NOT NEWS

No. 4 *** July 1991

Nordic Optical Telescope Scientific Association

Wide Field Imaging with the NOT

Deep CCD photometry of large, nearby galaxies

A sample of interesting nearby spiral galaxies has been studied with the new Stockholm focal reducer and the CCD camera. The picture of NGC 4565 attached is a typical mosaic of three V band 15 minutes exposures covering a total of 15 arc minutes on the sky. This way, fields large enough to cover also „blank" sky can be obtained. More than ten images with the focal reducer are required.

Details on page 32

Active Optics

Nordic astronomers are rather satisfied with the present image quality of the NOT. In the future, they may well be even more satisfied. The STC has decided to support the installation on the NOT of an active optics system. After installation of this system, the telescope should approach diffraction limited performance in the visible. Work on the project is in full progress.

Report on page 21.

Today's menu

HP Work Station

Niklas Holsti and Hannu Karttunen

The HP work station is ready for use by staff as well as by visiting observers. So far, it has mostly been used by members of staff. One problem affecting the HP work station has been the fact that due to heavy work with the control system, the development of the higher-level environment of the HP system has, necessarily, had to be assigned a relatively low priority. We hope that the situation will improve in the future.

The disk capacity has been doubled to 1 Gigabyte. An HP Laserjet II laser printer is available for monochrome output. As to magnetic tapes, we can only handle 1600 bpi density. An EXAbyte or an equivalent unit is foreseen. See special article on this issue.

The HP runs under Unix (HP-UX) and has compilers for C, Fortran, and Pascal. There is MIDAS for astronomical data analysis. It runs acceptably well using X Windows and the colour display. At the same time, not all of its parts are functioning ideally. To enlarge the selection of software, it may be of interest to ponder on acquiring also IRAF and/or IDL, which may be easier to install and maintain than MIDAS. For those writing their own programs, the Nag sub-routine library will soon be available.

Editorial

Whether we like it or not, there are a number of signs pointing to the fact that our project is approaching a new phase. Infancy is giving way to adolescence, baby hiccups to pimples.

A definite sign of project ageing is the turn experienced by the discussion of auxiliary instrumentation. Until recently, the great problem was the shortage of such instruments. Today, we are increasingly being cautioned concerning a park of auxiliary instruments too large to be maintained by our small operation staff.

Small may not necessarily always be beautiful but large may often be synonymous to difficult. Thus, the caution is adequate. But how are we to arrive at a good compromise? Experience tends to indicate that a majority of astronomers can be convinced that acquisition of new instruments has to be accompanied by elimination of some older counterparts. This should, however, naturally and evidently, not concern my own favourite instrument, so absolutely necessary for my beautiful project. Individual priorities may have to be sacrificed but mine are absolute.

Another sign of project growth and, at the same time, of the pressure for observing time, is the way the community treats the observing time allocation committee. The happy feeling that things are moving, develop into critical views on how movements are organized. Watching eyes are invaluable but so are people prepared to take on tasks not always rendering complete popularity. Some reflections on this subject are included in this issue.

Naturally, we count as a further sign of a certain maturity of our project the fact that NORDITA has celebrated an international Workshop on Astrophysics with the Nordic Optical Telescope. A large number of prominent international specialists participated and smashing papers dealt with a variety of leading developments concerning telescopes, instrumentation, data reduction and science. Overcoming our modesty, we note the many kind comments on our telescope.

The Nordic Optical Telescope (NOT) Scientific Association was founded in 1984 to construct and operate a Nordic telescope for observations at optical and infrared wavelengths. Associates are Statens naturvidenskabelige Forskningsråd, Denmark, Suomen Akatemia, Finland, Norges almenvitenskaplige forskningsråd, Norway, and Naturvetenskapliga forskningsrådet, Sweden. Executive bodies are the Council and the Directorate. Advice and assistance is provided by an Observing Programmes Committee and Scientific-Technical Committee.

The Nordic Optical Telescope is a 2.56 m telescope with altazimuth mounting and Cassegrain focus. The primary mirror has a focal ratio of f/2.0, the combined optical system a corresponding focal ratio of f/11.0. The telescope is installed at Cruz del Fraile, Observatorio del Roque de los Muchachos, La Palma, Islas Canarias. Geographical longitude is 17° 52' 59.7'' West, geographical latitude 28° 45' 20.5'' North, and altitude 2382 metres above sea level.

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Interferometric Wavefront Sensor for the NOT

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Introduction

A wavefront sensing system for the NOT has been developed and it was tested in the telescope at the end of March 1991. The purpose of it is to enable correct alignment of the optics so that the optimal imaging quality can be achieved. It also gives the necessary information of the low frequency aberrations of the optics, which can then be corrected by regulating the primary mirror support forces.

Principles

The wavefront sensor is based on the interferometric modification of the Hartmann optical testing method. This modified test has been developed at the optical laboratory of Turku University Observatory in Tuorla, and it has been used for optical testing during manufacture of optics. Most telescope wavefront sensors are based on the Hartmann-Shack modification, where the Hartmann screen has been replaced with a microlens array. This reduces the detected spot size and improves the light efficiency. In the interferometric modification, a Hartmann screen is used, but the measurement is based on the detection of the interference spots produced by adjacent holes of the screen.

With the interferometric modification, the spot size, as determined by the diffraction, is about 2.5 times smaller than with the Shack modification. It is assumed that the number of the sampling points is equal and that the microlenses are optically perfect. With both methods, the wavefront is computed from the measurement of the spot positions, and this can be done more accurately if the spot size is smaller.

Design and fabrication

The wavefront sensor attached to the NOT adapter is seen in Figure 1. It is opposite to the stand-by CCD camera and the stellar light is reflected to it with a 45 degree flat mirror. The mechanical design of the instrument was made by Niels Christian Jessen from the Nordic Telescope Group. The main mechanical parts were made by Per Nordahl at the mechanical workshop of the Institute of Theoretical Astrophysics in Oslo. The optical design, the main optical components, the integration of the instrument and the analyzing software were made by the authors at Tuorla.

Detector and Hartmann screen

The detector of the instrument is a thermoelectrically cooled Cryocam Model 80D CCD, having 512x480 pixels of 15 micron size. An AT PC is used for the system control and for the reductions. The Hartmann screen included in the instrument has in total 792 holes. The interference spots produced are less than 1 arc sec in diameter (FWHM). The device includes a pinhole point light source for calibrating the wavefront errors produced by the instrument itself.

Software

The reduction software was originally developed for optical testing during manufacturing of optics at Tuorla laboratory. It comprises a least squares fit with Zernike polynomials corresponding to wavefront aberrations of decentering coma, spherical aberration, astigmatism, triangular coma and quadratic astigmatism.

Tests of the NOT

Three nights from 22 March to 25 March were allocated for optical tests of the NOT, but only two of them were useful. During the first night, tests were made at different zenith distances to get an impression of the functioning of the support system of the primary mirror and of the stability of the alignment of the mirrors. During the second night, the alignment of the mirrors was corrected to reduce the decentering coma and a number of measurements were made for a more detailed analysis.

Performance

This was the first time that the wavefront sensor system was used for testing telescope optics in observatory conditions, but it functioned without problems from the beginning. It turned out that the measuring accuracy was more than two times better than in the laboratory tests of the NOT primary. In those tests, photographic detection was used. Now, the average mean error of the telescope wavefront measurements was typically 10 nm, which corresponds to 5 nm on the mirror surface. A typical integration time was 60 sec. The measuring accuracy with the calibration light source was even two times

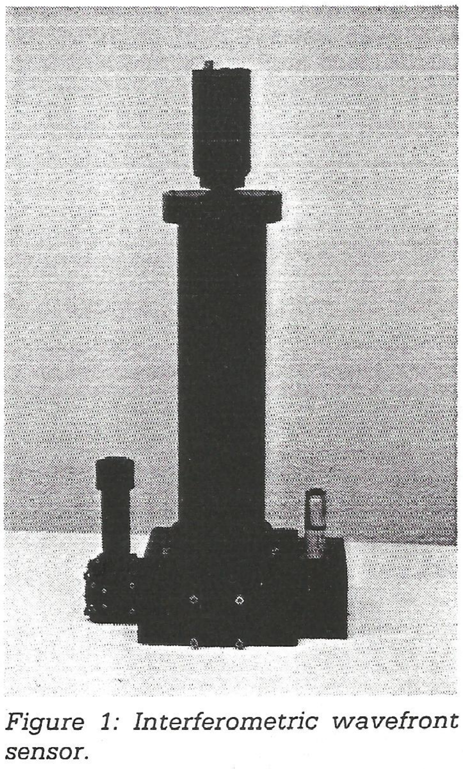


Figure 1: Interferometric wavefront sensor.

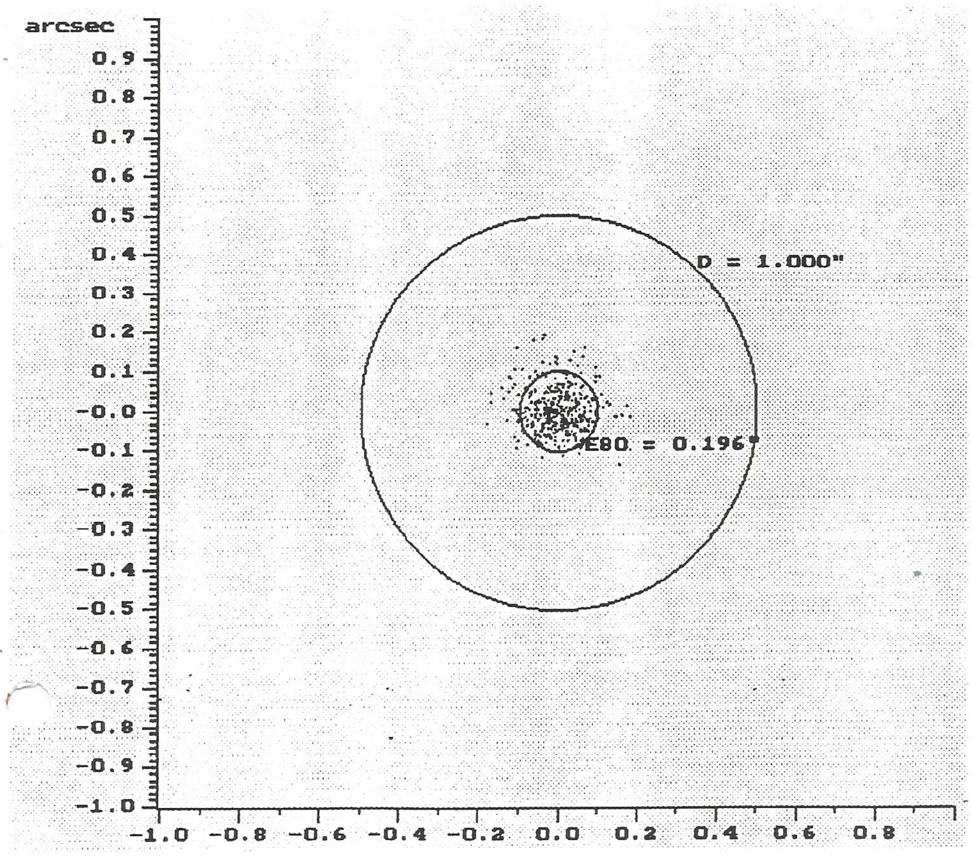


Figure 2: Geometrical optics spot diagram. 80% of the light is within a circle 0.196 arc sec in diameter.

better. It corresponds to the measuring accuracy obtainable in laboratory conditions, because it is not disturbed by the turbulence of the atmosphere.

Results for the NOT

The original specification for the image quality of the NOT is to have 80% of the light within a circle 0.4 arc sec in diameter. The tests show that this has been met. After correction of the decentering coma, the average image diameter is 0.35 arc sec. Due to the variability of the optical aberrations, mainly spherical aberration and astigmatism, the 80% image diameter varies between 0.30 and 0.42 arc sec.

Discussion of results

The primary mirror of the NOT is in fact a very thin mirror. Its average diameter-to-thickness ratio is 16.8, even larger than that of the primary of the NTT of ESO. Its actual surface shape is completely dependent on the functioning of the support system.

The tests indicated that the optical aberrations are usually largest at large zenith distances. In addition, the spherical aberration showed strange behavior. At the beginning of the second night, the wavefront spherical aberration was about 850 nm, but it decreased continuously to -40 nm during the night. Because the zenith distance didn't change much during these tests, the reason cannot be in the mirror support system. Probably it has a thermal origin.

The primary mirror was sliced from an original blank almost 0.5 m thick. It may have some asymmetric internal variation of the coefficient of thermal expansion, which causes the variability of the spherical aberration. During that night, the temperature of the mirror was dropping all the time, which supports the theory. During manufacture, the primary and secondary mirrors were tested together with the pentaprism test, which assures that the system is free of spherical aberration. In any case, the largest measured spherical aberration is about five times smaller than that of the Hubble Space Telescope.

Mirror support system

The intrinsic optical quality of the optics is obtained by correcting all those low frequency aberrations, which can be corrected by adjusting the mirror support forces. What remain, are the high frequency errors originating mainly from the figuring errors of the mirrors. A computational correction of the aberrations mentioned was made and an average wavefront was computed by using data of all tests. The rms wavefront error is 40 nm, which corresponds to a 20 nm error on the mirror surface. Figure 2 shows the corresponding spot diagram. It has 80% of the light within a circle 0.196 arc sec in diameter. This image quality can be

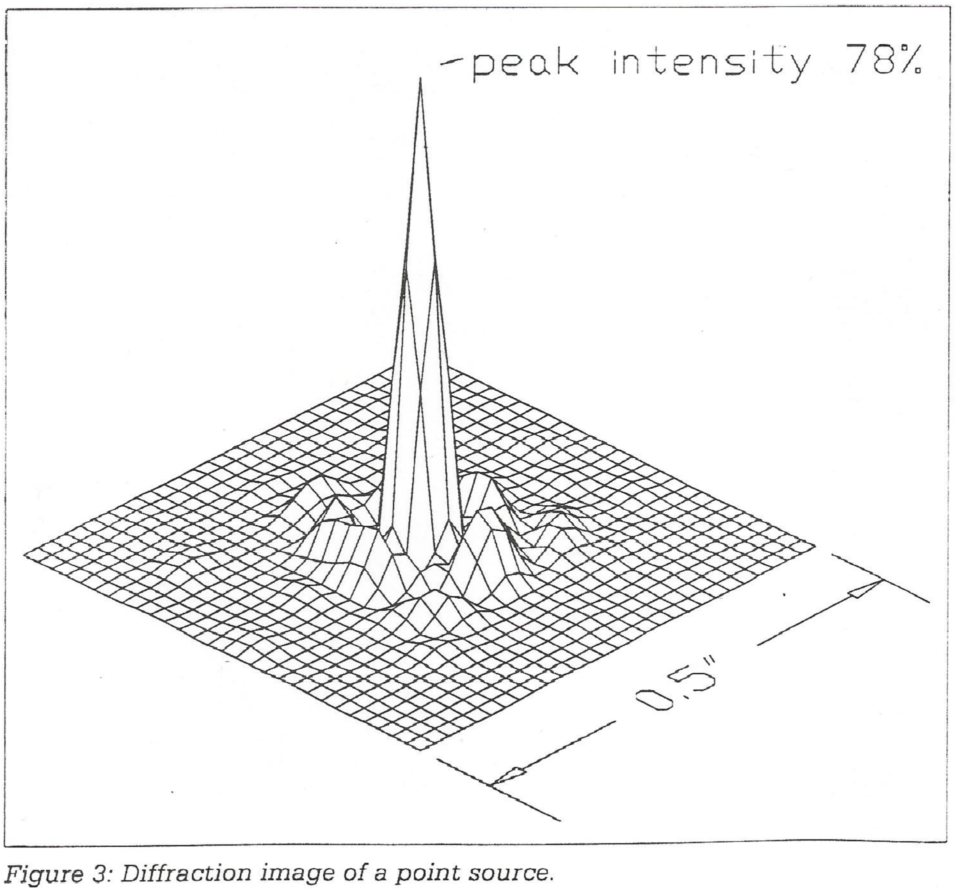


Figure 3: Diffraction image of a point source.

achieved if the support forces of the primary mirror are optimized.

The diffraction image was computed from measured wavefront errors and is shown in Figure 3. The Strehl ratio of the diffraction image is 0.78, e.g. the central peak is 78% of that of perfect optics. Thus, the image quality is in practice diffraction limited.

Active optics system
The wavefront sensing system of the NOT can be used to maintain the alignment of the mirrors so that the specified image quality can always be maintained when the seeing is sufficiently good. To obtain the best possible image sharpness, it is necessary to regulate individually the air pressure in the supporting bellows. If such an active optics system is implemented, it is possible to reduce the image size to a value two times smaller than the specification. This should guarantee that even during the best seeing conditions, the imaging sharpness is not limited by the optical quality of the telescope.

Multi-Object Spectroscopy with the NOT

Commissioning of a fibre-optical link for multi-object spectroscopy

Bertil Pettersson

Multi Fibre Link 1
During July 1991 a new common user instrument will be commissioned on the NOT, the Multi Fibre Link 1 (MFL1). It is an instrument intended for simultaneous observing of up to 55 different objects over the complete 25 arc minute diameter field-of-view of the NOT. The instrument is in principle very simple, its main parts being (i) a fibre bundle consisting of 55 individual fused silica fibres with a 200 micron core, (ii) an aperture plate holder that accepts an aperture plate with pre-drilled holes to correctly position individual fibre ends in the focal plane and (iii) an interface box that couples the aperture plate holder to the NOT Cassegrain focus.

The Fibre Bundle
The fibres selected for this version of MFL1 are Polymicro FHA 200/240/500 micron fused silica fibres. The reasons for this choice were mainly the good UV transmission of this brand of fibre and its documented good focal ratio degradation (FRD) properties. FRD is a measure of how well the fibre will preserve the entering f-number of a beam of light. Tests with the current fibre showed that the NOT f/11 beam would exit the fibre at about f/8-f/9, which is above average for most fibres.

The individual fibre ends, that will go into the aperture plate, are epoxied into thin stainless steel tubes and polished to a flatness of better than 0.3 microns. The outer diameter of the terminations is 0.8 mm and they can be placed at a distance of approximately 3 mm in the focal plane, corresponding to a minimum separation of 20 arc seconds on the sky. Each fibre core subtends a 1.5 arc second diameter circular aperture on the sky.

At the opposite end of the fibre bundle, the fibres are collected in a slit assembly where they are lined up and epoxied to form a slit, 45 mm high and 0.2 mm wide. This slit assembly will then feed a spectrograph that preferably can be placed on the floor or on an optical bench. The length of the bundle is 5 metres.

Guiding bundle
For the dual purpose of properly aligning the aperture plate with the sky and to provide guiding, a dedi-

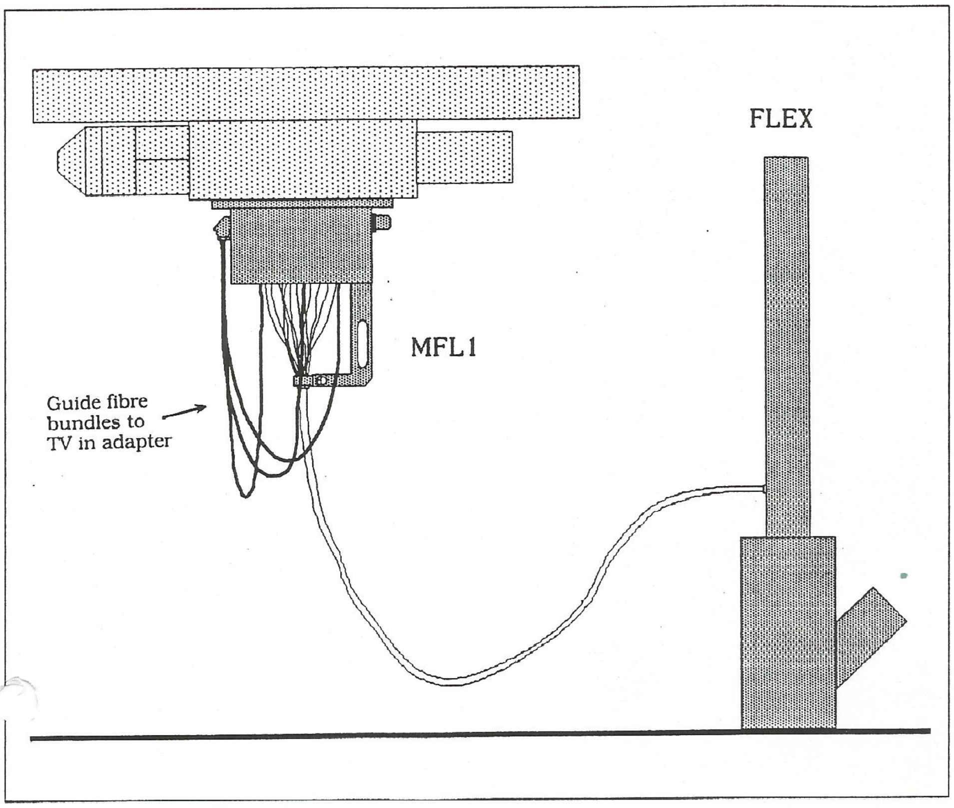


Figure 1: A sketch of the Multi fibre link, MFL1, mounted on the NOT and connected to FLEX, a low to intermediate resolution spectrograph. The handle protruding down from the right hand side of the interface box is attached to an aperture plate holder that slides into the box. The individual fibres of the fibre link are inserted into the aperture plate in the focal plane of the telescope and are gathered in a protective jacket and fed to the spectrograph. Note the three guide fibres leading to the left hand side of the instrument box where they are imaged onto the internal TV camera in the NOT adapter.

cated guiding bundle will be available. This bundle is composed of three separate bundles, one for each of three selected alignment/guiding stars. Each bundle is in turn made up of several single fibres of different diameters to allow good centering of the star images, see Figure 2. The guide bundles are collected and terminated in a face plate imaged onto the internal ICCD TV camera in the NOT adapter house. This will hopefully also allow the use of the NOT autoguider.

The Aperture Plate

The aperture plate is a 25 cm by 25 cm, 8 mm thick aluminium plate that accepts the individual fibre ends. Its main purpose is to accurately position the fibre ends in the strongly curved Cassegrain focal plane of the NOT. To allow for the curvature, a vertical displacement relative to the on-axis focus is computed for every position and a stop is drilled at the same position as the fibre hole. As the size of the fibre end is only 1.5 arc seconds, the position of the objects to observe must be known to a high precision, preferably better than 0.5 arc seconds. A special computer program exists that will transform the (α, δ) of an object to the (x,y,z) system of the aperture plate, taking into account effects caused by temperature changes, differential refraction, different epochs, etc.. A separate aperture plate is needed for every field to be observed. These have to be fabricated using a numerically controlled milling machine to provide the required precision.

The Interface Box

The interface box is a 37 cm by 37 cm by 20 cm box that couples the aperture plate to the instrument flange of the NOT. It also contains the optics for imaging the faceplate of the guide fibre bundles onto the cathode of the ICCD TV camera in the Cassegrain adapter house.

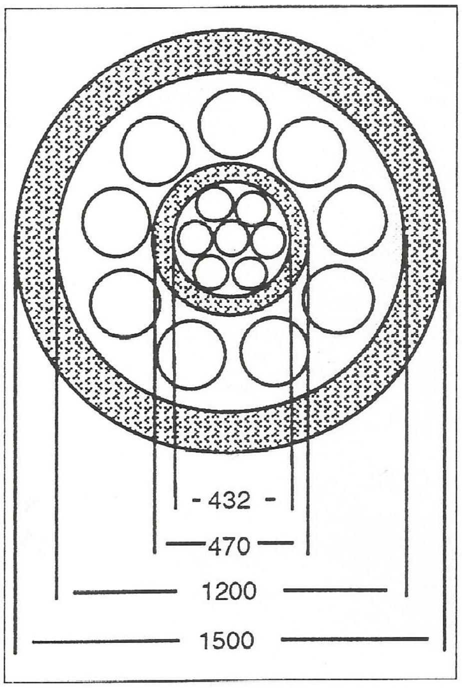


Figure 2: A cross-section of a guide fibre bundle. All measures are in microns. The fibre core diameters in the inner part of the bundle are 100 microns (0.75 arc seconds) and in the outer ring 200 microns (1.5 arc seconds).

FLEX

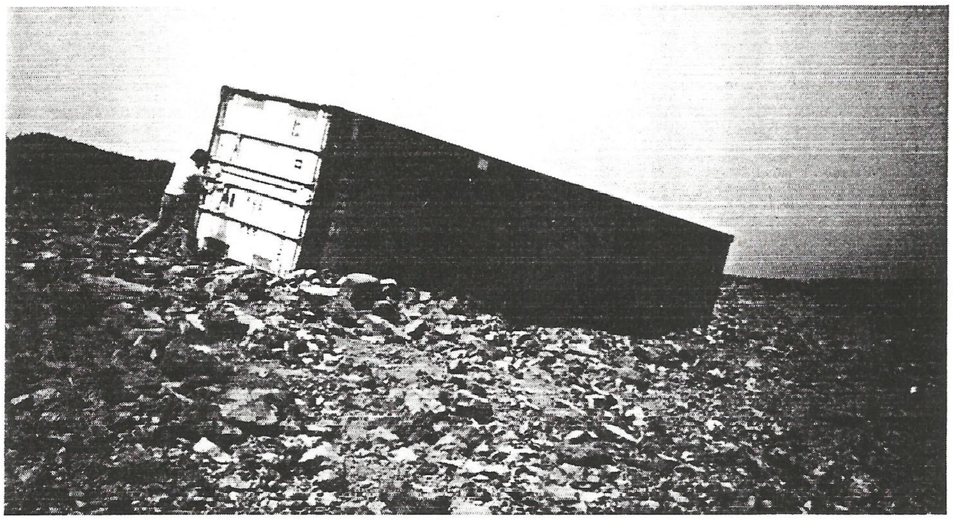
The MFL1 can in principle be used with any spectrograph capable of accepting the slit assembly. During the commissioning, it will be used together with the FLEX, a low to intermediate resolution spectrograph, operated by the IAC.

Although the FLEX is not ideally suited for fibre optics fed spectroscopy, it will serve well as an experimental platform for this time. In the long run it is hoped that a dedicated all refractive spectrograph will be available.

An Astromed CCD will be used as a detector. The chip is a 770x1152x22.5 micron UV coated device. The big chip is needed to accommodate all 55 spectra. The CCD camera does not belong to the FLEX and may be used together with other instruments if needed.

The commissioning of MFL1 will begin in late July and in a forthcoming NOT News contribution I hope to be able to give a more detailed description of the performance of the instrument and some guidelines as an aid for writing future proposals.

Technical Activities at the Telescope Group



Fine-tuning at La Palma

The Nordic Telescope Group at Risø is presently working hectically on various projects related to the Nordic Optical Telescope on La Palma.

In June, when this issue of NOT NEWS is in the press, it is planned to aluminize the primary mirror of the telescope and to install part of the active optics system. The rest of this system will be installed during the fall and will hopefully be operating before the end of the year.

It is foreseen to install the new filter mechanism, described in the last issue of NOT NEWS, in the end of July. At the same time, the cooling system will be upgraded. A backup for one of the cold water generators will be installed. This will increase the reliability of the cooling system and reduce the risk of a longer down-time of the telescope due to failure in one of the cold water generators. Also, extra cooling capacity will be added in the observing room around the telescope. Furthermore, the rotating joint which transmits cooling water from the moving telescope and building to ground, will be exchanged with a more servicable type. Presently, the new unit is being manuactured in Norway. Finally, the outside heat exchanger near the service building will be boosted to account for the higher heat flux.

Also, work is done to improve the blind tracking of the telescope. This involves minor adjustments of the newly installed incremental friction-wheel coupled Heidenhain encoders and installation of a better clock. It will be a clock connected to the GPS satellite system. Also, a unified measurement standard for quality of tracking will be defined.

Furthermore, in the near future, the focusing motor will be exchanged for a new unit of a more modern type. Another point is sealing of the dome which will be done from the outside.

Finally, there are plans to increase the dome slewing speed from 2.5 to 4 degrees per second.

Further, an important project is installation of an active cooling system for the adapter electronics. Presently, the heat dissipation of the electronics in the adapter is conveyed to surrounding air, certainly not an optimal feature. At the same time, a day-time cooling facility for the primary mirror will be installed. In connection with these installations, it is foreseen to add an additional cable wrap to take cables down from the telescope tube to the observing floor.

It is also planned to install an instrument handling system. The basic philosophy is that each of the ancillary instruments should have its own box with a support and handling structure. Also, the instruments should have their own dedicated parking places at the periphery of the observing floor.

Considering that the Nordic group also will be active on other projects, such as the LEST, the Velux Spectrograph and some ESO activities, there is no doubt that the coming time will be a busy one for the group.

Soft and Strong

Despair was in the air. Niklas Holsti was on his way back to Finland. Even with a cosmic outlook, it did not seem realistic to hope for a replacement filling the space left empty. Most luckily, we were all mistaken. We did it again. We had a new bingo in software. Thanks to the Finnish Academy, to Niklas and, of course, to Hannu Karttunen, we can breath freely again, looking forward to new soft miracles.

Since the middle of April this year, Hannu Karttunen is our new soft Strongman at Cruz del Fraile. Hannu has it all. His basic education is in mathematics and computer science. He has an impressive record as a teacher at the computer science department in Helsinki. Here, he steered his students through their studies with a hand firm yet exceedingly helpful.

Some people have stamp collection as a hobby, some belly dancing. Hannu opted for something with a larger perspective. He chose to study astronomy in his free time. And he did it rather thoroughly, ending up with a Ph.D. in astronomy.

Before we managed to convince him to come to our telescope, Hannu worked as a publishing and training manager at the Finnish Super Computer Centre. Again, the firm and helpful hand was Hannu's signature.

Hannu Karttunen is not only a celebrated software scientist and astronomer. He is also a true field worker. He feels fine at La Palma, at higher as well as at lower altitudes. He, as many other people, would be even happier, if local transport arrangements were more in line with optimistic promises.

We are most happy to see Hannu Karttunen on La Palma. We hope that he will receive his belongings soon enough to be able to recognize them.

Scintillation at La Palma

Observations of defocused bright double stars

Hans Kjeldsen

Scintillation errors

Scintillation is an effect caused by atmospheric turbulence. The nature of scintillation, the main source of photometric error for observations of bright stars, has rarely been studied photometrically. Still, our main source of knowledge about scintillation is the article by Andrew T. Young in Astronomical Journal 1967 (AJ 72, 747). This is an indication of the limited interest which the phenomenon has received. According to Young, the amplitude of scintillation noise is nearly independent on wavelength, and proportional to the -2/3 power of telescope aperture and to 3/2 power of air mass. The scintillation amplitude also depends on altitude above sea level h and the exposure time (Δt). It is proportional to exp ($-h/h_0$), where the density scale height (h_0) is 8 km, and proportional to $\Delta t^{-1/2}$.

Theoretical scintillation estimate

I have been observing bright stars with the NOT in order to detect low-amplitude variability of δ-Scuti stars, and I have tested the size of scintillation noise. Adopting the value from Young's article, the theoretical value for scintillation for a 1 min. exposure at zenith is 245 µmag/min.

CCD Observations of defocused double stars

Some double stars have been observed. As an example I describe the results for the double F star HD 132909 / HD 132910.

The observations were done using the Low Dispersion Spectrograph in direct imaging mode (secondary channel, Tektronix 512) through a Strömgren v filter. The integration time was 65 sec/frame and the air mass was about 1.15. After preprocessing, each frame was reduced using specially designed software (photometry on defocused stars) and the internal noise was found to be 315 µmag/frame/star. The photon-counting noise is about 130 µmag/star, flat field photon noise is 30 µmag/star, sky+readout noise is 5 µmag/star, general reduction error is 110 µmag/star and the flat field colour error is at least 60 µmag/star. As a result, the scintillation for a 1 min. exposure at zenith is found to be below 215 µmag/min. This gives the following equation for the scintillation noise at the NOT in magnitudes

$$\sigma_{scint} < 0.00167 \cdot X^{3/2} \cdot \Delta t^{-1/2}$$

where X is the air mass and Δt is the exposure time in sec. The values found by Young is about 15 % higher, so in that sense La Palma seems better than the western part of America. However, we have to remember that there are several so far unanswered questions about scintillation. For instance, is scintillation correlated in small areas ? Is the basic scintillation variable from night to night ?

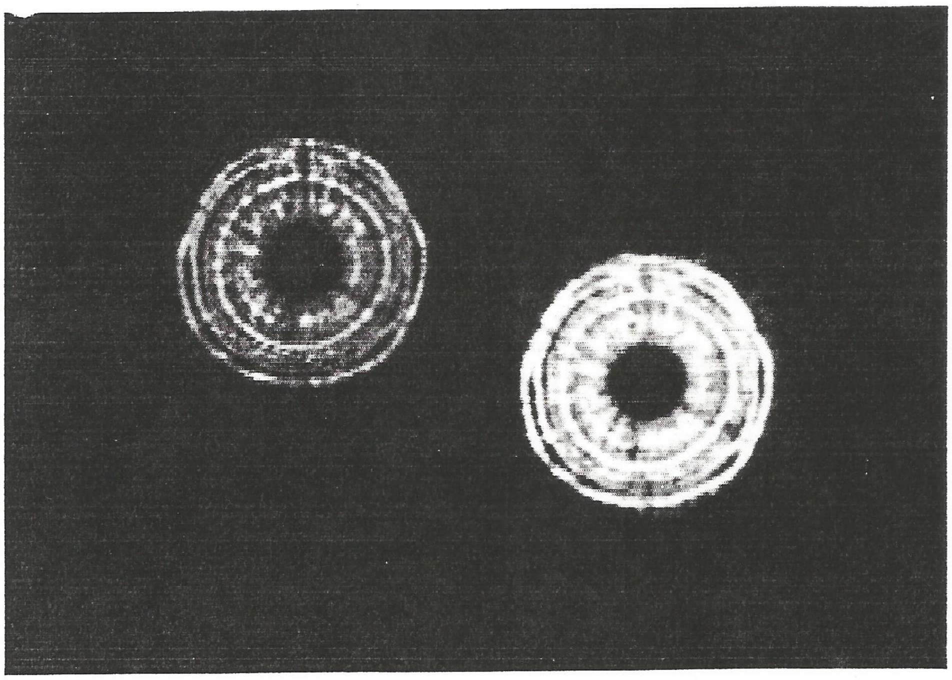


Figure: CCD frame containing HD 132909 and HD 132910 (defocused)

The Student who came in from the Cold

Most people on La Palma seem to find work at the Roque de los Muchachos Observatory in winter time beyond discussion. To Per-Ivar Emanuelsen this must be amazing. Coming from northernmost Norway (close to the Soviet border even), he feels really comfortable only when close to the CCD Dewar.

When Per-Ivar came to La Palma last fall to overlap with Øystein Olsen, he was already quite at home at Cruz del Fraile. Experienced from observing runs as well as from the Nordic Research Course in August 1990, centred around the Nordic Optical Telescope, he had few problems feeling at ease. Except for that pressing heat.

At the time of writing, Per-Ivar has already spent some months with our telescope. Both seem to like it a lot. And so do other staff members and visiting scientists. Per-Ivar, cool and efficient, warmly invites and introduces observers to the telescope, to the CCD camera, to the photopolarimeter, to the low-resolution spectrograph, to computers as well as to a lot of other things. He quickly made himself a most needed person on site. And that need has certainly not decreased.

Per-Ivar has wide scientific and observational interests. One of his favourite topics seems to centre on gravitationally lensed quasars. This project has got him involved in collaboration with several astronomers from the Nordic countries and from elsewhere. We wish Per-Ivar successful observations and cool weather.

The Stockholm Focal Reducer

or How to ruin excellent seeing

Steven Jörsäter

Disaster

Bad news can be good news sometimes. I was quite shocked when Jeff Hester finally told me that it would be impossible for him to bring his focal reducer (which we have used jointly several times) to the NOT for the upcoming observing run in February this year. There were only 6 weeks left to the long awaited scheduled observing time. What could I do ? Observing large galaxies with a 100 arc sec field would not do us much good. After the final week of Christmas celebrations, I went into Göran Olofsson's office and asked him for advice - should I give up the time or should I redefine the project. Build a focal reducer, he said. Impossible, one cannot build an instrument in 4 weeks, I replied, thinking he was joking. But yes, it should be quite straightforward...

Hectic weeks

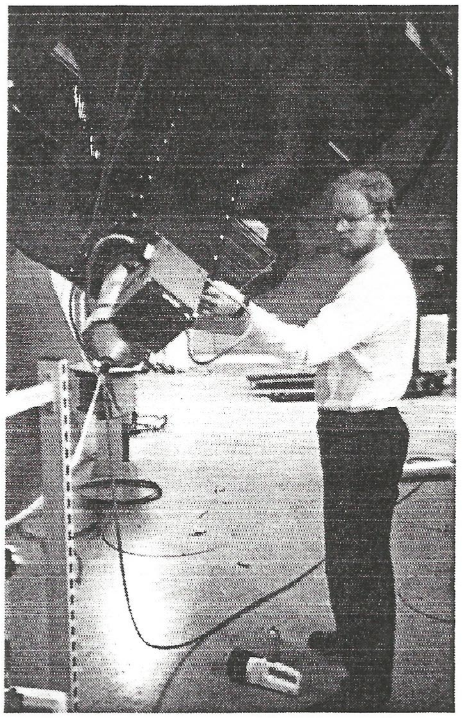
Four weeks later, the focal reducer was finished, ready to be transported in pieces as hand luggage to La Palma. These were hectic weeks when both the mechanical design (done by Göran) and the optical design (done by me) were to be made and we also had to have the instrument actually built.

Optics and filters had to be purchased. The most suitable reimaging optics that could be found on such short notice was a Konica f/2.5 135 mm camera lens that I happened to have in a drawer and which proved to be of excellent quality. The field lens is a standard 70 mm diameter spectacle lens. As for the filters, I already had 3 inch square narrow band ones which were of excellent quality. But what about the broad bands which constituted the bulk of the proposal ? The final solution was Kodak Wratten gelatine filters at a cost of about 60 SEK each. Optically they turned out to have excellent properties, the only remaining problem being that since they had to be used in conjunction with an IR blocker, the transmission was somewhat low (about 30 %).

The Instrument

The table summarizes the properties of the Stockholm Focal Reducer (SFR). The SFR is mounted as a normal instrument and the stand-by CCD camera with its Tektronix 512 x 512 CCD is mounted on it. The SFR can take two kinds of filters. Large 3 inch square filters (round ones are sufficient if you provide a holder) can be mounted in front of the field lens and are thus placed in the f/11 beam of the NOT. The other place where you can mount filters is on the reimaging lens itself (62 mm round with standard camera filter threading). The latter place is only recommended for exceptional cases, since it will probably increase internal reflections and it is awkward to change the filters.

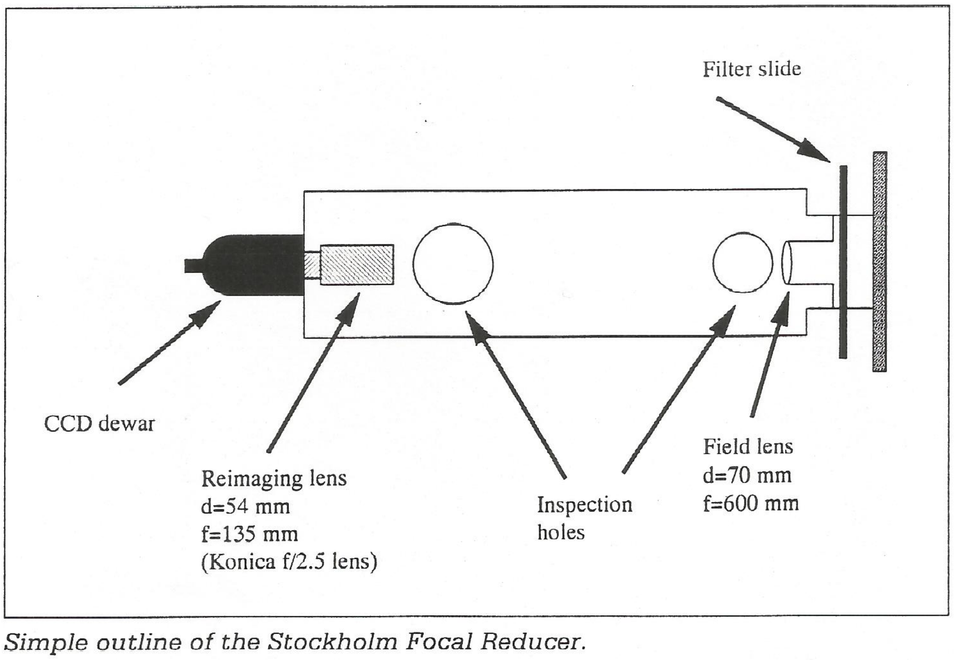
For the first observing round, I used a primitive filter mount for square gelatine filters which was put on top of the camera lens. There are 3 filter slides available and each of them takes 5 filters. The filter slides are operated manually so you will have plenty of opportunities to exercise during the night. We will have permanently mounted broad band interference filters in one of the filter slides and these filters will be the only generally available ones. The SFR is currently in Stockholm but will be offered to the NOT users after mid-August.



The Stockholm Focal Reducer and Steven Jörsäter.

Blurred images

A focal reducer actually produces blurred images. The properties of the SFR are rather good in this sense - the best images we have obtained are smaller than 2 pixels FWHM which is about the smallest images one can use for sampling reasons anyway. The limiting seeing for which the SFR produces negligible additional blurring is thus 1 arc sec FWHM. A focal reducer also produces some geometrical distortion of the field but this is very modest with the SFR.



Simple outline of the Stockholm Focal Reducer.

Some properties of the Stockholm Focal Reducer

Property	Value	Comment
Incoming beam	f/11	
Outgoing beam	f/3.5	
Field of view	5.4'	
Projected pixel size	0.63"	
Maximum resolution	< 2 pixels FWHM	
Geometric distortion	< 1 pixel	Over whole field
Ghost images	Almost non-existent	Filter dependent
Sky counts/min V*)	38 ADU/pix	Gain 10 (No moon)
Useful wavelength	4400A	Low efficiency in B

*) 30 % transmission V

The most important property of a focal reducer which is to be used for photometry of extended objects is that it has a clean PSF without ghost images. The SFR has excellent performance in this sense and ghost images can only be seen on grossly overexposed images of bright stars. The focus variation over the field is also very modest - in fact, we have not been able to measure it.

Observing strategies

The SFR is the right instrument whenever you need a large field of view. You may need it either because your object(s) cover a large field or because you want to have plenty of „blank“ sky around it to be able to estimate the sky accurately.

It may also be that you need to have reference objects in the same field as e.g. astrometric purposes. If the seeing is good, you clearly don't want to use it if the image quality is critical to your application. However, if the seeing is 1 arc sec FWHM or more, you will not loose in resolution.

The images obtained with the SFR look rather different from those obtained directly with the standby camera. As a matter of fact, you will discover that there is no such thing as „blank“ sky - on a deep exposure you will see stars and galaxies everywhere. You will typically have several quite well exposed stars in the field and you will almost certainly saturate on some star in the broadband filters if the exposure is more than a minute long. Remember that you have the double effect of having more stars in the field and that the stars which are there dump their energy into a smaller number of pixels. This frequently leads to stripes of residual images.

If you are trying to do accurate surface photometry and can afford the time, you will normally do best by flat-fielding on the night sky itself. Dawn flats will in most other cases give a satisfying result. Dome flats are not recommended.

As a concluding remark, it should be noted that the SFR is a primitive instrument which will do a decent job in some cases. When we get the real 4096 pixels square Ford Aerospace 2K CCD mosaic Focal Reducer, it will be reduced to a toy, but this will take some time. Until then, have fun...

Aluminization

The optical elements were installed in the Nordic Optical Telescope in the summer of 1988. Since then, much effort has been invested in fine-tuning of the telescope. Thus, it was found appropriate not to aluminize the primary and secondary mirrors during these first three years.

Meanwhile, the mirrors have become rather affected by dust causing the reflectivity to go down. Before aluminization in June, the reflectivity of the primary mirror has been measured and found to be well below 50 % and that of the secondary around 70 %. These values are far too low to be acceptable. However, already long ago, time vas set a side for realuminization.

The aluminization is planned for the technical period in the second part of June. The work should be terminated by the time that this issue of NOT NEWS is on the street.

Aluminization will be done in cooperation between the Nordic Telescope Group and local staff on La Palma with kind and most essential assistance from the British WHT staff. It will be performed in the vacuum tank of the British 4.2 m WHT.

From the Nordic countries a total of 9 persons will go to La Palma for the aluminization. The primary mirror will be lifted down from the telescope and wheels will be mounted under the mirror cell. Cell and mirror will be rolled onto an external elevator, assembled outside the telescope building. The elevator lowers the mirror, places it onto a truck which takes it to the British installations.

While the mirror is out of the telescope, a number of tasks will be performed. New pipes will be installed for the compressed air system used for the pneumatic bellows of the mirror system.

Other equipment for the active optics will be installed on the centre section. A new hatch drive system will be mounted and should go into operation at the same occasion. Also, thermal sensors will be mounted on the lower side of the primary mirror. These are intended for the thermal monitoring system described elsewhere in this issue.

Numerous discussions have taken place concerning the adequacy of washing of the primary mirror at regular intervals between aluminizations. Although everybody seems to agree that such a procedure is attractive, there are some doubts regarding the practicalities of the process. It is essential that the telescope mechanics do not suffer from the cleaning fluid. Also, the risk of damaging the mirror has to be avoided. For these reasons, a final solution to the mirror washing problem is still pending.

Processing NOT Images at the Lund Observatory

Peter Linde

Introduction

In an age when rapidly increasing amounts of digital data is coming out of modern telescopes, image processing is becoming an indispensable tool in order to arrive at relevant astronomical conclusions. At Lund Observatory, this was recognized already. about twelve years ago, when analysis of electronographic and satellite images prompted the purchase of the first image handling system. Successively, a well-suited and user-friendly general software was created, which is still in use today.

Peter Linde

Later, more specialized techniques were developed, usually in close connection to on-going astronomical projects. Today, astronomical image processing has become a speciality of its own. In Lund, close contacts exist with other image processing groups, also outside the field of astronomy.

Philosophy

Image processing can be divided into two categories, qualitative and quantitative analysis. Qualitative techniques produce new images as output products. These images usually are modified in order to suppress irrelevant information (e.g. noise), while relevant information (e.g. object structures) is amplified. Thus, one important function of qualitative processing is to maximize attention.

Quantitative processing deals with precise measurements in images, resulting in a few parameters describing objects, e.g. magnitudes and positions of stars. Although traditional astronomical image processing is mostly quantitative, both categories play important roles. In Lund, attention is being given to both types.

Lund research

Current image processing research in Lund is concentrated to four areas; (1) crowded field photometry, (2) high-precision analysis of IUE and HST satellite images, (3) restoration of high-resolution solar surface images and (4) development of image sharpening techniques.

The Lund method for crowded field photometry was originally developed for electronographic data but has since been adapted to CCD images. User interactivity plays an important role in this method, in order to get reliable results also in very crowded fields.

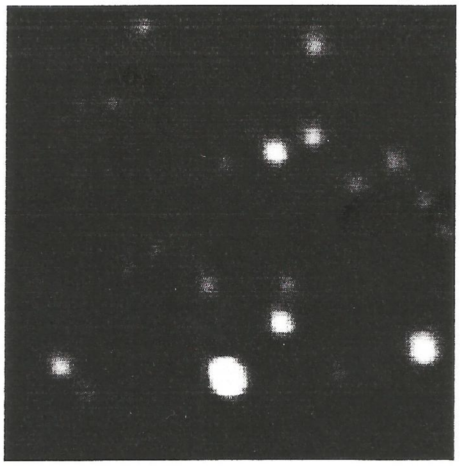


Figure 1a: Part of a CCD image of the cluster C1427-057, with a resolution of 0.7 arcsec. The image has been resampled to increase the number of pixels.

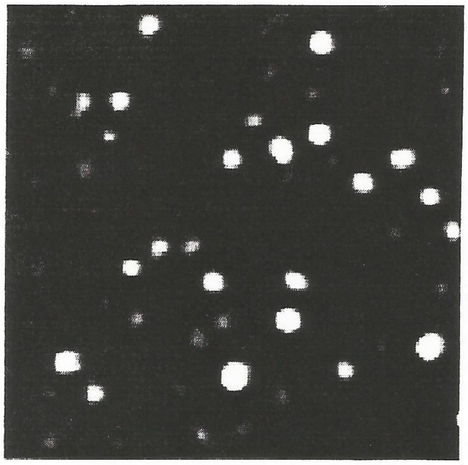
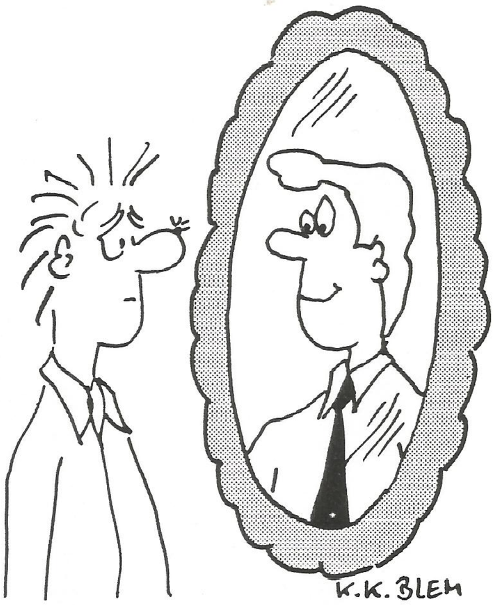


Figure 1b: The same field as in Figure 1a, after 50 iterations of the deconvolution algorithm. The resolution has increased to 0.3 arcsec.



IUE echelle spectroscopical images have been analyzed with a new technique, which improves the signal to noise ratio in the spectral orders. The Lund technique, now adopted by NASA, has prompted a reprocessing of the entire IUE data archive.

Images from the Swedish solar telescope at La Palma are being reconstructed through corrections for image motion induced by atmospheric turbulence. Parameter images describing magnetic and velocity fields are derived from one-dimensional spectral scans.

Image sharpening techniques are studied with the GOP system (see below), where algorithms from modern image processing research are being adapted to astronomical images for the first time.

Lund participates in a Scandinavian group aiming to use the Hubble Space Telescope to study stellar population properties at the centre of the Large Magellanic Cloud. The combined experiences from the above projects will be necessary to successfully overcome the difficult image processing problems currently presented by this instrument.

State-of-the-art equipment

In order to do and develop advanced image analysis, powerful computer equipment is necessary. At Lund

Observatory, two systems are available for image processing.

A Hewlett-Packard 835 RISC computer is used for running the MIDAS software system and for development work. Some of the algorithms described above have been developed and run on this machine. Purchased in 1989, it performs at 14 MIPS and 2.2 MFLOPS. It has 1.8 Gb of disk storage and is shared with other projects.

The GOP system
The GOP system at Lund Observatory is a dedicated processing system with unique capabilities for advanced image processing. This is achieved through a combination of sophisticated software and hardware, allowing for the execution of powerful algorithms in an interactive mode. It contains two specialized processors, a display processor and a convolution processor. Both are controlled by a built-in SUN-3 UNIX-based host computer with 1 Gb of disk storage.

The display processor controls all aspects of image display. It has three different 512x512x20 bit video memories, which are useful for comparative blinking and for movie sequences. Other features are continuous hardware zoom/scroll and true colour image manipulation. All display functions may run independent of other system functions and are controlled via a user-friendly mouse-driven menu system.

The General Operator Processor (GOP) is the other specialized hardware unit. This hardware performs image convolution at super-computer speeds and then feeds the result to a floating point array processor. Since a large family of image processing operations can be expressed as a convolution between a mask (window, kernel) and an image, this unit can be used for very computing-intensive algorithms. This can be illustrated by some examples of simple but demanding operations:

Image size (pixels)	Operation	Kernel size (pixels)	Time (min)
1024 x 1024	median filter	11 x 11	5.2
1024 x 1024	weighted average	15 x 15	0.8
1024 x 1024	weighted average	31 x 31	1.9
2048 x 2048	weighted average	15 x 15	3.0
4096 x 4096	weighted average	15 x 15	12.0

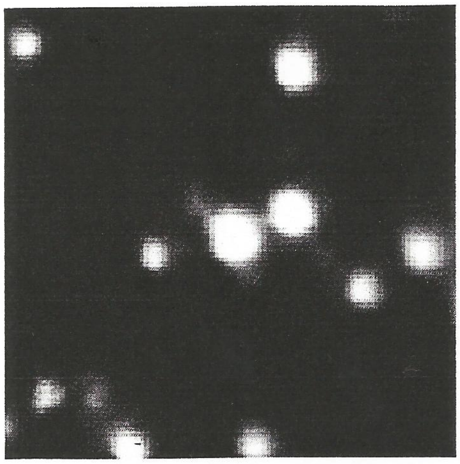


Figure 2a: A subfield selected from the field in Figure 1a. At the center, a group of stars has been selected for decomposition and measurement.

Since the speed of the GOP is due to parallel processing, the gains become larger with more complex operations involving larger kernels. A convolution on an image using a small 3 x 3 pixel kernel is performed only marginally faster than by the HP 835, while a 63 x 63 pixel convolution is about 40 times faster.

The GOP software
The powerful GOP hardware allows running of complex algorithms which would not be practical to run on a general purpose computer. The system was delivered with a rich and versatile toolbox of algorithms in such fields as structural enhancement, context-controlled filtering, classification, geometric transforms, FFTs and others. This software includes many techniques derived from modern image processing research.

Applications to NOT images
Many of the techniques discussed above have already been tested on NOT CCD images. Image enhancement and true-colour optimization have been applied to images of objects such as M57, Jupiter and Saturn. Crowded field photometry is used in a NOT search for optical variability in x-ray sources.

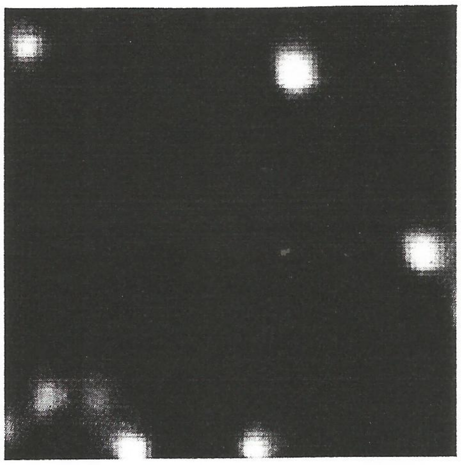


Figure 2b: The same field as in Figure 2a. The group, containing 10 stars, has been subtracted in order to check the photometric accuracy.

Lately, the GOP has been used for deconvolution of NOT images. A fast implementation of an iterative deconvolution algorithm is giving promising results. An example is seen in Figures 1a and b. Figure 1a shows a part of the cluster C1427-057, with an image resolution of 0.7 arc sec. In 1b, the same field is seen after 50 iterations of the algorithm (one hour of computing time). The resolution is now 0.3 arc sec. Although some artifacts can occasionally be produced, the deconvolved image is very useful for identifying individual stars in a crowded field.

Figure 2a shows a star group analyzed with the crowded field photometry software. Figure 2b shows the result after subtraction of the computed model of the group. The absence of residuals, except for background, indicates photometric accuracy.

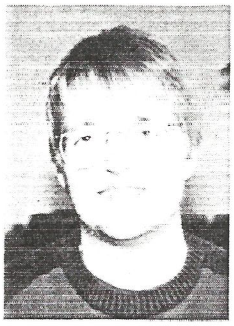
An invitation
The facilities in Lund thus include the MIDAS system mainly intended for standard image processing and the GOP system for more specialized processing purposes. Other facilities are also available, including high-quality hardcopying. A couple of high-resolution X-terminals will arrive shortly, and an A3 format colour printer is expected to be available soon. The new Hewlett-Packard 76 MIPS/22 MFLOPS machine has been tested and is one possibility for further hardware upgrades.

In Lund, we are eager to share knowledge and experiences with other groups and individuals. Those in the NOT community who want to try more unusual techniques on their NOT images are most welcome to visit us.

High-Precision CCD Photometry

Variable stars in open clusters observed using CCDs

Hans Kjeldsen



Introduction

High-precision CCD photometry is used to investigate variability of stars in open clusters, primarily δ-Scuti variability. The study of variable stars provides information on the mechanism of pulsation. Especially, we can get information on the general properties of the observed stars. Time series observations of open clusters should be a powerful tool.

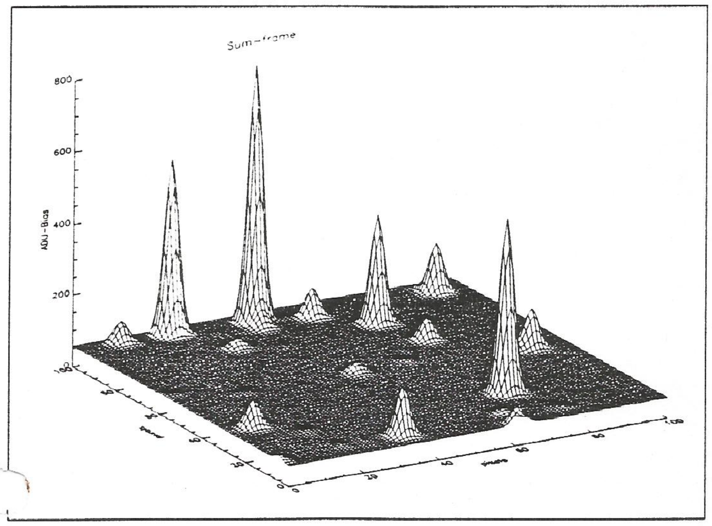


Figure 1: Sum of 200 CCD frames in a 20' x 20' field (the seeing is about 0.8 arcsec = 4 pixels FWHM).

The nature of variability

At different positions in the HR diagram we find groups of stars whose luminosity varies with time. The underlying mechanism for the variability is generally very different, but a large part of the variable stars can be classified into distinct types of variability, such as Cepheids and RR Lyrae stars. The *nature* of the variability mechanism is not always obvious, and for pulsating stars it might be different for the different groups of stars. In fact, this can be the case for Cepheids and δ-Scuti stars. The question is if a δ-Scuti star is a small-scaled version of a Cepheid?

Delta-Scuti stars

The observational review article about δ-Scuti stars written by Breger in 1979 (PASP 91,5) contains many important questions which still do not have any definite answer. This shows how difficult it is to observe low-amplitude variables. The typical pulsation periods for the known δ-Scuti stars are between 30 minutes and 6-7 hours. Some δ-Scuti stars show very constant periodicity, but others have significantly variable periods and amplitudes (semi-periodic). There are, at least, two different explanations for this fact. Either the stars are pulsating quasi-periodically (unstable pulsations), or the pulsations consist of multiple pulsation modes so that the beat among the modes causes the apparent chaotic variations, or both at the same time.

The excitation mechanism for δ-Scuti stars is the κ-mechanism, which also causes the Cepheids to pulsate, but the amplitude is generally small. If we take all stars within the instability strip, it is interesting that not all of them are observed to be variable. Only 30 % of the stars in the strip seem to be δ-Scuti stars. However, the number of low-amplitude variables increases exponentially with decreasing amplitude, and therefore the 70 % stable stars could in fact be variable with very low amplitude.

Time series observations

The principle of the observations in this project is very simple, and we have used it during several observing periods at the NOT and at ESO, La Silla (Danish 1.5m) in Chile. We observe the same area in each cluster (with typically 300 stars) for up to 7-8 hours throughout the night. Per night, this results in about 500 CCD images. It is not a simple problem to

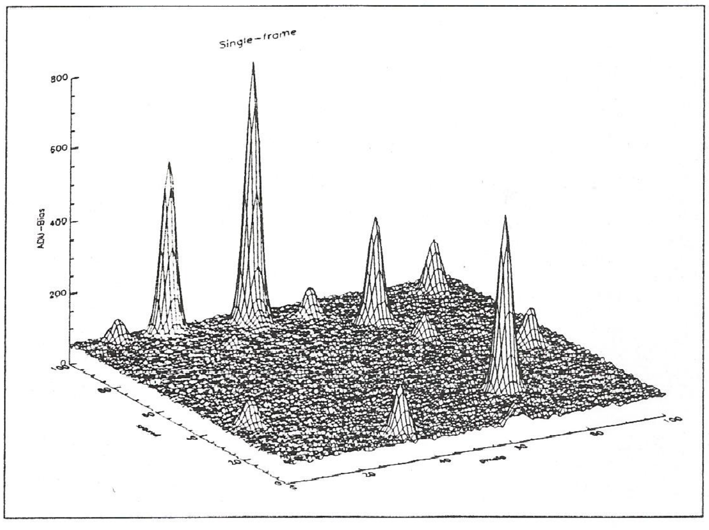


Figure 2: The 20' x 20' field in a single frame (the readout noise is about 2.4 ADU/pixel).

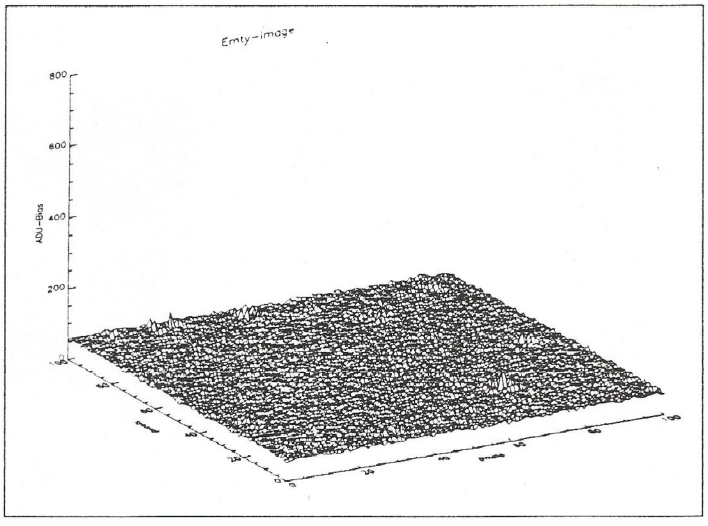


Figure 3: The 20' x 20' field in the PSF-cleaned frame.

reduce the large amount of CCD images, but we have developed software for this purpose. In order to reach the highest possible precision, we have made quite a lot of flat fields and bias frames, to be able to correct for unexpected effects. As a part of our programme, we also made linearity tests for the different CCD cameras, and in fact one of these shows a very strong non-linearity (The Stockholm CCD shows up to 10 % non-linearity from high to low light levels).

Time series photometry
The reduction procedure for the time series is as follows. One image is selected as a reference image. Then useful reference stars are selected in the reference image followed by construction of a *sum-image* containing the sum of all images in the time series. In order to correct for tracking errors, the pixel values are moved so that stars are well placed before the summation.

Useful point-spread-function (PSF) stars are then selected on the sum-image. The main reduction is the photometric reduction and the output from these reductions is, apart from lists of photometry for each frame, also light curves for the individual stars. In Figure 1, I show an example of a CCD image (the sum of 200 CCD frames) for NGC 6802 taken with the Stockholm CCD at the NOT.

Precise photometry - General philosophy
From calculations of the intrinsic noise of different photometric methods, it turns out that for non- or half-crowded photometry, PSF fitting is the most precise method for faint stars. For brighter stars, aperture photometry (AP) is the most precise method (if no neighboring stars are present). In order to use these conclusions and avoid some of the sources of noise, we have developed a general method which *combines* the ideas for aperture photometry and PSF fitting.

Photometry-Combined PSF/AP
The combined aperture and profile fitting routines (PSF/AP routines) perform the following steps. From the PSF stars found on the *sum-image,* the PSF is calculated and the result is stored as a two-component model: (1) A non-Gaussian description of the stellar core, and (2) a table containing the residuals, used as corrections from the stellar core description. It is a fully empirical PSF. For each star the sky background is found and by use of the PSF, profile fitting and PSF photometry are made for each star in the frame. Starting with the brightest star, we remove the stars from the frame, when the photometry is done. In the resulting clean frame, a new background determination is made. In order to correct for errors introduced by faults in the PSF, we finally correct the PSF magnitude by use of aperture photometry. As the important errors normally occur near the center of the star where the signal is largest, we only have to use small apertures in order to correct the PSF magnitude.

Observations from La Palma 1990-91
During 1990-91, we have observed 6 open clusters, and some new δ–Scuti stars have been detected, but the amount of data is too large to be described in this article. The photometric noise is generally low, about 0.0015 mag/frame for the brightest stars. This means that we in one night have a 4 σ-detection level for individual oscillation modes above 600 μmags. The data reduction is still going on, but should be finished during the summer of 1991. However, a preliminary conclusion is that there seems to be only a few low-amplitude δ–Scuti stars in the open clusters, a conclusion which has no theoretical explanation so far. The observations at the NOT have been made using the Stockholm CCD and the Low Dispersion Spectrograph in imaging mode. The quality of the data is very high due to the high image quality and the low scintillation.

Harri hurries home

In 1980, Harri Lindgren left the Lund Observatory to look for new (southern) horizons. He found the horizons especially attractive as seen from La Silla. This finding had a number of consequences. It lead Harri to take up a position as staff astronomer of the European Southern Observatory (ESO). It implied long and intensive studies of the southern skies. Further, it resulted in the accumulation of major experience with frontier (as well as somewhat less frontier) telescopes and adhering instrumentation. Likewise, it meant that Harri introduced a large part of the European observing astronomers to telescopes, control systems, various pieces of instrumentation and to computers and programmes dedicated to reduction and analysis of observing data, on-line, as well as off-line.

Finally, Harri took up detailed studies at the La Silla library. In addition to extended insights in astronomy, this lead to his marriage with Maria-Eugenia Gomez, well-known ESO librarian at La Silla. As a natural consequence of this happy marriage, Harri got gradually more latin in manners, gestures and verbal communication, yet not touching the limits of exaggeration.

We are most happy to announce that Harri has decided to switch back to his original hemisphere, joining the NOTSA as staff astronomer and coordinator at Cruz del Fraile. We know that his experience will be invaluable to the association, to the observatory, to his fellow staff members and to visiting scientists. We advice the La Palma jet set to get prepared.

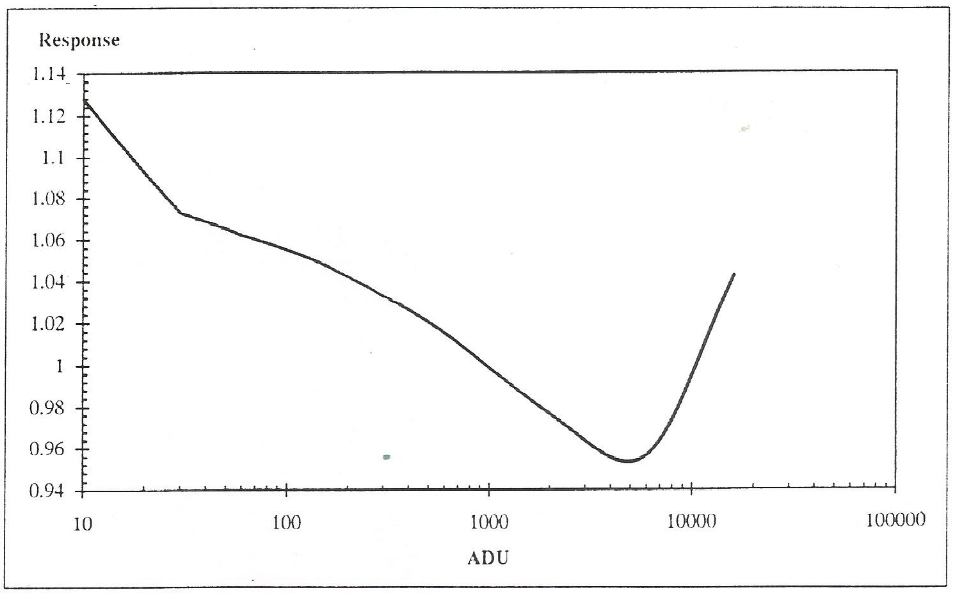
Having a number of observing projects in mind, many of them directed towards the old stellar population in the Galaxy, Harri's personal research interests will cover a wide range of scientific topics and, consequently, of instrumentation. He has been working intensively with high-precision photometry, with accurate radial velocities and with spectroscopy, mainly at higher resolutions, as well as with large-field imaging.

We extend our warmest welcome to our new international couple, Harri and Maria-Eugenia.

NOT corrected CCD data

Steven Jörsäter

Since the thorough investigation of the Stockholm CCD camera by Hans Kjeldsen (special report), it has been clear that the camera has a non-linearity problem which is very substantial. The origin is not understood but it seems stable and may be calibrated to better than 1 %.



The response curve of the Stockholm CCD. We can see that the sensitivity has a minimum at about 5000 ADUs, after which it slowly increases. The sharp kink of the curve at about 30 ADUs is uncertain but seems real.

The non-linearity originates after the readout of the chip. It shows no dependence on colour, pixel position or exposure time - only on the number of ADUs registered in a particular pixel. It seems to be weakly dependent on the GAIN factor. One should try to avoid exposing objects on which photometry is to be made to more than 5000 ADUs peak value (saturation at 16383), since the precision in the non-linearity correction will then drop somewhat.

We will of course try to have the problem fixed but since the CCD camera is on such heavy demand, this may take a while. In the meantime, we will have to live with the problem. I have made a MIDAS procedure which corrects for the effect of non-linearity.

The response curve by Hans Kjeldsen (verified by us), is approximated by a polynomial of order 19 with a linear dependence at very low levels. The correction is strictly valid only for GAIN 10 (default) data but seems to do a decent job also at other gains. Data should be bias subtracted before the non-linearity correction is applied. The MIDAS routine may be requested from me via e-mail to:
steven@astro.su.se.

NOT Observations and Team-Work

L.O. Lodén

An abundance of new auxiliary instruments are being added to the armoury of the telescope. Together with the „veteran" equipment, they will constitute an impressive resource for observers.

All instruments are of modern design with application of the most recent developments in instrumental technology. This concerns every aspect, all the way from optics to software. As a consequence, they are highly sophisticated. This in turn implies that they may not always be particularly trivial to operate.

The Nordic Telescope cannot permanently provide an expert on all instruments available. Local staff members exert themselves to the utmost to give best conceivable service to guest observers, but they are no magicians. This circumstance might create certain problems and maybe even some irritation, growing with the continued addition of new instruments. The problems are connected with service of the instruments, observations and subsequent reduction of observing material.

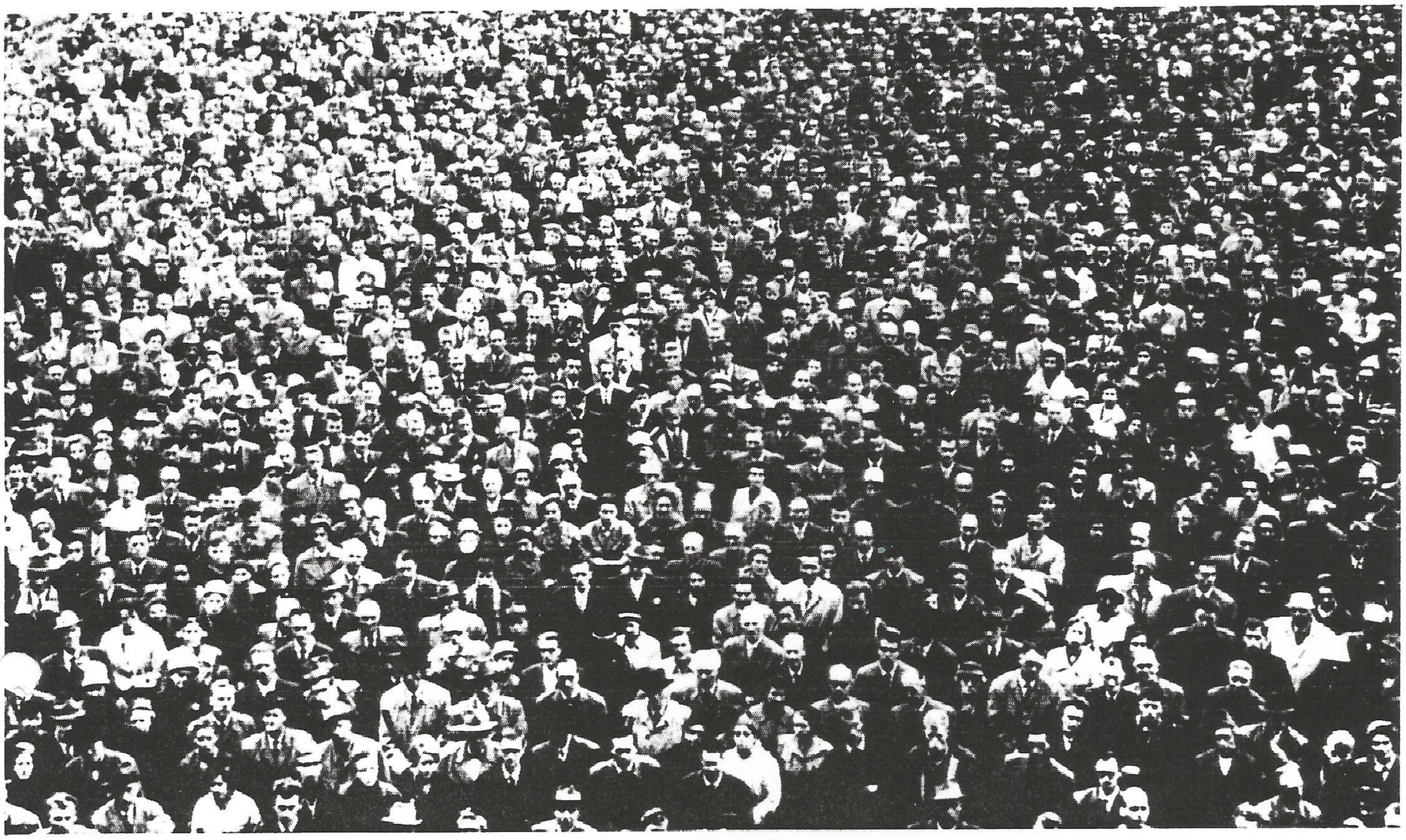
Is there any way to meet this unavoidable inconvenience? To a certain extent, yes.

All instruments concerned have been constructed at institutes in the NOT countries, often through collaboration between institutes (not necessarily always in NOT countries). At these institutes, one will then find the very best experts of the particular equipment and its handling, i.e. the constructors themselves. It is also evident that the construction of an instrument at a certain institute in some way reflects the scientific traditions of the place and its interest profile. In other words, as a rule, the constructors and a group around them constitute not only the most skilled users but also the most zealous ones. This is a phenomenon already statistically verified by observing time applications.

If a presumptive NOT guest observer has a project requiring an equipment that he or she does not master or feels a bit uncertain about, we would give the following little advice:

Invite one or more members of the constructor-group to join the project! Presumably, they accept the invitation with pleasure. You may then perform observations together, or the reductions, or both. The time has passed when researchers fenced themselves in with their own projects.

A procedure of this kind cannot be applied in all situations, and in many cases it is not necessary either. However, there may be good reasons to take it in serious consideration.



Astronomers waiting for observing time at the NOT.

Principles of Allocation of Observing Time

Esko Valtaoja
NOT Observing Programmes Committee Chairman

As reported in the previous issue of NOT NEWS, last October the NOT Council established a separate Observing Programmes Committee for the scientific evaluation of observing proposals. This task had earlier belonged to the STC, but it was felt that a separate committee unburdened with all other NOT business could better concentrate on the review process. After discussion, the Council decided not to use external referees. Instead, a member and a substitute member were appointed from each of the four participating countries. Since all these eight OPC members were themselves active astronomers with wide-ranging research interests (or at least we prefer to think of ourselves as such...), it was hoped that this peer review would ensure the best possible scientific evaluation of the observing proposals.

The OPC met for the first time in March 1991, allocating time for the period April-September 1991. In connection with our first meeting we established a set of guidelines for our work, which were subsequently accepted by Council.

Selecting the OPC members from among the NOT users might potentially cause some problems, especially in the rather small Nordic astronomical community. Not surprisingly, it has been claimed that the conflicts of interest would inevitably make the OPC members disqualified to evaluate fairly the proposals of their colleagues. This is a legitimate worry, but the OPC has especially tried to ensure that it is groundless. Perhaps the most important guarantee is our pre-rating system, which ensures that each and every proposal gets four independent evaluations of its scientific merit. Another is the iron-clad rule that we judge all the proposals solely on the basis of the information presented in the application. Kindergarten rejects and globally revered Senior Scientists all start on the same line. If we feel that the scientific case for the project, as described in the application, is not strong enough to merit observing time, you won't get it for any other reasons. It is our hope that this also ensures equal and fair treatment to everybody.

In particular, we do not consider national quotas nor other external factors such as possible national scientific priorities. These are thorny questions with no simple answers, extensively discussed at both the OPC and the Council meetings. As for the quotas, it was decided that in the long run the correct balance must naturally be maintained, but so far, statistical fluctuations in the percentages are too large for any firm conclusions. However, following Council's recommendation, we will also take into account the country of origin in those last cases where we must choose between two proposals of otherwise equal merit.

The astronomical communities of the participating countries may also harbor ideas different from those of the OPC about the best use of the NOT. However, the OPC felt quite unanimously that the only thing we can properly attempt to do is to consider the science as well as we can - science policy is one can of worms which we definitely do not want to open.

So what fate awaits your proposal once you've mailed it to the Director? First of all, he forwards copies of it to all eight members and substitute members. In each country either the member or the substitute member - depending on how they have decided to split the work load between them - carefully reads your proposal and also gives it a numerical rating using the ESO scale (1 - outstanding, 1.5 - excellent, 2 - very good, 2.5 -good, 3 - sound, 3.5 - acceptable, 4 - doubtful, 4.5 - very doubtful, 5 - useless). Each member then sends these pre-ratings to the OPC Chairman. The pre-ratings are not final. They are only meant to help in the actual selection process in the meeting, and to provide four independent opinions of each proposal. A large spread in the four pre-ratings may be a sign that the strengths (or, as the case may be, the weaknesses, but let's think positively) of the proposal have not been equally appreciated by all OPC members, and a more extended discussion is needed. Similarly, if all have given the proposal outstanding ratings, there is a fair chance that it really is good.

For each proposal, the OPC Chairman has appointed a main referee, whose duty is to look especially closely at the proposal. When the OPC meets, the main referee first presents the proposal and gives his opinion and proposed rating. The other three members then take turns and voice their opinions. The Director (who is present at the meeting but does not participate in the evaluation) gives any comments he may have, and after discussion the final rating is determined. Thus, the final fate of your proposal does not rest on any single member of the committee. We act collectively and are collectively responsible for each and every decision (although if you do decide to go on a killing spree, start with the Chairman who must bear the final responsibility).

Naturally, a member does not rate proposals in which he is participating, nor is he present when they are discussed in the OPC meeting. However, given the size of the Nordic astronomical community, it is unavoidable that the OPC members often must rate proposals from close colleagues.

The ratings are for our internal bookkeeping only, to establish the ranking order of the proposals, and we do not intend to make them public. When all proposals have been rated, we start with the highest rated one, decide how many nights should be given to it, and then continue downwards until we run out of nights. This, inevitably, is long before we run out of good proposals. Especially dark time is so heavily oversubscribed that quite a number of proposals simply cannot be given observing time even if they well deserve it.

Roughly speaking, slightly over one half of the proposals can be given time during a period, and on the average these proposals do not get more than half the number of nights requested. This is a compromise between the need to provide sufficient observing time for major projects and the need to let all astronomers with reasonably good proposals get at least a taste of the goodie.

(It might be noted here that only a very small fraction of the proposals are so bad that they would not merit any observing time even if we had twice the number of nights available).

Finally, the Director prepares a night-by-night schedule for the period, following as closely as possible the decisions of the OPC (some slight change may be necessary, for example due to unforeseen technical problems) and informs the observers. We wish we could provide detailed written comments and criticisms of each proposal, but this would mean an unreasonably large extra work load. Instead, we decided that the OPC member from each country would function as an interface to the users in his country. Thus, if you need to know something about your proposal beyond the mere fact of acceptance or rejection, start by contacting your country's OPC representative. (If he pretends to have a sudden case of amnesia, ask the Chairman. But please have pity and do not ask how to improve a proposal so that it would be guaranteed to get time in the next round - if I knew the patent answer to that I'd certainly use it to rescue my own brilliant proposals rejected by those scientific morons of the OPC).

In conclusion, two more things should be made clear. First, the OPC exists to serve the user community, not vice versa. Anyone who has complaints or suggestions about how we might better fulfill our duty is welcome to voice her or his opinion. There remain also many questions which should in the end be decided by the NOT users, not by the NOT OPC, but which affect our work. Should a large fraction of time be reserved to long-term major projects, should we have „key" projects, special scheduling for monitoring-type programs (implying, in the long run, service mode observations), preferential treatment (or at least „affirmative action") for student/thesis projects, and so on.

Second, the rumors that the OPC is just a gang of evil-minded old men hoarding observing time for themselves and their cronies are not true. The Chairman is still an evil-minded thirtysomething.

NOT NEWS is no newspaper

L.O. Lodén

A daily newspaper is normally nothing you save in a file or send to the bookbinder. Only occasionally you save a specimen from a day when something really dramatic or exciting occurred. NOT NEWS is different in that respect. A considerable fraction of its content consists of sometimes indispensable information, particularly to presumptive NOT guest observers. It could be a description of a new instrument, a new procedure or some practical advice of more or less technical nature. The message may in many cases remain up-to-date far beyond the time of next issue. It would not be particularly entertaining to repeat all this information in each issue, however. Therefore, please do not throw away this paper once read. Save it. You may need it.

Ethernet opens New Possibilities to Instrument Designers

Kim Steenberg

Are you designing an instrument for the NOT? Do you worry about your connections between the instrument on the adapter and your control and data acquisition computer ?

If your answers to these questions are affirmative, we might have some good news for you. In March, the first part of the NOT ethernet was installed, and the remaining parts will be installed in June, when this issue of NOT NEWS is in press. This installation will allow instrument designers to connect their instruments mounted on the adapter to the control and data acquisition computer placed in the control room (or the service building if so desired). Yet another possibility might be to use the image processing facilities on the HP computer in the service building for data acquisition and to place the control computer in the control room.

By the way, if you already have an instrument with dangling wires, and are considering a redesign, you might also consider using the ethernet.

We emphasize that the ethernet connection eventually will allow access from NORDUNET. According to specialists at the IAC, this possibility should materialize during spring-92. The approach is interesting not only for remote observing. The connection will also enable valuable expert back-up from home institutes during testing. Software modifications can be implemented at the home institute by the author of the program, transferred to La Palma and tested immediately. The importance of this is easily spotted.

Some limitations:

1) We require that you do not load the ethernet excessively i.e.:

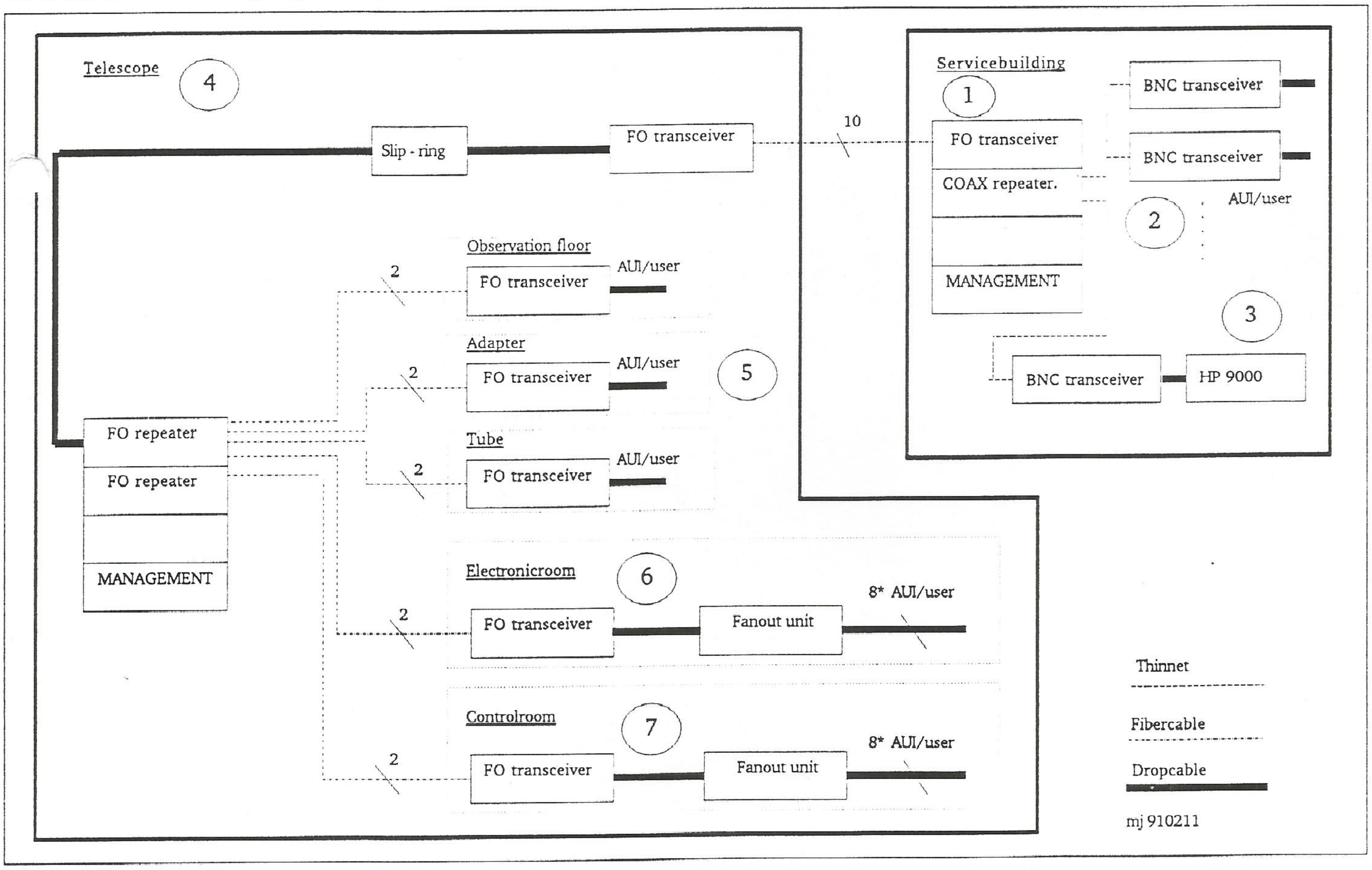
   average load < 100 kbit/s
   peak load < 1 Mbit/s
   for max 10 sec

This will allow multiple users to co-exist on the network simultaneously without disturbing one another.

2) You connect to the ethernet with AUI-cables only, available on-site.

Apart from these restrictions, the system is rather versatile, and we are convinced that the system will prove extremely useful to instrument designers and astronomers.

Ethernet configuration:
1. Network in Service building.
2. In each office, there is a coax-transceiver with an AUI user attachment .
3. The HP 9000 has its own segment.
4. Telescope network.
5. In the dome , there are three possible user attachments.
a. Tube.
b. Adapter.
c. Observation floor.
There is an extra fanout unit which can be connected to one of these connectors and give 8 user attachments.
6. In the Electronics Room, there are 8 possible connections. These are reserved for the controls system.
7. In the Control Room, there are also 8 user attachments which can be used freely.



Holstis at home in Helsinki

When Niklas Holsti jumped off his bicycle that sunny afternoon in the end of May in Santa Cruz, he looked like simply ending another of those bicycle trips up and down the 2400 metre Roque de los Muchachos which always seemed so perfectly natural for him. However, this one was slightly different. Getting off his bike, Niklas terminated a new forceful athletic masterpiece. But he also terminated something else. It may well be that he did not see it all that dramatic. Niklas normally did not dramatize things. Still, his step off the bicycle marked the end of an epoch. An epoch only two years long but of utmost importance to the running of our telescope.

Niklas was amazing on his bike. But he was certainly not less amazing in his profession. Smashingly knowledgeable in computer science, in astronomy, in technical details and in most other things, he was a veritable corner stone for our project.

It took some hard effort to convince Niklas to join our project. Once duly convinced, he agreed to stay for a year. We managed to convince him to double his time on La Palma. But that was it. Niklas closed his loop and programmed himself for Helsinki. The people at the Helsinki department of computer science and computer centre were happy. We were considerably less so.

Niklas came to La Palma at a time when everything seemed to happen at the same time. The telescope had just come into its first shaky commissioning phase. Expectations were enormous and problems more than abundant. Miracle people were badly needed. And there he came, just in time.

From that moment, Niklas took over a very essential part of the running of the Nordic Optical Telescope. Software was safely in his hands, and so were a lot of other things. He seemed close to unlimited in his understanding of virtually everything going on at Cruz del Fraile, bridging from software to hardware to mechanics to optics to astronomy and to administration alike.

And on top of everything, Niklas was a team worker like few. An ideal collaborator, always available. Not completely always though. After all, he was really quite incomunicado when he rode his bike. And he did ride his bike quite a bit. 45 kilometres and an ascent of close to 2400 metres does not sound like inviting for a bicycle trip. To Niklas it was not even a matter worthy of comments.

Niklas, Sigrid, Allan and Leo are back in Finland. We wish them all possible success there, hoping that they recall their time at La Palma with some pleasure. We certainly do so.

The Spanish Connection

Vicente Maeso
IAC La Laguna

I have been given the opportunity to forward to the readers of the NOT NEWS my first impressions of my stay in Denmark.

I am a Spanish student from the Canary Islands. I graduated in astrophysics in June 1990 at the University of La Laguna, Tenerife. Once I finished my studies, I wanted to continue my education but in a different way, that would bring me new experiences. That's why I was very happy when Manuel Collados from the IAC told me about the existence of the scholarship that I now have, as a result of the international agreements signed on the occasion of the installation of the NOT. The subject of this thesis, its director and the place where I would study were very interesting, so I applied for it at once.

I have been in Denmark for three months now and I'm trying to get the best of it in the three years that I'm going to stay here.

The center where I'm working on my thesis is NORDITA, in Copenhagen. My director is Professor Bernard Pagel. The research plan has been designed by B. Pagel from NORDITA and by J.M. Vilchez from IAC. For the investigation in question, a solid base of observations of high quality is needed.

We are interested in a study of the stellar population in HII galaxies by deep multicolour photometry. We will try to detect an underlying component. This should help us in our understanding of the environment of the starbursts that we observe in these galaxies.

I'm getting used to live in Copenhagen quite easily. Denmark and Spain are very different countries in all levels: cultural, gastronomical, meteorological... but to me it's not difficult to live here being a foreigner, because people in this country are very warm and welcoming, so one feels very much at home.

Finally, I would like to thank the staff of NORDITA and my colleagues there and in the Niels Bohr Institute for their welcome and help to facilitate my integration here. Also I want to encourage everyone that wishes to continue his studies in a foreign country.

Dome Seeing with the NOT

Jean Vernin
Département d'Astrophysique.
Université de Nice, CNRS

Casiana Munos-Tunon
Instituto de Astrofísica de Canarias

Introduction

As part of an intensive Site Testing Campaign carried out at the Observatorio del Roque de los Muchachos (ORM) in July 1990, different experiments have been conducted using a variety of instrumental techniques in simultaneous mode. This involved the Nordic Optical Telescope (NOT). As a result of these measurements, the dome contribution to the degradation of images of point sources taken with the telescope has been estimated. The measurements and the techniques used plus some results are described below.

Design of Experiment

The measurement techniques employed were based on simultaneous observing with a number of instruments. We used a well-equipped meteorological mast, sounding balloons, a scintillation detection and ranging instrument (SCIDAR) attached to the focus of the telescope and a SCIDAR in its seeing monitor mode.

The first two instruments (mast and balloons) operate in line with the philosophy of „in situ" measurements, and allow us to determine the profile with height of the atmospheric turbulence, given by the structure constant of the refractive index C_N^2. In order to do so, we sample the macroscopic atmospheric parameters, pressure, temperature, humidity and wind, as well as microfluctuations in temperature which provide the structure constant of the temperature C_T^2. The latter is related to the turbulence by the following expression.

$$C_N^2(h) = (80.10^{-6}\frac{P(h)}{T(h)^2})^2 C_T^2(h)$$

Arrangement of instrumentation

The SCIDAR technique is based on a statistical analysis of the scintillation of a binary star. Scidar comprises a block of instruments that were coupled to the Cassegrain focus of the NOT. In this technique, the primary mirror of the telescope is used as a collecting area to record the scintillation images.

Technique

Two atmospheric speckle patterns, produced by a single turbulent layer, are projected on the ground by two differentiated sources. A triangulation method allows us to obtain the height of this layer, as well as the corresponding value of C_N^2. With the same instrumentation it is also possible to analyze the spatial profile of the image of a star taken with a long exposure. From the measurement of the width of the stellar image, it is possible to estimate the seeing in its classical sense. It is related to the structure constant of the refractive index C_N^2 by the following expression

$$\varepsilon_{fwhm} = A(\lambda)(\int_0^\infty C_N^2(h)dh)^{3/5}$$

Both Scidar modes are used alternatively during the night. With the resulting measurements, it is possible to estimate the contribution to image degradation from the set atmosphere-telescope.

Results

In the Table, we have summarized the values of the integral of $C_N^2(h)$ over different heights corresponding to different atmospheric layers. These values were calculated from data taken with the instrumental devices mentioned above and correspond to balloon sounding launched during the night of July 22, 1990, at 22.00 and 01.30h UT. Please note that the free atmosphere (FA) corresponds to the complete atmosphere above one kilometre, and that the boundary layer (BL) refers to the fraction enclosed in the volume between the ground and the one kilometre limit. The contribution from the dome is expressed by D=(D+BL+FA)-BL-FA.

Conclusion

From this study it is evident that dome contribution is absolutely negligible. We can conclude that **within the measurement errors, the NOT dome does not contribute to seeing.**

D+BL	BL
2.35E - 13 1.44E - 13	2.57 ± 0.85E - 13 1.6 ± 0.4E - 13

Turbulence	FA	D+BL+FA	BL
$\int C_N^2(h)\,dh$	1.19E - 13 1.32E - 13 SCIDAR	3.54E - 13 2.76E - 13 SCIDAR SM	2.57 ± 0.85E-13 1.6 ± 0.4E-13 BALLOON + MAST

Hard and handy

Optics are crucial to the performance of telescopes and so are mechanical elements. Crucial but far from sufficient. Excellent as these items may be, everything falls flat in the absence of efficient electronics hardware and software tools.

With its status as a frontier (at least we hope so) telescope with a structure as squeezed as its operation staff, efficient running of the Nordic Optical Telescope is heavily dependent on both high-class electronics equipment and on presence of qualified specialists mastering this equipment. In spite of his obvious excellence, Toomas Erm is only one person and cannot be present at the telescope more than a limited amount of time. Thus, the need for more staff on the hardware side is obvious and very strong.

Following a recent decision by Council, funding has been made available to support a post as hardware technician to be locally recruited. We take pleasure in announcing that successful recruitment has already been made. From the middle of February this year, Carlos Perez is working for the NOTSA operation staff at Cruz del Fraile.

Carlos Perez is a hardware technician with ample experience from the site test investigations at Roque de los Muchachos and Izaña performed by the Large Earth-based Solar Telescope (LEST) foundation. Clearly, he is now getting ample possibilities to extend this experience in a number of fields.

Active Optics on the NOT

Final tests of the NOT optics were made in March using the interferometric Wavefront Sensor described in the present issue of NOT NEWS. The results were highly encouraging. The optical quality of the telescope is, even in an entirely passive mode, better than specifications.

An important result of the tests was the confirmation that removal of some low-order aberrations would approximately double the intrinsic sharpness of NOT images, thus making the telescope close to diffraction limited. These effects are apparent from Figure 1, showing the 80 % energy concentration as directly observed as well as with various aberrations numerically removed by postprocessing. It can be seen that the 80 % image diameter will go down to about 0.25 arcsec if low order aberrations are removed. Actually, through averaging of several measurements from the wavefront sensor, it is possible to reach a corresponding image diameter of around 0.2 arcsec. It seems obvious that the image quality can be improved very significantly through installation of active optics.

NOT suited for Active Optics
The Nordic Optical Telescope is well suited for active optics. It has a thin mirror which relatively easily can be deformed in its low-order modes. Also, the axial supports are of pneumatic type with bellows (Figure 2). It is rather straightforward to install a

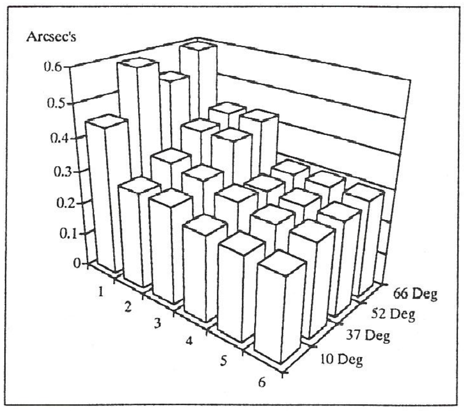


Figure 1: A set of results from optical tests of the Nordic Optical Telescope in March 1991 at various Zenith distances.
1: Raw data
2: Coma removed in postprocessing
3: Spherical aberration removed
4: Triangular coma removed
5: Quadratic astigmatism removed

Figure 2: One of the bellows used for axial support of the primary mirror of the NOT.

system which regulates the pressure individually in all of the bellows.

There is quite a number of bellows (45) and they are placed along three concentric rings. Also this fact facilitates correction for various aberrations. For our system, we intend to correct for the five aberrations as shown in Figure 1.

Planned System
The active optics system will use the interferometric wavefront sensor referred to above. It will be mounted on one side of the adapter. Light can be directed to the wavefront sensor by insertion of a 45 degree mirror under full computer control. The CCD camera of the wavefront sensor records the interference pattern. The image is grabbed and an AT computer analyses this pattern and calculates the wavefront aberrations.

On the basis of the wavefront aberrations, the AT computer calculates the 5 aberrations indicated above. The values resulting are transmitted to a VME microprocessor system integrated with the telescope control system. The microprocessor derives the corrections to be applied to the support forces in order to achieve best possible image quality. Changing the settings of electronically controlled pressure regulators for each of the pneumatic bellows, these corrections are implemented on the axial mirror support system.

Further, the secondary mirror can be shifted sideways under computer control to correct for coma. This is, obviously, in addition to computer controlled axial movements for focusing.

To improve reliability, there will be an independent pressure sensor system monitoring the pressure in the support bellows. Thus, the computer has the capacity to check whether all pressure regulators function correctly.

Corrections of the aberrations will be implemented using a combination of low-order eigenmodes calculated by finite element methods. Figure 3 shows one of these eigenmodes.

Operation modes
The active optics system will operate in a semi-closed loop. It is anticipated

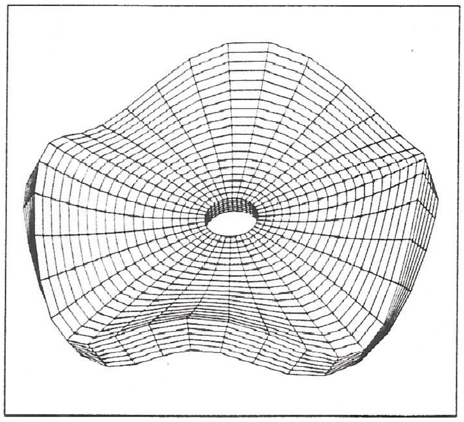


Figure 3: One eigenmode of the NOT primary mirror.

that it will take approximately 5 minutes to point and centre a bright star and adjust the optics. Thus, it may not always appear attractive to go through this adjustment procedure several times during an observing night. Neither will it, normally, be necessary, since it is expected that the telescope will stay well calibrated for longer periods of time.

It is intended to incorporate the active optics adjustment procedure in the normal user interface. Whenever the seeing appears excellent and the observer wants to exploit the conditions as fully as possible, he or she may choose to use a bright star for adjustment of the telescope optics. From then on, the telescope will operate in its calibrated mode with respect to the parameters so deter-

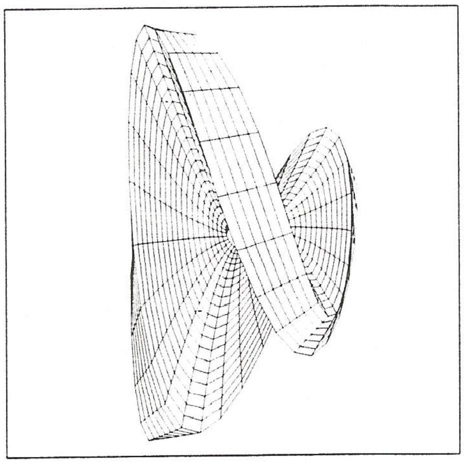


Figure 4: Optical mirrors get increasingly deformable.

mined, correcting for altitude-dependent optical aberrations.

Time Schedule

The pneumatic support system will be modified when the mirror anyway is taken out for aluminization in June 1991. The new part of the control system is presently being integrated by the Nordic Telescope Group in Denmark. The wavefront sensor is basically operative already now, although a few minor corrections are necessary. Installation work should be terminated during the fall and the system should, according to plans, be ready for first tests before the end of the year.

Safety on Cruz del Fraile

Göran Cedergren
Safety Engineer
Lund University

I visited the NOT in the summer of 1990, and the purpose of my visit was to inspect the working environment safety of the observatory. The first problem I met was the trip up from Santa Cruz to the NOT. The road was the kind of road I would not like to drive on in heavy rain or dense fog. There were small „landslides" on the road and the turns were very sharp and innumerable. When I reached the site of the NOT, there was a sharp turn down to the service building. The road from the Roque de los Muchachos met the NOT road here, and there was absolutely no chance to see down-traffic. A stop sign is necessary for the down-going traffic.

I began inspecting the observatory and found a lot of minor faults and some bigger ones. The latter could lead to serious accidents. The transportation of liquid nitrogen was done in a combi-coupé. If a car accident should occur, the driver would be drenched in nitrogen! Transports of liquid nitrogen must be made in a car with a separate luggage compartment or on a pick-up. When the nitrogen arrived at the observatory, it was taken inside via the entrance steps which can be very icy and slippery in winter. Then it was taken up to the observing floor via a very steep and narrow spiral staircase. If one of the carriers should lose his grip on the nitrogen cylinder, a serious accident could occur. The nitrogen cylinder must be taken up to the observing floor the safest and easiest way: by the hoist!

The motors that manoeuvre the hatches are placed in the top of the dome. To service them, the staff used an ordinary step-ladder, which is highly dangerous. Service must be done from a platform. The observing floor had no emergency exit, but a rope-ladder down to the ground should be sufficient.

Example of a too high fire load spotted during the visit of Göran Cedergren

I found that the general illumination in the control room was too bright for monitor work. The easiest way to reduce light intensity is to change the fluorescent tubes to a weaker type (Philips TLD 92).

The fire safety in the observatory building was rather neglected, crates and boxes were placed in the entrance hall under the staircase up to the observing floor. In the cellar, I found a lot of insulating material, crates, boxes, lumber etc. which made the fire-load far too high. All these combustible materials were placed there because of inadequate storage capacity.

The stretch between the telescope building and the service building can sometimes be a very dangerous walk. At night, in snow, fog or heavy rain, you cannot see more than a foot or two in front of you. There is a safety barrier on the left side and on the right side a steep slope. A barrier on the right side is needed.

In the service building, I found some small faults. The soldering place had no mechanical ventilation, and the power drill and the grinding machine were not bolted on to the floor.

In the dormitory flat, I found that, at night when you go to sleep, you have to lock the door from the inside with a key. In case of fire you have to take your key with you to the door in order to get out. The key must be replaced with a knob to open the door from the inside.

Many of the problems I observed on the NOT were due to insufficient knowledge and to the fact that after a long time in a place you become more or less „blind" to your surroundings. I hope that my report on the NOT has been read, the faults have been heeded and that the staff of the NOT makes a safety inspection of the premises every year, so as to remove all new safety risks that have been piling up during the year.

If all this is done, I think NOT is a fairly safe working environment. The only problem that is difficult to attend to, is the road from Santa Cruz. All personnel must be aware of the dangers on the road and drive very carefully, especially in the winter when there is snow and ice.

Thermal Monitoring System

Toomas Erm

Aim of system

A system has been developed for monitoring of temperatures at different locations of the Nordic Optical Telescope and its adhering building. The monitoring system will be used to improve the temperature equilibrium between all parts of the telescope, its building and ambient air. This should serve to improve prevailing image qualities even beyond present performance.

Temperature sensors

The sensors selected are solid-state temperature dependent current generator sensors. They are reasonably cheap, an important quality, permitting us to use virtually as many sensors as we may ever want to install.

The temperature range covered by the sensors is from -8 to +40 degrees C, with an accuracy of +/- 0.1 degree. In order to take advantage of this accuracy, we have to calibrate the temperature sensors. Figure 1 shows a plot of temperature measurements made with a sensor before and after calibration. The curves obtained after calibration were measured during two weeks. As can be seen from the results, the repeatability of the sensors is better than +/- 0.1 degree.

Sub-systems

The total system is divided into four sub-systems. This division is done to decrease the amount of sensor cables passing through the cable twisters and slip rings. These subsystems are intelligent units which can read up to 104 sensors each. Thus, with the existing setup, the maximum number of sensors is 416. At the moment, the total amount of sensors is 152, but this number can, at any time, easily be increased or decreased.

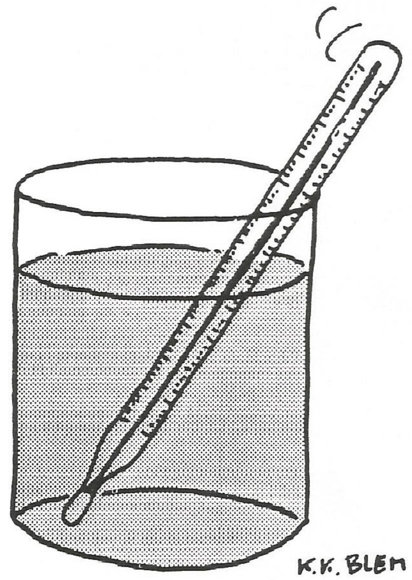
Measurement areas

For the monitoring of temperatures, we have divided our programme structures into four areas, corresponding to the sub-systems described above. These areas are the instrument adapter, the telescope tube, the fork structure and the telescope building, and, finally, external ambient air.

Monitoring unit

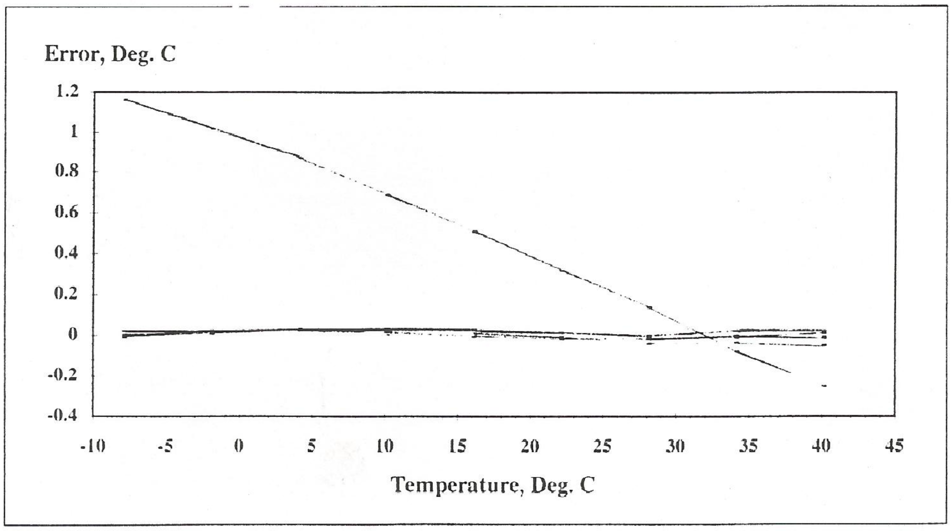
The measurement areas are all connected to the main controller, which is an 386 computer. These connections pass via a multi-drop link. Further, connection to the telescope control computer will be implemented. This connection will provide the control system with access to the temperature data monitored.

On the 386 computer, an on-line monitoring programme will be running. The programme will automatically save all the sensor temperatures every fifth second. The data will be analyzed and correlated to the seeing data derived with the telescope. Such correlations will provide the basis for decisions regarding control of the cooling systems of the telescope and the telescope building.



Further actions

Some of the data from the tube subunit will be used for automatic optimization of telescope focusing as a function of temperature. Other data from the same sub-unit will be used to detect disturbing conditions such as overheating in motors and imperfections in the cooling systems. At the same time, the temperature data collected will, together with corresponding data on observed image qualities, be used for increased understanding of the thermal situation around the telescope. This, in turn, will set the scene for more sophisticated measures aiming at improved temperature equilibrium.



Sensor accuracy with and without calibration. Uncalibrated relation highly inclined, calibrated relations all close to horizontal.

More Lucky People

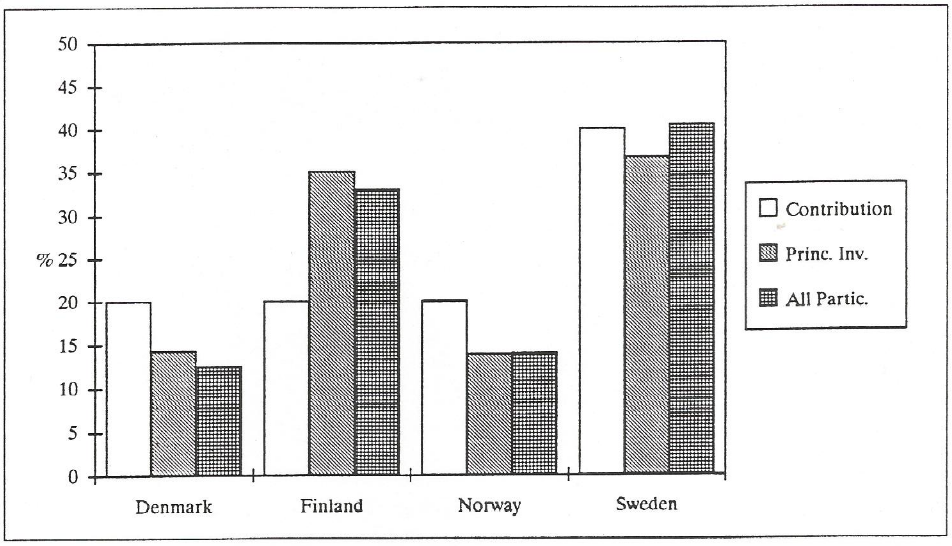


Figure 2: Distribution of observing time between Nordic astronomers. Comparison is made with contribution levels.

How to get luck

As was hinted in the previous issue of NOT NEWS, astronomers, in order to get observing time with our telescope, need a convenient mixture of good programmes, convincing arguments and good luck. In another article in the present issue, this is de[illegible]ed by the young bloke heading the allocation mafia.

They made it

We are happy to continue being flooded by excellent programmes clearly needing several Nordic optical telescopes. In the previous issue, we published a table of allocations covering the first year of regularly scheduled observing time. Here, we provide a continuation of that table, comprising the programmes allocated observing time from April to October 1991. It should be noted that, in addition to the programmes displayed in detail in these tables, considerable observing time has been allocated to Nordic groups of observers monitoring effects of gravitational lensing. In abbreviated form, this is noted in the Remarks column.

Some daring statistics

With an increasing amount of scheduled observing time available, some first hand statistical conclusions may seem appropriate, however tentative in nature. Such conclusions can be forwarded regarding popularity of the auxiliary instruments so far available and the national distribution of observing time.

Being popular

In Figure 1, some details are given concerning the distribution among auxiliary instruments of the observing time scheduled. In general, the tendencies noted after one year of time allocation still prevail. The CCD camera continues high in popularity. Also the photopolarimeter maintains its attraction, albeit somewhat less so than the CCD camera. At the same time, the low-resolution spectrograph gains in popularity. With a number of new instruments now in a commissioning phase, competition for popularity will most certainly be increasingly strong.

Distribution among nationalities

Also concerning the distribution among nationalities, some tentative conclusions may seem appropriate. Our figures show that a minor but still rather significant part of the observing time has been allocated to non-Nordic observers. We find this most positive.

The distribution of observing time within the Nordic block may be displayed as in Figure 2. As an alternative to equal division of observing time among all team participants, national labeling has been made with regard to principal investigators only. The difference resulting from the two approaches is hardly significant. As can be seen from the figure, distribution of observing time deviates somewhat from the distribution of contributions among associates. As decided by Council, for the time being, no special correcting measures will be considered, although the situation will be subjected to close watching.

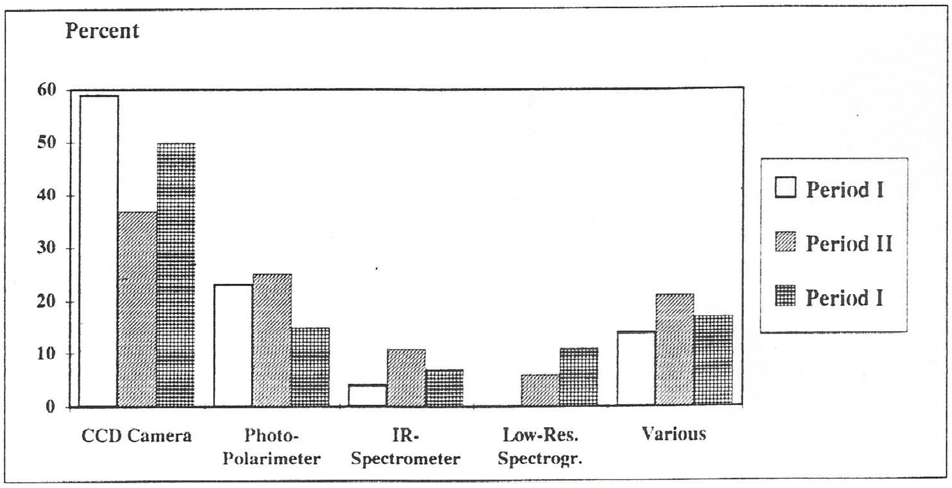


Figure 1: Observing statistics for some auxiliary instruments at the NOT.

Nordic Optical Telescope Observing Schedule

Starting date	Ending date	Principal investigator	Institute	Programme	Instrument(s)	Remarks
Apr 03	Apr 05	L. Colina	IAC	Medio interestelar en los nucleos de	CCD Camera	
Apr 05	Apr 09	I. Pérez/Fournon	IAC	El medio interestelar en galaxias S0	CCD Camera	
Apr 09	Apr 21	L. Colina	IAC	Medio interestelar en los nucleos de	CCD Camera	
Apr 21	Apr 24	H. Rickman	Uppsala obs.	A search for activity in near-earth asteroids	CCD Camera	MoQ 21
Apr 24	Apr 26	E. Pérez	IAC	Espectroscopia IR	IR Spectrometer	
Apr 26	Apr 27	B. Pettersson	Uppsala obs.	Abundance gradients in near-by galaxies	Special	MoQ 26
Apr 27	May 02	M. Selby	IAC	Espectroscopia de estrellas brillantes	IR Spectrometer	
May 02	May 06	B. Thomsen	Aarhus obs.	Population gradients in elliptical galaxies	Aarhus spectr/CCD	MoQ 02
May 06	May 07	O. Vilhu	Helsinki obs.	CCD photometry of low-mass x-ray	CCD/Polarim	MoQ 06
May 07	May 10	J.Huovelin	Helsinki obs.	Investigation of particle beams in	Polarimeter	Even-24.00
May 07	May 10	O. Vilhu	Helsinki obs.	CCD photometry of low-mass x-ray	CCD/Polarim	00.00-morn
May 10	May 12	B. Thomsen	Aarhus obs.	Population gradients in elliptical galaxies	Aarhus spectr/CCD	
May 12	May 15	H.I. Lehto	Tuorla obs.	Identification of faint x-ray sources	Aarhus spectr	MoQ 13
May 15	May 18	E. Laurikainen	Turku obs.	Imaging and spectroscopy of GPS sources	CCD Camera	
May 18	May 20	P. Møller	Copenh. obs.	Cores of ellipticals	CCD Camera	
May 20	May 22	H. Jõnch-Sõrensen	Copenh. obs	Structure and chemical evolution	Aarhus spectr	MoQ 21
May 22	May 29					Techn. time
May 29	Jun 01	J. Egonsson	Lund obs.	Polarization effects in accretion disks	Polarimeter	MoQ 29
Jun 01	Jun 11	I. Tuominen	Helsinki obs.	Commissioning	SOFIN Spectr	MoQ 05
Jun 11	Jun 14	J. Kotilainen	Cambridge	Continuum imaging of Seyfert	CCD Camera	MoQ 12
Jun 14	Jun 17	J Egonsson	Lund obs.	Polarization effects in accretion disks	Polarimeter	MoQ 17
Jun 17	Jul 01					Techn. time
Jul 01	Jul 04	B.E. Westerlund	Uppsala obs.	Distribution of carbon stars	Polarimeter	Even-01.00
Jul 01	Jul 04	B. Pettersen	Oslo obs.	Simultaneous x-ray and optical	Polarimeter	01.00-morn
Jul 04	Jul 07	B.E. Westerlund	Uppsala obs.	Distribution of carbon stars	IR spectrometer	MoQ 04
Jul 07	Jul 08	B.E. Westerlund	Uppsala obs.	Distribution of carbon stars	Polarimeter	
Jul 08	Jul 11	E. van Groningen	Uppsala obs.	The infrared dependence of Seyfert gal.	CCD Camera	MoQ 10
Jul 11	Jul 13	J. Egonsson	Lund obs.	Optical variation of an x-ray nova	CCD Camera	
Jul 13	Jul 16	M. Fridlund	ESTEC	A detailed study of Herbig-Haro objects	ESA PCD/CCD	
Jul 16	Jul 19	E. Laurikainen	Turku obs.	Imaging of interacting galaxies	CCD Camera	MoQ 17
Jul 19	Jul 24	B. Pettersson	Uppsala obs.	Abundance gradients in near-by galaxies	FLEX	
Jul 24	Jul 29	R. Stabell	Oslo obs.	Search for gravitationally lensed quasars	CCD Camera	MoQ 24, 28
Jul 29	Aug 05					Techn. time
Aug 05	Aug 09	P. Lilje	NORDITA	Gravitational lensing by rich galaxy clusters	CCD Camera	MoQ 05
Aug 09	Aug 12	B. Gustafsson	Uppsala obs.	Imaging of circumstellar shells of carb. stars	Special	
Aug 12	Aug 15	M. Näslund	Stockh.obs.	Deep surface photometry of nearby spiral galaxies	Stockh focal reducer	MoQ 12
Aug 15	Aug 18	M. Vestergaard	Copenh.obs.	QSO emission line properties	Aarhus spectrogr.	MoQ 17
Aug 18	Aug 21	A. Aparicio	IAC	Fotometria de cumulus abiertos	CCD Camera	
Aug 21	Sep 04	CCI time				
Sep 04	Sep 07	E. Valtaoja	Turku obs.	Optical counterparts of radio hot spots	CCD+pol. plate	MoQ 04
Sep 07	Sep 09	E. Valtaoja	Turku obs.	What is the parent population of	CCD Camera	
Sep 09	Sep 10	A. Campos	IAC	Propiedades fotometricas de galaxias compactas	CCD Camera	
Sep 10	Sep 13	V Piirola	Helsinki obs.	UBVRI polarimetry of Herbig Ae/Be stars	Polarim/CCD	MoQ 11
Sep 13	Sep 16	A. Campos	IAC	Propiedades fotometricas de galaxias compactas	CCD Camera	
Sep 16	Sep 22	L. Valtaoja	Turku obs	Wavelength dependent pol. of blazars	Polarimeter	MoQ 16, 21
Sep 22	Sep 29					Techn. time
Sep 29	Oct 03	P. Lilje	NORDITA	A new radio loud QSO survey	Aarhus spectrogr.	MoQ 29,

uvbyHβ Photometer

Arne Ardeberg, Nils Hansson and Torbjörn Wiesel

Introduction
The Strömgren uvby system combines a number of essential features. It is based on bands giving resolved consistent data on stellar effective temperature, surface gravity or luminosity, metallicity and age. The bands are wide enough to permit light economy, yet narrow enough to avoid problems of second-order effects of atmospheric extinction. In addition, the uvby system rests on large amounts of calibration data.

Originally designed for stars of spectral types A and F, the uvby system has proven highly successful for a much wider spectral interval, including objects of highest as well as very low temperatures. For hotter stars, combination of the uvby and the Hβ or, sometimes, Hα system can give considerable advantages. With such a combination, also stars affected by large amounts of inter-stellar absorption can be successfully analyzed. This compensates for the disadvantage of the narrow Hβ and Hα filters with their relatively low penetration power.

Design of photometers
Many photometers for the uvby and Hβ systems have been constructed, largely influenced by the basic outlines of Strömgren. This has, especially, been the case in Denmark. Design has aimed at simultaneous observations in four and two bands, respectively. This provides important advantages concerning both efficiency and elimination of spurious effects caused by instrumentation and atmosphere.

Our instrument
We adopted a design aiming at use of a single photometer for both the uvby and, optionally, the Hβ or Hα systems. For the uvby photometry, pass bands are defined using a reflecting grating followed by a unit finally defining the pass bands. This unit can be either slots plus optical filters or, optionally, slots only. The Hβ pass bands are defined through beam splitting and interference filters. This approach closely follows that recently adopted in Denmark. Our final design may be seen as a modification of those Danish instruments. We note that whilst provision is made also for Hα photometry, for the time being, this has not been implemented.

An overview of the design of our uvbyHβ photometer is given in Figures 1 to 3. The total length of the photometer is close to 75 centimetres and its weight, including all components, is around 100 kg. With proper devices for storage and handling, the photometer can be mounted on the telescope by a single person with adequate experience.

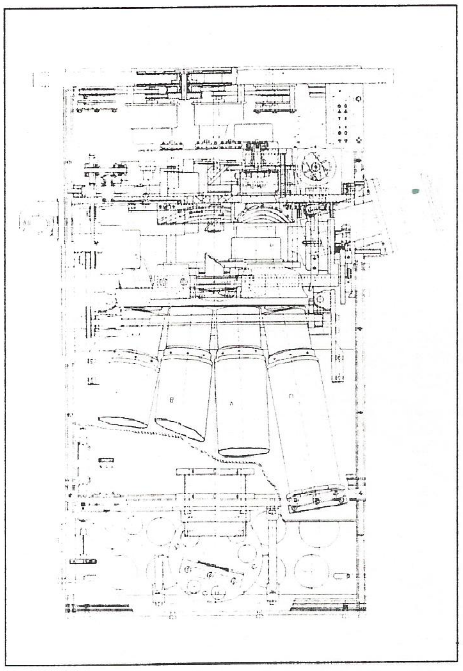


Figure 1: Overview of mechanical design of uvbyHβ photometer. From the top, we can identify the two filter wheels in the front flange. Lower, an intermediate wall carries most optical components. Easily distinguishable is the plane Hβ deflection mirror. The housings for the uvby photomultipliers occupy central section. Below these housings, we can identify the Littrow lense and the grating. On the right-hand side of the photometer housing, the Hβ unit sticks out.

Mechanical elements common to the uvby and Hβ units
Except for the photometer housing, the mechanical parts common to the uvby and Hβ units comprise the adapter flange, the diaphragm wheel and two filter wheels.

The adapter flange has a diameter of 76 centimetres. It conforms to NOT standards, coupling the uvbyHβ photometer to the telescope.

The diaphragm wheel has 6 positions. These provide diaphragm sizes of 8.0, 2.0, 1.2, 0.6, 0.45 and 0.25 millimetres, respectively. On the

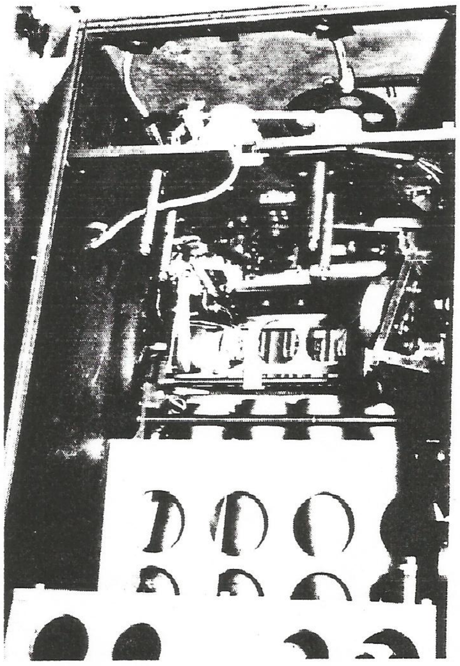


Figure 2: Photo of photometer with one side wall removed. This photo shows the same features as given in the design drawing in Figure 1, although seen from the opposite direction.

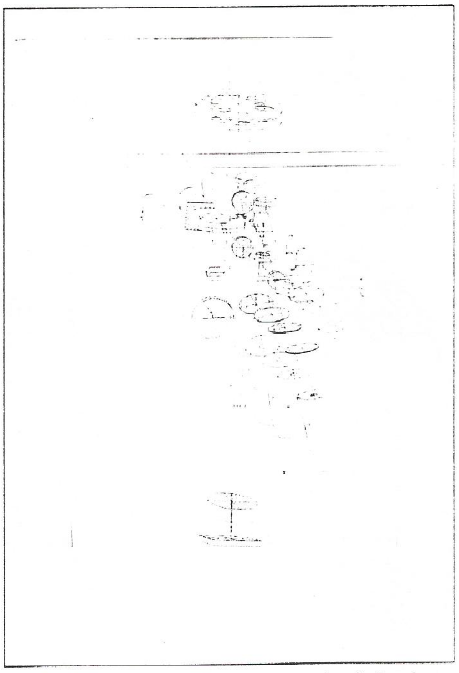


Figure 3: Layout of the optical design. In this figure, optical elements can be distinguished more clearly than in Figure 1.

Table of mechanical slots for uvby part of photometer. Slot edges are given in nanometres.

Filter designation	u	v	b	y
Slots plus filters	332.4 - 368.6	400.6 - 422.2	457.2 - 480.1	534.6 - 563.6
Slots only	335.8 - 366.0	402.4 - 421.3	456.1 - 479.5	532.0 - 560.6

NOT, this corresponds to diaphragms on the sky with diametres of 60, 15, 9.0, 4.5, 3.4 and 1.9 arc seconds, respectively. The largest of these diaphragms is convenient for detailed field inspection.

Two filter wheels provide possibilities for various functions and elements. These include a shutter function and a hole for field inspection. The diameter of this hole is 40 millimetres. In addition, there are four positions free for other elements. Elements possible to mount are neutral filters, polarization filters and wedges for rapid wobbling between programme object and background. The filter wheels accept circular filters with diametres up to 25 millimetres and thicknesses up to 20 millimetres.

Optical elements common to the uvby and Hβ units
In addition to wedges and filters positioned in the filter wheels, optical elements common to the uvby and Hβ units are view finders showing the field before and after the diaphragm. The wide-field view finder covers a field of 3.4 arc minutes. It is equipped with an indexed reticule. This reticule can be illuminated to fit he brightness of the background and the programme object. The diaphragm view finder can be illuminated around the rim, again so as to match the brightness of the object observed.

The choice between the uvby and Hβ/Hα modes depends on the positioning of an entrance mirror. With this mirror out of position, light is directed towards the uvby unit, whilst the Hβ unit is reached with the entrance mirror in position.

Electronics
Electronic elements belonging to the uvbyHβ photometer are a high voltage power supply, signal amplifiers for photomultipliers, control units for motors, a CCD camera system for view finding and a computer for control and data collection. In addition to the six photomultipliers for the uvby and Hβ/Hα channels, there is a seventh photomultiplier monitoring background current. The computer is of PC/AT IBM compatible type.

Software
The uvbyHβ photometer is equipped with three principal software packages. One of the packages is designed for control of various functions defining the working modes of the photometer. Another package takes care of storage of observing data. Finally, a third software package is designed for on-line calculation and display of approximate results. All packages can be run at a variety of speeds, including high-speed modes with a limiting speed corresponding to 2 kHz.

uvby unit
In the uvby unit, principal components are a Littrow lens, a reflecting grating, mechanical slots, concave dichroic mirrors, pass band defining filters, Fabry lenses and photomultipliers. The observer can choose to work either with observing pass bands defined by pre-selecting slots and filters or with pass bands defined entirely by mechanical slots. In the first case, the slots are relatively wide, still participating in the final definition of measurement pass bands. In the second case, the slots are narrower, completely defining rectangular pass bands.

The filters are of interference type and have highly favourable peak transmission values corresponding to 76.5 percent in u, 82.9 percent in v, 88.6 percent in b and 90.0 percent in y. It is noted that these filters have to be used together with a dispersing unit and pre-selecting slots. In the Table, the slots used with and without filters are detailed. For the combination of filters and slots, the slot edges join the filter transmission curves at their 20 percent levels.

The concave dichroic mirrors included have special coatings with reflectivities optimized for the pass bands concerned. The photomultipliers are of type EMI 9789A for the v, b, y and Hβ bands and of type EMI 9789QA for the u band. The photomultipliers have been tested for linearity. They maintain full linearity up to around 10 MHz. It is noted that the adhering electronics has been designed to accept even higher frequencies. The photomultipliers work highly efficiently and stably without cooling.

As an option, grey filters may be inserted in the v and b channels. This may be useful when bright standard stars have to be included for calibration purposes. The standard grey filters available have neutral transmission values of close to 50 percent.

Hβ unit
Following the entrance mirror, the Hβ unit has a beam splitter, dividing the light into two paths. These paths are given 80 and 20 percent, respectively, of the incoming light. In one of the channels, light goes directly to an interference filter, followed by a Fabry lens and a photomultiplier. In the other channel, a concave mirror is added following the beam splitter.

Tentative time schedule
Following final tests and possible minor modifications, the photometer should be shipped to La Palma. We hope to be able to commission the instrument by the end of this year.

NORDBOARD

New communication tool for Nordic astronomers

Peter Linde

Introduction
Since September 1990, a new, computer-based, communication medium is available for Nordic astronomers. It is implemented as a „mail-exploder" at Lund Observatory, using ordinary computer e-mail as its transfer mechanism. Any e-mail sent to specific addresses (see below) is automatically rerouted to everybody on the mailing-list. This mechanism was chosen because of its simplicity and reliability. Currently. about 180 people are reached. In addition, a so called „anonymous ftp" account has been set up on the Lund computer (ASTOL). For users having access to Nordunet via TCP/IP communication,

a limited login can be made to ASTOL in order to send or copy files.

Why?
The intended purpose of Nordboard is to provide a modern, informal and practical communication channel between Nordic astronomers. It is up to the users themselves to decide what the actual usage will be. It should, however, be noted that Nordboard does not constitute a replacement for other media (like this publication). Additionally, it does not carry any official status, and there is currently no guarantee for its future continuation. Contributions should be seen as informal and individual, with no immediate connection to any institution. In spite of this (or perhaps because of this?), many useful purposes can be imagined, including the following:

1) NOT related news and discussion
2) News about other Nordic resources (SEST, ULDA database, etc)
3) Announcements of workshops, seminars, etc
4) Announcements of jobs and/or scholarships in astronomy
5) Software related experiences (regarding MIDAS, etc)

Further suggestions for usage are welcome. It may be noted that current usage has not yet been very high and that more contributions are certainly welcome.

Current organization
There are many ways of organizing this kind of communication. One alternative is a remote login mechanism, where all information is stored in a single machine. Another alternative is to have a structure similar to or even using the USENET Netnews. However, for some astronomers in the Nordic countries, remote login to an Internet host is not yet simple or even possible. The Netnews structure is elegant, but the need for special software for receiving and reading the information is a complication. E-mail, on the other hand, usually crosses between different computer networks without problem. Each receiver gets his own copy and need only master his own e-mail system to access the information.

The currently chosen organization is very simple. Two categories, „nordboard info" and „nordboard disc" have been created, with one mailing list each. The names imply one information category and one discussion category. This scheme can easily be extended if so desired by the user community. As an example, purely national categories could be considered.

The FTP account on ASTOL is intended to be used for larger documents, images, etc, that cannot easily be sent as e-mail.

Using Nordboard
The current user database for Nordboard has been derived from the RGO electronic mail directory, with some additions and deletions. If you want to be added to the list, please send a note with your name and e-mail address to:

„postmaster@astro.lu.se".

If you want to contribute do the following:

1) Write your contribution with your standard editor or possibly with your mail-distributing program.

2) Send the message as a normal e-mail to either of the following addresses:

nordboard_info@astro.lu.se
(for informative messages)
nordboard_disc@astro.lu.se
(for discussion contributions)

If you are not using standard Internet addresses (for instance if you are DECNET-connected), the address syntax will be slightly different. To make sure, ask your system administrator.

Notice that your message will be seen to be distributed from „nordboard-disc" or „nordboard-info", i.e dash instead of underscore. This is to avoid infinite loops of automatically rejected messages. You should always add your own name and e-mail address explicitly in the text. Also, the „reply" facility of your mailing program should not be used.

The „anonymous ftp" facility is used in the following way (for those who are TCP/IP-connected):

1) Enter „ftp astol.astro.lu.se".
2) If successful, ASTOL will answer „Connected to astol.astro.lu.se", etc.
3) ASTOL asks „Name:", you answer „anonymous".
4) ASTOL asks „Password:", you answer „guest".

After the login procedure, you have access to a designated part of ASTOLs file system. Check your local manual for available „ftp" commands (or use the ftp „help" command). Typically, „put" is used to send a file from your machine to ASTOL and „get" to copy a file from ASTOL. If you add a file of common interest, please send also a note about this to „nordboard_info". Current contents include files containing all previous Nordboard messages, NOT information, etc.

If you have further ideas or comments about Nordboard, you may contact me, peter@astro.lu.se (or use Nordboard!).

Data Interchange with the NOT

Peter Linde
Ove Hagerbo

Lots of data
Some of the current users of the NOT find a problem in transporting their data back to their home institutions. The available magnetic tape station allows only about 40 Mb of data per reel. For observers making frequent use of the CCD-based instruments, the amount of tapes produced quickly becomes a practical problem. In view of the further data production increase that can be expected, some new transportation medium must be found. Lately, some efforts have been made to solve this problem.

During the last four years, several new high-capacity storage media have entered the market. Two major alternatives exist today, optical disks and magnetic tape cartridge media. In addition, direct computer links to the NOT are reaching a state where they can be put into practical use.

Optical disk storage
Optical disks exist in various forms The newer generation allows rewriting and functions similar to a normal hard disk, albeit with slower access times (100 ms). Typical storage capacity for one disk is in the range 0.5 - 1 Gb. A major advantage is that they provide on-line access to well structured data in the form of complete file systems. Optical disks seem to be the currently best choice for archival storage. However, the cost per stored megabyte is much higher than for the new magnetic tape cartridges.

High-capacity magnetic tape storage
For users of the NOT, the most urgent need is to provide a practical means for transporting large quantities of data. For this purpose, the new magnetic tape devices, using so called helical scan technology, seem most appropriate. They fall into two categories, 4 mm DAT devices and 8 mm Exabyte devices. Both technologies are rapidly evolving and a choice between the two is far from simple. A rough comparison looks like this:

	8 mm Exabyte	4 mm DAT
Storage capacity	5 Gb	2 Gb
Transfer speed	500 Kb/sec	180 Kb/sec
Search speed	37 Mb/sec	35 Mb/sec
Tape media	Video-8 cartridge	4 mm DAT cartridge
Standardization	De facto standard	Emerging standard
Price	30000-70000 SEK	15000-50000 SEK

Exabytes came onto the market in 1987 and have therefore already become an established standard. Basically, all Exabytes are manufactured by a single source. DAT drives, on the other hand, are quite new on the market, being developed by a variety of manufacturers. The compatibility between these units remains to be demonstrated. However, the backing from major computer companies should result in a rapid growth for 4 mm technology.

Current status
The preferred solution for the NOT must be to combine the need to transport large amounts of data with the wish for compatibility with the user community. Some time ago, Nordboard was used to inquire the NOT community regarding possible preferences.

The responses showed that Exabyte devices existed in several places. It would therefore seem to be the highest priority to connect an Exabyte to the available Hewlett Packard system. This system is the on-site data analysis system, and has 1.2 Gb of disc storage. It is now becoming interconnected to the other NOT computers with a TCP/IP based local area network. However, connecting an Exabyte to the HP 835 presents some practical problems, and they are currently being investigated. Firstly, HP does not support Exabyte themselves, therefore other suppliers must be used. Secondly, the HP 835 system has up to now not supported the SCSI interface, which is standard for Exabyte. Some vendors provide HPIB interfaces, but such solutions seem inefficient and costly. During the summer, SCSI interfaces will however become available to the HP 835 system. Providing the proper software driver can be found, it should then be possible to interface an Exabyte.

On the other hand, 4 mm DAT technology is supported by HP and would be easier to implement. We believe a decision can be taken shortly, so that the current data transportation situation can be alleviated.

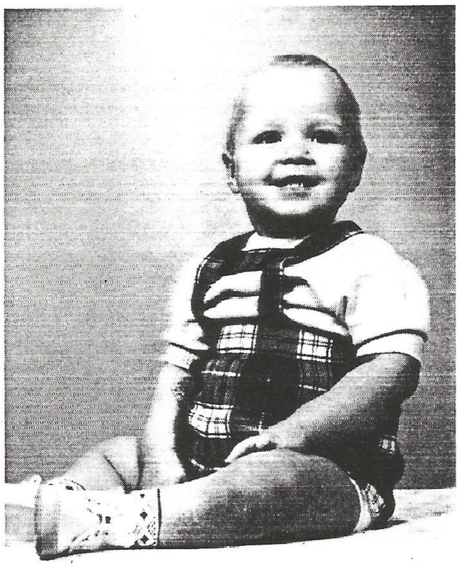
Using computer networks
An alternative means for data transportation is to use computer networks. The plans are to use TCP/IP communication on European academic networks all the way down to the NOT. Real progress has been made in this area lately. Firstly, most NOT users are already connected to NORDUNET, the joint Nordic academic computer network. Secondly, administrative and technical difficulties were recently solved, allowing connection to be made to Madrid, using the corresponding Spanish network, ARTIX.

The ARTIX continuation to IAC on Tenerife is now being set up, simultaneously with the further extension to La Palma and the NOT. The nominal transfer speed will be 64 kbits/s. Actual tests to Madrid have given 1-2 kbytes/s. With some data compression, a current size CCD image can thus be expected to be transferred to home institution computers within three minutes. The final links to the NOT are expected to be in place within a few months, allowing test transfers to be made already in the autumn.

Young Astronomers at the NOT

Students working as staff members at the Nordic Optical Telescope

Hans Kjeldsen



Hans Kjeldsen observing variable stars

Students as staff members

Modern telescopes and observatories are placed on isolated mountains far away from universities and institutes. This means that young astronomers (e.g. Ph.D. students) normally do not have the possibility to experience daily work at a telescope. However, this is not fully true. At the NOT, the staff includes two students, one from Norway and one from Denmark. From January 1990 until April 1991, I have been one of these students.

Daily work

I stayed on La Palma as a part of my PhD studies, and during this period I worked with many aspects of observational astronomy. My main interest has been CCD photometry, and I have, therefore, done a lot of work on the Stockholm CCD and the Low Dispersion Spectrograph. However, my work has not only been on aspects releated to my thesis. Also normal staff work, such as supporting visiting observers and working together with technical staff, has been part of my daily life on La Palma. During my stay on La Palma, I have seen lots of interesting observations and tests (e.g. tests with the Korhonen device).

Students from all Nordic countries

Despite some financial problems, the benefit of my stay at La Palma has been very large, and I strongly recommend other students to take a year on La Palma, if possible. As it is now, only students from Norway and Denmark can be staff members, but I suggest that also students from Sweden and Finland are given the possibility to go to La Palma for more than only a short visit. More students at the NOT would give a quite unique environment, with benefit for both young and older astronomers, and it would also solve a part of the problems due to the small staff.

From Mural Quadrants to Adaptive Optics

-High Technology at NORDITA

VIPs

Sporting its utmost technical resources, NORDITA probed its way into deep space for a week. Arranging a Workshop on Astrophysics with the Nordic Optical Telescope, NORDITA succeeded in attracting a large number of prominent specialists from the astronomy community both in the Nordic countries and from the outside. Especially noteworthy was the impressive display of well-known authorities from the European Southern Observatory, from the Spanish and British communities and from the Large Earth-based Solar Telescope foundation.

Telescopes

Several interesting items were thoroughly penetrated during the Workshop. A number of contributions on telescopes gave breathtaking accounts of frontier developments. These included optics, mechanics, alignment, image quality, active and adaptive systems. Optical and mechanical designs of modern telescopes were penetrated in fascinating detail as was optical figuring and optical testing. Descriptions were given of leading modern facilities in observational astronomy.

Instrumentation

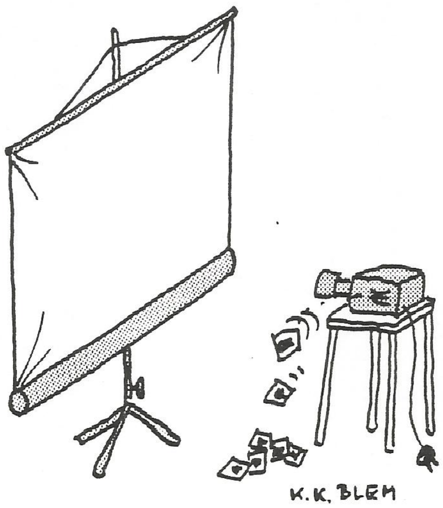
A number of contributions described highly sophisticated auxiliary instruments. Imaging devices were presented as well as photometers and spectrographs. Especially concerning spectroscopy, many of instruments were discussed, covering wide ranges in resolution. Classical and frontier approaches were described.

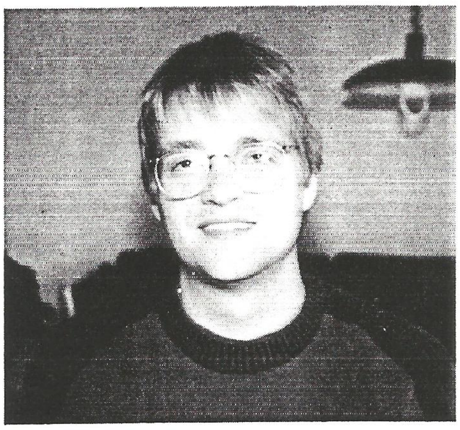
Research Programmes

Together with methods for reduction and analysis of data, samples of recent results testified to a forceful development of astrophysical research based on new telescopes and instruments. These results covered a wide range of topics as well as of approaches. Many contributions dealt with large-scale structures in the Universe.

Extra

In addition, the Workshop programme included one morning of discussions of instrumentation requirements. Special emphasis was given to development of facilities for the NOT community. Finally, also a historical lecture on Tycho Brahe was combined with a visit to the Ole Rømer museum.





Hans leaves the cluster

Stellar clusters get major imprints from the behaviour of their brightest members. The loss of some of these members will inevitably be a considerable loss to the cluster. Recently, Hans Kjeldsen decided to leave the NOT cluster at Cruz del Fraile. Predictably, the loss is severe.

Hans and Anne arrived to La Palma just at the start of the first period of regularly scheduled scientific programmes. The phase was critical and the need for competent staff was heavy. Already from the very beginning of his stay, Hans turned out a true asset to our operation. With solid knowledge and highest spirits, Hans coupled hard work with a most friendly attitude. Colleagues at the mountain as well as visitors were exceedingly pleased as were the telescope and its adhering facilities.

Quickly yet thoroughly Hans learnt to master virtually everything at Cruz del Fraile, from the telescope to the adequate handling of eager tourists. It is hard to imagine what things would have looked without Hans. Hard and shaking. We will never forget how Hans had a special hand on the telescope and its peripherals, on the ancillary instrumentation, on the computers, on their programmes, and on everything else. Be it a linearity or a non-linearity, Hans knew it, investigated it and explained it. From our point of view, we are unhappy with one single item, his decision to go back home to Denmark.

No doubt, we paid Hans richly in terms of hard responsibilities. Many were his tasks and limited his free time. Marvelously, he still managed to pursue his own research work, centred on stellar variability in clusters. At the same time as he systematically arranged the most superb images for visiting scientists, he still managed to get a fair collection of observing data for his own programme. We look forward to the results of his analysis of these results.

At the time of writing, Hans, Anne and Signe have already left La Palma. Our gratitude is great. In addition, we extend our hope for a successful repatriation in wild Denmark. Especially, we hope that Hans will be able to get some rich and most deserved scientific benefits of his time at Cruz del Fraile, and that Anne will be able to continue successfully her studies of the more subtle aspects of our environment. In parallel, we wish Signe a new exiting life at home in Aarhus.

Deep Photometry of Large, Nearby Galaxies

Steven Jörsäter and Magnus Näslund

Background

One of the most central problems in modern astronomy shows up most clearly in disc galaxies, the riddle called dark matter. The discs normally show an exponential drop in surface brightness with radius, and this law is generally quite well obeyed. Yet, rotation curves do not, with few exceptions, show any significant drop in rotation velocity at the outer borders, not even in those cases where the rotation curves can be traced out to many optical scale-lengths using the HI 21 cm line.

Present photographic photometry typically reaches a limiting surface magnitude in blue light of 28 magnitudes per square arc second. It is of great importance for the understanding of disc galaxies, and of dark matter in particular, to be able to trace the disk and its colours to fainter levels. It has for instance been suggested that galaxies may be surrounded by discs with longer scale-length and higher mass to light ratios than the ordinary discs and they would show up only at very faint levels.

Until recently, most photometry of galaxies has been made using photographic techniques, the main reason being that the CCD systems in the past have not provided a sufficient field of view. To be able to improve on the best photographic work requires an extremely accurate sky subtraction (better than 1 in a thousand) and a correspondingly accurate flat field subtraction. Although resolution is in itself not a primary condition, it is still important - blank sky is everything but blank and the ability of removing background and foreground objects is directly related to the resolution.

Improving on existing photographic photometry of galaxies is not easy but we decided to make a try using the excellent imaging properties of the NOT and the dark skies of La Palma. In order to be able to do something with the present rather limited CCD camera system we built a focal reducer which is described in a separate article in this issue of the NOT NEWS.

Our project

We have selected a sample of spiral galaxies for which the velocity field has been well observed in HI and/or in optical emission lines. We plan to obtain images in B, V and I as well as

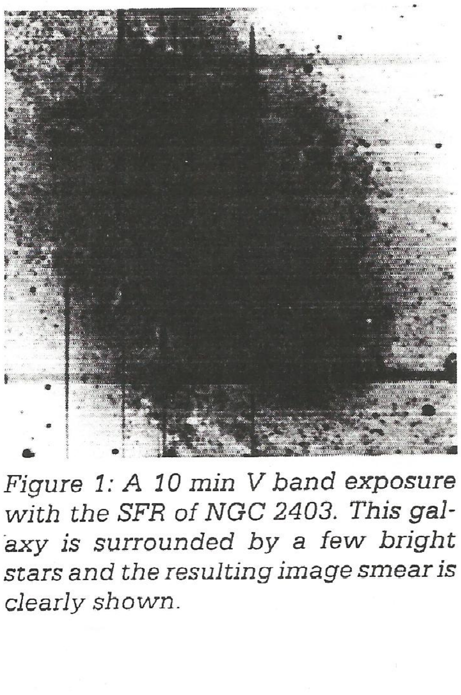


Figure 1: A 10 min V band exposure with the SFR of NGC 2403. This galaxy is surrounded by a few bright stars and the resulting image smear is clearly shown.

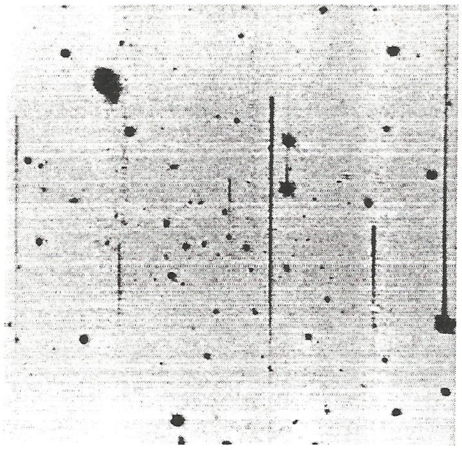


Figure 2: A 15 min V band exposure of a „blank" field. This gives an idea of the problems encountered in finding the night sky flat fields and the reference night sky level. Residual image smearing from bright stars is also present.

in Hα. Here are a few galaxies presented (see also figures).

UGC 2885: This is a very large, regular and symmetric Sc galaxy. It is known to have a flat outer rotation curve, but the neutral hydrogen does not extend very far outside the optical radius R25. H I is traced out to 4-5 disc scale lengths.

NGC 2403: Resembles M33 in appearance and in stellar content, and contains many known H II regions. The rotation curve of this Sc galaxy extends to more than twice the optical size, or to about 9 disc scale lengths (Fig. 1).

NGC 2775: An Sa galaxy seen almost face-on. An optical rotation curve showing a flat form has been published.

NGC 4565: A well known edge-on Sb system, with a warp in the optical image as well as in the outer parts of the H I image, which exhibit a slow decline in rotation velocity (See Picture on front page).

NGC 4736: Also known as M94. This one is of type Sb and differs greatly in surface brightness between the nucleus and the outer parts. The rotation curve seems to decline at the outer edge.

Flat fielding

The main problems in this project concern the night sky and flat fielding. In order to get accurate flat fields we use the night sky itself. This means that we are taking multiple exposures of „blank" fields around the galaxies we are observing. A substantial amount of image processing is then required in order to remove objects. Dawn/dusk flats are used as reference. Needless to say, this method requires lots of observing time (subtle hint to the OPC).

Sky subtraction

Finding the correct sky background is the most critical task. We do this by making overlapping mosaics that extend beyond the „edge" of the galaxy. In this way we can keep track of the time variation in the sky level. The problem of determining the sky „level" is also non-trivial. We are trying to describe the contaminating stars and galaxies in a statistical way.

Results

Our project is still in its beginnings and lots of work remains. Extensive amounts of image processing is required in order to reach the low light levels necessary. The figures give an idea of the performance, however, and it looks quite promising. We will come back to NOT NEWS with some hard core results when we get them.

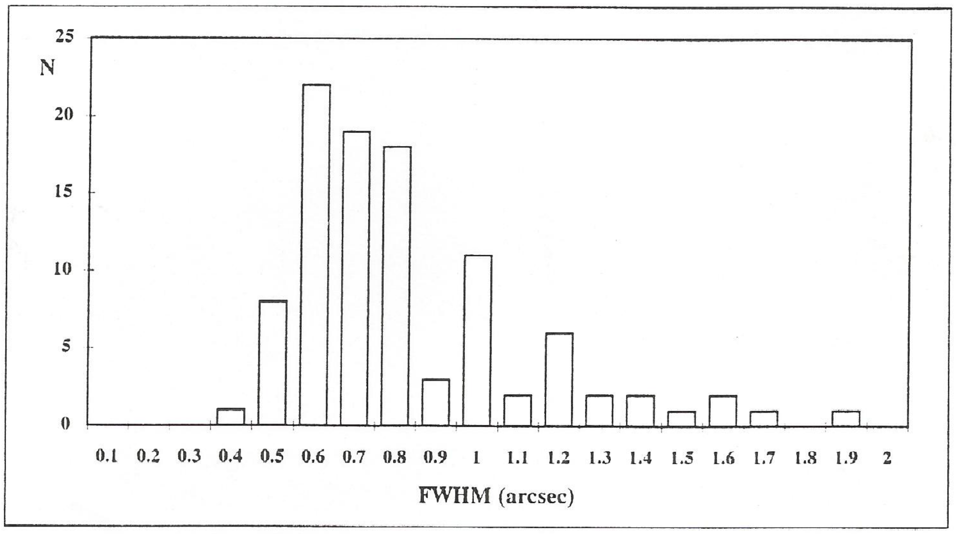
Some Seeing Statistics

Few things seem to arouse emotions of astronomers as much as those caused by discussions of image qualities of telescopes. At the same time, few things are spuriously treated as much as image quality statistics. Critical visitors having bad luck sometimes relate terrible stories. At the same time, project responsibles may well feel tempted to select rather different samples for their argumentation. Fairy tales tend to dominate the market.

We have said so before and we repeat it. Before all installations concerning thermal control are in place, image quality statistics will remain plagued by bias. Still, under pressure of increasingly pushy discussions, we have decided to give some raw statistics. We have chosen the period following optical alignment in connection with the installation of our new wavefront sensor.

The optical alignment of our telescope took place on March 24, 1991. For our statistical sample, we have used the period starting this night and ending June 1, 1991. For this period, we have included all FWHM seeing data recorded with the CCD camera.

In the figure attached, the distribution of seeing data is given. One single observation (at a terrible FWHM value of 2.5 arcsec) falls outside the scale in the figure. The median value for the seeing data displayed is FWHM = 0.75 arcsec. We note that the sampling period is short, only slightly more than two months. Thus, the corresponding statistics have to be taken with some caution. Still, we feel like insisting that with the active thermal monitoring and control system pending, seeing data could be worse.



Histogram showing FWHM seeing at the NOT in a period from March 24 to June 1, 1991. Recordings with the standby CCD camera have been used. The median value is FWHM = 0.75 arcsec.

Control System News

Niklas Holsti and Hannu Karttunen

Introduction

One of us (NH) is now leaving NOT to continue his career in computer science. HK took over his duties at the end of May, and will now be happy to receive all your complaints concerning software problems. We will here briefly summarize the recent changes and the evolution of the computer environment in the near future.

Networks... current state

The NOT facility now enjoys a local area network. Installed in March this year, the network posed some interesting challenges, such as the problem of connecting an Ethernet to a rotating building, lightning protection, and the noisy electrical environment in the telescope building.

The network components were selected and installed by Michael Jensen and Kim Steenberg from the Nordic Telescope Group. Logically, the network is a single Ethernet that reaches most rooms in the telescope building and the service building. The two buildings are connected with an optical fiber.

Inside the service building, the net uses a thin coaxial cable. One or two transceivers are provided in each office room and in the electronics workshop. The repeater box has capacity for up to three Ethernet segments. One segment is intended for the wide-area network, under construction by the IAC and to cover both the La Palma and Tenerife observatories.

The optic fiber cable from the service building ends in the basement of the telescope building. The „AUI" (digital electronic) signals to and from the optical transceivers run through the slip rings in the center of the telescope azimuth axis. Two slip ring contacts are used for each signal to avoid momentary electrical breaks during building rotation. The slip ring system was tested in Denmark and has given no problems on La Palma.

Coaxial cable is not used in the telescope building. Instead, optical fibers radiate from a central („star") repeater located in the „azimuth" box below the telescope. In the control room and the electronics room, the fibers terminate in fan-out units with capacity for eight AUI connections in each room. Single transceivers with AUI connections are mounted on the instrument adapter, the telescope fork, and in the dome.

Both the on-line telescope control computer and its stand-by copy are connected to the network, as is the HP 835 work station in the service building. We hope that eventually all instrument control computers will be connected. At the moment, only the HP Vectra PC of the Aarhus Low Dispersion Spectrograph is connected. The telescope control computers support file transfer (FTP) and remote login (telnet). The HP 835 and the HP Vectra also have network file access (NFS).

The network has already been very useful in transmitting LDS images to the HP for processing and has, finally, made it possible for observers to bring their object catalogues on PC diskettes. Telescope and weather status can now be displayed on a terminal in the service building, very convenient for those (rare) nights of bad weather. Of course, the network is also a prerequisite for any future remote observing system.

Networks...future

Later (during this year, we hope), all computers on the Roque de los Muchachos will be connected to a central node located in the Residencia. And, eventually, we will obtain access to the rest of the world via Internet.

The network access will greatly improve our communication possibilities with the outside world, when we can exchange e-mail instead of sending letters (probably carried by pigeons) or shouting across the awfully bad telephone lines.

The work station will probably be the only computer directly accessible through the network. The control computers must be reserved for running the telescope. Also, the HP is the only computer with an operating system that can be made relatively secure against inquisitive hackers. This increased security requirement also means a little more responsibility from the users, who will have to protect their accounts with non-trivial passwords.

Telescope Control from Instrument Computers

During the infrared observing run in March, we tested the interconnection of an instrument control computer and the telescope control system for the first time. The IR camera MicroVAX was connected using a serial port as a „pseudo-user" of the telescope control system. The MicroVAX sent offset commands for on-off „nodding" and the telescope control system informed the MicroVAX when the telescope was tracking stably. After some initial problems due to the difference between the Finnish and French interpretations of the word „tracking", the communication worked well. Of course, the connection can now be done over the Ethernet, if desired.

Recent Changes in the Telescope Control System

Only a few visible changes have occurred in the telescope control system. Guide stars that have been found by scanning the field can now be entered in the catalogue. The command „probe-coordinates" computes the equatorial coordinates of the centre of the guide TV image and stores them in the catalogue.

The autoguider program has been moved to run in the same processor as the altitude and azimuth servo programs, to reduce the delay in autoguider corrections. The autoguider algorithm has been changed in several respects. It now measures the position of the star using the centre of gravity of the row and column sums of the aperture, rather than the sums of the four quadrants of the aperture. A seeing estimate is also computed. Finally, the autoguider corrections are derived from a PII algorithm, which should be faster and more stable than the old I algorithm. The new algorithm was designed by Kim Steenberg.

We are still investigating and improving the friction-roller coupled incremental encoders. Without them, tracking is not yet satisfactory.

Tracking has also been worsened by timing problems in the control software, which fortunately seem to have been overcome.

Future Plans for the Control System

The programs controlling the telescope finally seem to be approaching a reasonably functional system. The following improvements will take place probably during this summer:

- Timing problems have often caused „tracking lost“ errors and jerky motion of the dome. A new version of the control program, already developed by NH, will compute a sequence of future positions to keep the altitude-azimuth servo program busy, even if some other task momentarily slows down the master processor.

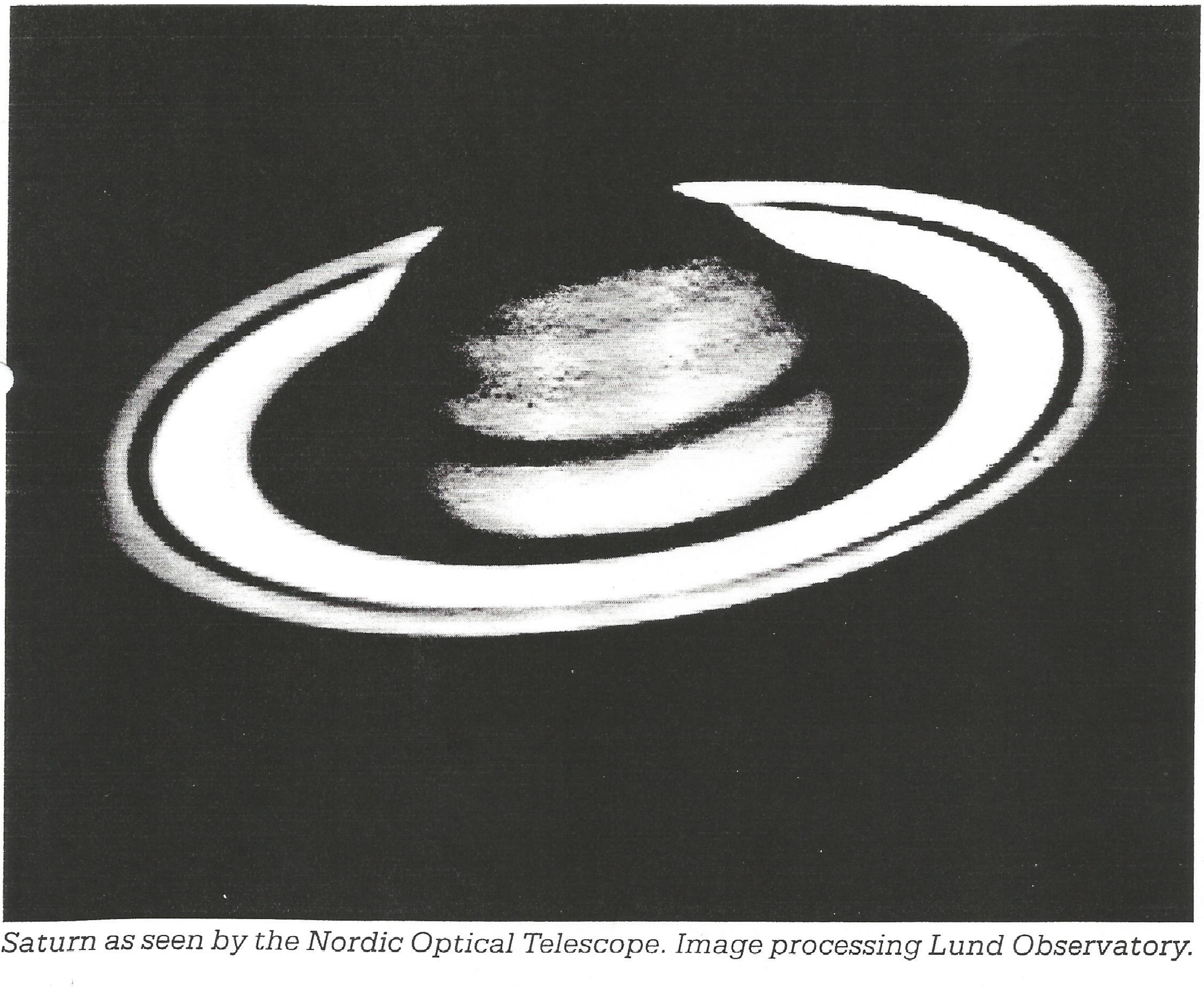
- The user interface program will be modified so that it can read commands also from a disk file. Thus, observers can prerecord their observation programs on a diskette. We would like to remind that it is already possible to write object catalogues on a diskette and transfer them from a PC to the control computer. The figure shows a sample catalogue, which is a free-format text file. The only restriction is that the name of the object occupies column 1-9 and column 10 must be empty.

```
OBJECT-1   14:13:20.10 11:43:38.1 M
OBJECT-2   20:16:55.40 11:17:45.5 M 2000.0
OBJECT-3   16:34:59.10 26:42:06.0 A
UFO        23:45:45.70 0:40:38.0 M 1950.0 1.5000 0.2000
```

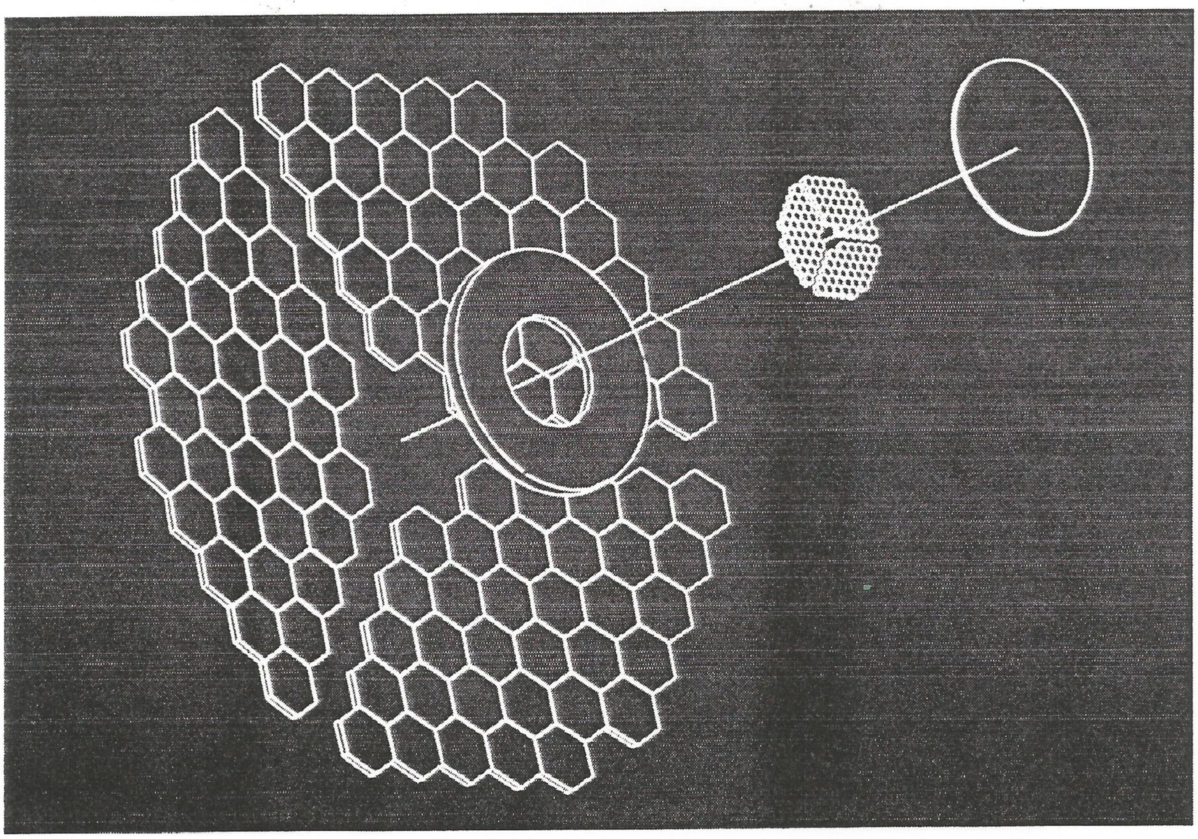
A sample catalogue. Each line can contain the name of an object, its right ascension, declination, coordinate type (M-Mean at epoch, A=Apparent of date), epoch (default is 1950.0) and proper motion in right ascension and declination (arcseconds per century). The three last columns are optional.

An additional slave processor will be installed to run the program controlling the active mirror support system. The program will be developed by Ingvar Svärdh.

There are still some problems, which we are well aware of, although it is not exactly clear now, how much is due to the hardware. Tracking and pointing still remain as the main problems. Hopefully, the control system will otherwise work satisfactorily enough to leave time to analyze these problems more carefully.



Saturn as seen by the Nordic Optical Telescope. Image processing Lund Observatory.



One possible optical design of an Extremely Large Telescope

100 NOTs in One Go

Swedish Research Council convinced

Relaxing all safety belts, the shameless editor and coeditor of the present publication have sported a project aimed at a study of new methods for design and construction of an extremely large telescope (ELT). Leaving also the safety chair, the editor asked the Swedish Natural Science Research Council (NFR) for their support of a pre-project study. Following a close look at our plans and a hearing, NFR now wants to support such a study and discussions will be forthcoming.

500 square metres dish

Plans are centred on a telescope featuring a segmented single dish with a reflecting surface of close to 500 square metres, or the equivalence of a 25 metre monolithic mirror. Tentatively, 102 hexagonal segments, each with a size of 2.5 metres, define a spherical light collecting surface. This sets the scene for mass production replica techniques and for a low-cost solution. The low-cost profile for the mechanics and the building is further emphasized by the choice of a fast optical system.

Beam steering of segments

Naturally, a highly curved spherical mirror close to 30 metres in diameter produces massive spherical aberrations. This is accepted and a three or four mirror design is used to correct for these aberrations. The figure attached shows a tentative design possibility. Both the primary mirror and the fourth mirror are segmented with a 1:1 correspondence. The small segments can be beam steered in tilt and piston at high frequency.

As a reference for the beam steering system, a wavefront sensor should be used. Even with a reference star falling outside the isoplanatic field, correction can be made for gravity deflections, thermal deformation and effects of wind buffeting. With this type of live optics, it seems possible to combine a large light collecting surface with high image quality.

Realization

Further considerations include a frame/truss structure for the dish and tripod suspension of the second, third and (optionally) fourth mirrors. Two large horse-shoe bearings and an azimuth table are foreseen for telescope drive as well as a small and simple enclosure. We suggest that aluminization of mirror segments is made on a continuous basis. This is an attractive solution, given a limited number of spare segments and the fact that segments are identical.

We intend to perform the prestudy as a collaboration between the Lund Observatory, the Nordic Telescope Group and external consultants.

Large field CCD camera

Just in time for a press stop, the galaxy groups at Stockholm and Uppsala have been given SEK 865000 for purchase of a large field CCD camera, including Dewar, electronics and control computer. The camera will nicely fit our forthcoming Ford Aerospace 2000x2000 CCDs. Present news on these chips are most encouraging. There seems to be every reason to come back on this topic.