆ Lampens: "Search for pulsating visual double stars". Period 45.
  - ⋆ Sinachopoulos: "Wide visual double star formation: an attempt to understand stellar formation mechanisms". Period 48.
- 50-cm ESO, single channel photometer: Drechsel, Lorenz, Mayer: cf. 1.52-m.
- 50-cm ESO, uvby: Sinachopoulos: "Photometry of wide visual double stars". Period 45.
- GPO (Grand Prisme Objectif) 39-cm: Scardia: "Micrometric measurements of visual double stars", twice asked for.

3. SCIENTIFIC TOPICS

The separation of the proposals into scientific categories may not be entirely obvious, but this is the way I would classify them:

(i) Fundamental data:

⋆ Two "key programmes" (cf. section 4.1): "Radial velocity survey of late type HIPPARCOS stars" (Mayor, Duquennoy, Burki, Grenon, Imbert, Maurice, Prvot, Andersen, Nordström, Lindgren, Turon) (cf. Mayor *et al.* 1989)

and

"CCD and conventional photometry of components of visual binaries" (Oblak, Argue, Brosche, Cuypers, Dommanget, Duquennoy, Froeschle, Grenon, Halbwachs, Jasniewicz, Lampens, Mermilliod, Mignard, Sinachopoulos, Seggewiss, van Dessel) — cf. poster paper, this Conference.

Both programmes aim at having a complete as possible set of data about as many as possible visual double stars.

⋆ Identifying double stars: see section 2, the Ardeberg and Lindgren programme. I quote: "From our surveys of Population II stars with the CORAVEL, we have selected a high number of stars which have high

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space velocities and clear indications of radial–velocity variability." For the objects identified and reliable orbits acquired, periods cover 2.8 to 3000 days.

- ⋆ Removing double stars: see section 2, the Nordström and Andersen programme. I quote: "Colour–magnitude diagrams of open clusters are a powerful tool for testing stellar evolution models. (...) The detailed shape of the turnoff is then an important diagnostic of such model features as convective overshooting, provided that non-members and spectroscopic binaries are removed." And: "The precise interpretation of the turnoff shape depends on a few stars which now deviate from the cluster mean velocity". But it is to be expected that the data on binaries will be exploited as well.
- ⋆ Measuring relative positions, with the aim to determine orbits: see Scardia (1990).

(ii) Photometric studies

- ⋆ The Oblak *et al.* key programme has been referred to in section 3 (i).
- ⋆ In the same vein: the programmes of Sinachopoulos and van Dessel and Sinachopoulos: cf. the poster papers for the present Colloquium.

All these programmes, as well as Lampens and Dommanget's programme about pulsating visual double stars, have their origin largely in the constitution of the CCDM catalogue and the connection with the HIPPARCOS mission. All details can be found in the paper by Dommanget & Lampens, this Colloquium.

(iii) Search for low–mass companions

These are to come mainly from speckle interferometry and CORAVEL measurements. Argumentation to look for those objects ought to be unnessecary, but I can quote from a few proposals (cf. section 2):

- ⋆ Leinert and Haas: "...found one hitherto unknown companion, ... proposed survey is all M-dwarfs nearer than 5pc ...".
- ⋆ Perrier *et al.*: Three questions addressed: "The binary rate for the red end of the Hertzsprung–Russell diagram (...), correct derivation of the mass–luminosity relationship for masses between 0.08 to 0.5 solar mass (...), the observational evidence of this class of objects is still controversial", in other words: confirmation needed.
- ⋆ Neri *et al.*: "... refine the empirically determined mass–luminosity relationships. Further observations of previously examined objects (spectroscopy and micrometer objects) are quite often not consistent with new ones(..)." Cf. Barnstedt *et al.* for the instrument.
- ⋆ Mariotti *et al.*: "...a few candidates have been put forward, but none of these objects have been yet confirmed as being actually sub-stellar. This is of course because, as shown by recent models of evolutionary scenarios for extreme red dwarfs and BDs, it is exceedingly difficult to identify such an object on the basis of photometric observations only." (...) The near infrared domain (e.g., 2.2 micrometers) is well adapted to the detection of these objects (...). At this wavelength, the 3.6-m has a diffraction limit

of O″.13 (...). These performances cannot be reached neither by seeing–limited imaging (limited in resolution), nor by speckle–interferometry (limited in contrast)."

- ⋆ Coravel: Lindgren/Ardeberg: "... Detection and monitoring of low–mass objects on the border line between planets and brown dwarfs can be made by accurate radial velocity studies of stars, by highly resolved imaging in the infrared spectral region and by more conventional astrometric position measurements. (...). For old Population II stars our knowledge of the low mass/temperature end of the luminosity function is particularly deficient. (...) From previous work on stars of the halo population with Coravel on La Silla, we have have found a number of promising candidates which show radial–velocity variations of low amplitudes. These stars are Pop.II subdwarfs of spectral types G to K".

(iv) Binary Star formation

- ⋆ Coravel, Geneva team: "The observed distribution of the mass function in open clusters with ages of about 5×10^8 to 10^9 allows a direct determination of the mass ratio distribution f(M2/M1) for primaries with mass in the range of 2 to 3 Solar masses. This function is one of the most important constraints on the various scenarios of star formation". (...) "investigate the role of fission and fragmentation which is still poorly known" (...).
- ⋆ Reipurth and Zinnecker: cf. paper in this Conference. "(...) obtain BVRI colours for the components of 25 pre-main–sequence binaries, (...). These binaries have projected separations of order 1–2″ and have been discovered in our previous NTT survey."
- ⋆ Sinachopoulos: common origin binaries. "neighbouring stars, lying in the gap between visual binaries and open cluster members". See also: this Conference.
- ⋆ Lunar occultation proposal: "Submillimetre observations of young stellar objects clearly indicate the presence of circumstellar disk–like structures around these objects. Millimetre interferometry and speckle interferometry in the near I.R. give linear dimensions of the order of 100 to 1000 A.U.(...) Lunar occultations permit a one–dimensional angular resolution down to about 5 milliarcseconds, revealing structures less than 10 A.U. at a distance at 2 kpc where most of our target objects are located".

(v) Miscellaneous

This heading may look a bit vague, but it simply means that some programmes are not easily put into a category, or that they are tangent to visual double star research, but may furnish data about them as a byproduct.

- ⋆ CPM binaries with a white dwarf component: "14 common proper motion stars with a degenarate component shall be investigated with spectroscopic observation and model atmosphere technique. (...) The main aim of our research is to quantify the importance of abundance changes in wide degenerate binary systems compared to single white dwarfs with Hydrogen dominated atmospheres".

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- ⋆ Triple stars: "there is a lack of systematic astrometric, photometric and spectroscopic observations with the accuracy needed".
- ⋆ Dimensions of OB binaries: complementary to visual/speckle binary resarch.
- ⋆ Serendipitous discoveries by Exosat: "investigate the binarity among the sample".
- ⋆ Photometric calibrators (90-cm Dutch): in relation with HIPPARCOS and Tycho.

4. COMMENTS AND CONCLUSIONS

4.1. General

ESO asks applicants to indicate to what category their request belongs: the classification is: (1.) Galaxies, clusters of galaxies; (2.) Quasars, Seyferts, radio galaxies; (3.) Magellanic Clouds; (4.) Interstellar matter; (5.) Star clusters, galactic structure; (6.) X-ray sources; (7.) Stars; (8.) Solar system; (9.) Miscellaneous.

Proposals about visual or nearly visual double stars are of course to be found in categories 5, 6 (marginally) and 7. Category 5 gets (from all various interests) typically some 30 requests, category 6 some 15–20, and category 7 some 110 to 120.

My own comment is that, if you look at the number of proposals related to visual binary research (see section 2), that number is rather small. On the other hand, some of them require quite a large number of nights per season as well as on a longer time scale.

I should also comment on the creation of "key programmes". These have been introduced in 1988 (Van der Laan 1988) in order to be able to guarantee that certain programmes will not be interrupted. Originally mostly programmes on the biggest instruments were considered, because of the competition for the occupation of them, but the key programme status has later been recognized for "smaller" instruments programmes as well. Two examples have been mentioned in section 3.

4.2. Specific remarks

Please appreciate that these are my own personal remarks.

(i) About the number of requests: see above (4.1). The OPC has undoubtably shown to be sympathetic to the kind of projects of interest to this meeting.

(ii) I was not surprised to encounter no applications for the 2.2-m telescope, given the specific capabilities of the instrumentation. I was surprised, though, to see there were no proposals for the CAT/CES (Coudé Echelle Spectrograph — I almost said Coudé Excellent Spectrograph during my oral presentation): it is indeed an excellent tool for spectrographic work on visual binaries, where line component separations can be quite small.

(iii) My feeling is that micrometer measurements, although an "ancient" method, are still useful, because they cover a range that remains difficult for other techniques.

(iv) Our kind of research very often has to do with rather bright stars. A resolution about keeping "small" instruments operational and available has therefore been introduced to the members of this meeting.

5. ACKNOWLEDGMENTS

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7. DISCUSSION

STICKLAND: Concerning the small telescopes which are under threat, what is the oversubscription rate?

VAN DESSEL: I have only the figures of the last period with me, they are 1.1 (0.5m Danish) — usually higher, 1.8 (0.5m ESO), 2.2 (GPO) — usually lower. On the average, I would say normally something between 1.5 and 1.8 for the 0.5m telescopes

POVEDA: I do not understand why there are no applications for observing time at the 2m telescope.

VAN DESSEL: The applicants know that these proposals are discouraged. People are advised to apply at the 1.5m Danish instead. The pressure factor on the 2.2m is the highest of all instruments and more ambitious programs get the preference.

ABT: As you may know, we faced a similar threat at Kitt Peak about 10–12 years ago to close the small telescopes. So I made a study of the published papers and citations to those papers for each Kitt Peak telescope compared with original and maintenance costs. It showed that the small telescopes produced more papers and citations per dollar than the large telescopes and that stopped further talk about closing small telescopes. Of course that does not address the question of the importance of the research, which involves a subjective evaluation.

VAN DESSEL: I cannot agree more. Another example at ESO is the long-term program on variable stars, also on the the small telescopes, which has produced numerous papers.