

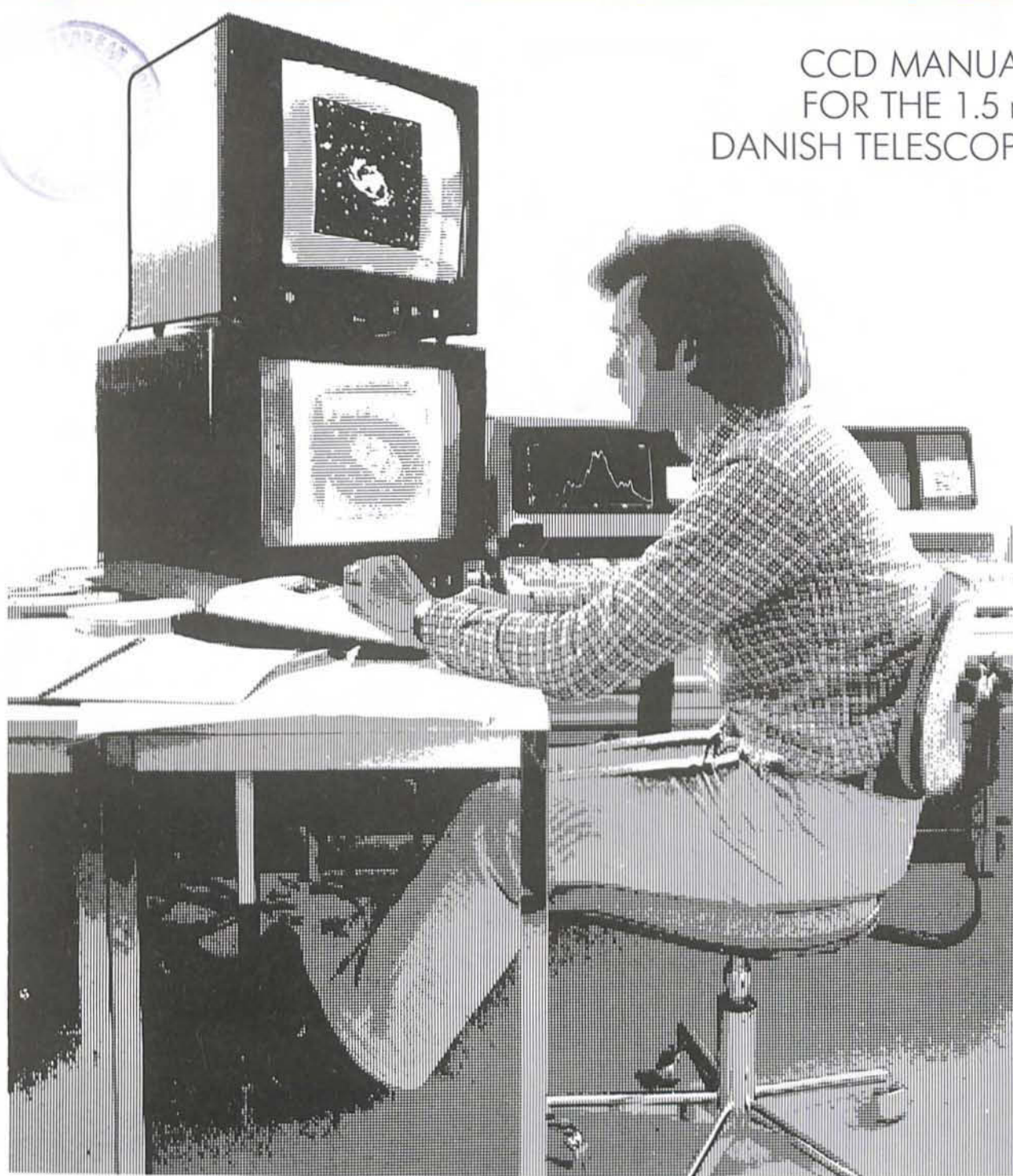


EUROPEAN SOUTHERN OBSERVATORY

# OPERATING MANUAL

No. 3—April 1985

CCD MANUAL  
FOR THE 1.5 m  
DANISH TELESCOPE



EUROPEAN SOUTHERN OBSERVATORY

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CCD MANUAL  
FOR THE 1.5 m DANISH TELESCOPE

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ESO OPERATING MANUAL No. 3

April 1985

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## 1. THE 1.5 M DANISH TELESCOPE

### 1.1 General rules for telescope and computer use

#### 1.1.1 Telescope safety

During CCD observations the telescope is used exclusively with the tube to the West of the pier ('West zenith'). The microprocessor safety system plug No. 5 must be engaged.

The cryogenic camera is mounted at the Cassegrain focus, under the filter/shutter unit M.E.K. It is connected to the control units by a number of cables. Hence, it is essential that great care be taken when operating the telescope.

#### 1.1.2 Day-time use of CCD computer

During the morning hours from 8 00 till 14 00 local time, the CCD computer is reserved for use by ESO staff and for service. Potential day-time users shall, however, arrange with the observer in order to minimize interference. Instrument change, including filter change, is normally carried out in the time interval 10<sup>h</sup>30<sup>m</sup> to 15<sup>h</sup>00<sup>m</sup> local time.

#### 1.1.3 Control room

Telescope control and picture acquisition is done from the second floor of the Danish 1.5 m building, below the observing floor. To avoid heat building up in the control room and in the ground floor kitchen where part of the electronics is located, the ventilation system should be turned-on most of the time. It sends a cold breeze through the rooms, so be sure to dress for open air observations.

#### 1.1.4 Assistance at telescope

It is the responsibility of the night assistant to ensure the safety of the telescope and the CCD. He is authorized to stop observations and close the dome according to ESO rules. The night assistant will do the pointing of the telescope, operate the Quantex TV camera and set up the automatic guiding. He is not expected to operate the CCD system.

The Operations Group may be called upon to prepare the telescope for day-time acquisition of flat fields.

### 1.2 Telescope setting

The telescope pointing model allows blind pointing to an accuracy of about 10" within a zenith distance of 40°. This assumes that a recursive procedure has been used when initialising the telescope. To achieve an even higher, 'half-blind' pointing accuracy, the following routine can be recommended:

- Provide high precision coordinates for the object to be observed. Any epoch will do. Notice, however, that the telescope control program does not allow for proper motion.
- Select a Perth 70 star with negligible proper motion as close to the object as possible.
- Move to the Perth 70 star and measure the error. Do NOT 'correct coordinates'.
- Move to the object and execute the pointing correction just measured.
- Move the guide probe to the precalculated X,Y values. Appearance of the guide star at the expected position confirms the pointing and there is then no need to check with finding charts.

## Introduction

This manual concerns an ESO CCD camera at its present installation at the 1.5 m Danish Telescope at ESO/La Silla. Contributions from several visiting astronomers are gratefully acknowledged. Further comments and suggestions are welcome. Write directly to the author.

Reference is made to

- ESO Users Manual no.3: Danish 1.5 m Telescope and Auxillary Equipment, Garching, January 1983.
- ESO Users Manual, Garching, April 1983.
- IHAP Manual, Garching, June 1983.

The detector described in this manual may, in the near future, be exchanged with one of improved operating characteristics.

In the present text the file-number symbol '#' appears as '\$'.

- Start autoguiding.

In the moment an exposure is started, the telescope coordinates are transferred via the computer link to the CCD/IHAP computer and recorded for later inclusion in the file header. The coordinates are corrected for refraction and are apparent places. They have not been calculated back via the pointing model.

### 1.3 Telescope focusing

In combination with the CCD, the telescope can only be focused by the acquisition of a special focus image. How to obtain and analyse this is described in Sections 3.4.1 and 3.4.2.

### 1.4 Automatic guiding. Selection of guide stars.

Guiding can only be done using the automatic guiding system. The stability of this will normally permit observation up to 45 minutes duration, but occasionally even much shorter exposures may be trailed by approximately one arcsecond. The observer is supposed to supply precalculated guide-star coordinates. The manual for the telescope gives several methods for finding these. Additionally, a computer program has been implemented at the computing center. It searches the SAO catalogue for suitable guide-stars. Notice that not all celestial positions has a useful SAO guide star. A request form is included in this manual as Appendix 3.

### 1.5 Sky coverage

With the tube West of the pier, sky coverage is as shown in the telescope manual, figure 2, with the added constraint that no object can be pointed in the corner West of hour angle  $2^h 10^m$  and South of declination  $-66^\circ$ . During tracking, the telescope may enter this corner in the declination range  $-66^\circ$  to  $-71.5^\circ$ . A warning from the micro-processor safety system may be killed by the night assistant. Tracking stops if the corner is approached South of declination  $-71.5^\circ$ .

### 1.6 Optical filters

#### 1.6.1 Filter installation

The set of filters currently mounted is listed in the telescope log book. Optical filters are installed in the filter/shutter unit M.E.K. before the CCD is mounted at the telescope. No change of filters will be made during an observing run and we strongly recommend that observers inform ESO well ahead of their observing time so that all filters are put in place when mounting the CCD at the telescope. The reason for this is that every time the CCD is dismounted, there is danger that dust particles will settle on the entrance window, ruining future usefulness of old flat fields. Also the focus scale zero point is likely to shift.

Filter wheel 'A' has space for 13 filters of maximum dimension 60 mm diameter, 'B' for 7 filters of size up to 110 mm diameter. Each filter wheel must be left with an empty position through which filters in the other wheel can be viewed. The empty positions are normally A=0 and B=0. For both wheels, the maximum filter thickness is 10.5 mm. Intermediate flanges exist for 50 mm circular filters to be installed in filter wheel 'A' and for 2 inch square filters to be installed in filter wheel 'B'. One inch square or circular filters should not be used since the corners of the CCD will be vignetted.

#### 1.6.2 Neutral density filters

Two neutral density filters are semipermanently installed in filter wheel 'A'. They serve to extend the useful range of illumination



levels, in which flat field and focus exposures can be done. The nominal densities are 1.0 and 2.2.

#### 1.6.3 Available colour filters

Standard filters used with the CCD camera are Johnson B,V and Gg, Gr, Gi, Gz. The latter were supplied by J. Gunn. The use of an available Johnson U filter is not recommended because of low top transmission, and a significant red leak. For very faint object work, two wide passband filters are available: an RG665 and a 'cold' filter. They transmit above 665 nm and below 780 nm respectively. In addition to the standard filters, all filters from the 3.6 m Gascoigne corrector and all two inch (square or circular) filters less than 10.5 mm thick may be used, provided that intermediate fittings are constructed.

Visitors bringing own filters should notice that red blocking is necessary up to 1.1 microns, the limit of the CCD sensitivity.

#### 1.7 Image shift between exposures

To minimise the influence of instrumental effects, it can be useful to divide long exposures into two or three shorter ones, each one shifted slightly with respect to the others. This is, however, contrary to the wish of diminishing the influence of a constant amount of read-out noise per picture! The automatic guiding system would normally not allow this. However, a special by-pass has been constructed so that the autoguide probe can be moved in 10-micron steps during autoguiding, thereby imposing a compensating motion of the telescope. The controls for this facility are placed on the adaptor control panel and must be reset after use. In order that individual exposures can be added pixel for pixel (in principle without fractional pixel shift), the telescope offset should correspond to an integer number of pixels, each of which is 30 microns across. To offset next exposure by  $n/3$  pixels in X and  $m/3$  pixels in Y, the following operations should be done:

- Put autoguide probe motion controls into 'special'.
- Push the X+ (but not the X++) button 'n' times.
- Push the Y+ (but not the Y++) button 'm' times.
- Push controls back to 'normal'.
- Start next exposure.

#### 1.8 Seeing records

Since January 1981, the 'seeing' has been recorded at the 1.5 m Danish telescope at the beginning and end of each night. A variety of methods have been used. With the installation of the CCD it became possible to do quantitative measurements. Since September 1982, the measurements have been done in the way described in Section 3.5. The histogram reproduced as fig 6 shows all data collected in two periods.

## 2. CCD SYSTEM

### 2.1 Cryogenic camera

The CCD is mounted in a cryogenic camera which holds two litres of liquid nitrogen. This can keep the detector cooled to 150 °K for about 48 hours. If, exceptionally, the cooling should be inefficient, call the Operations Group (phone 93 followed by paging code 34 or 54). Preparation of the camera for a new observing run includes a 24-hour pumping period, and a 4-hour cooling period.

The entrance window to the dewar is a 4 mm thick, uncoated quartz plate. The chip is 7 mm behind the exterior surface. An iris shutter, 60 mm diameter is placed about 10 mm in front of the same surface. The operation of this shutter is controlled by the CCD software.

### 2.2 Hardware

The CCD acquisition program runs on an HP 1000 E-series computer with 512 kbyte memory. The operating system is RTE-4B. It is equipped with the following peripherals: system terminal (HP2645A), CCD/IHAP terminal (HP2645A), graphics terminal (HP2648A), plotter (HP 7221B), image display memory and monitors (Ramtek), printer (Centronix), hard copy unit (Versatec), disc drive, magtape station (1600 bpi), and Camac. The latter unit houses modules for: CCD temperature control, filter wheels rotation, communication with the CCD microprocessor, and for image transfer. The use of plotter and Versatec copier during night time is not recommended as occasionally they may hang up the system.

### 2.3 CCD chip size, image scale and orientation

The present CCD chip is an RCA CID53612, ser. no. J 587BT-21B. It is a thinned, buried-channel, back side illuminated device. The read-out time is approximately 8 seconds. The active area consists of 320 by 512 pixels, while an additional 17 columns and 4 rows are over-clocked. The pixel size is 30  $\mu$ m which at the plate scale of the 1.5 m Danish telescope corresponds to 0."47. The standard orientation of the CCD camera implies that the long side is North-South. On the Ramtek displays, North will be up and East to the right. Use the IHAP command 'REVERSE' to inverse the East-West direction. Only in exceptional cases will the CCD be mounted in other position angles and only if all other observers in the run agree. This is to avoid any change in the flat fields due to accumulation of dust.

### 2.4 Conversion factor, dynamic range, read out noise

With the standard gain setting, the conversion factor between electron/hole pairs and A/D converter units (ADU) is 17.8. Other gain settings are in principle possible, but require changes in the micro-processor Forth program. The A/D converter saturates at 16383, close to the maximum charge capacity of each pixel. If a pixel is overexposed, the charge will spill over along the columns, i.e. along the direction of image read-out.

The zero signal read-out noise is approximately 85 electrons or 5 ADU. Future chips are expected to have considerably lower read-out noise (To determine this value in picture \$n, do the IHAP-command 'SAMPLE, \$n, X150, X160, Y250, Y260' to get the mean value and scatter in the middle of the picture).

### 2.5 Sensitivity versus temperature

The long-wavelength limit of the CCD sensitivity curve moves towards shorter wavelengths with deeper cooling. Near the standard oper-

ating temperature of the CCD (150°K), the sensitivity in the G<sub>2</sub> band drops by about 1.3 percent for each degree further cooling. In shorter wavelength bands the sensitivity loss is much smaller.

## 2.6 Electronic bias

The signal from the CCD is given a certain offset before it is converted to digital values. This so-called bias level must be subtracted from any exposure as a part of the reductions. The bias level is slightly variable, possibly as a function of the temperature of the CCD electronics. It is not known if the variability affects only the offset value or also the scale of the signal. In the present system, the bias level is in the range 180 to 200. For not too high sky background levels, the actual value may be extracted from column 1 of any picture. The operation to do this is SAMPLE,\$N,X1,X1,Y50,Y450. The result is available in global 39.

## 2.7 Pixel binning

During the read-out process but before amplification, the charge from several pixels may be combined. The read-out noise characteristics of the combined pixel will be nearly unchanged. Binning factors from 1 (default) to 10 are possible in X as well as in Y. To change the binning factors, use soft key operations: (MAIN MENU) > 'HARDWARE OPTIONS' > 'CHANGE BINNING'.

### 3. CCD OPERATION

#### 3.1 Start up and close down procedures

See Appendices 1 and 2.

#### 3.2 CCD picture acquisition

Except for some operations which should be done at start-up (see Appendix 1), the CCD acquisition program is rather self explanatory. The soft key tree gives rapid access to most of the normally used commands, starting with the 'MAIN-MENU'. After pushing 'EXPOSURE', the observer can choose between various types of exposures:

- Regular : See 3.3
- Flat field : See 3.8
- Dark : See 3.11
- Focus exposure : See 3.4
- Exposure sequence : See 3.9

In all cases, most parameters will be taken over from the previous exposure of the same kind. However, the identifier will have to be given again (blank not accepted) and the option for magnetic tape transfer is always preset to 1 (except for focus sequence pictures which have no option for magnetic tape transfer). Any exposure can be specified for up to 20 repetitions (default: 1). The exposure sequence can execute up to 16 times 20 exposures.

The requested exposure time may be changed at any time during an exposure by typing 'EXTM,<seconds>'. The parameter may be positive or negative. If the remaining exposure time becomes negative, the image will be read out immediately, conserving the picture (contrary to the 'ABORT' option). The 'EXTM' command should be used with restraint to avoid the need for extra flat fields.

The present version of the CCD program offers only little control over the telescope. Offset commands with direction indication are issued during the acquisition of a focus exposure. Telescope control is reset to 'guide' after the focus sequence. Communication the other way consists merely of the transfer of telescope coordinates to the data file header.

Also of interest to the observer are the following CCD-commands, which cannot be accessed by soft-key operations: DATE : to check universal time, EXTM : to change the exposure time of the ongoing exposure, and !!!! : to pause an exposure.

#### 3.3 Regular exposures

The exposure type 'regular' is normally used for 'science exposures' but is also useful for various tests. The parameter definition field includes the following :

- |                        |   |
|------------------------|---|
| Identifier             | : Predefined to 'blank', must be set by observer. Can be changed during exposure.   |
| Magnetic tape transfer | : Predefined to 'yes'.  |
| Exposure time          | : Predefined to that of last exposure. The exposure time limit for a regular exposure is 1 <sup>h</sup> 59 <sup>m</sup> 59 <sup>s</sup> , but an ongoing exposure can be extended by the 'EXTM,<seconds>' command. The remaining exposure time must at any moment be less than 5 <sup>h</sup> 50 <sup>m</sup> . |
| Filter positions       | : Predefined to those of last exposure.   |
| Telescope coordinates  | : Transferred from TCS-computer at start of exposure.   |

Autoguide coordinates : Predefined to blank; may be set by observer  
 Comments : Three lines predefined to blank. Can be set before the start of the exposure, and changed during the exposure.  
 Repetition parameter : Range 1 - 20, default 1 (only one exp.)  
 Automatic BATCH job : 0 No BATCH job (default).  
                           1 AVERAGE (see Section 5.3.6)  
                           3 KDISP (see Section 5.3.1)  
                           4 - 8 User defined (see Section 5.3.8)

### 3.4 Focusing

#### 3.4.1 Focus sequence acquisition

The telescope is focused on the CCD by moving the secondary mirror along the optical axis. A special handset controls this operation, but computer operation is under preparation. Focusing can most efficiently be done through a neutral density filter (during twilight) or in unfiltered light (dark sky). The focus sequence acquisition may start as soon as the sky level has fallen below ca. 1000 ADU per 30 seconds. This happens ca. 10, 30 and 36 minutes after sunset in the ND2.2, V and Gr filters, respectively.

Several filters have known offsets from Gr or no filter. These values are listed in Table 1. Visitors bringing own filters should arrange for the focal plane shifts to be measured prior to their observing run. Table 2 is a list of standard focus fields containing stars with a range of magnitudes. They are useful for focusing in filters of all bandwidths.

The acquisition of a focus exposure is made easy by the CCD control program. The soft key operations 'MAIN MENU', 'EXPOSURE', 'FOCUS EXPOSURE' gives access to a parameter definition field in which the most important parameters are the following:

|                                 | Recommended value  |
|---------------------------------|--|
| - Exposure time per step        | Minimum 30 seconds.  |
| - Number of focus steps         | 12   |
| - Focus start                   | in good seeing: $6410 + 14 \cdot t + dfoc$<br>in poor seeing: $6360 + 14 \cdot t + dfoc$ |
| - Focus step                    | in good seeing: 10<br>in poor seeing: 20   |
| - Offset size                   | 7 (arcseconds)   |
| - Offset direction              | 3  |
| - Automatic BATCH job execution | 2 (=FOCUS)   |

where 'dfoc' may possibly be found in table 1, and 't' indicates the dome air temperature. At start, two error messages are possible, see Section 5.2.

During a focus sequence, the telescope moves in such a way that when the image is displayed on the Ramtek monitor, the last sub-exposure is to the right, provided that the telescope is in 'west zenith', and provided that direction '3' has been selected. The direction parameter must be '3' in order that BATCH, FOCUS can work.

#### 3.4.2 Focus sequence analysis program

Normally, the focus image analysis program FOCUS is requested for automatic execution immediately after the image has been acquired. If the request was forgotten, the program may be called, typing BATCH, FOCUS, ,(<\$f>,<n> where 'f' is the file number of the focus file, and 'n' is the number of steps in the sequence minus one. If the file number is not given, the program will default to the highest numbered image. Also the KDISP batch job has a facility for measuring image di-

ameters. Any newly determined focus value should be recorded on a special form which is placed in the control room. When finally setting the value on the handset, please approach the setting from below.

#### 3.4.3 Focus drift with telescope temperature

For each degree increase in the dome air temperature, the telescope focus should be increased by 14 units. One unit corresponds to a change in image diameter of 2.0  $\mu\text{m}$ . It is possible to refocus during an autoguided exposure without lateral image motion.

#### 3.4.4 Focus as a function of telescope position

See ESO Users Manual no. 3, Section 1.9 and figure 4.

#### 3.5 Seeing measurements

The easiest way to measure the image size is to type BATCH, KDISP,, <\$f> where \$f is the number of the file to be examined. If \$f is omitted, the program will default to the highest numbered file.

Normally, the 'seeing' is recorded on a special form at the start and end of the observing night. The data accumulated since September 1982 are shown in figure 5.

#### 3.6 Exposure time, count rates, sensitivity.

##### 3.6.1 Calculation of exposure time

No general rule can be given on how to calculate the optimum exposure time. With the present chip, one should make sure that the sky background reaches approximately 200 ADU above the bias level. Below this level, the pictures will suffer from under-exposure, as described in Section 4.3. The approximate minimum exposure times to reach this level of sky background is given in Section 3.6.2. Quantum noise equals read-out noise at a level approximately 400 ADU above the bias level, corresponding to exposure times twice as long as listed in Section 3.6.2. For faint objects imaged on a sky background level lower than this, the CCD is an inefficient photon detector. If the calculated exposure time should be prohibitively long, use pre-flashing (Section 3.11).

##### 3.6.2 Sky brightness

On a moonless night, the following approximate fluxes may be expected from the sky:

| Filter    | Flux<br>[ADU/min/pixel] | Apprx. min. exp. time<br>[minutes] |
|-----------|-------------------------|------------------------------------|
| Johnson B | 4 to 5                  | 40                                 |
| Johnson V | 10 to 15                | 20                                 |
| Gr        | 10 to 19                | 20                                 |
| Gi        | 15 to 30                | 12                                 |
| Gz        | 10 to 15                | 20                                 |
| Cold      | 50 to 55                | 5                                  |
| RG665     | 52 to 60                | 5                                  |
| None      | 70 to 100               | 3                                  |

In some color bands, the temporal appearance of night sky emission lines may significantly increase the brightness of the sky background.

### 3.6.3 Standard star sample flux

Under photometric conditions, and near culmination, the standard star Ross 889 ( $m(V)=10.50$ ) gives the approximate flux 672000 ADU/minute in the B band, and 1161000 ADU/minute in V, uncorrected for extinction. The values are integrated ADU over the defocused stellar image. Bias level and sky background are subtracted.

### 3.7 Flat field

#### 3.7.1 The need for flat field exposures

The sensitivity of the present CCD chip is not uniform. This is seen most clearly in the red, where the difference reaches 20% between a high-sensitivity area to the left of the centre and a low-sensitivity region in the lower right part, as displayed on the Ramtek monitor. In order to correct for this variation in sensitivity, any exposure should be divided by a similar exposure made on a uniformly emitting source.

During the observing night, the usefulness of flat fielding can be tested, running batch FLAT. This is described in Section 5.3.2.

Ratios between flat fields obtained in the same color, but at different ADU levels show that certain columns and individual pixels deviate significantly from linearity. In general, the 'cold columns' are characterised by an offset value which is rather constant for all pixels in the given column, and which depends only little on the signal level. This effect can rather easily be corrected for. The non-linear pixels, however, are of more complex behaviour. For the best reduction, it is desirable to match the flat field level to the levels of interest in the science images. For faint object work, one must therefore obtain flat fields corresponding to the sky background. As the sky background will normally not be constant during the night, a range of flat field levels should be obtained. When finally applying them, use linear interpolation between the different images. The adjustment of the flat field level can be by any combination of exposure time and illumination level.

#### 3.7.2 Methods for flat field exposure

In connection with broad band work ( $\lambda > 500$  nm), the associated flat field exposures can be made either on the inside of the dome, on the twilight sky, or deduced from 'science frames' with low source density. Either method has its pros and cons.

- Dome exposures are easily controllable regarding exposure level and are well reproducible. The colour temperature of incandescent lamps, including halogen lamps, is so low, that the difference between the effective wavelength of flat field and sky background may turn up in the flat-fielded science frame as an overcorrection. To fight this problem, use linear interpolation between flat fields of different colours. Scattered sun light has a much higher color temperature, but not necessarily the correct one.

- Exposures on the twilight sky are hard to control regarding exposure level (and too little time is available!), but do give the correct f-ratio. To avoid stars in the flat field, use either of two neutral density filters in filter wheel A (densities 1 and 2.2).

- Flat fields obtained on the night sky may produce superb correction of the sky background. However, they are often affected by interference fringes, and may introduce shot-noise in the science frames, unless generated from many individual exposures.

Most users so far have preferred to use flat fields generated on the dome inside using diffuse sunlight. Caution: the main mirror has to be open during the exposures, therefore the observer must make sure

that the dome air is free of dust and must close the mirror as soon as possible.

Flat fields for use with narrow band exposures are normally also obtained on the dome inside. The phase of possible interference fringes may depend strongly on the color temperature of the light source. Observers have reported significant phase shift between the fringe structures in a 7 nm wide filter, depending on the light source being tungsten or sunlight. Reduction with a wrong flat field may thus amplify the fringe structure, rather than eliminate it. To obtain sufficiently high statistical significance, low-intensity flat fields must be made as the average of a large number of short exposures. These can conveniently be obtained using the exposure repetition facility. It is mandatory that such multiple flat fields be averaged before being transferred to magnetic tape. A BATCH program which automatically averages the 5, 10 or 20 highest numbered images can be executed typing BATCH,AVERAGE,,<number> where <number> is the number of images to be averaged, either 5, 10 or 20. If the flat fields are not consecutively numbered (or too few), use IHAP commands 'COPY', 'PURGE' and 'RENUM'. The BATCH job may be executed automatically provided that the last parameter in the exposure request is set to 1 (=AVERAGE). At the end of the batch job the resulting file will be written to magnetic tape, and all involved files will be purged, including the average image. This precaution ensures that automatic flat field acquisition can go on unattended, without the danger of disc space overflow.

### 3.7.3 Gradients in flat field

Uneven illumination of the dome interior during flat field exposures may produce gradients in the images. To check whether this is the case, run the BATCH,UNBALANCE,,<\$n> where \$n is the image to be analysed. Default is last image. The program lists, in percent, the relative difference of ADU in the East-West direction and in the North-South direction. Neither is independent on colour. Therefore, the optimisation of dome illumination should be done in blue light (e.g. Johnson B or V where colour effects are minimal. To evaluate the color effect, the program also lists the relative difference of sensitivity between the areas of high and low sensitivity to red light.

The data below exemplify the output of program 'UNBALANCE'. The flat fields were taken on the dome inside using scattered sunlight.

| Filter | N-S (%) | E-W (%) | Max-Min (%) |
|--------|---------|---------|-------------|
| V      | 0.761   | 3.150   | 1.408       |
| Cold   | -4.252  | 2.037   | 7.423       |
| RG665  | -2.783  | 2.274   | 16.581      |
| none   | -3.577  | 6.978   | 15.335      |

### 3.7.4 Check list for dome flat fields

- 1) Move telescope in 'slew' to H.A. = +3<sup>h</sup>00<sup>m</sup>00<sup>s</sup>; Decl. = -29°15'00."
- 2) Position telescope so that the telescope views a homogeneous part of the surface (note: visiting astronomers may call upon the Operations Group to do these preparations. Call 93-54 before noon and 93-34 from noon until midnight).
- 3) Open main mirror cover (controls on NW corner of telescope base).
- 4) For broad-band work: switch off all light in the dome. For narrow-band work: leave Tungsten light on.
- 5) Make sure that nobody enters the dome during the exposures.
- 6) Mount blank magnetic tape (usually the next week-day labelled tape). Load and push on-line.
- 7) Open sky baffle cover.
- 8) Move 'large field mirror' to position 'OUT'.



- 9) Open M.E.K. shutter.
- 10) Make regular exposures without magnetic tape transfer to determine exposure time. Purge these and other unused files. Pack.
- 11) Define a repetition of 5, 10 or 20 exposures to be done without magnetic tape transfer. Request automatic execution of BATCH job to average images and transfer to magnetic tape. When defining the exposures, please give a meaningful identifier, such as recommended in Section 5.2. This identifier will automatically be copied to the average image, together with the mean ADU level in the middle of the picture. Notice that the average image will contain little other information on its creation (neither filter combination, exposure duration of sub-exposures nor moment of creation). Eventually use the sequence facility to schedule several such repeated exposures.
- 12) Execute these exposures.
- 13) When finished, close covers for main mirror, M.E.K., sky baffle

### 3.7.5 Exposure times for flat fields

The below combinations of exposure times and ADU levels were determined on 1983 March 11, approximately 2 hours before sunset. The light source was sunlight leaking through the closed dome slit and under the closed door to balcony. The sky was cloudless, the sky baffle and main mirror were opened and the telescope was pointed  $2^h$  west of the meridian at declination  $-29^{\circ}15'$ .

| Filter | Exposure time | ADU level<br>(incl.bias) |
|--------|---------------|--------------------------|
| B      | 120 sec       | 3700                     |
| V      | 30 sec        | 3600                     |
| Gr     | 15 sec        | 4300                     |
| Gi     | 3 sec         | 4800                     |
| Gz     | 3 sec         | 3450                     |

Notice: The amount of light leaking through the dome slit has since been reduced significantly.

### 3.8 Exposure sequences

The soft key operation 'EXPOSURE', 'EXPOSURE SEQUENCE' gives access to a two level parameter definition field allowing 100 sequences of up to 16 different exposures each to be scheduled. This is a very powerful means of acquiring science pictures in a systematic way. The sequence facility is also useful for the acquisition of long series of flat field exposures. Each exposure may be specified for up to 20 repetitions, thus permitting up to 320 exposures to be taken without manual intervention. After each of the repeated exposures has finished, a user specified BATCH job may automatically be called to work the images.

The main purpose of the routine is to schedule a number of pictures to be taken of the same object, but possibly through different filters and with different exposure times. Notice, however, that any telescope focus change will have to be done manually during the approximately 30 seconds used for image read out, magnetic tape transfer and filter wheel rotation.

The time limit for each single exposure is  $1^h 59^m 59^s$ , but it can be extended as described in Section 3.3.

### 3.9 Dark current images

The dark current of a CCD cooled to  $150^{\circ}\text{K}$  is very low (about 0.002 ADU/s/pixel over most of the picture), and can, in many cases, be neglected. If, however, the correction is deemed necessary, remem-

ber that subtraction of a single-weight dark image will increase the read-out noise by approximately square-root 2.

Dark current pictures can be obtained with integration times between 1<sup>h</sup> and 5<sup>h</sup> 59<sup>m</sup> 59<sup>s</sup>. Each dark picture can be specified for up to 20 repetitions with possibility for automatic averaging. The longest possible dark pictures show of the order of 100 cosmic ray events. If two or more images are available, use batch job COSMIC (see section 4.2) to remove the affected pixels.

### 3.10 Photometric calibration

The proper photometric reduction of CCD images is a non-trivial exercise. Observers may choose between various methods: a) Photoelectric measurement of relatively bright objects which happen to be in the field, b) CCD measurements of faint sequences, c) CCD measurements of bright standard stars.

The main advantage with the first method is that it is rather independent of the photometric quality of the sky during the CCD exposure. It is, however rarely used because of the need for associated photoelectric observations. Measurements of faint sequences eliminate the aperture-function problem. Exposure times for bright standard stars can be kept so short that it is feasible to repeat the observations several times per night. However, the telescope must be defocused so that the chip does not saturate. The aperture function problem may give systematic effects.

Information on spectrophotometric standard stars (Oke standards) is available in the control room. CCD observations of photometric standard stars are presently being reduced. Provisional results are available from H. Pedersen or K. Jensen.

The observer is encouraged to monitor the sky visually, not only at the time of the standard star measurements, but also during the science exposures. Failure to detect transparency variations may obviously result in gross errors in derived magnitudes.

### 3.11 Optical bias (preflashing)

#### 3.11.1 Why do preflashing

Preflashing is required when the sky background is so low that the read-out process creates loss of charge transfer efficiency, see Section 4.3. This will generally be the case if a) the exposure time is short, b) the CCD has little sensitivity to the measured light, c) the picture is exposed through an interference filter. To possibly avoid preflashing, it may be advisable to work with moonlit sky. The level of illumination during the preflashing operation should only be so high as to achieve circular images of stars. Higher exposures will add shot noise to the picture. A level of approximately 200 ADU above the electronic bias is often used.

Flat fields corresponding to preflashed exposures should be obtained at exposure levels similar to and exceeding the level encountered in the preflashed exposure. Do not try to match the flat field level to the very low contribution of sky background.

#### 3.11.2 Preflash procedure

A small preflash lamp is mounted in the instrument adapter unit. It can be controlled from the CCD-control room using a 'Uni-blitz' timer unit. For reason of reproducibility, the guide probe should be at a standard position during the preflashing, e.g. at  $x=0$ ,  $y=0$ , and the 'large field mirror' should be in position 'IN'. This will interrupt automatic guiding. During reductions, a similar zero-exposure image should be subtracted, before flat field division. In order not to degrade the statistical quality of the science image, this subtraction frame should be generated as the average of several exposures

A level of 200 ADU above the electronic bias is reached after ca. 600 msec (no filter), 1.2 seconds (Gr), 35 seconds (ESO #1604). The operations procedure is:

- Start the science exposure.
- At any moment during the exposure, type !!!.
- When a few seconds of exposure time remains, pause the exposure (soft key 'PAUSE').
- Move autoguide probe out, large field mirror in.
- Position the clear filter wheel openings, normally A=0, B=0.
- Push soft key 'CONTINUE EXPOSURE'.
- Push the 'actuate' switch on the 'Uni-blitz' unit.
- Eventually terminate the exposure by EXTM, -<seconds>.

## 4. INSTRUMENTAL EFFECTS

### 4.1 Interference fringes

The CCD is partially transparent to red light. As the chip thickness is only a few microns, this may give rise to a Fabry-Perot effect in the sensitive layer (depletion layer). Because of slight non-uniformity of the thickness, this interference will show up as a fringe structure following curves of constant sensitivity. Affected exposures can be divided into three groups: 1) Exposures of continuum sources through narrow band filters. The fringe amplitude is approximately 20 % at 656 nm. In principle, the fringes can be divided out with the flat field. Check if the amplitude of the fringe pattern above bias level (ca. 200) is the same for the 'science' exposure and the flat field. If not, adjust the bias level of the flat field to optimise the result. In some interference filters, particularly very narrow band filters, the fringe pattern is composed by two sets of fringes. 2) Exposures through filters which transmit night sky emission lines. The problems are usually worst during the first couple of hours after fall of darkness. During this period it is advisable not to work in the Gr band. The fringes must be SUBTRACTED from the image, rather than DIVIDED out. The correction may be less than perfect if more than one line is transmitted and in particular if the lines are variable. To define the interference fringe pattern, see section 5.3. Corrections for interference fringes of this kind are usually applied after flat field division. 3) Exposures of emission line objects. The fringe structure can be divided out with the flat field provided that only one line and no continuum is transmitted and that the flat field has been generated with light of the same wavelength. No solution is possible, if the ratio between different lines or between line and continuum is unknown.

Interference fringe patterns are very stable in time. We encourage visitor contributions to a catalogue of such images.

### 4.2 Cosmic rays

Long exposures, including 'dark', will always show some pixels which are exposed more than the surrounding pixels, although usually not saturated. They are generally believed to be caused by cosmic rays passing through the CCD-chip during the exposure. Since usually only one or two pixels are affected for each cosmic ray, it is quite easy to replace the values with representative values of the neighbouring field. This can be done interactively or by automatic routines.

An easy way to clean two otherwise fully identical pictures for cosmic rays is to run the program `BATCH,COSMIC,, $n1,$n2,d` where \$n1 and \$n2 are the two files, and d is a discrimination level. This should be found by a study of the pixel value histogram. The routine takes the difference between two pictures and uses this image to identify spikes as pixel values deviating more than plus or minus d from the average difference. It will affect astronomical images if the shot noise is larger than 'd'. The command 'FCOMPARE', being prepared for inclusion in IHAP, will serve a similar function.

### 4.3 Effects of under- and overexposure

As a result of poor charge transfer efficiency, the quality of exposures with low background levels will be impaired: stellar images will become less sharp and the contours will extend towards the right and upward. The centre of gravity will therefore also move, making astrometry difficult. The effect is most pronounced for columns with  $x > 138$ , i.e. to the right side of the cold column in  $x=138$ . Another effect of under-exposure is that 'cold pixels' will develop into 'cold troughs' making flat field corrections inaccurate.

Overexposed single pixels, or groups of pixels will spill-over to

the neighboring pixels along the same column(s). This is illustrated in Figure 1. Exposures of objects extending over the whole chip (including sky background and flat fields) will show charge smearing much below the full well capacity, possibly at the 50 percent level, ca. 8000 ADU.

#### 4.4 Cold columns

Certain columns show a signal which is lower than the chip in general. This is due to charge loss in the horizontal shift register. In the present chip, the worst affected column is X=138, which is down by ca 110 ADU, provided that the general signal level is higher. The effect can fairly easily be corrected for using automatic procedures. The signal in the corrected columns will obviously remain of lower statistical significance.

#### 4.5 Scattered moon light

Moonlight falling on the telescope construction, and in particular on the main mirror, tends to scatter in any dust grain which may have deposited on the entrance window of the dewar. The resulting, crescent-shaped figures cannot be removed by any proven technique.

## 5. DATA HANDLING. PROVISIONAL REDUCTIONS

### 5.1 Standard notation for image files

Any directly observed CCD image should be given an identifier conforming to the format <object>/<filter>/<exposure time>. A maximum of 16 characters are allowed. Examples:

NGC7009/GR/30m  
M87/A0B5/45m  
Flat/V/15s  
Flat/A0B3/15s  
Dark/5h

Further details may be entered in the 'comments' field. Both the identifier and the comments may be changed at any time during an integration. Vax users should avoid using file identifiers starting with numbers or special characters! Only letters are allowed!

### 5.2 Standard identification for average images

Automatically executed and averaged series of flat fields and dark current images will be given file identifiers which are copies of the file identifier of the first image in the series. These should be of the formats F/<filter>/<exposure time> (for flat fields), DK/<exposure time> (for dark current frames). A maximum of 11 characters should be used, out of 16 available. Examples:

F/GR/20s  
F/A0B5/30s  
DK/20m

The average program will use the last five characters of the file identifier to state the average level at the middle of the picture. The above examples may finally appear like this:

F/GR/20s : 935  
F/A0B5/30s : 3544  
DK/20m : 203

The number of images used for the average is automatically written into the 'comment' block.

### 5.3 Provisional reductions.

It is beyond the scope of this manual to a tutorial on CCD reductions. Certain operations, done during observations may, however, help evaluate the data:

#### 5.3.1 Image display

BATCH, KDISP, , <\$F>, <scale>, <versatec> will display image <\$F>, using <scale> as a common scale factor for X and Y. <scale> must be an integer. The default value is 1. The program has an option for image diameter measurements. If the last value is given as 1, the image will be printed at the Versatec station.

#### 5.3.2 Flat-field corrections

Provisional flat-field reductions can be done during the observing night. The program BATCH, FLAT, , \$n, \$f, <1> will automatically subtract bias level from picture \$n, and divide it with flat field \$f minus bias. The picture will be displayed on the Ramtek monitors if the last parameter is NOT given. Dark current is neglected. The resulting file is normalised so as to conserve the number of ADU's in a stellar image (near the centre of the field). The bias level of science image and flat-field are deducted from the overclocked first column of each image. A range of consecutively numbered images, \$n1 to \$n2 may be flat field corrected with the call BATCH, HPFL, , \$n1, \$f, <1>, \$n2.

Final flat-field and dark current corrections may be done using the (very large) batch program CPRO1. A description is available at La Silla. Because of long execution times, the program should not be used at computers primarily intended for data acquisition.

### 5.3.3 Magnitudes

Instrumental magnitudes may easily be calculated using the 'JMAG' IHAP command. To set all necessary control parameters, type 'BATCH, CCDINIT' once per night. When comparing exposures with different exposure times remember to add  $-2.5 \log(\text{ratio of exposure times})$ .

### 5.3.4 Cosmic ray removal

Use batch job COSMIC to correct for cosmic rays in two otherwise identical dark current images. The call is BATCH, COSMIC, , \$F1, \$F2, D where D is the discrimination level. For dark images, try with D=50.

### 5.3.5 Interference fringe patterns

Interference fringe pattern may have to be deducted from 'science exposures'. These will normally have to be cleaned for stellar images. This can be done effectively, using the cosmic ray removal routine, assuming that there is no overlap between astronomical images. Preferentially work on 4 or more images, and finally run BSMOOTH on the resulting image.

### 5.3.6 Average

The BATCH job call BATCH, AVERAG, , , n will average the n highest numbered images and write the result to magnetic tape. n must be 5, 10 or 20. Successfully completed, all involved files will be purged.

### 5.3.7 Hard copies

The batch job KDISP has an option for image reproduction on the Versatec unit, see 5.3.1. Preferably do not use this command at night time, and in particular not during image read-out.

### 5.3.8 Batch jobs, user defined.

Observers who wish to run own BATCH programs while simultaneously doing CCD exposures should note that a) the 'RTTY' command must not be used, b) any request for mag tape operations will abort a batch job.

A user defined batch job may be executed automatically, following image read-out and before start of next exposure. The name must be either BATCH4, BATCH5, BATCH6, BATCH7, or BATCH8, and the last character in the file name must be given in the exposure request. In the observers own interest, the execution time should be short.

## 5.4 CCD image archive

A copy on any CCD image exposed at the 1.54 m Danish Telescope is kept on magnetic tape in the control room. This serves as a guarantee against loss of data. Requests for retrieval of own data should be sent to La Silla, attention Astronomy Secretary.

Certain 'standard' data may be copied quite liberally. This includes dark current images, flat fields, interference fringe patterns, subtraction frames for preflashed exposures etc. Notice, however, that the copying procedures are quite time consuming and that the work will be given low priority. The request for retrieval must be specific as to tape number and file number (interval(s)).

Requests for retrieval of any other data shall be reviewed on a case-by-case basis. The application will, in general, only be considered, if the written consent of the original observer has been obtained by the applicant.

#### 5.5 IHAP disc files

50 full CCD frames may be supported by the system at any time. If about to run out of space, purge files and pack data base (no packing can be done after definition of a coming exposure nor during an exposure). Files generated in IHAP may be of 'real'-format and will then fill twice as much as 'integer' files. Use the 'FIX' option in the end of a 'PFUN' string to convert the resulting file to integer format.

#### 5.6 Sequence numbers

Each directly observed CCD picture is assigned a name between AA-1 and AA-32767. This is automatically incremented by the CCD control program and is reset to AA-1 on the 1st of January each year. Unique reference to a CCD picture from the 1.5 m Danish Telescope can thus be made as e.g. ESO-AA-1984/12345.

Pictures generated using the AVERAGE program are given a sequence number equal to that of the lowest-numbered image used in the creation.

#### 5.7 Listing program

A program to list all file-headers on a given magnetic tape can be run from the system console, provided that the CCD program is not running. The program is called by 'RU,RLIST'. The program should be run at the end of each night. At the start of program, enter 6 for printer LU, 8 for magnetic tape LU, and any integer as tape identifier. If the program hangs, abort it with 'OF,RLIST,1'.

#### 5.8 Magnetic tapes

The following procedure for magnetic-tape handling is recommended:

- Of the seven magnetic tapes labelled SUNDAY, MONDAY, etc., each day mount a new one. Use this tape only for storage of ORIGINAL data. Do not record reduced or partially reduced data.
- At the end of night, run the 'RLIST' program as described in Section 5.7, label the tape with observer's name, date, number of files, bring the tape to the hotel, and put it in the software mail box.
- During daytime, the software department (phone 374) will update the CCD image archive, update a tape for the visiting astronomer, and bring the original tape back to the telescope.
- At the end of the run, the user will be given her/his magnetic tape copy together with the listing of its contents. This tape will normally be written in 'IHAP' format with density 1600 bit per inch. If other format (FITS) or density (800 bpi) is required, please contact the computing centre operator.



6. VARIOUS

6 1 Error conditions, trouble shooting

'Please check cables for Le Croy module of HP-CC!'

This message may occasionally be displayed before the start of a new exposure. The problem disappears with a renewed start request, but an ongoing exposure sequence might be stopped without the observer noticing it.

'Camac or CCD micropr. error!- Exp. nnn stopped at hh:mm:ss'

The exposure may still be going on and can be saved: simply start a new, short exposure and let it finish normally. The picture will contain the added information, but of course the start moment and exposure time will be wrong. The cause of this error is supposed to be overheating of the CCD electronics. Switch on the ventilation system.

'Bad status from TCS received'

Is the TCS-computer switched on? If yes, repeat the 'START EXPOSURE' request. If not, switch the TCS-computer on.

If stuck,

You may push 'microprocessor-reset' on the CCD-rack to cure the above and other errors. If that does not help, call Operations Group (Phone 93-34 or 93-54).

'Telescope did not move ???'

For unknown reasons, this message occasionally appears during a focus sequence. Before restarting the sequence, take the handset and move the telescope a few steps in offset.

IHAP abort

This is a very unpleasant consequence of some IHAP commands. It is bound to occur if a CCD image is read out while a Versatec image is being printed. To save most of the image, follow this routine. With a fast reaction to the last point it may be possible to save around 75 percent of the image.

- Go to the system terminal and type OF,CCD,1. Restart CCD program. If unsuccessful, bootstrap (Appendix 1, points 4, 6-11, 16).
- Define a short exposure to be taken through the current filter.
- In the 'comment' field describe that the exposure start time is wrong.
- Press 'START'.
- Ignore the message 'Clearing CCD - restart after some seconds'
- Immediately after, press 'START'.

Control over keyboard lost

The only activity is the updating of remaining exposure time. No complete recovery is possible. To save most of the exposure, follow the procedure described above.

No update of remaining exposure time

Type 'EXTM,0'.

### Terminal hanging

Try the following:

- Allow a time consuming process to finish, or to 'time out'.
- Push 'reset terminal' twice in quick succession, then 'return'.
- Push 'space bar' on all terminals.
- On the joystick, push 'enter', or 'visible off', then 'enter', or 'track off', 'track on'.

### Picture mix-up

In two situations can an earlier, not completely read out picture can contaminate the next one. 1) An exposure was aborted and the following one restarted before the chip was cleaned by two read-out cycles. 2) The CCD shutter was opened 'manually' (i.e. via 'MAIN MENU' and soft-keys 'SHUTTER/FILTER', 'SHUTTER OPEN') and was left open until the start of the following exposure. In both cases, the problem can be avoided by making sure that the shutter has remained closed for at least 20 seconds before the 'START' softkey is pushed.

### LOG,DUMP

This IHAP command may generate vast amounts of printer output with a very low information content. Do not use it unless having isolated the interesting part with the 'LOG,CLEAR' command.

### No output on printer

Nothing is printed in response to the soft key 'PRINT EXP.PARAM' or to the IHAP command 'log,dump'. Eventually the tip '\*NO NEW LST POSSIBLE' appears on the terminal. Sometimes, the observer can make the system recover by typing 'UP,31' or by running the 'GASP' program (see IHAP Manual version May 1981, ii-2). If the 'display spool' command 'DS' gives the tip 'SHUT,DOWN', then type 'SU,S'. Elsewise kill spool files. If stuck, do 'OF,GASP,1'. During daytime, the software department (phone 374) may give assistance.

### Temperature

Keep an eye on the CCD temperature indicator in the CCD rack. If it deviates more than 0.1 degree from the set temperature, call help.

### Image patterns

Watch out for possible patterns in the pictures, especially visible in dark exposures.

## 6 2 Frequently used IHAP commands, batch jobs, programs

| IHAP commands          | IHAP No. |
|------------------------|----------|
| SAMPLE,\$n             | 23       |
| SAMPLE,\$n,x1,x2,y1,y2 | 23       |
| CUT,\$n,<high>,<low>   | 165      |
| KDISP,\$n              | 158      |
| TRAN,\$n,y             | 22       |
| KCOORD                 | 169      |
| F/F,end                | 47       |
| MRES,all               | 52       |
| PURGE,\$n              | 14       |
| PACK                   | 15       |

| BATCH jobs                       | Section              |
|----------------------------------|----------------------|
| BATCH, KDISP, , <\$n>, <sc>, <v> | 3.3 and 5.3.1        |
| BATCH, FLAT, , \$n, \$f          | 3.7.1 and 5.3.2      |
| BATCH, FOCUS, , <\$f>, n         | 3.4.1 and 3.4.2      |
| BATCH, AVERAGE, , , <number>     | 3.7.2 and 5.3.6      |
| BATCH, CDSMIC, , \$n1, \$n2, d   | 4.2, 5.3.4 and 5.3.5 |
| BATCH, RAMTEK                    | Appendix 1           |
| BATCH, CCDINIT                   | 5.3.3, Appendix 1    |
| BATCH, UNBALANCE, , <\$n>        | 3.7.3                |

| Fortran program | Section |
|-----------------|---------|
| RLIST           | 5.7     |

| System programs | Reference                   |
|-----------------|-----------------------------|
| GASP            | IHAP Manual, May 1981, ii-2 |
| WHZAT           |                             |

### 6.3 Notes on good observing

- Provide high precision coordinates for the field centres.
- Precalculate autoguide star positions.
- Open the dome well before start of observations.
- Keep the sky under visual surveillance.
- Observe only within a zenith distance of 40 degrees. This ensures that the zenith distance dependencies of seeing and telescope focus have only little effect.
- Avoid moonlight shining directly on the telescope and, in particular, on the main mirror.
- Standardize the observations as much as possible. Use only one, at most two different integration times and few filters.
- Take great care with the focus routine. Repeat if the sequence is not well centered on the best focus or if image quality is variable.
- When acquiring large numbers of flat fields, use automatic average before magnetic-tape transfer.
- Follow the change of dome air temperature. If necessary, correct the telescope focus.
- Use the 'comment' field well (moon, clouds, details about the previous exposure: presence of asteroids, satellite trails, poor tracking).
- During the observing night, never use IHAP commands REWI, MRES, B/F nor F/F.
- Inform ESO (Astronomy Secretary, La Silla) well ahead of the observations which ESO filters should be mounted. Do not request filter change during the run.
- Help us keeping order in the CCD image archive: write date and observer's name in the first 'comment' field each night, use standardized file labels: <object>/<filter>/<exposure time>, do not mix observations with reduced data.

Table 1

Focus offsets from no filter

| Filter      | foc. pl. shifts<br>[μm] | dfoc<br>[steps] | Comments |                 |
|-------------|-------------------------|-----------------|----------|-----------------|
| Johnson U   |                         | -135+/-5        | T        | Danish, 110 mm. |
| Johnson B   |                         | -135+/-5        | T        | Danish, 110 mm  |
| Johnson V   |                         | -135+/-5        | T        | Danish, 110 mm. |
| ESO #1605   |                         | -215+/-20       | T        |                 |
| ESO #1604   |                         | -209+/-15       | T        | Hydrogen alpha  |
| ESO #1403   |                         | -121+/-15       | T        | Hydrogen beta   |
| ESO #1502   |                         | -130+/-20       | T        |                 |
| Cold filter |                         | -35+/-10        | T        |                 |
| Stromgren b |                         | -190+/-25       | T        | Danish, 60 mm   |
| Stromgren y |                         | -190+/-25       | T        | Danish, 60 mm.  |
| Gunn cold   | 645 +/- 20              | -37             | L        |                 |
| Gg=ESO #345 | 380 +/- 50              | -22             | L        |                 |
| Gr=ESO #346 | 1110 +/- 50             | -64             | L        |                 |
| Gi=ESO #347 | 1150 +/- 50             | -66             | L        |                 |
| Gz=ESO #348 |                         | (-64)           |          | Focus as Gr?    |
| ESO #334    | 1500 +/- 40             | -86             | L        |                 |
| RG 665      | 2450 +/- 35             | -141            | L        | Danish, 110 mm. |
| ESO #151    | 2428 +/- 25             | -140            | L        |                 |
| ESO #45     | 1448 +/- 36             | -83             | L        |                 |
| ESO #1401   | 3425 +/- 44             | -197            | L        |                 |
| ND1. 0      | 793 +/- 28              | -46             | L        |                 |
| ND2. 2      | 610 +/- 35              | -35             | L        |                 |

Note: 17.35 micron = one step on focus handset. Filters with comment 'L' were measured at the optical laboratory. Filters with comment 'T' were measured at the telescope relative to the Gr filter. These values are significantly poorer than those measured at the optical laboratory.

Table 2

Standard positions for focus and seeing determination

| Bright star | Position 1950 (*)                                  |              |      | Autoguide star (**) |       |
|-------------|--|--------------|------|---------------------|-------|
|             | R. A.  | Dec.         | M    | X                   | Y     |
| SAD 192397  | 00 <sup>h</sup> 09 <sup>m</sup> 55. <sup>s</sup> 6 | -30° 42' 20" | 9.7  | 5430                | 4770  |
| SAD 193048  | 01 16 35.2   | -30 14 21    | 9.8  | 4330                | 2220  |
| SAD 193576  | 02 10 45.9   | -30 34 44    | 10.2 | 11260               | 3130  |
| SAD 194115  | 03 07 10.8   | -30 55 18    | 10.1 | 5770                | 1970  |
| SAD 194817  | 04 09 53.3   | -30 28 28    | 9.1  | 0000                | 0000  |
| SAD 195635  | 05 09 40.8   | -31 24 56    | 9.8  | 1370                | 13810 |
| SAD 196519  | 06 06 14.2   | -31 11 36    | 9.6  | 7090                | 6650  |
| SAD 197616  | 07 06 16.1   | -31 21 48    | 7.0  | 6980                | 420   |
| SAD 198883  | 08 08 33.3   | -30 46 31    | 8.7  | 2530                | 7500  |
| SAD 200007  | 09 05 45.4   | -31 51 07    | 8.0  | 6300                | 1870  |
| SAD 201094  | 10 06 30.2   | -31 49 55    | 11.4 | 1480                | 1825  |
| SAD 202132  | 11 06 29.1   | -30 38 23    | 9.1  | 10720               | 5490  |
| SAD 203144  | 12 04 36.9   | -32 37 40    | 9.5  | 2340                | 6700  |
| SAD 204232  | 13 09 40.2   | -30 48 55    | 8.2  | 8820                | 440   |
| SAD 205235  | 14 06 08.0   | -30 21 09    | 9.6  | 3440                | 2470  |
| SAD 206343  | 15 06 23.2   | -32 19 04    | 9.2  | 1720                | 4620  |
| SAD 207363  | 16 05 01.4   | -31 29 35    | 9.2  | 6900                | 700   |
| SAD 208525  | 17 08 56.4   | -30 43 47    | 8.6  | 5770                | 5930  |
| SAD 209810  | 18 07 18.2   | -31 02 13    | 8.9  | 1530                | 6630  |
| SAD 210934  | 19 03 18.3   | -31 24 02    | 9.6  | 6010                | 2940  |
| SAD 211881  | 20 07 42.1   | -30 49 39    | 9.4  | 8320                | 8020  |
| SAD 212756  | 21 06 22.4   | -30 57 16    | 10.2 | 5880                | 9690  |
| SAD 213653  | 22 11 13.8   | -30 44 31    | 8.4  | 640                 | 12490 |
| SAD 214302  | 23 02 44.7   | -31 05 53    | 8.0  | 1630                | 610   |

\* The quoted declination is one arcminute south of the position of the bright star in order to avoid problems with eventual charge overflow. Do not use these positions for 'CC'-operations at the TCS-computer.

\*\* Autoguiding is recommended for seeing determination, but must not be used during focusing.

## Appendix 1: Start up procedure

- 1) In the control room, power-up and push on-line the following units:
  - TCS computer.
  - Centronix printer.
  - Ramtek displays.
  - Terminals ( System, CCD/IHAP, Graphics ).
  - Camac.
  - CCD-micro and power supply.
- 2) In the kitchen, switch on the Ramtek controller.
- 3) Power-up and push on-line:
  - HP 1000 computer.
  - Disc drive.
  - Magnetic tape unit.
- 4) Bootstrap the HP computer:
  - If the 'RUN' lamp is lit, push 'HALT'.
  - Use <\*> button to select S-register, press CLEAR DISPLAY, set S-register to 041200 octal (red labelled lamps).
  - Push 'STORE', 'PRESET', 'IBL/TEST', 'PRESET'.
  - When disc indicates 'DRIVE READY' push 'RUN'.
  - Several lamps should now be blinking during some seconds and some disc operations should be heard. If not, repeat.
- 5) Mount mag-tape, push 'LOAD' and 'ON-LINE'. Take great care that the tape is properly fixed!
- 6) In the control room, at the system console, type in time and date using the displayed example. The time should invariably be universal time. The date should be given with two digits, including an eventual leading zero.
- 7) The message 'RTE is up --- Strike any key' should appear on the CCD-IHAP console.
- 8) Strike any key on this console and log-on with password CCD (or 'IHAP', if you want to work with IHAP only).
- 9) The CCD-program may give a message that the TCS computer is not switched on. Switch it on and repeat from 8.
- 10) Type 'TR' as requested.
- 11) Under certain conditions, the message 'power failure! automatic file restore?' may appear. Answer 'YES' if the disc files from the previous session should be conserved.
- 12) Select menu 'MAINTENANCE'.
- 13) Push softkey 'TEST HARDWARE'.  
The message 'TYPE <CR> FOR START OR 1 FOR EXIT' should now appear. Push the 'return' key to start the test program.  
Check if all tests are o.k.  
Ignore the eventual message 'Camac Unit no 8 (Temp.Contr.) not in remote or not connected'.  
Ignore the eventual message 'module 3340: f16,a0 -----'.  
If any other test fails, repeat test program.  
If an error remains, call assistance from the Operations Group.
- 14) Assuming all tests o.k., enter '1' for 'exit'.
- 15) Beginners should now familiarize themselves with the acquisition program. Press 'PREVIOUS MENU', 'OBSERVATION'. Terminate any input by pushing 'ENTER' at the top middle of the keyboard. Try all kinds of exposures, starting with 'DARK EXPOSURE', then 'FLAT FIELD EXPOSURE', 'REGULAR EXPOSURE', 'EXPOSURE SEQUENCE', 'FOCUS EXPOSURE'. Before actually starting any exposure, make sure that opticians are not at the same time engaged in filter changing operations. Notice that exposures can be ended by pushing 'ABORT EXPOSURE' (twice!) and shortened by command 'EXTM,nnn' where 'nnn' is a negative number of seconds.
- 16) Check universal time by command 'DATE'. If not correct, reset UT by softkey operations: 'PREVIOUS MENU', 'HARDWARE OPTIONS', 'ETC', 'CHANGE TIME'.

- 17) Type 'BATCH, RAMTEK' and 'BATCH, CCDINIT' to set certain useful parameters.
- 18) At start of night, open sky baffle, main mirror, M.E.K.
- 19) Make sure that the 'large field mirror' is in position 'OUT'.
- 20) Acquire a focus sequence (Section 3.4.1), note value on special form, set value on handset.
- 21) Determine 'seeing at start of night' by this procedure:
  - Set telescope on a field near zenith.
  - Make either a normal 'science' exposure or a two-minute, guided exposure (without magnetic tape transfer). In the latter case, the focus field may be used. X and Y values for the guide probe are provided in table 2.
  - Measure the seeing typing 'BATCH, KDISP'
  - Communicate value to night assistant.

#### Appendix 2: Close down procedure

- 1) Measure the 'seeing at end of night' as described in the start-up procedure (Appendix 1, point 21).
- 2) Adjust down the brightness level on all monitors and blank the Ramtek monitors (KCLEAR command).
- 3) Close the M.E.K. shutter.
- 4) Close cover for main mirror and for sky baffle.
- 5) Rewind the mag tape and remove write ring.
- 6) Remount the mag tape, push 'load' and 'on-line'.
- 7) Check that the printer is ready.
- 8) Terminate the CCD program by typing 'TERM' twice. Do not worry: your files can easily be recovered from disc after next log-on. Go to the system terminal and log-on with 'ESD' if not already done. Type 'RU, RLIST' on the system terminal, answer 6 for printer LU, 8 for magnetic-tape drive LU and any integer for tape identifier.
- 9) Take off the magnetic tape, label it with your name, night of observation and number of files.
- 10) Make sure that the ventilation system is running.
- 11) Switch off all unused, power consuming devices.
- 12) Bring the magnetic tape to the software mailbox in the hotel.

Appendix 3: Autoguide star selection

- Fill in the below form (except 'X' and 'Y') and hand it over to the software department at least two days before the start of the observing run.
- The results will be returned to your mailbox in the hotel, together with this form.
- Extract one useful guide star for each field, selecting stars with small X and Y values and observing the zones of avoidance shown in the insert in the back of the telescope manual.
- Hand the form over to the night assistant for entry into the telescope control computer.

Observer:

Room no:

Period of observations at 1.5 m Danish Telescope:

Telescope East of pier                      or West of pier                      (CCD: West)

| Number | Object name | R. A. (1950) | Decl. (1950) | X | Y |
|--------|-------------|--------------|--------------|---|---|
| 1      |             |              |              | I |   |
| 2      |             |              |              | I |   |
| 3      |             |              |              | I |   |
| 4      |             |              |              | I |   |
| 5      |             |              |              | I |   |
| 6      |             |              |              | I |   |
| 7      |             |              |              | I |   |
| 8      |             |              |              | I |   |
| 9      |             |              |              | I |   |
| 10     |             |              |              | I |   |
| 11     |             |              |              | I |   |
| 12     |             |              |              | I |   |
| 13     |             |              |              | I |   |
| 14     |             |              |              | I |   |
| 15     |             |              |              | I |   |
| 16     |             |              |              | I |   |
| 17     |             |              |              | I |   |
| 18     |             |              |              | I |   |
| 19     |             |              |              | I |   |
| 20     |             |              |              | I |   |
| 21     |             |              |              | I |   |
| 22     |             |              |              | I |   |
| 23     |             |              |              | I |   |
| 24     |             |              |              | I |   |
| 25     |             |              |              | I |   |



1 FEB 9 1983

0116 1916-05/NOR/15W2



Figure 1. A typical CCD image. Notice that bright stars show charge overflow in the vertical direction.

1 FP1.. 9 SEPT. 1983  
0039 F/NON

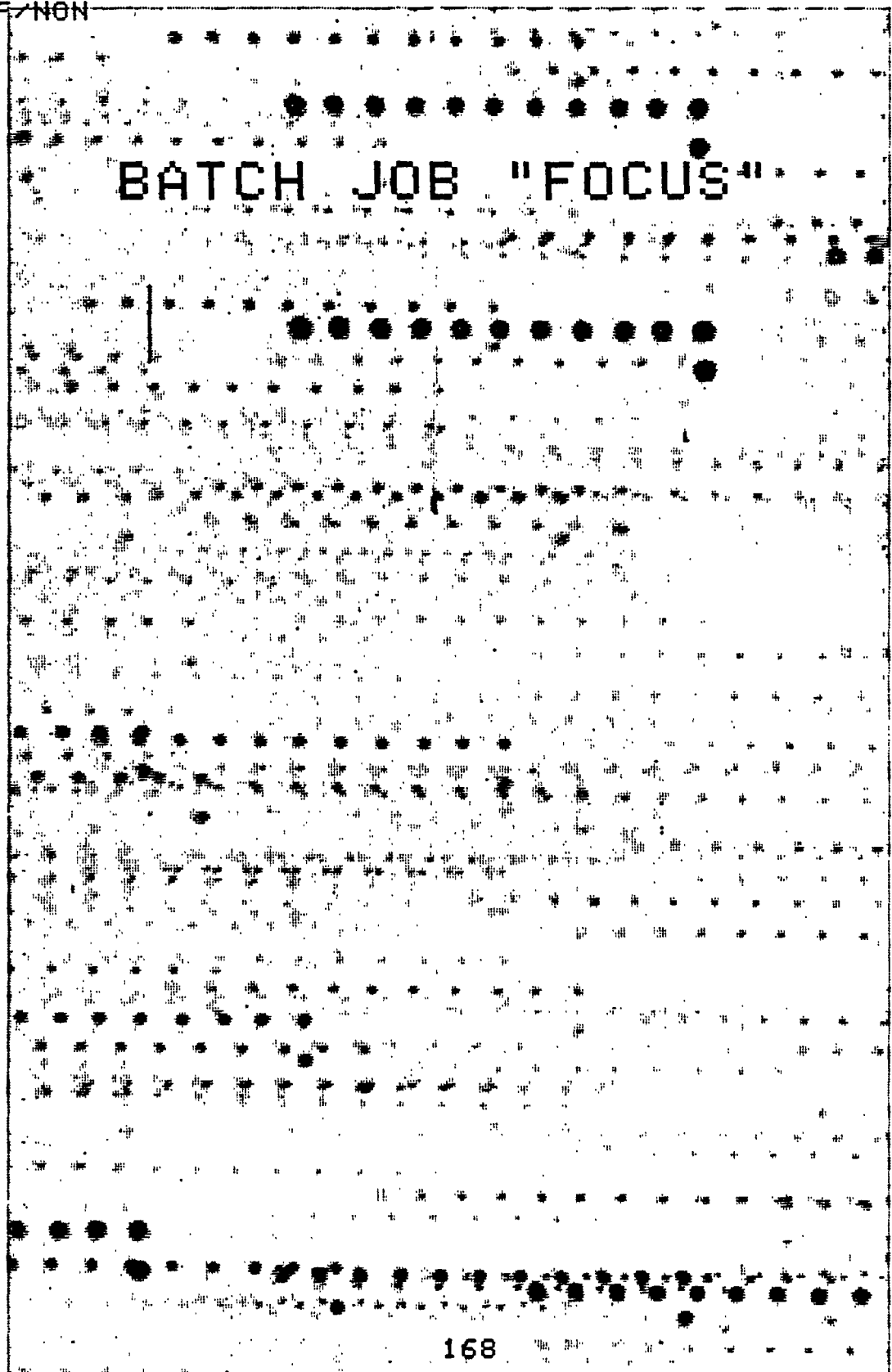


Figure 2. A focus sequence.

FRI., 9 SEPT. 1983  
0062 JOINTFLAT

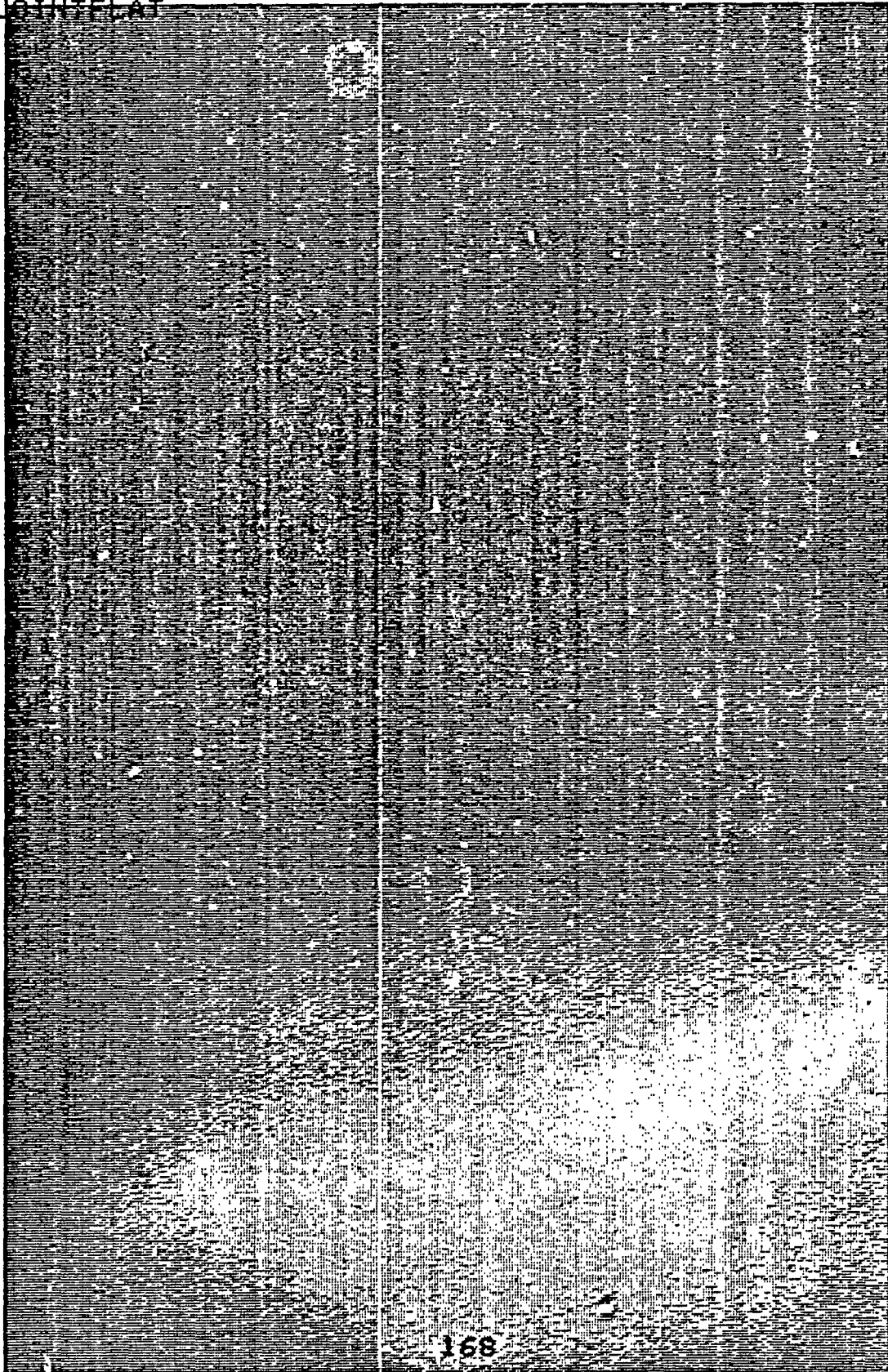


Figure 3. A flat field exposure obtained in the near-infrared Gz band. The brighter area in the lower right part has lower sensitivity than the rest.

1. 5. SEP 1964  
0001

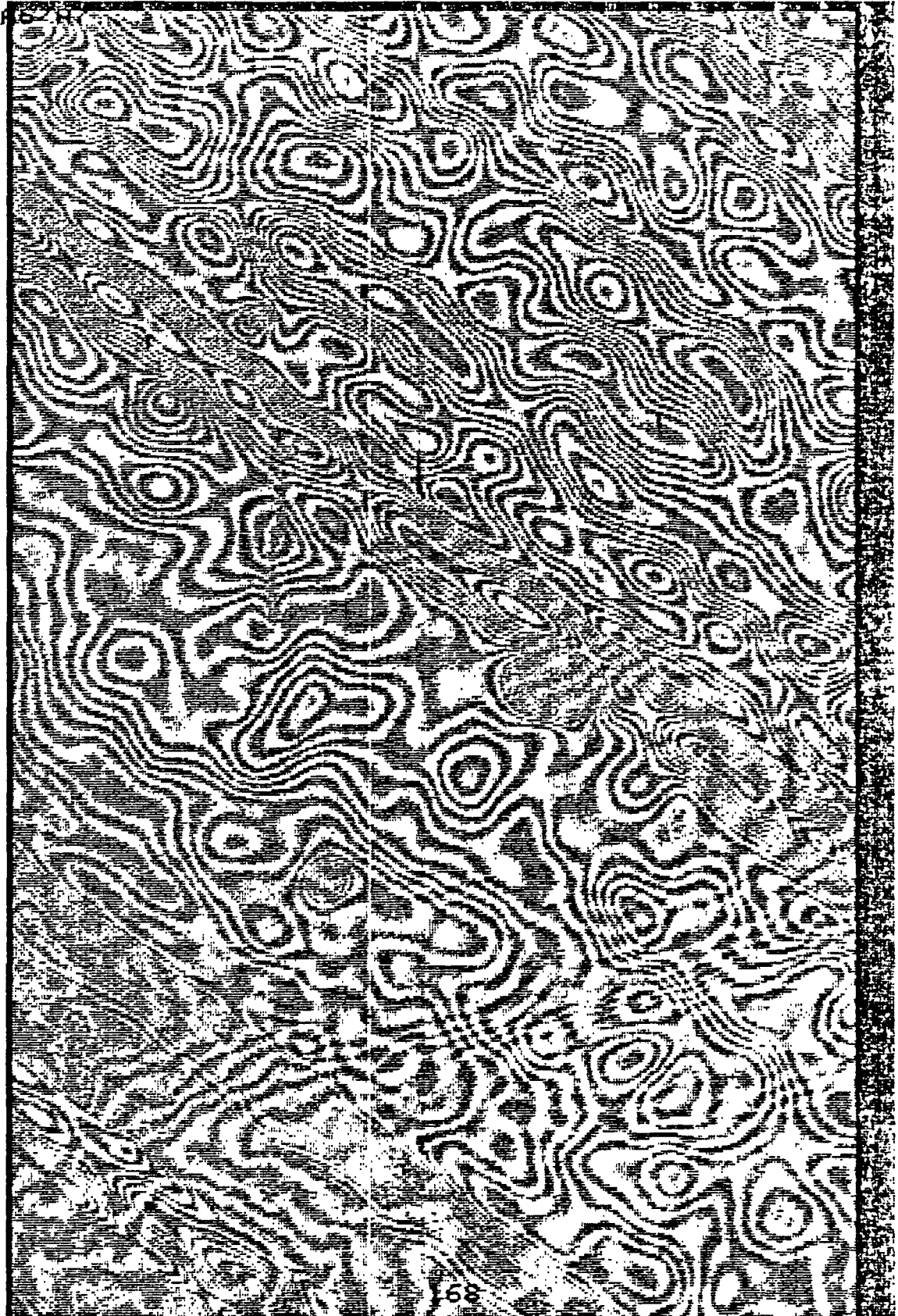


Figure 4. A flat field image obtained in an  $H\alpha$  filter. For clarity, the image has been divided by another, red wide-band flat field. Notice the presence of two sets of interference fringes.

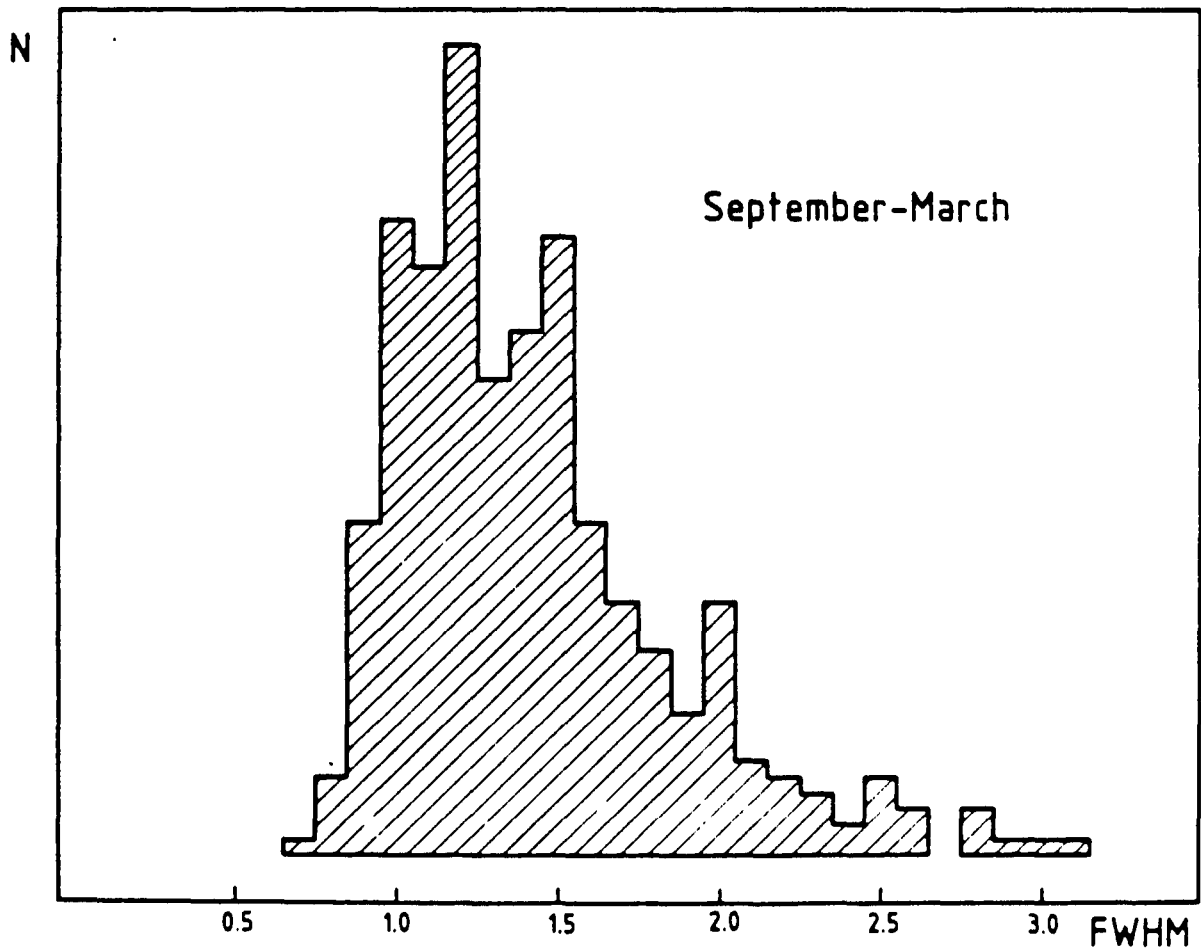
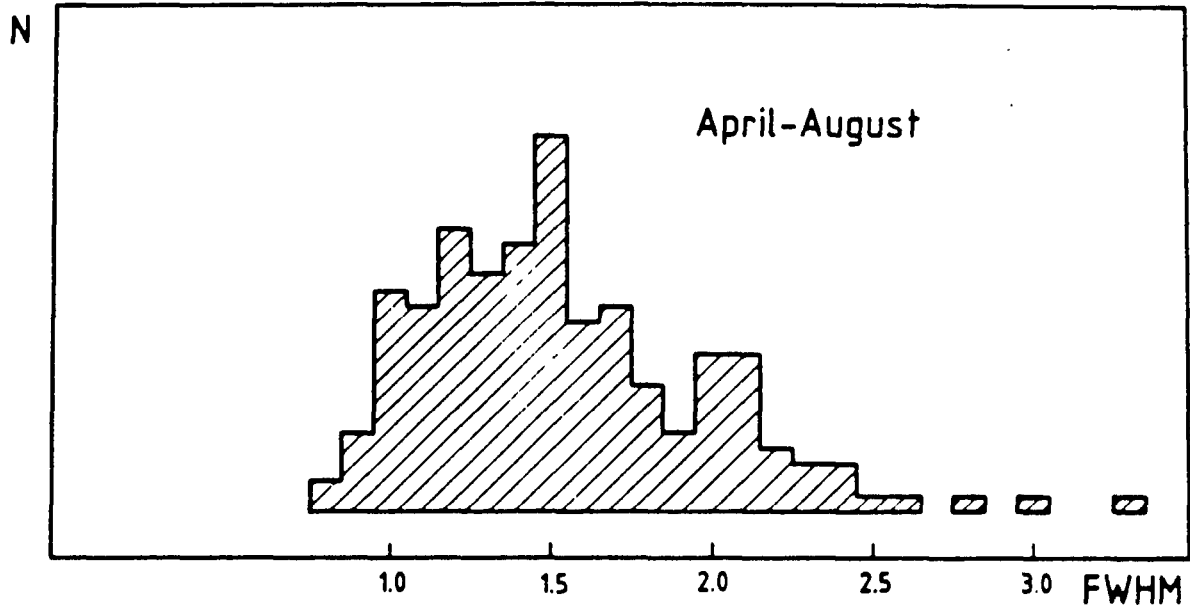


Figure 5. Seeing measurements.