

# Wise Observatory One Meter Telescope Manual

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## ABSTRACT

The Wise Observatory of Tel-Aviv University saw first light in 1971. Currently it operates a 40 inch telescope, a Centurion 18 inch telescope, and a Centurion 28 inch telescope. In the last few years a vast upgrading of the observing equipment and the operating systems has been conducted. The most frequent used observing systems for the 40" telescope are the PI-CCD Camera, and the eShel spectrograph.

The operating systems include programs to set the telescope to objects, automated guider, automated observations, operation of the CCD and the instruments, remote observing, and various other tasks.

The purpose of this manual is to describe the use of the above instruments on the 40" telescope as well as other instruments, programs and facilities at the Wise Observatory. The aim is to help the observer operate the instruments properly and avoid mistakes, so that the observing time will be fully and properly used.

Since the Wise Observatory is in constant development this manual will hopefully be updated according to the developments. This document is available via the WWW at <http://wise-obs.tau.ac.il/observations/Man/>

General information about the Wise Observatory is available at <http://wise-obs.tau.ac.il/>

Information about the Department of Astronomy and Astrophysics of Tel-Aviv University is available at <http://www.astro.tau.ac.il/>

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# Chapter 1

## Introduction

The Wise Observatory, named in honor of Florence and George Wise, the first president of Tel-Aviv University and his lady, was dedicated in October 1971. The observatory is owned and operated by Tel-Aviv University (TAU), Israel, and is dedicated to research in observational optical astronomy. It is located on a high plateau in the central part of the Negev desert (longitude  $34^{\circ}45'48''$  E, latitude  $30^{\circ}35'45''$  N, altitude 875 m, time zone  $-2$  hours relative to Universal Time. New Israel coordinates are 177040, 500876). The observatory code given by the International Astronomical Union is 097. The site is about 5 km west of the town of Mitzpe Ramon, 200 km south of Tel-Aviv and 86 km south of Beersheva. The town of Mitzpe Ramon has a population of about 6000 and offers facilities in housing, schools and basic medical services. The town management had cooperated with the observatory in controlling and shielding street lights and outside illumination to minimize the additional light background, but in the last few years together with a large development of the town, the light pollution from the town has increased considerably.

The characteristics of the site, prior to the establishing of an astronomical observatory on it, were described by Vidal and Feldman (1974). The number of clear nights (zero cloudiness) is about 170 a year. The number of useful nights is about 240. The best season, when practically no clouds are observed, is June to August, while the highest chance for clouds are in the period January to April. Winds are usually moderate mainly from NE and N. Storm wind velocities (greater than 40 km/h) occur, but rarely. The wind speed tends to decrease during the night. Temperature gradients are small and fairly moderate. After 23:00 LT, the gradient is usually  $0.2^{\circ}\text{C}/\text{h}$  the year round. The average relative humidity is quite high, with a tendency to decline during the night from April to August. The average seeing is about 2–3 seconds of arc. A few good nights have seeing of  $1''$  or less while some show seeing larger than  $5''$ . Typical extinction coefficients, in mag/airmass, are:  $k_V = 0.24$ ,  $k_{U-B} = 0.22$ ,  $k_{B-V} = 0.14$ ,  $k_{V-R} = 0.05$ , and  $k_{R-I} = 0.07$ . These are median values for the 1990s decade. A review of the observing conditions at the Wise Observatory (Brosch 1992)



is given in appendix A.

The Boller and Chivens telescope is a wide field Ritchey-Chretien Reflector mounted on a rigid, off-axis equatorial mount. The optics are a *Mount Wilson/Palomar Observatories* design, consisting a 40 inches diameter clear aperture f/4 primary mirror, a 20.1 inches diameter f/7 Cassegrain secondary mirror, and a corrector quartz lens located 4 inches below the surface of the primary mirror, provides a field of up to 2.5 degrees in diameter. A f/13.5 secondary mirror is also available. The secondary mirror can be slightly inclined with a stepping motor. The paper "The optical design of the 40-in. telescope and of the Irene DuPont telescope at Las Campanas Observatory, Chile." by Bowem and Vaughan (1973) describes the design of the Las Campanas 40-inch telescope which is the twin of the Wise Observatory 1 meter telescope and thus the information in that paper is relevant. The telescope is controlled by a control system, located in the telescope room.

The present most frequent used observing instruments are the CCD Camera for imaging and photometry, the Large Area Imager for the Wise Observatory (LAIWO) for imaging and photometry, The eShel spectrograph with a high resolution of  $R \sim 10000$ , and the Faint Object Spectrographic Camera (FOSC) for spectroscopy of  $R \sim 1000$ , polarimetry, and very rarely for imaging. Each of these instruments is mounted at the f/7 of the telescope, together with a guider CCD.

Research activities include: imaging and photometry of planets, asteroids, moons and comets, photometric and spectroscopic studies of novae, searches for nd follow-up observations of transiting planets, symbiotic stars and other cataclysmic variables, spectrophotometric studies of quasars and active galactic nuclei, photometry and spectroscopy of x-ray binaries, multi-color broad and narrow band imaging photometry of galaxies, studies of spectroscopic binary stars, participation in the international research project The Whole Earth Telescope.

The Wise 1 meter telescope took part in a number of international collaborations, particularly of simultaneous and nearly simultaneous observations of ground based and orbiting telescopes, such as IUE, GINGA, EXOSAT and others.

A few of the major astronomical discoveries made at the Wise Observatory are:

1. First detection of water molecules in comets.
2. One of the first identification of an X-ray binary with an optical star - HerX-1=HZHer.
3. Measurements of the size of the line emitting region in Seyfert galaxies and quasars.
4. Searches and followup studies of supernovae.

A list of phone numbers and contacts at the Wise Observatory is listed in section 1.4. There is an Internet connection to the observatory site which allows access to almost all computers at the observatory.

The purpose of this manual is to describe the use of the above instruments as well as other instruments, programs and facilities at the Wise Observatory 1 meter telescope. The aim is to help the observer operate the instruments properly and avoid mistakes, so that the observing time will be fully and properly used.

## 1.1 Observing Time Policy and Procedure

### Policy

The equipment and facilities of the Wise Observatory are constructed and maintained for the use of the general scientific community. Available observing time on the Wise Observatory telescope will be shared between staff members, students and visitors, and will be allotted on the basis of scientific merit and suitability of instruments. The final responsibility for all time allocation shall be the director's.

### Procedure

1. Requests for observing time are submitted to the observatory office using the standard Observing Time Request Form. Tex and postscript files of the Time Request Form are available over the Internet at <http://wise-obs.tau.ac.il/observations/forms/>.
2. Requests for observing time should be made for the six month periods October 1 - March 31 or April 1 - September 30, and should be submitted prior to the preceding August 1 and February 1 respectively. Late requests will be granted only in exceptional cases at the discretion of the director.
3. Graduate students must submit an endorsement from their faculty advisor along with the form. The endorsement must contain statements concerning the student's academic standing, the acceptability of the proposed research to the department, and the capability of the student to perform the proposed work.
4. Requests will be reviewed by a scheduling committee appointed by the director.
5. Any applicant who feels that the decision on the telescope allocation has been unfair may appeal directly to the observatory director for reconsideration.
6. Once telescope allocations have been made, revisions in schedules must be negotiated through the director.

## 1.2 Guidelines for Visiting Astronomers

The Observatory staff have put together a few guidelines with a view to making your stay a more efficient and pleasant one. If there are any questions or we can help in any way, please do not hesitate to contact us.

Our headquarters are situated on the university campus in Ramat-Aviv, a suburb of Tel-Aviv north of the city center. The Observatory site itself is about 200 km south of Tel-Aviv.

Prior to departing for the site, the astronomer is encouraged to visit the TAU office for briefing and discussions with the Observatory staff. It is therefore advisable to plan to be in Tel-Aviv at least one day earlier than the commencement date of the observing run.

Likewise, if the observer should need some assistance in transferring data or reduction, a day or two in Tel-Aviv will be required at the end of the run.

N.B. The visitor must take into consideration that Tel-Aviv University, as most public institutions in Israel, is closed on Friday, Saturday and religious or national holidays. Sunday is a working day in Israel.

### 1.2.1 Transportation

#### a. To and from Ben-Gurion International Airport:

Ben-Gurion International Airport is about 20 km from Tel-Aviv. There are taxicab, buses, and a train line between the airport and Tel-Aviv.

#### b. To and from Mitzpe Ramon:

The Wise Observatory is situated 5 km west of the township of Mitzpe Ramon. Buses run regularly every 15-20 minutes from the Central Bus Station of Tel-Aviv, or every 30 minutes from Tel-Aviv North (Arlozorov) Railway Station, to Beersheva (roughly 3/5 of the way to Mitzpe Ramon), and then somewhat less frequently (about every hour, depending on the time of day) from Beersheva to Mitzpe Ramon. There is also train line with a frequency of every half hour between Tel-Aviv and Beersheva. The trip takes all in all three and a half to four hours.

N.B. Buses and trains do not run on the Sabbath, from Friday afternoon to Saturday evening and the same applies from the afternoon before until the evening after official holidays.

Cars can be hired at the airport or in Tel-Aviv. At peak season it might be advisable to reserve in advance.

The observer should coordinate his arrival in Mitzpe Ramon with the Observatory staff in regard to time and meeting place.

**c. At the site:**

At Mitzpe Ramon there is a utility car, driven by the technical assistant, for traveling to and from the site. The utility car may not be used outside Mitzpe Ramon and the site, except in cases of emergency.

In order to drive the car there is a need for a special permit from the University authorities. Please consult with the Observatory technical manager regarding issuing this permit (it is a lengthy procedure which is not easy to complete).

## **1.2.2 Accommodation**

**a. In Tel-Aviv:**

It is advisable to reserve accommodation in Tel-Aviv a few weeks in advance through a reliable travel agency. We shall be glad to assist in making reservations for accommodation in Tel-Aviv (at the visiting astronomer's expense) if the following details are provided a few weeks in advance: arrival date and time, airline and flight number, room requirements (single or double accommodation) and duration of stay.

Likewise accommodation can be arranged for the end of the run, if we are advised of the visitor's requirements.

**b. In Mitzpe Ramon:**

In the town of Mitzpe Ramon there are several places to stay (hotel, youth hostel, etc.). Please consult the local site manager regarding the options. Observers may stay at one of the two furnished rooms in the observatory for the duration of the observing run; these rooms offer very basic accommodation. In such a case the observer's sleep will probably be interfered by the noise during the daily maintenance work.

Meals are obtainable at one of the few restaurants in the town of Mitzpe Ramon, but can also be self-prepared in the observatory where basic cooking facilities and utensils are available. It must be noted that no restaurants or shops are open in Mitzpe Ramon from Friday afternoon to Sunday morning. The same applies to official holidays.

Observers who wish to be accompanied by members of their families, students or other guests, should first obtain the consent of the director.

There are sets of keys for the observatory. Please consult the site manager in order to obtain the keys. **THE KEYS MUST BE RETURNED AT THE END OF YOUR RUN.**

## **1.2.3 The Observatory: Operating Procedures & Briefings**

As in every scientific laboratory, the basic rules are "if you are not sure, then don't" and "if something unexpected occurs, stop everything and call for help". For safety reasons no one is allowed to work at night alone.

1. Whenever a night assistant is assigned to an observer, the responsibility of the Observatory and the operation of the telescope rests with the night assistant.
2. Astronomers who receive permission from the director to work at the site without a night assistant must be thoroughly instructed by the site manager before the beginning of the observing run. It is the responsibility of the observer to see to it that he is properly instructed. Astronomers must strictly follow the local staff instructions and adhere to any written instructions that are supplied.
3. First-time visitors, or astronomers who have not been at the Observatory for more than 6 months, should plan to be at the site at least 6 hours before the actual run starts, in order to familiarize themselves with the Observatory, the safety procedures and the instruments.
4. Instruments will be changed only during the daytime shift, excluding Fridays, Saturdays, and official holidays.
5. Astronomers who plan to take away their data, should bring their own media. We currently use writable CD-ROMs and DVDs recorded on a PC platform.
6. The telephone +972-7-6588133 is a wireless one with an extension in the dome. It is to be used for work only, as every call outside Mitzpe Ramon is billed as a long distance call. No international calls are permitted, unless authorized by the director.

#### **1.2.4 Publications and Acknowledgment**

It is expected that visiting astronomers will utilize the observations they obtain at the Wise Observatory for the preparation of publications describing their research activity.

All publications using LAIWO data should carry the following credit lines:

“LAIWO, a wide-angle camera operating on the 1-m telescope at the Wise Observatory, Israel, was built at the Max Planck Institute for Astronomy (MPIA) in Heidelberg, Germany, with financial support from the MPIA, and grants from the German Israeli Science Foundation for Research and Development, and from the Israel Science Foundation.”

Also, a reference to the LAIWO paper (Gorbikov E., Brosch N., and Afonso C., 2010, *Astrophysics and Space Science*, Volume 326, Issue 2, pp.203-217) should be placed in the paper.

Publications by non-staff astronomers should carry the following credit lines: an asterisk by the author(s) name to refer to a footnote stating, “Visiting astronomer, the Florence & George Wise Observatory, Raymond and Beverly Sackler Faculty of Exact Sciences, Tel-Aviv

University, Israel”. The paper should carry the following acknowledgment: “This paper is [partly] based on observations collected at the Wise Observatory with the 1 meter telescope.”

Notification of any papers published for which the Wise Observatory is given a credit line would help keep the Observatory publication records accurate and current.

### 1.2.5 Import of Own Equipment

1. *As accompanied or unaccompanied luggage:* From past experience it was found that the clearing of such luggage is greatly facilitated by the use of a “Carnet de Passage” (obtainable at local, state or national Chambers of Commerce) with the addition of a detailed packing list for each packing.
2. *As separate shipment* (if too bulky or heavy for accompanied luggage): The Carnet de Passage and packing list as stated above is imperative. Due to delays in clearing customs, such shipments must reach Israel at least a week to 10 days before start of run.

The shipment should be sent “door to door”, to the Wise Observatory, Mitzpe Ramon. It might be convenient to use the services of the Tel-Aviv University customs brokers, but not necessarily so.

N.B. When filling in the Carnet, “Represented by” should stipulate the visiting astronomer’s name, the name of a member of the Wise Observatory staff and “all authorized representatives”.

The Wise Observatory should be advised well in advance of such shipping.

3. All expenses such as air freight, clearing incoming and outgoing shipments, and inland transportation must be borne by the astronomer.

## 1.3 Image backup and the permanent archive

As from 1997, all observations have been backed up on CD-ROMs and as of 2005 up to the end of 2013 all observations were backed up on DVDs. A copy of the archive is available in room 501 at the office on the Wise Observatory at Tel-Aviv University. If, for any reason, a required disk cannot be found at Tel-Aviv, a complete disk backup set is also kept at the observatory. Upon request, files can be transferred to a machine at the University using the network link.

Since the beginning of 2014 the backup is done on computer disks. At the end of the night the observation files are transferred from the image directory on the working computer to a dated sub-directory on the e:\ drive of mizpe-cdr computer (see section 2.4.3). They are also backed up in the /home/mizpe-bck/ directory on the computer wise-bck at the TAU

campus. To access the files one needs to log into wise-gate and change into the directory `/home/mizpe-bck/` .

## 1.4 Safety Instructions

1. When inside the dome, never slew the telescope without light in the dome.
2. When moving the telescope, you must ensure that it does not run into the platform or any other obstruction. When operating from the control room, the platform must be in its lowest position.
3. Never move the telescope, the dome, or the platform from two different locations.
4. Check the humidity in the dome at least once every 2 hours, and more frequently when humidity is higher than 80%. You must close the dome if water condensation begins to form on the inside of the dome or on the instruments.
5. Do not attempt to make any repair whatsoever to the telescope, measuring instruments, platform or dome on your own. Call a member of the staff in any event of breakdown.
6. Always lock the doors of the building and carry the distress button.
7. Always use a torch when moving in darkness.
8. Make sure you know the telephone numbers of the emergency services in Mitzpe-Ramon and those of the local staff members. These are posted in a number of prominent locations at the site.

### Telephone Numbers:

Dan Maoz, Observatory Director	W: 03-6408538
Ezra Mashal, Technical Director	H: 03-5400633 or 052-3529230
Sami Ben-Gigi, Site Manager	H: 08-6588829 or 052-2703382
Shai Kaspi, Electronics and Software	H: 09-7405648 or 054-7236295
Nachliel Levy, housekeeping	H: 08-6588705 or 052-8809342
Tel-Aviv Office	03-6408729 or 6409279
Tel-Aviv Office FAX	03-6408179
Site numbers	08-6588133 (FAX: 08-6588303)
Emergency mobile-telephone*	050-5075945

\*This telephone is in the site computer's room and is to be used ONLY for emergency, when none of the regular lines are available.

### Emergency Services:

<b>Police</b>	<b>100</b>
<b>Red Magen David (ambulance &amp; medical service)</b>	<b>6588569</b>
<b>Civil Guard</b>	<b>6588333</b>



### 1.4.1 Security at the Observatory Site

1. A list of emergency telephone numbers is posted in the office of the site manager, in the control room, and in the dome room. The observer should familiarize himself with the location of this list.
2. A document of "Security and Safety Rules" for the Wise Observatory is available at the observatory and through the Internet at:

[http://wise-obs.tau.ac.il/observatory/pakam\\_avtacha.pdf](http://wise-obs.tau.ac.il/observatory/pakam_avtacha.pdf)

The document is in Hebrew and cover different aspects of security and safety at the observatory. Any person working or observing at the observatory has to read and be familiar with these rules and has to sign at the observatory that he has read them and understood them.

3. The site manager, or, in his absence, the day/night assistant is in charge of all security measures, and observers are expressly requested to comply with his instructions.
4. The gate of the compound and the doors of the building must be kept locked.
5. During observation, every person in the dome room must be equipped with at least a red flash-light. It is forbidden to walk around without a flash-light.
6. The observatory is equipped with a "distress button" ("Lachtzan Metzuka"). This is a small black device (like a car key remote control) with two blue buttons that once a person press on it, it sends a signal to a control box which in turn dials to predefined numbers and send a distress signal.

The observers/workers at Wise have to carry this device on them while staying/working at the observatory. In case there is an emergency or an injury which prevents you from using the phone to call for help, you should immediately press one of the blue buttons (does not matter which, their operation is identical). You should carry the distress button at all times. It is equipped with a blue band so you can carry it on your neck.

The control box is placed in the observatory office, on the shelf near the big flashlight charger. The distress button is placed on the control box. Whenever you come to the observatory please take it from there and carry it, use it in an emergency, and return it to that place when you leave the observatory.

Currently, the control box dials to Ezra and Sami. When they will get the distress signal they will check first with the observatory if the button was not pressed by mistake, and will call for help in case no contact is made. We will work with the security department of the university, which has a 24 hour manned station, for them to get the first call from the observatory and act accordingly.

7. The whatcam at <http://132.66.65.17/> can be used to monitor the observatory yard.
8. There are 5 projectors on the observatory walls which light the surroundings of the observatory. In case there is something suspicious the projectors can be turned on. To turn the projectors on one can use a software on mizpe-cdr desktop which is call "Projectors" and has an icon of a lightening. When you run the program a window is opened with a button. when you hit the button its background will turn yellow and the projectors around the observatory will start to work. It take them a few minutes to get to their maximum illumination. The projectors can be turned on also using a switch in the main electricity board in the electricity/generator room. The switch is located on the left side of the main new electricity board, and is labeled as "outside light switch" and it is near switch number 54 (which is labeled "outside light"). Pay attention not to turn these projectors on when you are exposing an image as the light will ruin your observation.

## 1.5 Summary and Future Developments

By no means the programs described in this manual are "astronomer-proof", but they are certainly workable. A keen attempt was made to prevent foolish mistakes from ruining an observation, so the programs will warn you if you have blundered somehow. It is *certain* that there are operator mistakes that have not been covered. We shall attempt to modify the programs further, to make it more flexible and less attention-requiring.

We would like to emphasize that changes in the operation of the Wise Observatory, as a result of further developments, are imminent. New and updated editions of this manual will be issued as required.

# Chapter 2

## Computers

The observatory is equipped with several computers connected in a network. These control all the observing main functions, and enable the observing process to be as fully automated as possible. There are two computer locations: one is in the dome and a second is in the control room in the first floor. Observing during the night are done mostly from the control room in the first floor, but can also be done from the dome on the second floor. To access other computers we simply use the VNCviewer software (each computer has a "Remote" folder in its desktop and in it a quick links of VNC to the other computers).

**IMPORTANT:** Observers and accompanying persons are NOT ENTITLED to make any alteration to the settings of the computers at the Observatory, especially to the PCs located in the control room, or in the dome, not even making screen savers active, since this might interfere with the observing procedure.

### 2.1 Dome PC

This computer is located in the dome (in the glass room) and is running on it programs to control equipment in the dome, including the dome movements (Dome Agent), telescope pointing and movements (Telescope Agent), and the secondary movement for focus (Focus Agent). After booting this PC, all the three programs come up ready to be used.

#### 2.1.1 Telescope Agent

The "Telescope Agent" program is used to point the telescope. The program can be invoked from its icon on the desktop of dome-pc.

**CAUTION:** *Do not move the telescope from the "Telescope Agent" while moving it from the console buttons. This will severely damage the telescope.*

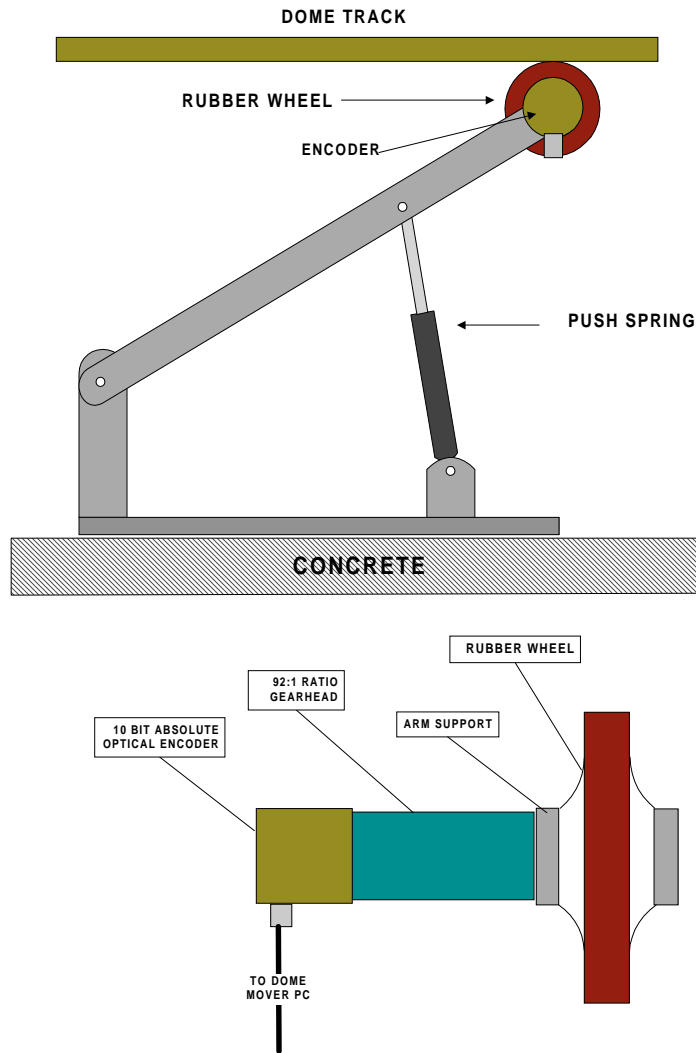


Figure 2.1: Mechanical wheel for dome positioning.

## 2.1.2 Dome Agent

This program is dedicated for moving the dome. It is connected to a potentiometer mounted with a gear reduction head and a pressure wheel in contact with the rotation track of the dome (Fig. 2.1) which enables to encode the dome position.

Usually this PC is interfaced from the “Remote Wise Commander” and the user doesn’t need to bother with the dome-pc, except for starting the program at the beginning of the night.

### Old Dome-Agent

At the beginning of each night the observer needs to check the calibration of the dome position in the computer. This is done by moving the dome from the console to be between the markers of the dome to be in front of the rails of the staircase. Then go to the dome computer and in the “Dome Agent” go to “Configure” → “Setting..”. Enter 90 in the “Dome Azimuth” and press “ok”. Then press “Configure” → “Save Settings” to save the settings.

The dome has an auto-calibration mechanism so that during the night whenever the dome is passing at the 156 degrees position this position is automatically calibrated in the program. This is done by a switch that is at the top of the staircase and a pin that is located on the rotating dome.

## New Dome-Agent

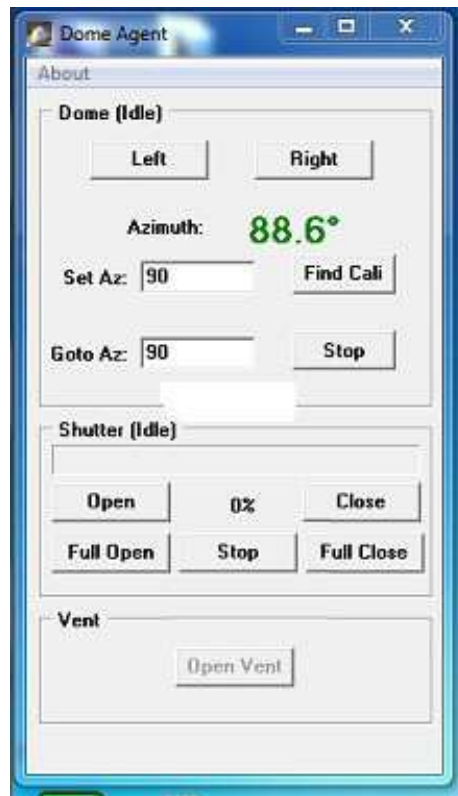


Figure 2.2: Dome-Agent window

Figure 2.2 shows a screenshot of the "Dome Agent" (written by Arie Blumenzweig based on a program by Yifith Lipkin).

There are two buttons at the top to turn it left or right.

Then there is the azimuth of the current position of the dome.

Below this there is a "Set Az" window in which at the beginning of the night when the observer wants to calibrate the dome one needs to write there the azimuth and press enter (don't forget the enter). If one puts the dome with the marks in front of the rails (as usual) then one writes 90 and press enter — this will calibrate the dome,

Next to this there is a button which says "Find Cal". When the "Dome Agent" starts (from its icon on the desktop) and one does not know what is its azimuth, one can calibrate in the usual way by putting it in front of the rails and write 90 and press enter, or to press the "Find Cal" button and the dome will move until it will find its mark and calibrate itself

automatically. Usually the observers at the observatory do not need this option since they use the rail option.

Below that line there is a “Goto Az” window in which one can enter an azimuth in it and press enter and the dome will go to that azimuth. Next to it there is a “Stop” button which will stop the movement of the dome.

On the middle part of the “Dome Agent” there is the shutter section which has an “open” and “close” buttons which while one press on them the shutter is opened or closed and if one stops pressing then it stops the movement in the middle. Also there are buttons of “Full Open” and “Full Close” which one press on them the dome will move and open or close to the end. Of course there is a “stop” button there to stop the open or close of the shutter in the middle if one changes one mind and do not want the open or close to reach to the end.

In the lower part of the “Dome Agent” there will be a button to open the “Vent”. This button is not active yet since the “Vent” is currently working from the “Telescope Agent” but in the future we will move it to the “Dome Agent”.

This version of the “Dome Agent” is suppose to exit a stuck situation by itself, in contrast to the old version which only notified you that it is stuck.

Changes in this version:

1. better stop debugging (when the dome stops it logs the azimuth and how many encoder ticks it took to stop)

2. better ”dome stuck handling”. When ”dome-stuck” is detected:

- Azimuth turns brown (instead of green) on the ”Dome Agent” form
- The dome-stuck handling phase is reported in the dome status (dome panel caption) on the main form
- The following phases occur:
  - phase 1 (cooling): dome is stopped for 10 seconds
  - phase 2 (backing) : dome moves backwards for two seconds
  - phase 3 (stopping): dome is stopped for two seconds
  - phase 4 (resuming): original motion is resumed
- At this point the dome is not considered stuck anymore (until it happens again :-). Azimuth goes green again.

3. fixed ”dome-stuck” report to remote commander, I hope :-)

### 2.1.3 Focus Agent

The “Focus Agent” window is started from an icon on the desktop of the dome-pc. The focus window may be started by double clicking on this icon.

If it is necessary to move the focus by a large amount, for example after the instruments have been changed or when the telescope’s f-ratio has been changed, then enter a numerical value to which the focus is to be moved and press the “move” key. Allow the focusing to proceed to completion before continuing. If the telescope is being focused with the same instrument and the same filter as on the previous night, then use the + or - keys to single step the focus position (by fixed several steps).

Since it is generally unnecessary to recheck the focus in the course of the night, provided the focus on all filters in use is the same, the focus window may now be left intact. If there is a significant difference in the required focus for two or more of the filters which are in use on a particular night you’ll need to use this window to make focus adjustment as required from a filter change.

The focus window always displays the current focus setting.

It is not desirable to use the old big blue console focus buttons.

It is not desirable to have several “Focus Agent” windows; the observer needs to close extra windows if they appear – always have only one “Focus Agent” window.

The current focus of the PI CAMERA is around 980 with turns=7 and for the FOSC it is around 1230 with turns=10, and for LAIWO is around 1340 with turns=10.

#### A Possible problem and its solution:

For the “Focus Agent” to work, the encoder readings must be available to the computer. If the computer is unable to read the encoder and the focus motor is started, it can only be stopped by the stop button. In the meantime, the focus shaft may well have turned through the encoder zero position at which point the turns counter should have been incremented or decremented. However, the new turns counter reading will not have been noted by the program. So when the encoder finally is powered the displayed reading may be out by 128 or a multiple of 128.

The encoder is only powered if the dome-pc computer is switched on. This situation arises because the focus encoder is connected to the dome-pc through one of the 24 bit I/O boards. The encoders takes its 5 volt power from the I/O board. So if the dome-pc is off the focus encoder is not working.

The encoder box is arranged so that its dial is visible beneath the old console beside the relay box. Each division represents one rotation of the focus encoder and the division numbers correspond to the turns count.

If the focus setting appears to be a long way out take a look at the coarse focus indicator

on the box beneath the console and note the number of the region the pointer is in.

Be sure that the dome-pc computer is turned on.

Click on “Preferences” in the “Files” menu of the “Focus Agent” window and in the ”Hardware” section set the turns to correspond to the focus region which the pointer is in.

All being well that should bring the focus reading to where it belongs.

## 2.2 Weather PC

A computer called weather-pc is in the dome and is connected to a small weather station which collects data from a wind vane which is on the roof of th observatory, temperature inside and outside the dome and humidity inside and outside the dome.

The weather data are displayed in a ”weather agent” tool that perform several actions, like displaying the data in forms of graphs and bars, sending the data to the TAU headquarters, saving a log of weather conditions, sending data to the “Remote Wise Commander”, etc.

**Observations operation should stop and the dome should be closed in one of the following event:**

1. When the wind speed is above 40 km/hour.
2. When the Humidity is above 90%.

## 2.3 FOSC PC

A PC is dedicated for moving the FOSC wheels and collimator. After booting, one needs to choose from the Norton Commander menu (pops up when hitting the F2 key) the program “FOSC”. This will result in a three-column menu corresponding to the FOSC’s three wheels. Also, it reports the last positions where the FOSC was left. After booting, the computer is zeroing the FOSC collimator. Then the user needs to initialize the wheels positions. This is done by putting “i” as an entry in the position number prompt, and pressing <cr>. This should be done for each of the three wheels.

In fact, this PC is interfaced from the Camera and FOSC controller PC through the “FOSC Control window” (section 3.2.2) and the user does not need to deal with that PC except for turning it on at the beginning of the night and initializing the wheels positions. Advanced users might want to use it for its special abilities described below, however they should **note** that if the wheels are not moved from the “FOSC Control window” then the key words in the image’s FITS-header referring to the wheels positions, will be incorrect.



For advanced users:

To move the wheels, enter a desired wheel position-number. Use the Left/Right arrows to move between wheels menus. After specifying all positions you want, press <cr>. The program will move the wheels one by one, position the collimator for the setup asked for, and report when ready.

There are four hot-keys to ease the work of obtaining spectra:

Hot key	Wheel		
	Aperture	Upper	Lower
Alt-n	none	none	none
Alt-g	none	Wedge3	600 grism
Alt-a	Aperture last used	none	none
Alt-s	Aperture last used	Wedge3	600 grism

To initialize (check) a wheel position put “i” instead of a position number as an entry, and press <cr>.

To leave the wheels program and back into the Norton Commander program, press Alt-x and then “x” to confirm your request. To operate the wheels program again, choose it from the Norton commander menu – “F2” key.

For more advanced users:

To change the collimator position, press “c” and then the desired collimator position (ranges from 0 to 540 in multiples of 10) and <cr>. Another <cr> will return the collimator position to the one corresponding to the wheels setup. To zero the collimator, enter (“i” instead of a position number.

By using the halogen and HeAr lamps and continues imagng in MaximDL, and moving the collimator, one can find the best collimator position for one setup by getting the narrowest image of the aperture. To make a collimator position the default for the system there is need to edit the file c:\misc\fosfile . This file consist of four columns: (1) capital letter describing the wheel (A - Aperture, U - Upper, L - lower), (2) number of wheel position (0 – 9), (3) information number, and (4) position name. The information number in the aperture wheel rows is the wheel offset when positioning it. The information number in the upper wheel rows is the default collimator position when this row is chosen and this number should be edited to make another default. Default collimator positions for some setups are:

## 2.4 mizpe-cdr

This PC is in the control room and is the main computer for the observing procedure.

This computer is used as the main computer to operate the camera and the telescope

Table 2.1: FOSC collimator position - INFORMATION NOT UPTODATE

FOSC Wheel			Camera wheel	collimator-position
Aperture	Upper	Lower		
10" slitR	Wedge3	600 grism	none	270
5" slit	Wedge3	600 grism	none	270
5" hole	150 grism	echelle	270	
none	R filter	none	Clear	400
none	Fos/none	none	Clear	470
none	Cam/none	none	U filter	0
none	Cam/none	none	B filter	300
none	Cam/none	none	V filter	380
none	Cam/none	none	R filter	320
none	Cam/none	none	I-old filter	100
none	Cam/none	none	I-new filter	200

through the “Remote Wise Commander” program that is in the Remote folder on the desktop.

### 2.4.1 Remote Wise Commander

The main program to operate the systems of the telescope.

To observe objects during the night one needs to prepare a list of one’s objects in a format: running number, Right ascension, Declination, epoch, object name, then filter and exposure time in sec etc. For example:

```

1  0:07:59.40  17:07:38.00  1950.0  PKS0008+171  U 300  R 400
2  0:14:04.10  81:18:28.00  1950.0  S5_0014+81  R 250  B 300  B 400
3  0:17:49.90  15:24:16.00  1950.0  3C9  B 300  I 400
4  0:26:38.10  12:59:30.00  1950.0  PG0026+129  R 120  V 180
5  0:42:22.70  10:10:30.00  1950.0  MC0042+101  R 300  B 400  I 30

```

Note: no spaces are allowed after the last character at the end of a line, no blank rows are allowed, and no <cr> at the end of the file. This list must be placed in the C:\misc\ directory of the mizpe-cdr computer, and must named with the extension: .lst . When starting to work, load the list to the “Remote Wise Commander”. To observe simply click an object and click ”observe”. The program will move to the right filter/s and will carry out the observation for each filter. If one wants two exposures with the same filter and same exposure time then one should specify this filter twice or more.

**CAUTION:** *Do not move the telescope from the “Telescope Agent” while moving it from the console buttons. This will severely damage the telescope.*

## Automatic Observations

Before starting the “Remote Wise Commander” you need to make sure that the programs of the camera you are using are running (SNI and “Filter Agent” for the PI camera, or the `laiwo_science` and `laiwo_guider` for the LAIWO).

When you start the “Remote Wise Commander” you need first to choose the camera you are about to use during the night in the box next to the title of the Camera section.

Then you connect to the sockets by “connect all”. If you are going to use the `laiwo` you will be prompted with a window which asks to enter the filters which are currently in `laiwo` and to mark the filter which is currently in front of the camera. In most cases the defaults will be fine and you only need to confirm, but you need to make sure it has the right parameters.

Then you need to start the tracking and load a list.

The operation for the PI and the LAIWO are the same:

- You can choose an object from the list by clicking twice on its line.
- Then point the telescope to the object by pressing “GOTO” and after it reached it you can do a sequence of filters on it by pressing the “Observe” button.
- You can start and stop the guider by pressing the toggle button in the “Guider” section.
- You can change a filter by pressing on the bullet of the filter in the “Filter Position” section.

Note that the “STOP” button in the “Telescope” section can be used to stop the movement of the telescope in the middle.

To use the auto mode:

- You need to load a list of objects with filters and exposure times.
- Make sure the RA Track is turned on.
- Click twice on the object in the list you want to start with.
- Then check-mark the box next to “AUTO” in the “Telescope” section.
- The “GOTO” Button will change to “START” and you should press it to start the sequence.
- You will be asked to confirm your choice and once you will confirm the “Remote Wise Commander” will start going over the list.
- The telescope will be sent to the object, once it will get there it will start the guider, and then start the sequence of exposures on that object with the filters and exposure times given in the list. Once done, the guider will be stopped and the telescope will be sent to the next object in the list. When the program will reach the end of the list it will start from object number 1, and will go down the list, and so on.
- To stop the Auto mode you need to press the “STOP” button in the “Telescope” section.

Once you'll press it, the program will finish the observation it is currently exposing and will stop after the exposure will be done.

— To stop a sequence of exposures and filters you need to press the “STOP” button in the “Camera” section. Once you'll press it, the program will finish the observation it is currently exposing and will stop after the exposure will be done.

— To stop an exposure in the middle of it (if you do not want to finish it) you need to press the relevant “STOP” button in the “Remote Wise Commander” and then to go to the laiwo\_science window on the laiwo computer and stop the exposure there by pressing the button with a square on it.

— If you are using the PI camera and want to stop an exposure in the middle of it (if you do not want to finish it) you need to press shift+click on “STOP” button in the “Camera” section. This will not work for the laiwo in which you need to use the procedure in the previous paragraph.

— While the AUTO is working the observer has to monitor its operation and make sure it is executing the list in order and in the correct way.

— Since the guider in the laiwo instrument is working fairly well it almost always lock on a star and starts guiding and so the AUTO procedure can work properly. There is a problem with the guider on the PI camera as often it does not find a star to guide on. In such a case the AUTO program will fail. You need to pay extra attention to this and not to use the AUTO mode with the PI if its guider keeps failing on your fields.

## 2.4.2 Focusing Aid

This is an EXCEL file written by Oded Spector which helps to determine the focus of the telescope. The file is located on the desktop of mizpe-cdr.

After you open the file you need to choose the right tab according to the filter and the instrument you want to focus. In the sheet of each tab there is a table with two columns, one is the ”Value” of the focus as appear in the “Focus Agent” window on the dome-pc, and the second column is the ”FWHM” in pixels of the star image (as in the “information” window of MaximDL).

The graph shows the points from the table with a parabola regression line. The minimum of this parabola is the recommended focus position for the secondary in the “Focus Agent” window.

A suggested procedure to focus the telescope:

— Delete all the previous FWHM values (if they are listed).

— Point the “Focus Agent” to a value which is about 20 lower then the focus of the previous observation.

- Take an exposure, measure the FWHM and put in the correct values in the table.
- Continue to check the focus in jumps of 5 until passing the point of the focus in about 20.
- Find the minimum of the parabola and point the “Focus Agent” to this point.

### 2.4.3 Images Backup

For archiving observations, the observer should transfer the images at the end of the night to backup disks. Once transferred, they should be left there until removed by the undaunted Wise Observatory staff.

The PI CCD files are kept in the pi2006 computer in the C:\outputimage\ directory in subdirectories named in the Japanese format date of yyymmdd (where yyyy is the year, mm is the month, and dd is the day, e.g., December 31 1999 is 19991231 ; the date is the date of the evening of the start of the observations and it continues up to the morning after even though the date is changed on midnight). This way, the list of sub-directories runs sequentially from earlier to later dates. There should be a directory named for the date of the files that have just been observed. If there is not such a directory, create it. Within the Total Commander this can be done using the F7 function key, as indicated on the bottom line of the Total Commander display.

This procedure of transferring the files, is done on the computer mizpe-cdr with the Total-Commander window using the pre-defined tabs for the working directories.

On the right side of the Total Commander window there is a tab called "PI-images" which is connected to the C:\outputimage\ directory on the pi2006 computer and list all the observation directories.

On the left side of the Total Commander window there is a tab called "mizpe-cdr-backup" which is connected to the E:\ directory on mizpe-cdr, which is a 3 TBy USB disc.

At the end of the night you need to copy the observations directory from pi2006 to mizpe-cdr.

On the left side of the Total Commander window there is also a tab called "mizpe-bck-backup" which connects to the directory /home/mizpe-bck/ on the wise-gate computer at TAU.

At the end of the night you also need to copy the observations directory from pi2006 to /home/mizpe-bck/.

You can put these copy procedure in the background so that you can continue to use the Total Commander window while copying.

If one or more of the pre-defined tabs for the working directories in the Total-Commander are not present one can access the working directory by pressing Ctrl-D on one of the sides

and choosing the needed directory.

Once the transfer is completed you need to check that the files were transferred correctly. The simple check is to check that their sizes are identical to their original sizes in the original directory. One can check the number of files and the total bits number in each panel of the Total Commander window and see if there is a discrepancy. If some of the sizes are different then something was wrong during the transfer and the procedure of transferring should be repeated. If all files were transferred well the numbers will be the same.

The above procedure ensures that two copies of the data are kept (one on mizpe-bck at TAU and one on mizpe-cdr disk at the observatory).

It is the night's Principal Investigator responsibility to make sure that the files were transferred correctly and fully - otherwise he will lose valuable data.

# Chapter 3

## The CAMERA

The camera consist of a filter wheel mounted directly on the telescope and the CCD mounted beneath it. The CCD is mounted at the  $f/7$  focus.

### 3.1 Camera Filter Wheel

The automated filter wheel (Fig. 3.1) has eight positions for 2 inch round or square filters (whose thickness is less than 8 mm). The wheel is absolutely encoded and a filter change is very rapid (a few seconds) and it is the most commonly used instrument now. If you change filters in the wheel, be sure to change the list on the “Filter Agent” window. In order to move the automated wheel one uses the “Filter Agent” window (sec. 3.2.1) on the desktop of the pi computer. However, usually this is not required since it is moved to the desired position by the “Remote Wise Commander” window on mizpe-cdr.

Note that when the automated filter wheel is in a “right” position, an “In Detent” indication is in the lower status bar of the “Filter Agent” . If this is not the case then the filter wheel needs to be adjusted. This is done by switching the wheel power supply off (using the black switch on its electric cable), moving the wheel by hand to the right positions according to the white marks, switching the power supply on again, and then resetting the position in the “Filter Agent” as indicated in section 3.2.1.

Sometimes, usually when operating an electrical system in the dome - like moving the dome or the platform, the wheel gets out of its “right” place in which case it need to be reset as indicated above.

A list of available 50mm filters is given in Table 3.1.

Another filter wheel at the Wise Observatory is one with 4 positions for filters which are 3 inches wide. The operation of this wheel is the same as the one with 8 positions and it was used for the SITe CCD which was a large CCD. The filters available for the 4 positions filter wheel are listed in Table 3.2.

Table 3.1: Available 50mm filters

Filter	$\lambda_{central}$	FWHM	Remarks
U	-	-	Bessell - purchased in 2007
B	-	-	Bessell - purchased in 1997
V	-	-	Bessell - purchased in 1997
R	-	-	Bessell - purchased in 1997
I	-	-	Bessell - purchased in 1997
Z	-	-	Blue cutoff + CCD response - purchased in 1987 from RGO
$I_{new}$	8100	1400	Cousins - purchased in 1997 from Custom Scientific
Red J-T	6400	1400	accepted from Arlin Crotts in 1995
Continuum	5300	144	(WB16) Kris Davidson's Crab Nebula filter
u'	-	-	SDSS filter - purchased in 2010
g'	-	-	SDSS filter - purchased in 2010
r'	-	-	SDSS filter - purchased in 2010
i'	-	-	SDSS filter - purchased in 2010
z'	-	-	SDSS filter - purchased in 2010
Stromgren v	4113	180	peak=51% at 25 degree Celsius
Stromgren b	4676	181	peak=65% at 25 degree Celsius
Stromgren y	5488	230	peak=65% at 25 degree Celsius
$H_{\alpha}$ v=0 km/sec	6562.8	25	with the Stromgren set
$H_{\beta}W$	4874	134	peak=64% at 25 degree Celsius; with the Stromgren set
$H_{\beta}N$	4865	30	peak=52% at 25 degree Celsius; with the Stromgren set
Continuum	6447	54	( $H_{\alpha}1$ ), Microcoatings, peak=64.4%
$H_{\alpha}$ v=0 km/sec	6562	50	( $H_{\alpha}2$ ), Microcoatings, peak=67.5%
$H_{\alpha}$ v=1050	6586	48	( $H_{\alpha}3$ ), Microcoatings, peak=66%
$H_{\alpha}$ v=2150	6610	55	( $H_{\alpha}4$ ), Microcoatings, peak=69.7%
$H_{\alpha}$ v=4390	6659	60	RGO 67, peak=46%
$H_{\alpha}$ v=6240	6700	53	( $H_{\alpha}5$ ), Microcoatings, peak=70%
$H_{\alpha}$	6635	55	( $H_{\alpha}6$ ), peak=55%
$H_{\alpha}$	6697	55	( $H_{\alpha}7$ ), peak=60%
$H_{\alpha}$	6760	60	( $H_{\alpha}8$ ), peak=55%
$H_{\alpha}$	6800	65	( $H_{\alpha}9$ ), peak=40%
$\sim H_{\beta}$	4883	32	RGO 53
He II, N III	4697	53	BARR associates - #2
He I	5874	62	BARR associates - #1
[S II]	6736	75	BARR associates #6
[O III]	5150	-	from Edmund Scientific - December 1995
Na I, He I	5890	-	from Edmund Scientific - December 1995
Continuum	6200	-	from Edmund Scientific - December 1995



Filter	$\lambda_{central}$	FWHM	Remarks
U	-	-	RGO 1 - Schott UG2
-	-	-	RGO - Schott UG2 - round
B	-	-	RGO 3 - Schott
V	-	-	RGO 6 - Schott
V	-	-	RGO - Schott - GG495 + BG18
R	-	-	RGO 8 - Schott OG570
I	-	88	RGO 9 - Schott
-	5800	-	RGO OG590 - Schott
-	-	-	RGO 11 - Schott
-	-	-	RGO 14 - Schott + Anti-Red Leak
Polaroid	-	-	0 degrees with a hole
Polaroid	-	-	60 degrees with a hole
Polaroid	-	-	120 degrees with a hole
Polaroid	-	-	RGO - Schott
Continuum	5107	29	RGO 59 - Schott - round
Continuum	5295	88	IR - 5300 - 7mm thick - round
METHANE	-	-	$\Omega$ 890BP30 - 35006/9418 - round $\times$ two filters
-	4363	18	Heliotek (0745)
#65.1315	-	-	GG495
U	-	-	Johnson/Cousins - purchased in 1987 from RGO - DEFECT
B	-	-	Johnson/Cousins - purchased in 1987 from RGO - some flaws
V	-	-	Johnson/Cousins - purchased in 1994 from RGO - some flaws
R	-	-	Cousins - purchased in 1987 from RGO - some flaws
$I_{old}$	-	-	Pseudo-Johnson - purchased in 1987 from RGO - some flaws
43162	4420	-	CWL - Edmond Scientific - DEFECT
-	5165	50	RGO - Schott - DEFECT
-	5165	-	RGO - DEFECT
-	5165	-	RGO - DEFECT
-	-	-	Schott BG18 6mm - DEFECT
$H_{\beta}$	4851	10	RGO 40 - Schott - DEFECT
[O III]	5010	40	RGO 56 - DEFECT
Continuum	5077	40	RGO 58 - DEFECT
Continuum	4919	38	RGO 54 - some flaws
$H_{\beta}$	4863	42	RGO 52 - some flaws
Continuum	4960	30	RGO 55 - NOT FOUND

Notes:

(a) The five Bessell filters UBVRI and the five SDSS filters u'g'r'i'z' are square and have the same thickness of 5 mm, hence when setting the telescope focus for one of them it will be good for the others. However the Z filter is thicker ( $\sim 7$  mm, same as all the old Johnson filters) than the above filters, hence if the telescope focus was set with one of the above five it will not be in focus for the Z, and vice versa. The same applies for using the round  $H_{\alpha}$  filters or the  $I_{new}$  filter - all of them have the same focus position as the five Bessell filters. Thus, with the Z filter one needs to move the position of the focus by 10 steps up if it was originally focused with one of the five Bessell filters or with any of the other  $H_{\alpha}$  filters. For the other filters it is advised to focus the telescope with the filter you need to use during the night.

- (b) The filters are 2 inch round or square and their thickness is no more then 7 mm (in order to be used in the FOSC. For use in the CAMERA the thickness limit is 8 mm).
- (c) A thorough study of the  $H_\alpha$  filter set was done by Oded Spector in September 2006 (see the web site below).
- (d) There is a set of UBVRI Bessell filters, which are of 3 inches square, which were purchased for the SITE filter wheel (4 positions wheel) in September 2000 from Omega Optical.
- (e) Transmission curves of the common filters as well as the  $H_\alpha$  filters study by Oded Spector are available at <http://wise-obs.tau.ac.il/observations/filters>

The observer should specify when a filter change or a filter-wheel change is required, since this operation is done only in daytime.

Table 3.2: Available 3" filters

Filter	$\lambda_{central}$	FWHM	Remarks
U	-	-	Bessell - purchased in 2000 from Omega filters
B	-	-	Bessell - purchased in 2000 from Omega filters
V	-	-	Bessell - purchased in 2000 from Omega filters
R	-	-	Bessell - purchased in 2000 from Omega filters
I	-	-	Bessell - purchased in 2000 from Omega filters
ON 26	-	-	Schott 2mm
UV	-	-	Schott 2mm
UG 1	-	-	Schott 2mm - 813573
BG 18	-	-	Schott 3mm - 16530
BG 23	-	-	Blue - Schott 3mm - 333101
BG 37	-	-	Schott 3/4mm + GG385 2mm (B)
BG 38	-	-	Schott 3mm
GG 495	-	-	Yellow - Schott 2mm - 16335
RG 715	-	-	Schott 2mm - 16442
RG 610	-	-	Red - Schott 2mm

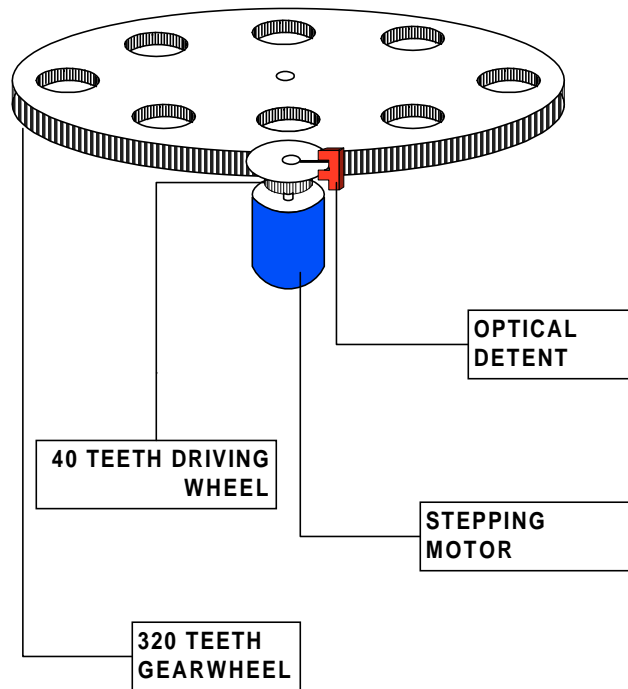
Some issues about the filters:

The narrow-bands filters are about 70–100 Å wide, this is about 10-15 narrower than broad-band filters (e.g.,the R-band). The exposure times used are usually longer by a factor of 2-4 for  $H_\alpha$  than for the R-band. This allows detecting point-like  $H_\alpha$  sources of EW~10–100 with sufficient signal-to-noise within galaxies.

$H_\alpha 5$  and  $H_\alpha 7$  are practically the same.

$H_\alpha 9$  is aimed for targets with 11000 km per sec, but not recommended to use since it distorts point sources.

The  $H_\alpha$  filters are of different band-widths, so they have different sensitivity to the twilight sky. You may find the following list, with the filters in order of exposure (from the



### 8 POSITIONS FILTER WHEEL

Figure 3.1: Camera filter wheel.

least sensitive to the most sensitive):

Flat Field - Filter order (for sunset) U, Ha2, Ha3, Ha9, Ha4, Ha5, Ha8, Ha7, Ha6, RGO67, Ha1, WB16, B, V, R, I, clear

The first filter (U) should be imaged at around sunset. If sky is clear, you can start it's flat field, when the sun is at about -1 deg. Many of the  $H_{\alpha}$  filters are very close in sensitivity to each other, so don't count of taking more than 4 or 5 filters' flats. After the H-alpha filters there's some gap before filter B.

## 3.2 pi2006 computer

### 3.2.1 Filter Agent

This window is used to control the automated filter wheel position (sec. 3.1). The program was written in July 2010 by Eli Ochayon and Roy Rozenman as their project toward their B.Eng. degree. The "Filter Agent" program is a Delphi interface which operate an Arduino Mega device through a Java script. This Arduino Mega device controls the operation of the filter wheel and is located in a black box connected to the filter wheel power supply and connected to the computer via USB cable. The USB port is marked on the computer in green color.

Under normal working conditions the “Filter Agent” window is continuously running on the pi2006 computer and the user only turns on and off the power supply of the filter wheel at the beginning and end of the night, respectively. If there are no problems The “Filter Agent” should not be closed at the end of the night, thus no need to open it in the evening.

At the begging of the night after turning on the filter wheel power supply the observer has to press on the “Look for Close Detent” button in the “Filter Agent” window to get the wheel to the right position. Then the observer should verify that the current filter position (by looking on the filter position in the filter wheel on the telescope) is the one which appears in the “Filter Agent” window. If it is not the observer need to write the current filter position in the window next to the “Set to Filter” button, and press “Set to Filter” which sets it correctly.

To move to a certain filter simply mark the button next to it and press the “move” button. Note that the wheel turns until you get that it is “In Detent” on the lower status bar. If it fails to reach to the detent position the status bar will be marked with red and the observer needs to press “Look for Close Detent” so it will get to the position of a detent.

Usually the “Remote Wise Commander” is communicating with the “Filter Agent” and is taking care of moving the filter wheel and the observer does not need to deal with this window which can be kept in a minimize state. Note that when the “Filter Agent” program is controlled by the “Remote Wise Commander” program the buttons in the “Filter Agent” program are disabled.

### **Initialization Procedure**

When the computer is booted, when the USB cable that connects the computer to the controller box is disconnected and connected again, when trying to move the filters while the power supply to the filter wheel is turned of, and in similar cases, the “Filter Agent” program will not communicate with the controller anymore.

This connection is reset by running a small program which is linked from the desktop and is called “Filter Agent Initialize”. This program is invoked automatically when the computer is rebooted and when the “Filter Agent” program is run, so in principle the observer will not need to actually use this “Filter Agent Initialize” icon on the desktop.

If this does not help and the filter wheel is not moving the observer should pull out the USB connection from the computer (the one marked in green) and put it back again. Opening the “Filter Agent” program after that should reset things correctly.

If the above does not work then, after disconnecting and connecting the USB, open the Arduino program which appears on the desktop under the “Arduino Initialize” icon. First make sure the filter wheel power supply is on. Then click twice on the icon and when the program is opened one needs to click twice on the most left icon in the second row on the

window. This will open a new window titled "com3". Then one needs to close the main Arduino window by hitting on the "X" on the top-right corner. This will reset the connection and enable the work with the "Filter Agent", which you should start after this initialization procedure.

### **Changing Filters**

When one is changing filters in the Filter Wheel (or changing the filter wheel between the 4 position filter wheel to the 8 position filter wheel) one need to also change the names in the "Filter Agent" program. This is done only by a qualified technician!!!

To change the filters name go the "Menu" → "Filter Names...". A "Filter Names" window will appear and in it you need to write the filters in the correct order (either for the 4 or 8 positions wheel). You can also choose which filter wheel it is - 4 or 8 filters. Then click "Save" to apply the changes.

### **For qualified technicians**

Choosing "Menu" → "Com Port..." will open a "Com Port Form" in which one can choose the communication port for the USB. Currently the Com Port is 3 and there is no reason to change it as long as using the same USB port.

Choosing "Menu" → "Initialization..." will open an "initialization Option" window where one can look for close detent, check the detent, set to filter 1, and make small, medium and large moves of the filter wheel either clock wise or counter clock wise. These can be used to check the filter wheel and its moves.

## **3.2.2 FOSC Control Window**

Not implemented yet.

## **3.3 STX16803-CAMERA**

### **3.3.1 The SBIG STX-16803 CCD**

The SBIG STX-16803 CCD was purchased by the Technion on mid-December 2011. It is a  $4096 \times 4096$  pixels CCD with squares pixels of  $9 \times 9$  microns in size (model: KAF-16803). The pixel size is  $0.261 \pm 0.002$  "/pixel (each 230 pixels are about 1 arcmin), which gives an over-sampling of the imaged objects. Thus, the optimal setup to work with that camera is by binning it  $3 \times 3$  and to get pixel size of  $0.783$  "/pixel. The overall field of view of the STX CCD is  $17.82 \times 17.82$  arcmin.

The STX CCD is operated directly through a MaximDL software which is on the computer called pi2006. To integrate the STX CCD with the other facilities at the observatory the STX CCD is operated through a DELPHI program called "STX/PI Interface" which

was written originally by Gil Ninveh and Adi Zitrin for the PI CCD (as part of Adi’s M.Sc. project). David Polishook has upgraded this DELPHI program so it can work with the ”Remote Wise Commander” program that Yiftah Lipkin wrote.

**Dead time between images:**

When using the guider the MaximDL program adds 5 sec before the beginning of each exposure. We have not found a way (yet) in the software to get rid of these 5 sec and so the current option is just not to use the guider.

When taking a sequence of a full frame (2048x2048 binned pixels) through the ”Remote Wise Commander” the overhead time of reading and displaying the image is about 10 sec (need to check this ●).

When guiding it adds to this 5 sec.

When taking a sequence and changing filters between exposures each 1 position filter move adds 3 sec to the dead time.

To shorten the overhead time one can observe with no guiding and save the 5 sec overhead on each frame due to it.

One can observe directly from the MaximDL and save about 1-2 sec of communication between the softwares/computers.

The main overhead shortening would come from taking a sub-frame of the STX CCD. The following table gives the overhead time of reading and displaying the image when not using an autoguider and when operating the CCD directly from MaximDL’s “Camera Control” window in the ”Expose” tab in its “AutoSave” mode. (sub-frames were taken about around the center of the CCD; the given average time is over about 100 images):

Sub-Frame	Overhead time (sec)
1340×1300	
750×750	
500×500	
250×250	
295×85	

**3.3.2 STX-CAMERA Operation**

A suggested procedure for operating the telescope with the CAMERA is outlined here. It is suggested to come to the observatory about an hour before sunset (if the CCD is warm you need to arrive 2 hours before sunset, so that you’ll have enough time to cool it).

**In the dome:**

- On the way to the dome go to the electric box in the room below the telescope and lift the three circuit breakers (CB2, CB3, CB4).
- Turn on the STX CCD, the filter Wheel, and the ST7 CCD guider.

- Make sure the rotator is on the STX angle, which is 82.4 degrees. At this position, the guider ST7 should point south. Any other direction will mess up your work.
- Calibrate the dome position by moving the dome from the console so that the rails will be between the markers.
- Then go to the dome computer and in the “Dome Agent” write 90 in the “Set Az” and press Enter.
- On the dome-pc make sure the time of the clock gets updated with the Dimension4 program: put the cursor on the Dimension4 icon and check if the time was updated in the last 5 min.
- Also check that the “Telescope Agent” and “Focus Agent” programs are running. If not then start them from the desktop.
- Make sure the set/guide switch on the small gray hand paddle next to the dome-pc is pointing to the ”guide” position. Otherwise the guider will not work properly.
- Open a VNC from the dome-pc to the pi2006 (use the ”Remote” folder on the desktop) and make sure the “Filter Agent” program is running on it. If not, start it from the desktop icon - use the initialization process if needed (see section 3.2.1).
- Press once on “Look for Close Detent” to set the filter wheel correctly. Then make sure it is on the right filter position.
- Use the “Filter Agent” window to position the filter wheel on your desired filter in order to observe flat-fields at twilight. Make sure the program moves the filters correctly.
- In the pi2006 VNC window click twice on the STX icon that is on the desktop. The STX/PI interface will be opened, then the MaximDL’s windows will be opened and automatically will connect to the CCDs and will start the cooler on.

However, if this is the first time the STX is used after the eShel was used (or sometimes another instrument) you will need to setup the CCDs according to the following procedure:

- Close the STX program and the MaximDL.
- Open the MaximDL program by clicking twice the icon on the desktop.
- If the “Camera Control” sub-window will not appear toggle it from its icon that looks like a small CCD.
- Goto the “Setup” tab and set Camera 1 to “SBIG Universal” with the camera “STX-16803” and Camera 2 to “SBIG Univerasl” with the camera “Parallel 378”.
- In the “Setup” tab press “connect” and make sure there is connection to the cameras (“Camera idle”) will appear on the info window of each camera.
- Set Camera 1 cooler temperature to  $-30$  and Camera 2 cooler to  $-10$ , and press “On”

in the “Coller” section.

— In the “option” button of Camera1 make sure that the option “Rotate 90 CCW” is checked in the boxes next to it and the other options are not checked.

— In the “Expose” tab set the radio button of Camera 1, and set the “Exposure Preset” to “STX16803\_camera”.

— In the “Guide” tab set the radio button of Camera 2.

– In the “Guide” tab Make sure that ”Pier Flip” is NOT checked and the “watch star” is checked, and that the “Aggressiveness” to is set to x=8 y=8. Click the “Settings” button and a “Guider Settings” Window will be opened. Set XSpeed to 0.9, Yspeed to  $-0.8$ , and Angle to 1.

— Take an exposure with in the “Expose” and “Guide” tabs.

— In the “Setup” tab press “Coolers off” and “Disconnect”, and close the MaximDL window.

— Now click twice on the STX icon that is on the desktop. The STX/PI interface will be opened, then the MaximDL’s windows will be opened and automatically will connect to the CCDs and will start the cooler on.

— In the STX/PI interface set ‘Binning’ to 3 both in the X and Y.

— Close the VNC to the pi2006 from the dome-pc.

— Turn OFF the dome air condition using its remote control which is on the big blue console.

— Check the blue big console; if it is off, turn it on. When turning on the breakers (CB2, CB3, CB4) might jump so you will need to go down to the electric box in the room below the telescope to lift them up again.

— Take off the telescope cover.

— Lower the platform all the way down.

— Position the telescope to declination of  $\sim 60^\circ$ , so that when opening the dome shutter debris accumulated on top will not fall into the telescope.

— Make sure the Dec (or any other) button is not stuck by pressing only the slew button and making sure the telescope does not move.

— Turn on the relay box switche - behind the old console.

– Make sure the platform is all the way down.

— Turn off all light in the dome (including computer screens).

### **In the control room:**

— On mizpe-cdr open VNC to dome-pc (from the remote folder on the desktop). In the



“Focus Agent” tool put the secondary to a position close to STX camera focus used last time (typically around 52600).

— On mizpe-cdr bring up the weather-pc VNC window (from the remote folder on the desktop) to be able to check the weather.

— On weather-pc make sure that in the “Volume control ” Window the “Mute” and “Mute all” of the “Mic Volume” and “Volume Control” are not checked so that you’ll be able to hear the sounds from the dome, and also that the “Balance” in the “Volume Control” is on the left speaker.

— On mizpe-cdr open VNC to the cloudwatcher computer and check the sky clarity.

— On mizpe-cdr bring up the pi2006 VNC window.

— In the MaximDL’s “Camera Control” window go to the Guide tab. Make sure that “Pier Flip” is NOT checked and that the “Aggressiveness” to  $x=8$   $y=8$ . Click the “Settings” button and a “Guider Settings” Window will be opened. Set XSpeed to 0.9, Yspeed to  $-0.8$ , and Angle to 1.

— In the “STX/PI interface” make sure the binning is set to 3 both in X and Y.

— On mizpe-cdr open the “Remote Wise Commander” program. In the “Camera” section set the instrument to “PI” and then choose the “Connect all” from the “Sockets” menu, which will initialize the connections to the different agents. Press the “FOV” button to reset a connection between the “Remote Wise Commander” and the “STX/PI Interface”. In the “Set CCD size” that will open just press “ok” - currently there is no meaning to the number in that window.

— Load the list/s you are going to use during the night from the List menu.

— Check the computers pi2006, mizpe-cdr, dome-pc, and weather-pc, that the Dimension4 program is running and updating the computer time and that it is correct.

— About 15 minutes before sunset, you should take a bias sequence by choosing the “bias” from the “Remote Commander”, entering the number 5, and pressing “ok”.

— NOTE: Take the bias only when the CCD temperature stabilized on  $-110$  degrees and while the dome is in complete darkness, in order to prevent light leaks into the camera. The average bias level should be around 1200.

### **Taking Flat Field:**

— On sunset open the dome from the “Remote Wise Commander” using the “shutter” button and the “open” option.

— Turn on the dome ventilation and open the dome’s openings around the dome using the “Dome Vent” button in the “Telescope Agent” window. Wait for two seconds to allow it to respond.

— Move the telescope using the buttons of the “Telescope Agent” on the dome-pc so that it will point to about the zenith.

— Start the tracking of the telescope and the dome by pressing the “RA Track” to “on” in the “Remote Wise Commander” window.

— Point the telescope to “Sky flat” position and start taking sky flats. Start with pressing the “Test” button in the “Remote Wise Commander” tool and taking 4 sec exposures until the counts in the image will get to below saturation. Then in the “STX/PI interface” press the “FlatField” button and put in the filter you are using. Using the green “observe button” to take about 3 to 5 flat field images.

Alternatively you can take images using the “Remote Wise Commander” tool By setting parameters in the “Camera” section and using the green “observe button” to take about 3 to 5 flat field images.

Move the telescope a bit between the flat-field exposures so that in case there will be a star in one flat-field it won’t appear in the same position in the next flat-field (this enable to get a good median flat-field later in the reduction procedure). Hence, Enter “FF” as the object name and move the telescope a bit between exposures. Take 4-5 exposures of about 5 sec each with each filter you are about to use during the night. Check the number of counts, the maximum should be around 60000. Remember that the STX saturates at about 65000 counts and the bias level (of the  $2\times 2$  binned image is around 1200).

### **Calibration:**

— After the flat field were done send the telescope to a bright star by choosing a star from the “\_BrightStarsCatalog” list which is in the mizpe-cdr computer and sending the telescope by pressing “goto”.

— Once the telescope reached the position take a 0.5 second “Test” exposure on the STX/PI interface. Since right in the middle of the STX CCD there is a row which seems less sensitive to light than all the others it is best to position the object about 100 pixels above it, so if the star is not at [1024, 924] move it using the buttons of the “Telescope Agent” window on dome-pc.

— Once the star is at position you want it to be on the CCD, press the “calibration” button on the “Telescope Agent” window on dome-pc. A confirmation window will appear. Check that the suggested shifts of calibration are not too large (according to the movement you

did and up to a few arcmin), and confirm the new shifts, or cancel if you did not moved the telescope.

### **Focusing:**

— To focus the telescope you can point it to a field with stars of magnitude  $\sim 10$  to 13. One option is to use the objects from the "\_spec\_std" list in the "mizpe-cdr" computer.

— Take a 2 second exposure and find a suitable star.

— In the "Expose" tab in the "Camera Control" checkmark "Mouse" in the "Subframe" area, and also check mark "Continuous".

— Mark a subframe with a suitable star for focusing on the image by clicking on the left mouse button in the upper-left corner of the subframe you want and dragging the mouse to the lower-right corner of the subframe you want. The subframe will be marked on screen and its parameters will appear in the "Subframe" section in the "Camera Control" window.

— Choose about 3 seconds for an exposure and binning of 2. Then press the "start" button.

— The tool will take continuous exposures of the subframe.

— Enlarge the image using the "+" magnify mark and put the cursor on the star to see its FWHM in the information window.

— On the "Camera Control" window choose from the "Options" menu the "Display large Statistics" option to see the parameters of the star.

— Check the FWHM in a few images.

— Now move the secondary using the "Focus Agent" window until you'll get the narrowest image possible. You can use the "FocusAid" excel sheet in order to plot the V-curve of the focus and to choose the best focus place. When done stop the focus.

— In the "Expose" tab in the "Camera Control" check mark "Single", and in the "Subframe" area un-checkmark the "Mouse" and press the icon with the arrows to reset the subframe into the maximum dimension of the CCD.

— Press the "object" button in the "STX/PI Interface" tool.

— The telescope is now ready for work. It is advised to observe when the Sun is more than 12 degrees below the horizon (or even 15 degrees for galaxies and faint objects).

### **Observations:**

— Choose an object from your list.

— Point the telescope at the object using the "Remote Wise Commander" window.

— Press the "object" button in the "STX/PI Interface" tool.

— If you want to use the autoguider, then press the “start” from the guider section of the “Remote Wise Commander” tool. This will put the right declination the the guider and exposure time of 10 seconds. See if the guider is able to start automatically. If it will fail then check the bullet next to “expose” in the “Guide” tab and obtain an image with the guider.

If the guider finds a guide star then start guiding by clicking the bullet next to “Track” and pressing “start”; if not, choose a guide star, put in its right coordinates and start guiding (see also section 3.4.3).

— Press the green ”Observe” button in the “Remote Wise Commander” tool.

This will take the sequence of observations you want.

— Take another exposure of the same object, or stop the guiding and go to your next object.

— Alternatively to the above, You can use the AUTO mode of the “Remote Wise Commander” to automatically go over a list of objects and exposures. For details see section 2.4.1.

— It is recommended that the last exposure of the night should not continue beyond the time when the sun is 12 degrees below the horizon.

### **End of night:**

— Stop the guiding by pressing “stop” in the “Guide” tab.

— If you have time, take a final bias sequence.

— If sky flats were not taken at the beginning of the night, take them at dawn as described above.

— In the “Camera Control” window on the “setup” tab, in the “coolers” area press “warm up” and wait for the cooler power to get to 0% . Only then press “off” and “Disconnect”.

— Close the “STX/PI interface” window.

— Using the “Remote Wise Commander” tool position the dome to the east by pressing the “Sky Flat” button and “Go To” - the dome will move the east and the telescope to the zenith. Then disconnect the Dome Track by pressing its “off” button, and move the telescope to declination of 75 (this way when you’ll close the dome the hazard of things falling into the telescope is minimized).

— Close the dome using the “Shutter” button on the “Remote Wise Commander” tool.

— Turn OFF the RA tracking in the “Remote Wise Commander”.

— In the “Remote Wise Commander” disconnect all sockets.

— Exit the “Remote Wise Commander” program.

— Turn off the dome ventilation and close the dome’s openings around the dome using the “Dome Vent” button in the “Telescope Agent” window. Wait for two seconds to allow it to respond.

- Exit all VNC windows that are opened on mizpe-cdr.
  
- Backup the image files from the pi2006 computer to the mizpe-cdr computer and to the mizpe-bck, using a simple "Total Commander" copy procedure on the mizpe-cdr computer. Verify that the files were copied correctly, i.e. check the image sizes in kb (see section 2.4.3).
- It is the responsibility of the principal investigator (PI) of the night to make sure that all files were backed up correctly.
  
- Go up to the dome and cover the telescope and position it to a DEC of about 75.
- Fill nitrogen into the CCD.
- Turn off the ST7, the STX CCD, and the filter Wheel.
- Switch off the relay box and the focus switch behind the blue console.
- Turn on the air conditioners.
- Make sure the platform is all the way down.
- Switch off all lights in the dome.
- On the way down switch off the three circuit breakers (CB2, CB3, CB4).
- Fill out the nightly log in: <http://wise-obs.tau.ac.il/observatory/log.html>
- Before leaving the site, please check that all the books are back at their place, the kitchen is clean and all lights are off.
- Lock the observatory up and go to sleep.

## 3.4 PI-CAMERA

### 3.4.1 The PI CCD

The PI (Princeton Instruments) CCD was purchased at the beginning of 2006. It is a 1300×1340 pixels CCD with squares pixels of 20×20 microns in size (model: VersArray:1300B). The pixel size is  $0.580 \pm 0.002$  "/pixel (each 100 pixels are about 1 arcmin), which gives a very good sampling of the imaged objects. The overall field of view of the PI CCD is 12.57×12.95 arcmin.

The PI CCD is operated directly through a MaximDL software which is on the computer called pi2006. To integrate the PI CCD with the other facilities at the observatory the PI CCD is operated through a DELPHI program called "PI Interface" which was written originally by Gil Ninveh and Adi Zitrin (as part of Adi's M.Sc. project). David Polishook has upgraded this DELPHI program so it can work with the "Remote Wise Commander" program that Yiftah Lipkin wrote.

**Dead time between images:**

When using the guider the MaximDL program adds 5 sec before the beginning of each exposure. We have not found a way (yet) in the software to get rid of these 5 sec and so the current option is just not to use the guider.

When taking a sequence of a full frame (1340x1300 pixels) through the "Remote Wise Commander" the overhead time of reading and displaying the image is 20.7 sec.

When guiding it adds to this 5 sec.

When taking a sequence and changing filters between exposures each 1 position filter move adds 3 sec to the dead time.

To shorten the overhead time one can observe with no guiding and save the 5 sec overhead on each frame due to it.

One can observe directly from the MaximDL and save about 1-2 sec of communication between the softwares/computers.

The main overhead shortening would come from taking a sub-frame of the PI CCD. The following table gives the overhead time of reading and displaying the image when not using an autoguider and when operating the CCD directly from MaximDL's "Camera Control" window in the "Expose" tab in its "AutoSave" mode. (sub-frames were taken about around the center of the CCD; the given average time is over about 100 images):

Sub-Frame	Overhead time (sec)
1340×1300	18.53
750×750	7.94
500×500	4.65
250×250	2.34
295×85	1.41

### 3.4.2 PI-CAMERA Operation

A suggested procedure for operating the telescope with the CAMERA is outlined here. It is suggested to come to the observatory about an hour before sunset (if the CCD is warm you need to arrive 2 hours before sunset, so that you'll have enough time to cool it).

**In the dome:**

- On the way to the dome go to the electric box in the room below the telescope and lift the three circuit breakers (CB2, CB3, CB4).
- Turn on the PI CCD, the filter Wheel, and the ST7 CCD guider.
- Make sure the rotator is on the PI angle, which is 82.4 degrees. At this position, the guider ST7 should point south, the CCD filling hole should point north and the CCD electronics should point east. Any other direction will mess up your work.
- Calibrate the dome position by moving the dome from the console so that the rails will

to be between the markers.

- Then go to the dome computer and in the “Dome Agent” write 90 in the “Set Az” and press Enter.
- On the dome-pc make sure the time of the clock gets updated with the Dimension4 program: put the cursor on the Dimension4 icon and check if the time was updated in the last 5 min.
- Also check that the “Telescope Agent” and “Focus Agent” programs are running. If not then start them from the desktop.
- Make sure the set/guide switch on the small gray hand paddle next to the dome-pc is pointing to the ”guide” position. Otherwise the guider will not work properly.
- Open a VNC from the dome-pc to the pi2006 (use the ”Remote” folder on the desktop) and make sure the “Filter Agent” program is running on it. If not, start it from the desktop icon - use the initialization process if needed (see section 3.2.1).
- Press once on “Look for Close Detent” to set the filter wheel correctly. Then make sure it is on the right filter position.
- Use the “Filter Agent” window to position the filter wheel on your desired filter in order to observe flat-fields at twilight. Make sure the program moves the filters correctly.
- In the pi2006 VNC window click twice on the SNI icon that is on the desktop. The PI interface will be opened, then the MaximDL’s windows will be opened and automatically will connect to the CCDs and will start the cooler on.

However, if this is the first time the PI is used after the eShel was used (or sometimes another instrument) you will need to setup the CCDs according to the following procedure:

- Close the SNI program and the MaximDL.
- Open the MaximDL program by clicking twice the icon on the desktop.
- If the “Camera Control” sub-window will not appear toggle it from its icon that looks like a small CCD.
- Goto the “Setup” tab and set Camera 1 to “Roper PVCam” and Camera 2 to “SBIG Univerasl” with the camera “Parallel 378”.
- In the “Setup” tab press “connect” and make sure there is connection to the cameras (“Camera idle”) will appear on the info window of each camera.
- Set Camera 1 cooler temperature to  $-110$  and Camera 2 cooler to  $-10$ , and press “On” in the “Coller” section.
- In the “option” button of Camera1 make sure that the options “No rotation”, “Flip Horizontally”, and “Flip Vertically”, are checked in the boxes next to them and the other options are not checked.

- In the “Expose” tab set the radio button of Camera 1, and set the “Exposure Preset” to “PI-camera”.
- In the “Guide” tab set the radio button of Camera 2.
- In the “Guide” tab Make sure that ”Pier Flip” is NOT checked and the “watch star” is checked, and that the “Aggressiveness” to is set to x=8 y=8. Click the “Settings” button and a “Guider Settings” Window will be opened. Set XSpeed to 0.9, Yspeed to  $-0.8$ , and Angle to 1.
- Take an exposure with in the “Expose” and “Guide” tabs.
- In the “Setup” tab press “Coolers off” and “Disconnect”, and close the MaximDL window.
- Now click twice on the SNI icon that is on the desktop. The PI interface will be opened, then the MaximDL’s windows will be opened and automatically will connect to the CCDs and will start the cooler on.
  - Close the VNC to the pi2006 from the dome-pc.
  - Turn OFF the dome air condition using its remote control which is on the big blue console.
  - Check the blue big console; if it is off, turn it on. When turning on the breakers (CB2, CB3, CB4) might jump so you will need to go down to the electric box in the room below the telescope to lift them up again.
  - Take off the telescope cover.
  - Lower the platform all the way down.
  - Position the telescope to declination of  $\sim 50^\circ$ , so that when opening the dome shutter debris accumulated on top will not fall into the telescope.
  - Make sure the Dec (or any other) button is not stuck by pressing only the slew button and making sure the telescope does not move.
  - Turn on the relay box and the focus switches (behind the old console). Make sure the MAALA switch is on “Normal” and press the “Reset”.
  - Fill the CCD with liquid nitrogen for about 5 minutes (lasts for about 14 hours work). Don’t open the tap of the nitrogen fully open with a strong stream of nitrogen. Use a weak stream and the filling of the dewar will be better. When filling, the telescope should be at declination of  $\sim 50$  degrees.
  - Disconnect the nitrogen filling pipe.
  - Make sure the platform is all the way down.
- Turn off all light in the dome (including computer screens).



### **In the control room:**

- On mizpe-cdr open VNC to dome-pc (from the remote folder on the desktop). In the “Focus Agent” tool put the secondary to a position close to PI camera focus used last time (typically around 980).
- On mizpe-cdr bring up the weather-pc VNC window (from the remote folder on the desktop) to be able to check the weather.
- On weather-pc make sure that in the “Volume control ” Window the “Mute” and “Mute all” of the “Mic Volume” and “Volume Control” are not checked so that you’ll be able to hear the sounds from the dome, and also that the “Balance” in the “Volume Control” is on the left speaker.
  
- On mizpe-cdr open VNC to the cloudwatcher computer and check the sky clarity.
- On mizpe-cdr bring up the pi2006 VNC window.
- In the MaximDL’s “Camera Control” window go to the Guide tab. Make sure that “Pier Flip” is NOT checked and that the “Aggressiveness” to  $x=8$   $y=8$ . Click the “Settings” button and a “Guider Settings” Window will be opened. Set XSpeed to 0.9, Yspeed to  $-0.8$ , and Angle to 1.
- In the PI interface make sure you have the CCD area you want (“All Chip” or “25% Chip”).
- On mizpe-cdr open the “Remote Wise Commander” program. In the “Camera” section set the instrument to “PI” and then choose the “Connect all” from the “Sockets” menu, which will initialize the connections to the different agents. Press the “FOV” button to reset a connection between the “Remote Wise Commander” and the “PI Interface”. In the “Set CCD size” that will open just press “ok” - currently there is no meaning to the number in that window.
- Load the list/s you are going to use during the night from the List menu.
  
- Check the computers pi2006, mizpe-cdr, dome-pc, and weather-pc, that the Dimension4 program is running and updating the computer time and that it is correct.
  
- About 15 minutes before sunset, you should take a bias sequence by choosing the “bias” from the “Remote Commander”, entering the number 5, and pressing “ok”.
- NOTE: Take the bias only when the CCD temperature stabilized on  $-110$  degrees and while the dome is in complete darkness, in order to prevent light leaks into the camera. The average bias level should be around 115–120.

### **Taking Flat Field:**

— On sunset open the dome from the “Remote Wise Commander” using the ”shutter” button and the ”open” option.

— Turn on the dome ventilation and open the dome’s openings around the dome using the “Dome Vent” button in the “Telescope Agent” window. Wait for two seconds to allow it to respond.

— Start the tracking of the telescope and the dome by pressing the ”RA Track” to ”on” in the “Remote Wise Commander” window.

— Point the telescope to “Sky flat” position and start taking sky flats. Start with pressing the “Test” button in the “Remote Wise Commander” tool and taking 4 sec exposures until the counts in the image will get to below saturation. Then in the “PI interface” press the “FlatField” button and put in the filter you are using. Using the green ”observe button” to take about 3 to 5 flat field images.

Alternatively you can take images using the “Remote Wise Commander” tool By setting parameters in the “Camera” section and using the green ”observe button” to take about 3 to 5 flat field images.

Move the telescope a bit between the flat-field exposures so that in case there will be a star in one flat-field it won’t appear in the same position in the next flat-field (this enable to get a good median flat-field later in the reduction procedure). Hence, Enter “FF” as the object name and move the telescope a bit between exposures. Take 4-5 exposures of about 5 sec each with each filter you are about to use during the night. Check the number of counts, the maximum should be around 60000. Remember that the PI saturates at about 65000 counts and the bias level is around 115–120.

### **Calibration:**

— After the flat field were done send the telescope to a bright star by choosing a star from the “\_BrightStarsCatalog” list which is in the mizpe-cdr computer and sending the telescope by pressing ”goto”.

— Once the telescope reached the position take a 0.5 second ”Test” exposure on the PI interface. If the star is not in the middle move it to the center of the CCD using the buttons of the “Telescope Agent” window on dome-pc.

— Once the star is at position you want it to be on the CCD, press the ”calibration” button on the “Telescope Agent” window on dome-pc. A confirmation window will appear. Check that the suggested shifts of calibration are not too large (according to the movement you did and up to a few arcmin), and confirm the new shifts, or cancel if you did not moved the

telescope.

### **Focusing:**

- To focus the telescope you can point it to a field with stars of magnitude  $\sim 10$  to 13. One option is to use the objects from the "\_spec\_std" list in the "mizpe-cdr" computer.
- Take a 2 second exposure and find a suitable star.
- In the "Expose" tab in the "Camera Control" checkmark "Mouse" in the "Subframe" area, and also check mark "Continuous".
- Mark a subframe with a suitable star for focusing on the image by clicking on the left mouse button in the upper-left corner of the subframe you want and dragging the mouse to the lower-right corner of the subframe you want. The subframe will be marked on screen and its parameters will appear in the "Subframe" section in the "Camera Control" window.
- Choose about 3 seconds for an exposure and binning of 1. Then press the "start" button.
- The tool will take continuous exposures of the subframe.
- Enlarge the image using the "+" magnify mark and put the cursor on the star to see its FWHM in the information window.
- On the "Camera Control" window choose from the "Options" menu the "Display large Statistics" option to see the parameters of the star.
- Check the FWHM in a few images.
  
- Now move the secondary using the "Focus Agent" window until you'll get the narrowest image possible. You can use the "FocusAid" excel sheet in order to plot the V-curve of the focus and to choose the best focus place. When done stop the focus.
- In the "Expose" tab in the "Camera Control" check mark "Single", and in the "Subframe" area un-checkmark the "Mouse" and press the icon with the arrows to reset the subframe into the maximum dimension of the CCD.
- Press the "object" button in the "PI Interface" tool.
  
- The telescope is now ready for work. It is advised to observe when the Sun is more than 12 degrees below the horizon (or even 15 degrees for galaxies and faint objects).

### **Observations:**

- Choose an object from your list.
- Point the telescope at the object using the "Remote Wise Commander" window.
- Press the "object" button in the "PI Interface" tool.
- If you want to use the autoguider, then press the "start" from the guider section of the

“Remote Wise Commander” tool. This will put the right declination the the guider and exposure time of 10 seconds. See if the guider is able to start automatically. If it will fail then check the bullet next to “expose” in the “Guide” tab and obtain an image with the guider.

If the guider finds a guide star then start guiding by clicking the bullet next to “Track” and pressing “start”; if not, choose a guide star, put in its right coordinates and start guiding (see also section 3.4.3).

— Press the green “Observe” button in the “Remote Wise Commander” tool.

This will take the sequence of observations you want.

— Take another exposure of the same object, or stop the guiding and go to your next object.

— Alternatively to the above, You can use the AUTO mode of the “Remote Wise Commander” to automatically go over a list of objects and exposures. For details see section 2.4.1.

— It is recommended that the last exposure of the night should not continue beyond the time when the sun is 12 degrees below the horizon.

### **End of night:**

— Stop the guiding by pressing “stop” in the “Guide” tab.

— If you have time, take a final bias sequence.

— If sky flats were not taken at the beginning of the night, take them at dawn as described above.

— In the “Camera Control” window on the “setup” tab, in the “coolers” area press “off” and “Disconnect”.

— Close the “PI interface” window.

— Using the “Remote Wise Commander” tool position the dome to the east by pressing the “Sky Flat” button and “Go To” - the dome will move the east and the telescope to the zenith. Then disconnect the Dome Track by pressing its “off” button, and move the telescope to declination of 50 (this way when you’ll close the dome the hazard of things falling into the telescope is minimized).

— Close the dome using the “Shutter” button on the “Remote Wise Commander” tool.

— Turn OFF the RA tracking in the “Remote Wise Commander”.

— In the “Remote Wise Commander” disconnect all sockets.

— Exit the “Remote Wise Commander” program.

— Turn off the dome ventilation and close the dome’s openings around the dome using the “Dome Vent” button in the “Telescope Agent” window. Wait for two seconds to allow it to respond.

— Exit all VNC windows that are opened on mizpe-cdr.

- Backup the image files from the pi2006 computer to the mizpe-cdr computer and to the mizpe-bck, using a simple "Total Commander" copy procedure on the mizpe-cdr computer. Verify that the files were copied correctly, i.e. check the image sizes in kb (see section 2.4.3).
- It is the responsibility of the principal investigator (PI) of the night to make sure that all files were backed up correctly.
  
- Go up to the dome and cover the telescope and position it to a DEC of about 50.
- Fill nitrogen into the CCD.
- Turn off the ST7, the PI CCD, and the filter Wheel.
- Switch off the relay box and the focus switch behind the blue console.
- Turn on the air conditioners.
- Make sure the platform is all the way down.
- Switch off all lights in the dome.
- On the way down switch off the three circuit breakers (CB2, CB3, CB4).
- Fill out the nightly log in: <http://wise-obs.tau.ac.il/observatory/log.html>
- Before leaving the site, please check that all the books are back at their place, the kitchen is clean and all lights are off.
- Lock the observatory up and go to sleep.

### 3.4.3 Automatic Guider

The automatic guider is used to guide the telescope on exposures longer than a few minutes. The autoguider is an ST-7 CCD camera (from Santa Barbara Instruments Group — SBIG) and is operated via the MAXIM-DL program that operated the PI-CCD.

- The guider can be operated from the "Remote Wise Commander" (bottom left).
- It can be equally operated from the PI Interface (it will automatically notify the "Remote Wise Commander").
- The commands are sent to the PI interface using the socket and vice versa.
- After you push "start", an exposure is taken, a star is chosen and the tracking starts. Both the "PI Interface" and the "Remote Wise Commander" show the status of the guider:
- Exposing (The guider is taking its initial image).
- Tracking (meaning the guider is working).
- Idle (The guider is doing nothing).
- Failed ( the guider failed to locate a star or the cooler is off, etc.).
- Fade (the guiding star has faded).
- In case the auto-guiding fails, the user is notified to use the guider manually.
- In this case, the "PI Interface" and the "Remote Wise Commander" are notified auto-

matically that the guider is operating (though it takes up to 5 minutes).

— Cooling-on is done automatically by the PI Interface as the program starts.

# Chapter 4

## The Reimager+PI

The Reimager is a set of 11 lenses which squeeze the field of view. On the PI CCD one gets about 30 arcmin X 30 arcmin.

**IMPORTANT: The Reimager instrument is long and thus one cannot observe objects at declination above 60. It is forbidden to move the telescope to declination above 60 since the Instrument and telescope will collide and will break!!!**

A suggested procedure for operating the telescope with the Reimager is outlined here. It is suggested to come to the observatory about an hour before sunset (if the CCD is warm you need to arrive 2 hours before sunset, so that you'll have enough time to cool it).

### **In the dome:**

- On the way to the dome go to the electric box in the room below the telescope and lift the three circuit breakers (CB2, CB3, CB4).
- Turn on the PI CCD and the ST7 CCD guider.
- Make sure the rotator is on the Reimager angle, which is 163.4 degrees. At this position, the guider ST7 should point east, the CCD filling hole should point north and the CCD electronics should point north. Any other direction will mess up your work.
  
- Calibrate the dome position by moving the dome from the console so that the rails will be between the markers.
- Then go to the dome computer and in the “Dome Agent” write 90 in the “Set Az” and press Enter.
- On the dome-pc make sure the time of the clock gets updated with the Dimension4 program: put the cursor on the Dimension4 icon and check if the time was updated in the last 5 min.
- Also check that the “Telescope Agent” and “Focus Agent” programs are running. If not then start them from the desktop.

- Make sure the set/guide switch on the small gray hand paddle next to the dome-pc is pointing to the "guide" position. Otherwise the guider will not work properly.
- Open a VNC from the dome-pc to the pi2006 (use the "Remote" folder on the desktop) and make sure the "Filter Agent" program is running on it. If not, start it from the desktop icon - use the initialization process if needed (see section 3.2.1).
- In the pi2006 VNC window click twice on the SNI icon that is on the desktop. The PI interface will be opened, then the MaximDL's windows will be opened and automatically will connect to the CCDs and will start the cooler on.
- Close the VNC to the pi2006 from the dome-pc.
- Turn OFF the dome air condition using its remote control which is on the big blue console.
- Check the blue big console; if it is off, turn it on. When turning on the breakers (CB2, CB3, CB4) might jump so you will need to go down to the electric box in the room below the telescope to lift them up again.
- Take off the telescope cover.
- Lower the platform all the way down.
- Position the telescope to declination of  $\sim 50^\circ$ , so that when opening the dome shutter debris accumulated on top will not fall into the telescope.
- Make sure the Dec (or any other) button is not stuck by pressing only the slew button and making sure the telescope does not move.
- Turn on the relay box and the focus switches (behind the old console). Make sure the MAALA switch is on "Maala" and press the "Reset".
- Fill the CCD with liquid nitrogen for about 5 minutes (lasts for about 14 hours work). Don't open the tap of the nitrogen fully open with a strong stream of nitrogen. Use a weak stream and the filling of the dewar will be better. When filling, the telescope should be at declination of  $\sim 50$  degrees.
- Disconnect the nitrogen filling pipe.
- Make sure the platform is all the way down.
  
- Turn off all light in the dome (including computer screens).

**In the control room:**

- On mizpe-cdr open VNC to dome-pc (from the remote folder on the desktop). In the "Focus Agent" tool put the secondary to a position close to PI camera focus used last time (typically around 1040).
- On mizpe-cdr bring up the weather-pc VNC window (from the remote folder on the desktop) to be able to check the weather.



— On weather-pc make sure that the in the “Volume control ” Window the “Mute” and “Mute all” of the “Mic Volume” and “Volume Control” are not checked so that you’ll be able to hear the sounds from the dome, and also that the “Balance” in the “Volume Control” is on the left speaker.

— On mizpe-cdr open VNC to the cloudwatcher computer and check the sky clarity.

— On mizpe-cdr bring up the pi2006 VNC window.

— In the MaximDL’s “Camera Control” window go to the Guide tab. Make sure that “Pier Flip” is NOT checked and that the “Aggressiveness” to  $x=8$   $y=8$ . Click the “Settings” button and a “Guider Settings” Window will be opened. Set XSpeed to  $-0.96$ , Yspeed to  $0.82$ , and Angle to  $-170.7$ .

— In the PI interface make sure you have the CCD area you want (“All Chip” or “25% Chip”).

— On mizpe-cdr open the “Remote Wise Commander” program. In the “Camera” section set the instrument to “PI” and then choose the “Connect all” from the “Sockets” menu, which will initialize the connections to the different agents. Press the “FOV” button to reset a connection between the “Remote Wise Commander” and the “PI Interface”. In the “Set CCD size” that will open just press “ok” - currently there is no meaning to the number in that window.

— Load the list/s you are going to use during the night from the List menu.

— Check the computers pi2006, mizpe-cdr, dome-pc, and weather-pc, that the Dimension4 program is running and updating the computer time and that it is correct.

— About 15 minutes before sunset, you should take a bias sequence by choosing the “bias” from the “Remote Commander”, entering the number 5, and pressing “ok”.

— NOTE: Take the bias only when the CCD temperature stabilized on  $-110$  degrees and while the dome is in complete darkness, in order to prevent light leaks into the camera. The average bias level should be around 115–120.

### **Taking Flat Field:**

— On sunset open the dome from the “Remote Wise Commander” using the “shutter” button and the “open” option.

— Turn on the dome ventilation and open the dome’s openings around the dome using the “Dome Vent” button in the “Telescope Agent” window. Wait for two seconds to allow it to respond.

— Start the tracking of the telescope and the dome by pressing the "RA Track" to "on" in the "Remote Wise Commander" window.

— Point the telescope to "Sky flat" position and start taking sky flats. Start with pressing the "Test" button in the "Remote Wise Commander" tool and taking 4 sec exposures until the counts in the image will get to below saturation. Then in the "PI interface" press the "FlatField" button and put in the filter you are using. Using the green "observe button" to take about 3 to 5 flat field images.

Alternatively you can take images using the "Remote Wise Commander" tool By setting parameters in the "Camera" section and using the green "observe button" to take about 3 to 5 flat field images.

Move the telescope a bit between the flat-field exposures so that in case there will be a star in one flat-field it won't appear in the same position in the next flat-field (this enable to get a good median flat-field later in the reduction procedure). Hence, Enter "FF" as the object name and move the telescope a bit between exposures. Take 4-5 exposures of about 5 sec each with each filter you are about to use during the night. Check the number of counts, the maximum should be around 60000. Remember that the PI saturates at about 65000 counts and the bias level is around 115–120.

### **Calibration:**

— After the flat field were done send the telescope to a bright star by choosing a star from the "\_BrightStarsCatalog" list which is in the mizpe-cdr computer and sending the telescope by pressing "goto".

— Once the telescope reached the position take a 0.5 second "Test" exposure on the PI interface. If the star is not in the middle move it to the center of the CCD using the buttons of the "Telescope Agent" window on dome-pc.

— Once the star is at position you want it to be on the CCD, press the "calibration" button on the "Telescope Agent" window on dome-pc. A confirmation window will appear. Check that the suggested shifts of calibration are not too large (according to the movement you did and up to a few arcmin), and confirm the new shifts, or cancel if you did not moved the telescope.

### **Focusing:**

— To focus the telescope you can point it to a field with stars of magnitude  $\sim 10$  to 13. One option is to use the objects from the "\_spec\_std" list in the "mizpe-cdr" computer.

— Take a 2 second exposure and find a suitable star.

- In the “Expose” tab in the “Camera Control” checkmark “Mouse” in the “Subframe” area, and also check mark “Continuous”.
- Mark a subframe with a suitable star for focusing on the image by clicking on the left mouse button in the upper-left corner of the subframe you want and dragging the mouse to the lower-right corner of the subframe you want. The subframe will be marked on screen and its parameters will appear in the “Subframe” section in the “Camera Control” window.
- Choose about 3 seconds for an exposure and binning of 1. Then press the “start” button.
- The tool will take continuous exposures of the subframe.
- Enlarge the image using the “+” magnify mark and put the cursor on the star to see its FWHM in the information window.
- On the “Camera Control” window choose from the “Options” menu the “Display large Statistics” option to see the parameters of the star.
- Check the FWHM in a few images.
  
- Now move the secondary using the “Focus Agent” window until you’ll get the narrowest image possible. You can use the “FocusAid” excel sheet in order to plot the V-curve of the focus and to choose the best focus place. When done stop the focus.
- In the “Expose” tab in the “Camera Control” check mark “Single”, and in the “Subframe” area un-checkmark the “Mouse” and press the icon with the arrows to reset the subframe into the maximum dimension of the CCD.
- Press the “object” button in the “PI Interface” tool.
  
- The telescope is now ready for work. It is advised to observe when the Sun is more than 12 degrees below the horizon (or even 15 degrees for galaxies and faint objects).

### **Observations:**

- Choose an object from your list.
  - Point the telescope at the object using the “Remote Wise Commander” window.
  - Press the “object” button in the “PI Interface” tool.
  - If you want to use the autoguider, then press the “start” from the guider section of the “Remote Wise Commander” tool. This will put the right declination the the guider and exposure time of 10 seconds. See if the guider is able to start automatically. If it will fail then check the bullet next to “expose” in the “Guide” tab and obtain an image with the guider.
- If the guider finds a guide star then start guiding by clicking the bullet next to “Track” and pressing “start”; if not, choose a guide star, put in its right coordinates and start guiding

(see also section 3.4.3).

— Press the green "Observe" button in the "Remote Wise Commander" tool.

This will take the sequence of observations you want.

— Take another exposure of the same object, or stop the guiding and go to your next object.

— Alternatively to the above, You can use the AUTO mode of the "Remote Wise Commander" to automatically go over a list of objects and exposures. For details see section 2.4.1.

— It is recommended that the last exposure of the night should not continue beyond the time when the sun is 12 degrees below the horizon.

### **End of night:**

— Stop the guiding by pressing "stop" in the "Guide" tab.

— If you have time, take a final bias sequence.

— If sky flats were not taken at the beginning of the night, take them at dawn as described above.

— In the "Camera Control" window on the "setup" tab, in the "coolers" area press "off" and "Disconnect".

— Close the "PI interface" window.

— Using the "Remote Wise Commander" tool position the dome to the east by pressing the "Sky Flat" button and "Go To" - the dome will move the east and the telescope to the zenith. Then disconnect the Dome Track by pressing its "off" button, and move the telescope to declination of 50 (this way when you'll close the dome the hazard of things falling into the telescope is minimized).

— Close the dome using the "Shutter" button on the "Remote Wise Commander" tool.

— Turn OFF the RA tracking in the "Remote Wise Commander".

— In the "Remote Wise Commander" disconnect all sockets.

— Exit the "Remote Wise Commander" program.

— Turn off the dome ventilation and close the dome's openings around the dome using the "Dome Vent" button in the "Telescope Agent" window. Wait for two seconds to allow it to respond.

— Exit all VNC windows that are opened on mizpe-cdr.

— Backup the image files from the pi2006 computer to the mizpe-cdr computer and to the mizpe-bck, using a simple "Total Commander" copy procedure on the mizpe-cdr computer. Verify that the files were copied correctly, i.e. check the image sizes in kb (see section 2.4.3).

— It is also the responsibility of the principal investigator (PI) of the night to make sure that all files were backed up correctly.

- Go up to the dome and cover the telescope and position it to a DEC of about 50.
- Fill nitrogen into the CCD.
- Turn off the ST7 and the PI CCD.
- Switch off the relay box and the focus switch behind the blue console.
- Turn on the air conditioners.
- Make sure the platform is all the way down.
- Switch off all lights in the dome.
- On the way down switch off the three circuit breakers (CB2, CB3, CB4).
- Fill out the nightly log in: <http://wise-obs.tau.ac.il/observatory/log.html>
- Before leaving the site, please check that all the books are back at their place, the kitchen is clean and all lights are off.
- Lock the observatory up and go to sleep.

# Chapter 5

## The FOSC

The Faint Object Spectrographic Camera (FOSC) is a general purpose instrument that permits imaging of a  $\sim 17'$  diameter field through different filters and rapid change to an operation mode of spectroscopy of point-like or extended objects, within a few minutes and without refocusing the instrument.

The FOSC is patterned after the EFOSC instrument built by ESO (Dekker and D’Odo-rico, 1985), but realized on a “shoestring” budget. Thus, it may not be so versatile as the EFOSC, or so efficient, and we certainly compromised on the quality of images in order to be able to afford it. A description of the FOSC *as delivered* can be found in the “User’s Manual” (Hilliard, 1989).

The optics and mechanics of the FOSC were contracted out to Optomechanics Research, Inc. of Tucson, AZ (*i.e.* Dr. Ron Hilliard). The detector mounted on the FOSC is the PI CCD chip.

The FOSC is controlled by the pi2006 computer (3.2) and the FOSC PC (2.3). After its acquisition and delivery, the FOSC was modified at the Wise Observatory by incorporating simple absolute encoders for three main functions and adding He-Ar and Th-Ar spectral lamps. The encoders will be described below.

### 5.1 FOSC Optics

The FOSC is designed as a transmission optics instrument in which all elements are collinear and on the telescope optical axis. In particular, the spectral dispersion is by grisms, that is, prisms with transmission gratings replicated onto their faces. This ensures that the first order of the dispersion is directed along the optical axis. A schematic diagram of the FOSC optics is shown in figure 5.1. Figs. 5.2 and 5.3 show two views of the instrument with various parts identified.

The internal parts of the FOSC are not visible and should not be accessed by regular

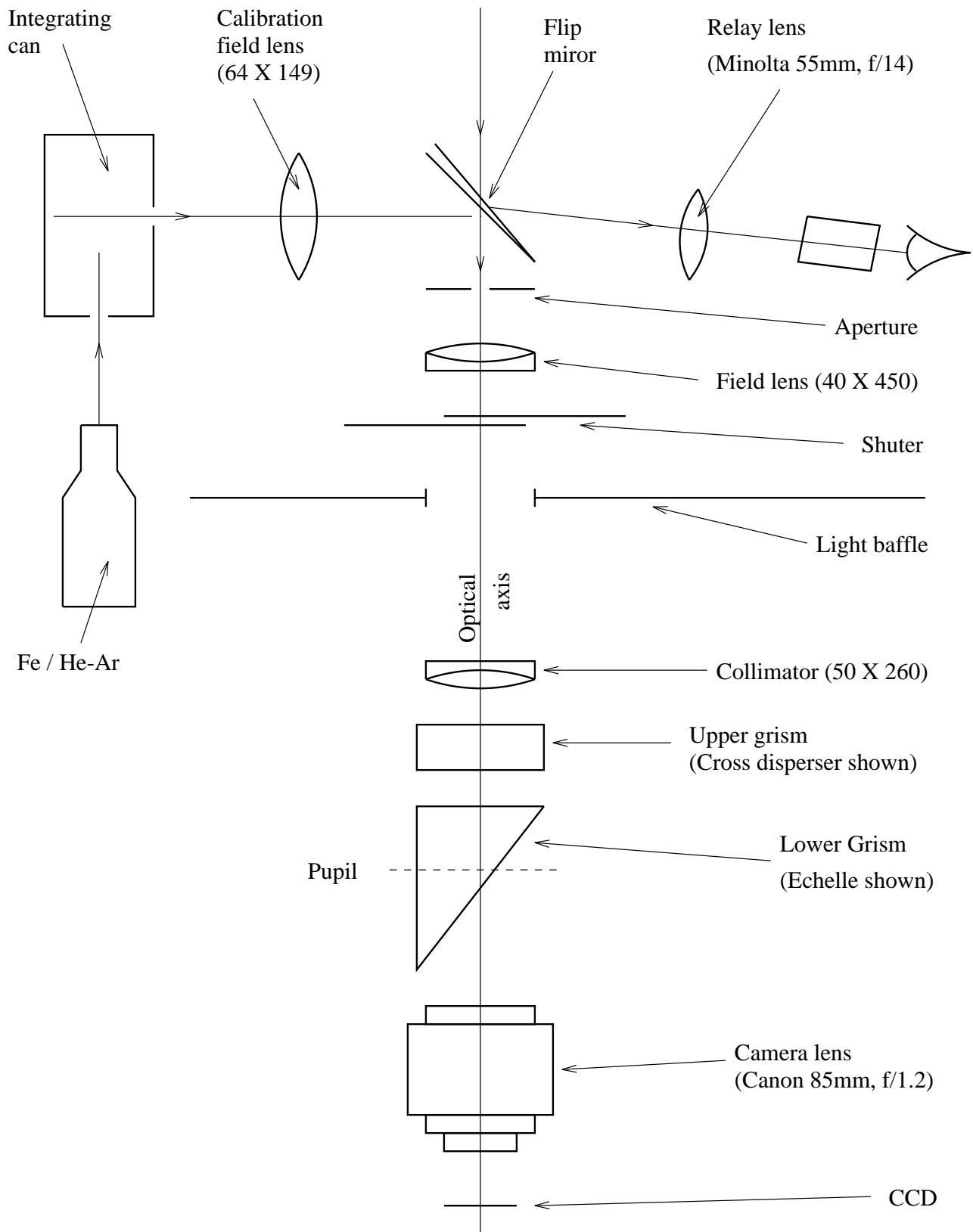


Figure 5.1: Schematic description of the FOSC optics.

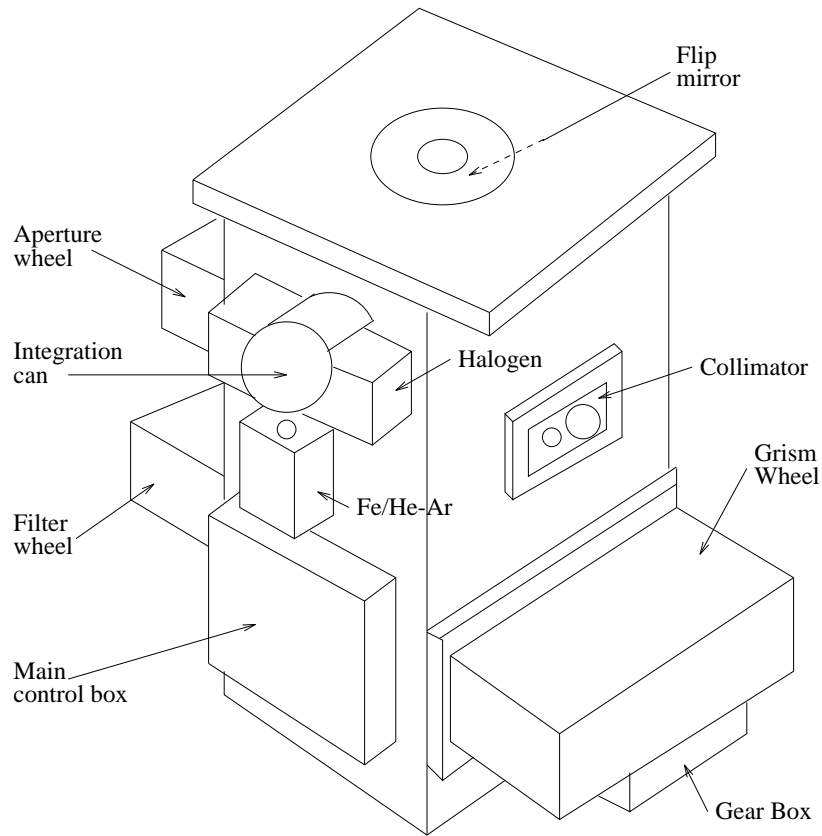


Figure 5.2: FOSC mechanical layout - top view.

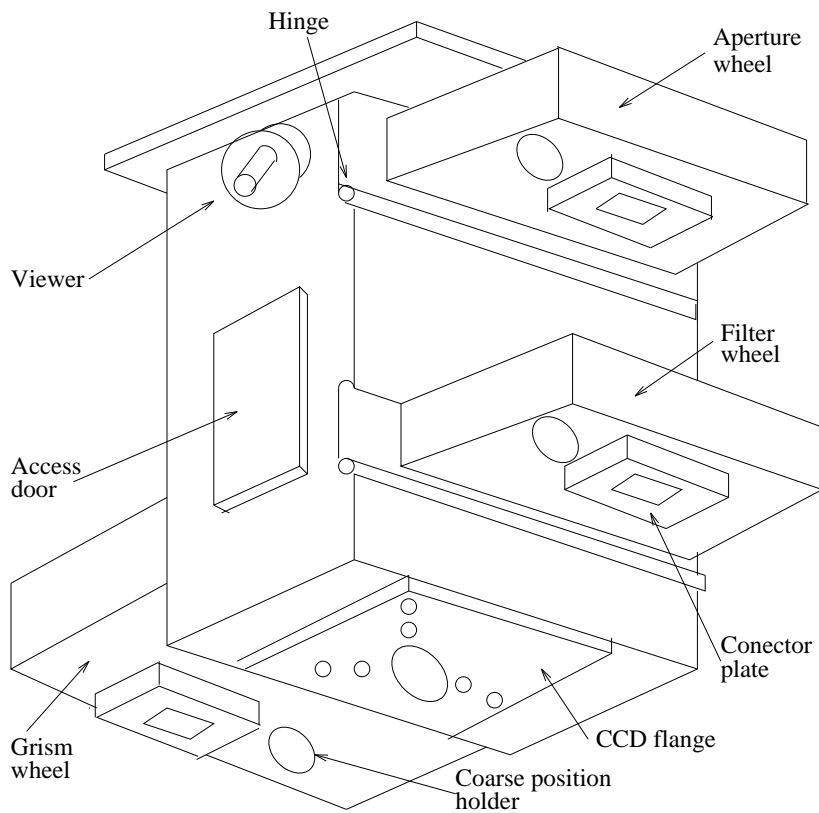


Figure 5.3: FOSC mechanical layout - bottom view.



users. If there is need for special filters, gratings, or other elements to be mounted, these should be requested from the day/night assistant preferably well *before* the beginning of the observing run, and he should be instructed in which location should these elements be inserted. Note that the operating program must be told about the modification - this is not a trivial task as one of the files must be modified. Also, the wheel where a new element has been installed needs, sometimes, to be balanced, otherwise it will not rotate properly.

The FOSC is mounted on the Cassegrain Camera (CAM) mounting box at  $f/7$ , and the offset guider (using the autoguider - section 3.4.3) is available for guiding. The plate scale on the focal plane is  $\sim 30''/\text{mm}$ . However, this is a focal reducing instrument, producing an  $f/3$  beam, which is collimated prior to being re-imaged. The projected pixel size of the FOSC was about  $0.9''$  with its original CCD, with the TEK CCD it was  $2.081 \pm 0.003''/\text{pixel}$ , but now with the PI-CCD it is about  $1.7''/\text{pixel}$ .

The field imaged by the FOSC is  $\sim 17'$  in diameter (this limit is due to the collimator lens). There is considerable vignetting at the outer  $2'$  of the field, or central field intensity flare in the innermost  $15'$ . This, however, is removed by flat fielding. There are also various distortions of the images at the outer field; the most prominent being coma. Also, various optical elements may produce ghost images when bright sources are in the field.

A viewing eyepiece is provided on the FOSC, that looks at the center of the field reflected off a  $45^\circ$  mirror. The visible part of the field is  $\sim 1'$  in diameter and is well centered onto the chip. An illuminated cross-hair is provided. The cross-hair LEDs should be turned off after using this periscope. The lens itself should be covered with the black cap provided, to minimize external light entry into the FOSC. The  $45^\circ$  mirror can be inserted in the optical axis for visual inspection of the field, or can be removed from the field, on command from the PC. Note that the field looked at with the viewing eyepiece is in *front* of the apertures.

### 5.1.1 The Integrating Can and Lamps

Whenever the viewer is IN, the FOSC can be fed light by an “integrating can”, a cylindrical box mounted on its side and painted with Lambertian reflecting white paint. The can may be illuminated by an incandescent filament halogen lamp (for flat-fielding), by a He-Ar arc, or by a Th-Ar arc. The He-Ar lamp can be replaced with a Fe-Ar lamp, however, this lamp is VERY weak, and only a long exposure will show lines. Another lamp that can replace the He-Ar lamp is a Ne lamp. The Fe-Ar and Ne lamps are in the cupboard in the dome.

In addition, a  $\beta$  light can be inserted manually into the extended cylinder that contains the He-Ar arc and may be used to test the instrument’s linearity. The  $\beta$  light produces light from the radioactive decay of (probably) Tritium ( $^3\text{H}$ ), whose positrons activate a phosphor. The light output is supposed to be constant, apart from long-term effects of half-life and

possibly a temperature dependence of phosphor efficiency. The insertion of the  $\beta$  light in the integrating can should be done by the night assistant. Table 5.1 shows the available light sources that may feed the integrating can.

Table 5.1: Available light sources

Lamp	Consists of	Remarks
1	He-Ar arc	Low and intermediate dispersion
2	Th-Ar arc	Low and intermediate dispersion
3	Fe-Ar arc	High dispersion (weak source)
4	Ne arc	
5	Halogen	Flat-fielding
6	$\beta$ light	For tests

The can projects a beam with the same shape as the telescope beam, *i.e.* a converging f/7 beam, with a central obscuration similar to that produced by the secondary mirror. The light that enters the can from any lamp is diffused by multiple Lambertian scattering along the sides of the can before reaching the viewer mirror. Extraneous light may enter the FOSC through the entrance holes of the integrating can. We recommend keeping the inside of the dome dark while calibrating, for this reason.

### 5.1.2 The Apertures

Below the mirror, at the focal plane of the telescope, are the entrance apertures of the FOSC. These are mounted into the aperture wheel (AP) with 10 positions. The AP wheel has the apertures mounted at 9.45 cm from the center of rotation of the wheel. With the present optical train, a 10 step move corresponds approximately to one pixel on the detector.

The original FOSC apertures are two round apertures of 2" and 5" diameter (pinholes from Melles-Griot), and three slits, of 2", 5" and 15" width, all  $\sim 15'$  long. Two new "flexible" slits were assembled at TAU workshop. The width and the position of those slits can be changed in order to get an optimal slit for specific observation. Both of them are  $\sim 10'$  long, and currently are about 11" wide. One is centered on the blue side of the spectrum and the other on the red side. The different apertures of the AP wheel are detailed in the table 5.2.

The shutter of the instrument is located immediately below the apertures. This is a fairly large electro-mechanical shutter (three-blade, solenoid driven), that may take a while to fully open, so the observer should be careful with short exposures. Timed exposures as short as 0.1 sec are possible, though due to the way the shutter opens, vignetting of the field edges will certainly occur. The shutter is *normally open*, thus it requires current to close and stay closed, but not while exposing. This is done to minimize heat dissipation inside the FOSC while observing.

*TIP:* it is possible to know the amount of light from the object passing through the slit by taking two images, one with the full aperture and no grism and another with the slit and without the grism.

Table 5.2: FOSC's Apertures

Name	Width/Diameter
2" hole	75 $\mu$ m pinhole=2.2"
5" hole	200 $\mu$ m pinhole=5.8"
2" slit	15' long and 69 $\mu$ m=2" wide
5" slit	15' long and 172 $\mu$ m=5" wide
15" slit	15' long and 516 $\mu$ m=15" wide
10"B slit	$\sim$ 11' long and $\sim$ 400 $\mu$ m=11.6" wide
10"R slit	$\sim$ 11' long and $\sim$ 400 $\mu$ m=11.6" wide

All slits are normally oriented North-South with the instrument rotator at the back of the telescope in its normal (353.4 $^\circ$ ) position.

### 5.1.3 The Field Lens and the Collimator

A field lens is mounted below the shutter. This is a 40 mm diameter coated achromat. The field lens forms a system pupil near the location of the lower grism wheel (see below). Below the field lens is the collimator lens that can be moved by computer control along the optical axis. It creates a (hopefully) collimated bundle of light, that is further manipulated by the optical elements in the upper filter wheel and the lower grism wheel (FI and GR). The collimator is a 50 mm diameter coated achromat.

The collimator position is relative to a single encoded location near its lowest point of travel. The position is actually the number of steps of the motor moving an eccentric cam, and is in the range 0 to 550 steps. Note that the collimator is initialized at startup of the control program. If power to the FOSC is lost, the collimator position might change. We suggest to zero its position and initialize the wheels position using the FOSC PC (see section 2.3).

Although the collimator should not require refocusing when the optical elements in the light path between the collimator and the CCD camera lens are changed, in practice it turns out that it does need refocusing. This, no doubt, is the result of the lack of auto-collimation of the FOSC. Hence, whenever the setup of the elements in the light path is changed it moves automatically to the its right position for that setup.

### 5.1.4 The Filter Wheel

The FI wheel (named also the Upper wheel) has 10 positions (for 2 inch round or square filter with thickness no more than 7 mm) and is used mainly for filters, but also for wedged windows, that steer the beam of the 300 gr/mm and 600 gr/mm grisms in the GR wheel, and for the 150 g/mm “cross-disperser” grism, that serves as the cross-disperser for the echelle grism.

The wedged windows may also be used for imaging, to shift the image of a star off a bad column. As these are essentially prisms, they will cause the images of stars to become enlarged, by dispersing the light along the columns.

The two wedged windows currently in use has a 50 mm diameter. The older (wedge 2) has a 2° wedge angle, and the newer (wedge 3) has a 3° wedge angle. A small wedged window is also exist. It has a circular aperture of 37 mm diameter and a wedge angle of 4°. It is made of fused silica and is **not** anti-reflection coated. The deflection angle of a wedged window is approximately half the wedge angle. The various combinations of spectral coverage and dispersion are detailed in table 5.3.

Note that, as the beam through elements in the FI wheel is almost collimated, incidence effects on narrow band filters should be negligible! On the other hand, the filters mounted in the beam should be of **image** quality. The elements mounted in the FI wheel may be changed quite often, according to the requests of the observers, except for the cross-disperser grism and the wedged windows. Table 3.1 shows the filters that can be mounted into the FI wheel. The U filter is available in principle, but due to the quality of the UV images of the FOSC, it is not recommended to use it.

Care should be taken when mounting slightly undersized filters in the FI wheel. No clear unblocked areas should remain beyond the filter edges. This may cause light leakage out of the filter band, internal reflections, and other unwanted effects. Changing of filters in the FI wheel should be left to the the day technician.

### 5.1.5 The Grisms

The GR wheel (named also the Lower wheel) has 10 positions. Three are taken by the 300 g/mm, 600 g/mm grism, and the echelle grism. It is possible to mount other elements in this wheel, if required. Because of the large mass of the grisms, it is recommended **not** to change their positions as this may destabilize the GR wheel with catastrophic positioning results. New elements should be mounted in symmetric positions in this wheel, that should be re-balanced afterwards. Therefore, we recommend not changing elements in the FI or GR wheels at night. This means that the observing program should be well thought of in

advance and the requests from the day assistant be also made in advance.

All three gratings are mounted in the same orientation and will produce spectra with blue at the right, on the computer display. The echelle with the cross-disperser in the FI wheel will produce lower orders of dispersion with shorter wavelengths higher on the display.

The echelle grism has a 79 g/mm grating replicated onto the prism. This provides the highest resolution available at the Wise Observatory, of  $\sim 2\text{\AA}/\text{pixel}$  at  $5345\text{\AA}$  in the 11th order of diffraction, allowing a resolution of about  $5\text{\AA}$ . The blazing angle of the echelle is  $63.5^\circ$ , and for the gratings: 150, 300, and 600, is  $8.6^\circ$ ,  $14.6^\circ$ , and  $34^\circ$ , respectively.

### 5.1.6 FOSC Wavelength Ranges

Details about the different available setups and the wavelength coverage and dispersion are given in tables 5.3 and 5.4. Those wavelength ranges are from a test done on October 8, 1994 with the TEK when the telescope was vertical. It should be noted that the numbers can vary up to 10 pixels due to flexure in the instrument, when the telescope is tilted to any direction.

The setup of the  $2''$  slit with the 300 grism and no wedge has in its spectra the 0th order of dispersion. Also a possible setup can be with a slit and the 150 grism. Such setup gives dispersion of about  $17\text{\AA}/\text{pixel}$  and covers the entire wavelength range (from 0 to about  $15000\text{\AA}$ ).

The FOSC has poor blue response as the optics is not adjusted and optimized for this spectral region. Hence, the spectral response does not extend below about  $4000\text{\AA}$  and one should not use it that limit.

An example of the He-Ar arc spectrum with the setup of  $2''$  slit, Wedge 3 and the 600 grism, on the TEK CCD, including line identification, is shown in Fig. 5.4.

### 5.1.7 The Camera

The beam from the optical elements is imaged by a camera lens. In order to save costs, this was chosen to be a stock camera lens, a Canon 85 mm f/1.2 lens. The lens images the field/spectrum onto the CCD detector. Since this is a stock lens not designed specially for astronomy, it will not image well in the near UV and in the IR. It is also fairly certain that some chromatic effects will be apparent at intermediate  $\lambda$ s. The FOSC is designed to operate properly from about  $3900\text{\AA}$  longward up to about  $8000\text{\AA}$ . The images near the end of this spectral range will certainly be out-of-focus. Nominally, the FOSC should provide images that are  $25\mu\text{m}$  or smaller in diameter.

The effective f/number of the FOSC is  $\sim 2.5$ , much faster than the f/7 beam normally used for imaging with the  $40''$  reflector. This implies that the plate scale is also changed,

Table 5.3: Wavelength ranges for different FOSC setups.

Slit name	Wedge (number)	Grism line/mm	Coverage Å	Dispersion Å/Pixel
2''	Wedge 3	600	3493 – 7263	3.68
2''	Wedge 2	600	3403 – 7156	3.67
2''		600	3201 – 6948	3.66
2''		300	783 – 9130	8.16
2''	Wedge 3	300	1511 – 9874	8.18
2''	Wedge 2	300	1183 – 9623	8.25
10''R	Wedge 2	300	2089 – 10905	8.62
10''R	Wedge 3	300	2267 – 11161	8.69
10''R		300	1361 – 10458	8.62
10''R		600	3681 – 7515	3.75
10''R	Wedge 3	600	3980 – 7821	3.76
10''R	Wedge 2	600	3878 – 7717	3.75
10''B	Wedge 2	600	3619 – 7433	3.73
10''B	Wedge 3	600	3725 – 7544	3.73
10''B		600	3425 – 7222	3.71
10''B		300	859 – 9787	8.73
10''B	Wedge 3	300	1657 – 10524	8.67
10''B	Wedge 2	300	1459 – 10263	8.61

in such a manner that the PI CCD pixels would under-sample the seeing disk. The current plate scale of the FOSC is about 1.7 ''/pix.

Although most optical surfaces of the FOSC are anti-reflection coated, ghost reflections are almost certain to occur when a bright star is in the field. These are most prominent in narrow-band imaging. Finally, expect some image distortion near the edges of the field. The full 17' field is unvignetted only in its inner  $\sim 15'$ . The vignetting is normally taken out by the flat field compensation, but the S/N will always be lower in the outer one arcmin ring.

The aperture positions on the PI CCD when mounted to the FOSC are listed in the

Table 5.4: Wavelength ranges for the cross disperser (150 grism) + echelle.

line number	Coverage Å	Dispersion Å/pixel
1	8604 – 11192	2.59
2	7408 – 9636	2.23
3	6515 – 8453	1.94
4	5823 – 7538	1.72
5	5272 – 6803	1.54
6	4829 – 6203	1.38

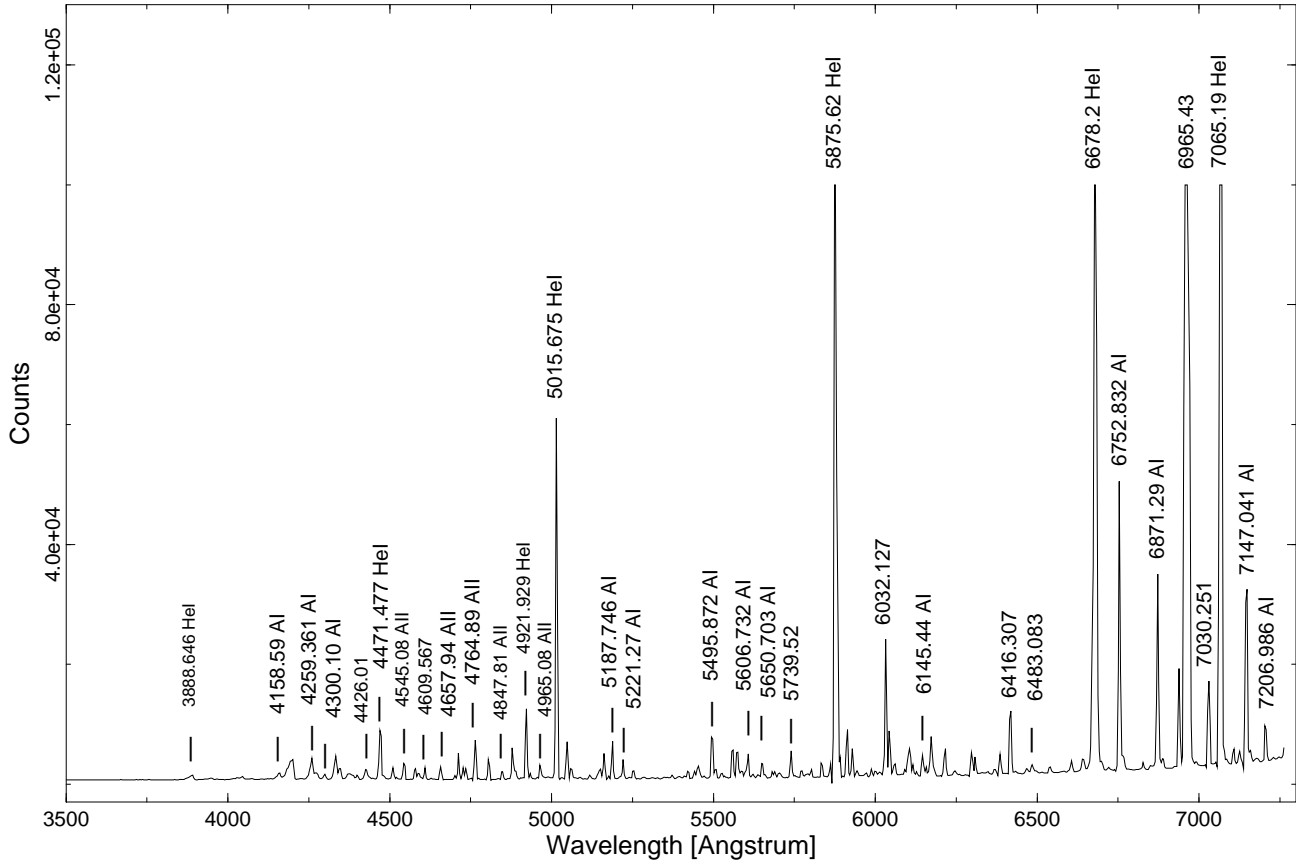


Figure 5.4: The He-Ar spectrum with the 2" slit, 600 g/mm grism and wedge3

Table 5.5. First Column lists the aperture position in the apertures wheel. Second column the aperture name. Third column the offset of the filter wheel in the c:\misc\fosfile file (see section 2.3). Forth column is the X position on the 600×600 pixels image of the PI CCD (FOSC FOV - the FOV center is at x=240 y=380) and the fifth column is the Y position where the object should be placed in order to be in the specified aperture.

With the PI CCD the central part of the CCD used for the "FOSC FOV" is left=370, top=350, width=600, highet=600. For the "spectrum" part it is left=0, top=545, width=1340, highet=350.

The camera lens of the FOSS is 36mm so the CCD needs to be very close to the camera to get in focus.

The 10" Slit is 0.35 mm wide.

### 5.1.8 The Wheels

The entire internal surface of the FOSS is covered by black felt-like fabric to reduce scattered light. Baffles are provided between the wheels for the same purpose. The scattered light

Table 5.5: FOSC’s Apertures positions on the PI CCD

Number	Aperture	Wheel Pos.	X	Y
1,3	none	000	240	380
2	10" slit R	530	38	380
4	2" slit	450	228	380
5	5" hole	220	247	380
6	5" slit	430	216	380
7	2" hole	000	271	379
8	15" slit	400	213	380
9	2" new	360	217	380
0	10" slit B	620	130	380

problem, as well as that of the internally-produced light, were demonstrated when an unexplained dark-count enhancement was traced to the LEDs mounted in the position detectors of the “absolute encoders” of the AP, FI and GR wheels. These were emitting very faint light, in a location far from the optical axis, that was nevertheless detected by the CCD. This problem was solved by disabling the encoders and the drive motors whenever observing. This turns the illumination off except when moving the wheels but implies that the refining function of the stepper motor is absent.

The FOSC functions are controlled by the Camera and FOSC controller PC and the FOSC PC. The position of the AP, FI and GR wheels, as well as that of the collimator, are read and can be modified by the software. The position of the wheels can be read to within a few arcsec, because of “absolute encoders” that are mounted near the centers of the apertures. These encoders are essentially slits of different widths fixed to the wheels, that are sensed by optical switches connected to Schmitt triggers that respond within a few steps. One rotation of any wheel corresponds to 72,000 steps of the driving motor. The repeatability of any position is from 2 to 8 steps, depending on the position of the telescope and on the balancing of the respective wheel.

The software used for moving the wheels is described in sections 2.3 and 3.2.2.

### 5.1.9 Unorthodox Users

Being a flexible instrument, the FOSC is allowing modes of operation that can hardly be found elsewhere. It is possible, in principle, to have a narrow-band filter as pre-disperser in the FI wheel to work in conjunction with the echelle grism in the GR wheel. In this case, the idea would be to use a long and narrow slit in the AP wheel and to image possibly a single emission line. A possible observing project with such a setup would be rotation curves of galaxies, by setting the spectral range to  $H_\alpha$ . Another would be a study of the kinematics



of emission line nebula. This observational setup has been tested with the STL-6303 CCD.

Another possibility used in the past is to insert Polaroid filters, with the polarizing axes at  $120^\circ$  spacings, in the AP wheel and use the FOSC for imaging polarimetry, either with broad or with narrow-band filters. Such three Polaroid filters are available at the site and studies using this setup were already published.

## 5.2 FOSC Operation

A suggested procedure for operating the telescope with the FOSC is outlined here. It is suggested that one should arrive to the observatory about an hour before sunset (if the CCD is warm you need to come 2 hours before sunset, so to have enough time to cool it).

### **In the dome:**

- On the way to the dome go to the electric box in the room below the telescope and lift the three circuit breakers (CB2, CB3, CB4).
- Turn on the PI CCD, the FOSC, and the ST7 CCD guider.
- Make sure the rotator is at the FOSC angle, which is 353.4 degrees. At this position the guider ST7 should point south, the CCD filling hole should point south, the CCD electronics should point north, the FOSC power supply should point westwards. Any other direction will mess up your work.
- Calibrate the dome position by moving the dome from the console so that the rails will be between the markers.
- Then go to the dome computer and in the “Dome Agent” write 90 in the “Set Az” and press Enter.
- On the dome-pc make sure the time of the clock gets updated with the Dimension4 program: put the cursor on the Dimension4 icon and check if the time was updated in the last 5 min.
- Also check that the “Telescope Agent” and “Focus Agent” programs are running. If not then start them from the desktop.
- Make sure the set/guide switch on the small gray hand paddle next to the dome-pc is pointing to the ”guide” position. Otherwise the guider will not work properly.
- Check the fosc-pc and make sure the fosc wheels program is running on it, if not then start it from the initial screen menu.
- Zero the collimator by pressing <c>, <i> and then <cr>.
- Send the wheels to a desired position to reset the collimator.
- In the pi2006 VNC window click twice on the SNI icon that is on the desktop. The PI interface will be opened, then the MaximDL’s windows will be opened and automatically

will connect to the CCDs and will start the cooler on.

- Close the VNC to the pi2006 from the dome-pc.
- Turn OFF the dome air condition using its remote control which is on the big blue console.
- Check the blue big console; if it is off, turn it on. When turning on the breakers (CB2, CB3, CB4) might jump so you will need to go down to the electric box in the room below the telescope to lift them up again.
- Take off the telescope cover.
- Lower the platform all the way down.
- Position the telescope to declination  $+10^\circ$  so that when opening the dome shutter debris will not fall into the telescope.
- Make sure the Dec (or any other) button is not stuck by pressing only the slew button and making sure the telescope does not move.
- Turn on the relay box and the focus switches (behind the old console). Make sure the MAALA switch is on “Normal” and press the “Reset”.
- Fill the CCD with nitrogen for about 5 minutes (lasts for about 14 hours work). Don't open the tap of the nitrogen fully open with a strong stream of nitrogen. Use a weak stream, and the filling of the dewar will be better. When filling, the telescope should be at declination  $\sim +10^\circ$ .
- Disconnect the nitrogen filling pipe.
- Make sure the platform is all the way down.
  
- Turn off all light in the dome (including computer screens).

**In the control room:**

- On mizpe-cdr open VNC to dome-pc (from the remote folder on the desktop). In the “Focus Agent” tool put the secondary in the position close to fosc focus used last time (typically around 1230).
- On mizpe-cdr bring up the weather-pc VNC window (from the remote folder on the desktop) to be able to check the weather.
- On weather-pc make sure that the “Volume control ” window the “Mute” and ‘Mute all” of the “Mic Volume” and “Volume Control” are not checked to be able to hear the sounds from the dome and also that the “Balance” in the “Volume Control” is on the left speaker.
- On mizpe-cdr open VNC to the cloudwatcher computer and check the sky clarity.
- On mizpe-cdr bring up the pi2006 VNC window.
- In the MaximDL’s “Camera Control” window go to the “Guide” tab. Make sure that ”Pier Flip” is NOT checked and that the “Aggressiveness” to x=8 y=8. Click the ”Settings”

button and a “Guider Settings” Window will be opened. Set XSpeed to 0.9, Yspeed to 0.8, and Angle to  $-179$ .

— In the PI interface press the ”Fosc Aid” tab and define in it the aperture, wedge and grism setup you are about to use.

— In the PI interface define spectra area by pressing ”Spectrum”.

— On mizpe-cdr open the “Remote Wise Commander” program. In the “Camera” section set the instrument to “PI” and then choose the ”connect all” from the sockets menu, which will initialize the connections to the different agents. Press the ”FOV” button to reset a connection between the “Remote Wise Commander” and the ”PI Interface”. In the ”Set CCD size” that will open just press ”ok” - currently there is no meaning to the number in that window.

— Load the list/s you are going to use during the night from the List menu.

— Check the computers pi2006, mizpe-cdr, dome-pc, and weather-pc, that the Dimension4 program is running and updating the computer time and that it is correct.

— **On the “Telescope Agent” tool press ”Fosc Mirror” to have the internal mirror to move out of the light path. For sky observations the ”Fosc Mirror” has to be yellow. For HeAr and lamp-FF observations the ”Fosc Mirror” has to be gray.**

— About 15 minutes before sunset, you should take a bias sequence by choosing the “bias” from the “Remote Commander”, entering the number 5, and pressing “ok”.

NOTE: Take the bias while the dome is in complete darkness in order to prevent light leaks to the camera. The average bias level should be around 119.

### **Taking Flat Field:**

— On sunset open the dome from the “Remote Wise Commander” using the ”shutter” button and the ”open” option.

— Turn on the dome ventilation and open the dome’s openings around the dome using the ”Dome Vent” button in the “Telescope Agent” window. Wait for two seconds to allow it to respond.

— Start the tracking of the telescope and the dome by pressing the ”RA Track” to ”on” in the “Remote Wise Commander”.

— Point the telescope to “Sky flat” position.

— **Make sure the ”FOSC Mirror” button on the “Telescope Agent” window is yellow.**

— Right after sunset start taking sky flats. Start with pressing the ”Test” button and taking a 4 sec exposures until the counts in the image will get to below saturation. Then press the ”FlatField” button, and using the green “observe” button take about 3 to 5 flat field images.

- After taking flat fields put all the FOSC wheels in the “none” positions closest to the positions used before using the FOSC PC.
- Press “FOSC FOV” on the PI-interface window.

### **Calibration:**

- After the flat field were done send the telescope to a bright star by choosing a star from the “\_BrightStarsCatalog” list which is in the mizpe-cdr computer and sending the telescope by pressing ”goto”.
- Once the telescope reached the position take a 1 second ”Test” exposure on the PI interface. It is best to calibrate the telescope to the position where the aperture (slit) you are going to use during the night. If the star is not in the place you want it move it to there by taking a sequence of images using the “repeat” option and the buttons of the “Telescope Agent” window on dome-pc.
- Once the star is at position you want it to be on the CCD, press the “calibration” button on the “Telescope Agent” window on dome-pc. A confirmation window will appear. Check that the suggested shifts of calibration are not too large (according to the movement you did and up to a few arcmin), and confirm the new shifts, or cancel if you did not moved the telescope.

### **Focusing:**

- Put the bright star to where your slit/aperture should be during the night - if you have not done so already.
- Move in the dispersing elements you need (i.e., wedge and grism) using the FOSC PC (no aperture is necessary at this stage).
- Take a spectrum of the bright star using a ”Test” observation of 3 sec.
- In the “Expose” tab in the “Camera Control” checkmark “Mouse” in the “Subframe” area, and also check mark “Continuous”.
- Mark a subframe at the center of the spectrum by clicking on the left mouse button in the upper-left corner of the subframe you want and dragging the mouse to the lower-right corner of the subframe you want. The subframe will be marked on screen and its parameters will appear in the “Subframe” section in the “Camera Control” window.
- Choose about 3 seconds for an exposure and binning of 1. Then press the “start” button.
- The tool will take continuous exposures of the subframe.
- Enlarge the image using the ”+” magnify mark
- On the “Maxim DL” window press “line profile” icon.

- Choose the "line" option and mark a vertical line on the image so that you'll get its graph in the "line profile" window.
- Now move the secondary using the "Focus Agent" window until you'll get the narrowest spectrum possible.
- When done, press "stop" in the "Expose" tab to stop the focus loop.
- In the "Expose" tab in the "Camera Control" check mark "Single", and in the "Subframe" area un-checkmark the "Mouse" and press the icon with the arrows to reset the subframe into the maximum dimension of the CCD.
  
- The telescope is now ready for work. It is advised to observe when the Sun is more than 12 degrees below the horizon (or even 15 degrees for galaxies and faint objects).

### **Observations:**

- Use the FOSC-PC to put all the FOSC wheels in the "none" position close to the position of the elements you need to use.
- Make sure the "FOSC Mirror" button on the "Telescope Agent" window is yellow.
- If needed, rotate the rotator to the angle of your first object.
- Point the telescope at the object using the "Remote Wise Commander" window.
- In the pi2006 click "FOSC FOV" and take a test image to identify your field.
- Move your object to where the slit is suppose to be (see Table 5.5). On the "FOSC FOV" and for the 10"slitR it is on x=38 and y=380. For the 10"slitB it is on x=134 and y=380.
- In the "Expose" tab of the "Camera Control" of MaximDL Choose about 3 seconds for an exposure, binning of 1, and check mark "Continues". Then press the "start" button. Move the telescope until you get the object in position.
  
- While the "Continues" loop working put in the slit you want to use.
- Once the slit is in position stop the loop.
- In the "Expose" tab in the "Camera Control" checkmark "Mouse" in the "Subframe" area.
  
- Mark a subframe around where the objects are in the slit by clicking on the left mouse button in the upper-left corner of the subframe you want and dragging the mouse to the lower-right corner of the subframe you want. The subframe will be marked on screen and its parameters will appear in the "Subframe" section in the "Camera Control" window.
- Press "Start" to take continuous exposures of the subframe.
- Enlarge the image using the "+" magnify mark.
- Adjust the gray scale so that you'll see the objects.

- Move the telescope slightly using the guider hand paddle (while the focus loop running) until the object is centered in the slit.
- To use the autoguider, go to the “Guide” tab and press the “Setting” button. Set XSpeed to 0.9, Yspeed to 0.8, and Set the Angle to (175 - Rotator\_angle). The Guider Angle should be between -180 to 180. Then press “apply” and “ok” in the “Guider Settings” window.
- Put the object’s declination in right place on the “Guider” tab and exposure time of 10 to 20 seconds. Check the bullet next to expose and obtain an image in the guider. If the guider finds a guide star then start guiding, if not then choose a guide star, check its centroid coordinates and put them in the right place and start guiding.
- The guider and continues loop does not work together so stop the continues loop and enable to take a few exposures of the guider and check that it is stable in its guiding.
- Next, go back to the ”Expose” tab and start again the continues loop to see the slit and to make sure the objects did not move from the slit. If the objects are centered fine then stop the continues loop and check again that the guiding is working correctly.
- Put in the dispersing element you want to use.
- Press the “spectrum” button.
- Take a test image to see that all dispersion elements went into their place correctly.
- Press the “object” button.
- Put in the object name and exposure time and start the exposure.
- When the exposure is done take a He-Ar image by pressing on the “Telescope Agent” window the “FOSC Mirror” button to make it gray, and also press the “FOSC HeAr” button to make it yellow.
- On the “FOSC Aid” window press “HeAr” and then take a 5 sec HeAr image by pressing the green “observe” in the PI-interface window.
- Then turn off the HeAr by pressing the “FOSC HeAr” button to make it gray.
- Take a lamp-ff by pressing on the “Telescope Agent” window the “FOSC Halogen1” button to make it yellow.
- On the ”FOSC Aid” window press “lamp-ff” and then take a 10 sec exposure of the lamp-ff twice (by pressing the green ”observe” in the PI-interface window).
- When done press “FOSC Halogen1” button to make it gray and “FOSC Mirror” button to make it yellow.
- On the “FOSC Aid” window press “Back To Object” button.
- Take another exposure of the same object or stop the guiding and go to your next object after putting all FOSC wheels on ”none” positions, and repeat the above sequence.
- It is recommended that the last exposure of the night should not continue beyond the

time when the sun is 12 degrees below the horizon.

**End of night:**

- Stop the guiding by pressing “stop” in the “Guide” tab.
- If you have time take a final bias sequence.
- If sky flats were not taken at the beginning of the night, take them at dawn as described above.
- In the “Camera Control” window on the “setup” tab, in the “coolers” area press “off” and “Disconnect”.
- Close the “PI interface” window.
- On the “Telescope Agent” window press the “FOSC Mirror” button to make it gray.
- Using the “Remote Wise Commander” tool position the dome to the east by pressing the “Sky Flat” button and “Go To” - the dome will move the east and the telescope to the zenith. Then disconnect the Dome Track by pressing its “off” button, and move the telescope to Declination of 10 (this way when you’ll close the dome the hazard of things falling into the telescope is minimized).
- Close the dome using the “Shutter” button on the “Remote Wise Commander” tool.
- Turn OFF the RA tracking in the “Remote Wise Commander”.
- In the “Remote Wise Commander” disconnect all sockets.
- Exit the “Remote Wise Commander” program.
- Turn off the dome ventilation and close the dome’s openings around the dome using the ”Dome Vent” button in the “Telescope Agent” tool. Wait for two seconds to allow it to respond.
- Exit all VNC windows that are opened on mizpe-cdr.
  
- Backup the image files from the pi2006 computer to the mizpe-cdr computer and to the mizpe-bck, using a simple ”Total Commander” copy procedure on the mizpe-cdr computer. Verify the files were copied correctly, i.e. check the image sizes in kb (see section 2.4.3).
- It is also the responsibility of the principal investigator (PI) of the night to make sure that all files were backed up correctly.
  
- Go up to the dome and cover the telescope and position it to a DEC of +10°.
- Fill nitrogen into the CCD.
- Turn off the ST7, the PI CCD, and the FOSC power supply.
- Switch off the relay box and the focus switch behind the blue console.
- Turn on the air conditioners.

- Make sure the platform is all the way down.
- Switch off all lights in the dome.
- On the way down switch off the three circuit breakers (CB2, CB3, CB4).
- Fill out the nightly log in: <http://wise-obs.tau.ac.il/observatory/log.html>
- Before leaving the site, please check that all the books are back at their place, the kitchen is clean and all lights are off.
- Lock the observatory up and go to sleep.



# Chapter 6

## The eShel Spectrograph

### 6.1 The eShel Spectrograph - General Description

The eShel spectrograph was bought on July 2012 and was commissioned for work on the 1m telescope of the Wise observatory by Micha Engel as part of his Ph.D. thesis.

The eShel spectrograph consists of three main units connected by optical fibers:

1. The **FIGU- Fiber Injection and Guider Unit** mounted on the telescope.
2. The echelle **Spectrograph Unit** located in the observer room.
3. The **Calibration Unit** also located in the observer room.

Two 20 m optical fibers connect the subsystems:

**Object fiber** ( $50\mu m$ ) diameter - Yellow marked - connects the FIGU to the spectrograph  
**Calibration fiber** ( $200\mu m$ ) diameter- Blue - connects the calibration unit to the FIGU.

In the following paragraph we shall give a general description of the eShel parts, for further information you may refer to the two pdf manuals that are on the eShel computer:

**DC0009B eShel User Guide.pdf**

**DC0010C eShel Installation and Maintenance Manual.pdf**

Both documents are stored on the eShel computer and can be viewed and downloaded from the eShel supplier web site: <http://www.shelyak.com>

#### 6.1.1 The FIGU - Fiber Injection and Guider Unit

The FIGU is mounted on the telescope at the focal plane via a focal reducer which adapts the focal ratio of the telescope to the focal ratio of the FIGU. The FIGU has a built-in flip



Figure 6.1: The FIGU mounted on the 1m Telescope through a focal reducer

mirror, two fiber optic connectors and a CCD camera that images field around the fiber opening.

A yellow marked fiber is connected to the rear end of the unit. This fiber transmits the light from the FIGU to the spectrograph unit.

A blue marked fiber connected to the side of the unit brings the light from the calibration unit to the FIGU.

A gray electrical cable connects the FIGU to the calibration unit. This cable brings command voltage from the control box to an actuator in the FIGU. This actuator inserts a mirror into the light path. When the mirror is "off" the light from the telescope (the observed object) is injected to the yellow object fiber and transmitted to the spectrograph. When the mirror is "on" the light from the calibration unit going through the calibration fiber (blue) is injected to the object fiber and transmitted to the spectrograph. There is a click sound when the mirror is inserted into the optical path.

An SBIG ST-i CCD camera is mounted on the FIGU. This camera transmits an image of the field around the pinhole and allows centering the object to be measured on the entrance pinhole. The light that enters the pinhole is fed into the fiber. The ST-i camera is connected to the pi2006 computer USB port.

### 6.1.2 The Calibration Unit

The calibration unit serves two functions:

- Supply and control calibration sources

- Control the FIGU mirror and calibration sources through an RS232 serial port connection to the computer

The calibration unit contains 3 calibration sources:

1. ThAr lamp
2. Tungsten lamp
3. Blue LEDs

When turned on, the light from any of these calibration sources is injected into the calibration (blue) fiber and transmitted by it to the FIGU. When the mirror is "on" the light is transmitted to the object fiber and back to the spectrometer unit. This is done by the eShel software via the RS232 port and can be done manually using the switches on the front panel of the calibration unit.



Figure 6.2: The calibration unit with the switches that control the calibration sources and the FIGU mirror

### 6.1.3 The Spectrograph Unit

The spectrograph unit contains the heart of the eShel system. It houses the dispersive elements of the spectrograph with the accompanying optics. Light enters the spectrograph via the object fiber, goes through the dispersion section and the spectrogram is imaged on the SBIG ST-10ME CCD camera on top by a standard 85 mm Canon lens.

During observation session there is no need to adjust anything on the spectrograph unit.

**It is highly recommended not to touch it.**

The only thing that you may want to adjust is the focus of the objective lens. The focus should remain adjusted so it is unlikely that it needs readjustment.

Before trying readjust the objective focus check if it is really needed.



Figure 6.3: The spectrograph unit. The SBIG ST-10ME CCD camera is on top of the CANON objective lens. The object fiber connects to it from the back.

## 6.2 Preparation of the eShel for Observation

It is recommended to come to the observatory a few hours before sunset so that you will have enough time to prepare and calibrate the eShel.

### 6.2.1 Preparing the eShel Setup

#### **On the Telescope:**

- Check that the object (yellow) and calibration (blue) fibers are properly connecting the FIGU to the Spectrograph and calibration source.
- Make sure the rotator is on the eShel angle, which is 82.4 degrees. At this position, the guider ST-i camera (red one) should point north. Any other direction will mess up your work.

#### **In the dome's glass room:**

- Turn on the eShel computer.
- Turn on the Calibration control box.
- Check that the ThAr power supply switch is on the "on" position (the lights are off - see next step).
- Turn on the ThAr switch on the calibration unit. Check that the ThAr power supply

- starts working and that the current is 0.8mA. Adjust it if necessary using the knob. Turn off the ThAr switch on the calibration unit. (leave the power supply switch on).
- Turn on the SBIG CCD camera power supply. A green LED on the power supply will turn on.
  - Check that the SBIG camera is operating (Red LED is on and the small cooler fan is rotating).
  - Start the AuDela software from the desktop. In the AuDela "terminal" window you can see that AuDela detected the SBIG camera (message: "SBIG PORT (SBIG ST-10 Dual CCD camera):USB" in green). Minimize the "Terminal" window.
  - In the Audela window, check the temperature of the eShel camera (in Audela: **Setup**→**Camera**). The temperature should be set on -20C. The camera temperature should be -18C ÷ -19C.
  - On the dome-pc make sure the time of the clock gets updated with the Dimension4 program: put the cursor on the Dimension4 icon and check if the time was updated in the last 5 min.
  - Check that the "Telescope Agent" and "Focus Agent" programs are running. If not, start them from the desktop.
  - Open a VNC to the pi206 computer.
  - In the pi2006 VNC window click twice on the MaximDL icon that is on the desktop. The MaximDL interface will be opened.
  - Click on the "toggle camera control" button, and in the "camera control" window click on "setup" tab.
  - Setup camera 1 on SBIG universal and on ST-i.
  - Setup camera 2 on simulator (camera 2 is not going to be used).
  - Connect the cameras. Now you have the ST-i as camera 1. Camera 2 is not relevant.
  - Check the options of camera1 and make sure they correspond to what is seen in Figure 6.4. Both Flips should be unchecked.
    - In the "Guide" tab set the "Aggressiveness" to x=2 y=2. Then press "Settings" and setup the guide parameters: XSpeed= -4.34 YSpeed= 3.12 and angle= 179 (these parameters may change - Check the observers folder in the eShel web-site). Once the parameters are set press "Apply" to save and close the "Settings". See Figure 6.5.
  - Choose the **expose** tab and make sure "Camera 1" radio button is checked.
  - In **Exposure Preset** Choose **eShel\_cont**. Choose **Continuous** and press **Start**. Look on the live video from the ST-i CCD.
  - In the control box turn on the Mirror and the ThAr lamp on the calibration unit. You should see a bright round field appearing in the video and the fiber pinhole as a dark dot.

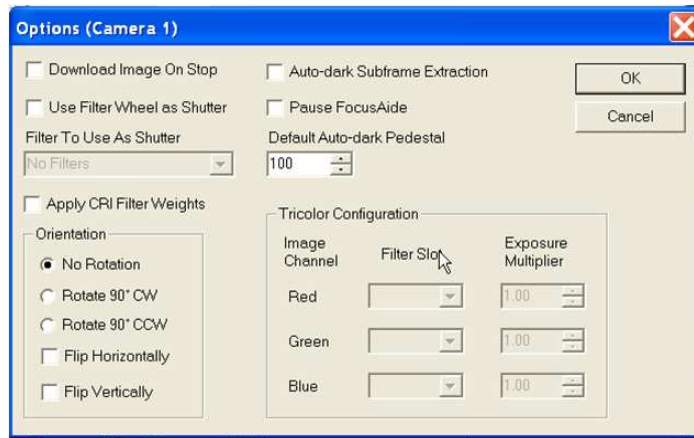


Figure 6.4: required camera1 (pinhole monitoring camera) options.

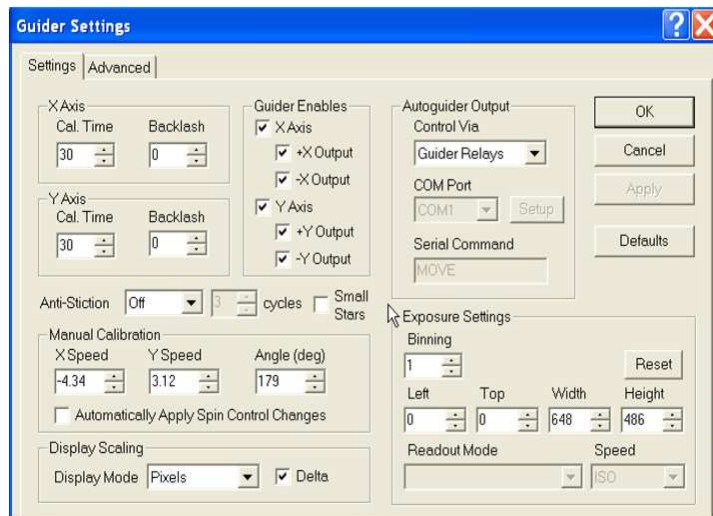


Figure 6.5: Required guider settings options.

(If the image is saturated adjust exposure time – 0.01s should work).

— Use **Toggle Screen Stretch** to adjust the dynamic range of the image so you can see the pinhole. The image should be sharp (see Figure 6.6). Note in your log the position of the center of the pinhole Also check that the pinhole is in focus and its width is about 10 to 12 pixels and not more.

— Turn off the mirror and the ThAr Lamp on the eShel control box.

**You can use this procedure during observations to locate the pinhole position in the image.**



Figure 6.6: Image of the pinhole as it is lit by the ThAr lamp (SBIG St-i CCD Image)

### 6.2.2 Checking the eShel Operation and Adjustment

The purpose of this stage is to verify that the eShel is working properly and that the adjustments were not changed. Using the AudeLa eShel program(see the *eShel user manual*):

— Below the "session" button choose "Preview Flat" `Preview Flat` and `10s exposure` and press "Acquire".

once the image is out check that it looks good (use Auto button at the bottom left of the window to adjust gray levels).

— Take ThAr image - `Preview ThAr`, `10s exposure` - check that it looks good (use Auto button at the bottom left of the window to adjust gray levels).

— Check the eShel camera focus by using the ThAr image and examining the FWHM size of the reference spot (See Figure 6.7 for its location).

— Mark a square around the reference spot using the cursor and then Choose from the upper menu `Analysis`→`Fit a Gaussian` to find the coordinate and the FWHM of the spot. The FWHM should be less than 5 pixels in both x and y axes. **The coordinate should be around (938,985)**. if they differ by more than 5 pixels make a note in the log at the end of the night.

—The eShel camera focus should be good and rarely needs readjustment. **It is unlikely that you will have to adjust it.**

BUT- If the FWHM is much larger than 5 pixels and it can be seen that the ThAr spots are blurry, check again that you took the image in the right condition and that the display is contrast and brightness were adjusted to Auto. Only when you are sure that you need to adjust the focus - turn the focus ring very slightly in one direction and recheck the FWHM in a new taken image. Repeat this procedure - each time taking new image and checking the FWHM until you get a satisfactory result. (A good focus is 4 pixel width in both axes).

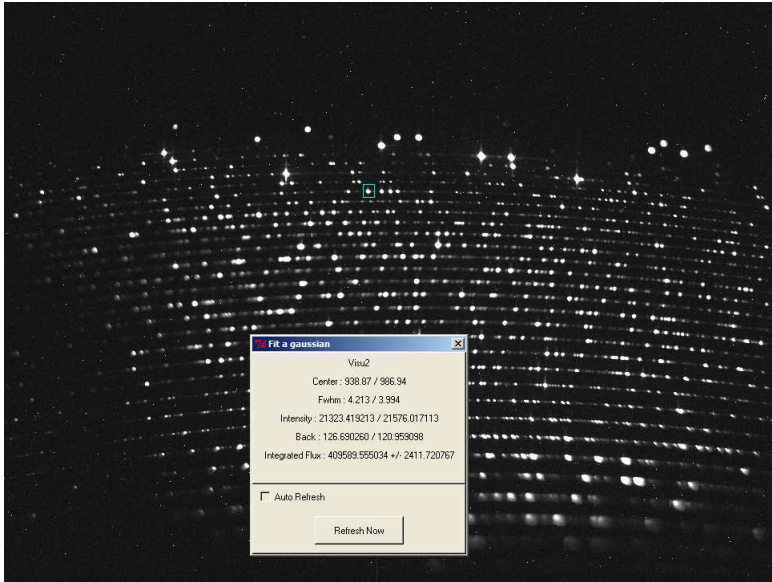


Figure 6.7: Image of the ThAr calibration with the reference line marked and measured with the "Fit a gaussian" analysis function

### 6.2.3 eShel Pre-Observation Calibration

Unlike other instruments in the observatory, you can calibrate the spectrograph before the night falls. (the dome should be dark with lights off). This is a major calibration, it takes time, so it is recommended to perform it early enough - not to waste precious observing time. In this first calibration procedure you will set-up the observation session in the eShel computer and perform a first calibration of the spectrometer.

- On the eShel Computer in the AudeLa program, make the window "Aud'ACE(visu1)" full screen.
- Press on the **Session** button.
- In the **Main Directory** entry browse and find the "c:\Users\mizpe\Documents\AudeLa\images\" - usually you only need to go up one directory. In the "Sub-Directory" entry write the date in the format yyymmdd which named by the date of today. Press the **Create and select** button. Check that the "configuration instrument" entry is "TAU1" which should be the default.
- When finished press the **OK** or **Apply** button.
- Once you have setup the session you can start the calibration, however if you have a long dark image you might prefer to do this in the morning. From the drop-down list below the **Session** button chose the proper calibration script to execute. To review or change the script press the **Instrument setup** button at the bottom left of the screen. Choose the



Reference Images tab. There you can choose the Calibration procedure and review or edit it. When finished press the OK or Apply button.

— When you are back in the main screen press the GO ACQ button. The software will run the calibration script and will take Bias, Dark, Flat, Tungsten, ThAr images for the calibration and store them in the `\images\today'sdate\raw` folder.

### Recommended Pre-Observation Calibration:

- **Bias:** 10 exposures
- **Dark:** Exposures with length longer than what you are going to use in the observations. The eShel processing requires that you have at least one dark exposure with longer length of the object exposures. The dark should be taken only once a month with a duration of the longest exposure (3600s — in most cases).
- You may want to postpone the long dark exposures to the end of the night or to the morning. Take darks before taking tungsten and ThAr exposures since the high intensity images leave some residual patterns that slightly affect the darks.
- **Flat:** 5 exposures of 10sec
- **Tungsten:** 5 exposures of 10sec
- **ThAr:** 2 exposures of 20 sec

— After the calibration process ends you should have the images in the "raw" sub-folder. You may inspect the images by pressing the Images button going to this folder and choosing the image to display.

— NOTE:

Take the bias only when the CCD temperature stabilized. Usually on  $\sim -18^{\circ}\text{C}$  The average bias level should be around 100.

Take the Dark images while the dome is dark (turn lights off in the dome and control room), otherwise you will have light leaks into the images.

## 6.2.4 Preparing for night measurements

### Start here after the calibrations

#### In the dome:

— On the way to the dome go to the electric box in the room below the telescope and lift the three circuit breakers (CB2, CB3, CB4).

— Check the blue big console; if it is off, turn it on. When turning on the breakers (CB2,

CB3, CB4) might jump so you will need to go down to the electric box in the room below the telescope to lift them up again.

— Calibrate the dome position by moving the dome from the console so that the rails will be between the markers.

— Then go to the dome computer and in the “Dome Agent” write 90 in the “Set Az” and press Enter.

— On the dome-pc make sure the time of the clock gets updated with the Dimension4 program: put the cursor on the Dimension4 icon and check if the time was updated in the last 5 min.

— Also check that the “Telescope Agent” and “Focus Agent” programs are running. If not then start them from the desktop.

— Make sure the set/guide switch on the small gray hand paddle next to the dome-pc is pointing to the “guide” position. Otherwise the guider will not work properly.

— Turn OFF the dome air condition using its remote control which is on the big blue console.

— Turn on the relay box and the focus switches (behind the old console). Make sure the MAALA switch is on “Normal” and press the “Reset”.

— Slew the telescope to the north and move the platform up enough so you can reach the telescope cover. Take off the telescope cover.

— Lower the platform all the way down.

— Position the telescope to declination of  $\sim 50^\circ$ , so that when opening the dome shutter debris accumulated on top will not fall into the telescope.

— Make sure the Dec (or any other) button is not stuck by pressing only the slew button and making sure the telescope does not move.

— On the dome-pc use the “Focus Agent” tool to put the secondary to a position close to the camera focus used last time (typically around 970). (You can look for the last values used in the telescope night logs).

— Turn on the dome vent by pressing the “Dome vent” button in the telescope agent. Wait for two seconds to allow it to respond.

— Turn off all light in the dome (including computer screens).

### **In the control room downstairs:**

— On mizpe-cdr bring up the weather-pc VNC window (from the remote folder on the desktop) to be able to check the weather.

**During the night close the dome if winds are stronger than 40km/h or condensation starts outside - usually this happens when the humidity outside is around**

90% .

— On weather-pc make sure that in the “Volume control ” Window the “Mute” and “Mute all” of the “Mic Volume” and “Volume Control” are not checked so that you will be able to hear the sounds from the dome, and also that the “Balance” in the “Volume Control” is on the left speaker.

— On the mizpe-cdr open VNC to the cloudwatcher computer and check the sky clarity.

— On the mizpe-cdr bring up the pi2006 VNC window.

— In the pi2006 pc in the MaximDL’s “Camera Control” window go to the Guide tab. Make sure that “Pier Flip” is NOT checked.

— On mizpe-cdr open the “Remote Wise Commander” program. Choose the “Connect all” from the “Sockets” menu, which will initialize the connections to the different agents.

— Load the list/s you are going to use during the night from the List menu. E.g., for focus you can use the `_bright_star_catalog` list, or choose a list from `List`→`Load`→`eShel`....

— Check the computers pi2006, mizpe-cdr, dome-pc, and weather-pc, that the Dimension4 program is running and updating the UT and that the UT is correct.

— Open the shutter using the “Remote Wise Commander” program in the mizpe-cdr pc.

— Set RA track and Dome track to ON.

#### **Focusing:**

— In the dome control room, on the dome-pc using the mizpe-cdr VNC window, send the telescope to a bright star by choosing a star from the “\_Bright\_Stars\_Catalog” list which is in the mizpe-cdr computer and sending the telescope by pressing “GOTO”.

**WATCH THE TELESCOPE!** Use the “dome-cam” and turn the lights on.

**Be careful not to allow the telescope to move to the required position below the polar axis. If this happens - stop the telescope by pressing the “STOP” button. Then slew the telescope manually above the polar axis close to the required position. Then press “GOTO” again.**

— Once the telescope reached the position, use the “Camera” window in the “Expose” tab to set the exposure time to 0.5 seconds and set it to “continuous”. Once you press “Start” you should see the star image in the FIGU CCD Camera live video window.

— To focus the telescope slew the telescope so that the star image is not on the pinhole.

— Check the FWHM of the star image Using the MaximDL tool. You can use the “Display large statistics” window from the “options” menu.

— Move the secondary using the “Focus Agent” window until you get the narrowest image possible. In good seeing conditions the FWHM should be around 11-12 pixels in both x and y, which is the size of the pinhole. The focus is around 970.

— When finished, write the focus position in the night observation log.



Figure 6.8: Image of the ST-i CCD with a star and pinhole after focusing.

- Then center the star on the hole using using the “set” and “guide” and direction buttons on the “Telescope Agent”.
- Once the star is at the position you want it to be on the CCD, press the **calibration** button on the “Telescope Agent” window on the dome-pc. A confirmation window will appear. Check that the suggested shifts of calibration are not too large (according to the movement you did and up to a few arcmin), and confirm the new shifts, or cancel if you did not move the telescope.

The telescope is now ready for work. It is advised to observe when the Sun is more than 12 degrees below the horizon.

## 6.3 Observations

An observation starts by positioning the star image on the eShel pinhole and setting up the guider to follow the star during exposures.

- In the “Remote Wise Commander” window on mizpe-cdr, choose an object from your list.
- Point the telescope at the object using the ”GOTO” button.

**WATCH THE TELESCOPE!** Use the “dome-cam” and turn the lights on.

**Be careful not to allow the telescope to move to the required position below the polar axis. If this happens - stop the telescope by pressing the ”STOP” button. Then slew the telescope manually above the polar axis close to the required position. Then press ”GOTO” again.**

- In the pi2006 VNC window, Choose the “expose” tab and make sure “camera 1” radio

button is checked.

- Start continuous exposures (1 sec continuous exposures).
- Bring the star to the pinhole using the “SET” and “GUIDE” buttons in the “Telescope Agent” (figure 6.9).
- Once the star is on the pinhole stop the continuous exposures in the “Expose” tab.

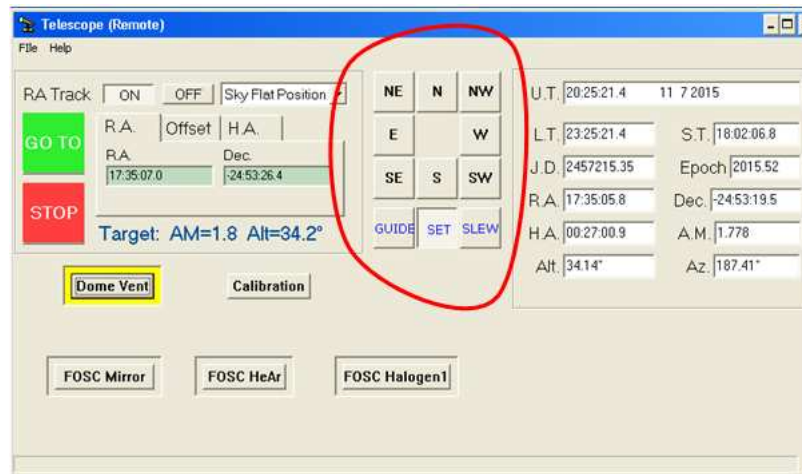


Figure 6.9: “SET” and “GUIDE” buttons in the “Telescope Agent”.

- Go to the “Guide” tab. Choose camera 1 (you will find it on camera 2).
- Enter the coordinate of the center of the pinhole in the x, y fields of the guide star. These coordinates remain fixed. You enter them only once during the night.
- Enter the star’s **declination** in the guide tab (upper right in the tab). **It is important to set the declination to the target star declination, otherwise the tracking will not be optimal.**

— Set the guider exposure time to get an image that is not saturated. (10 ses for most cases works fine). The guider gives the telescope correction commands at the end of each exposure – do not set exposure times shorter than 5 sec this will give too frequent correction commands to the telescope.

— Click on the Start tracking button.

The guider will start by creating a small image (64x64 pixels around the pinhole). You can magnify it by the zoom tool (400% is ok) to be able to watch it more comfortably (see figure 6.10).

— Wait a few guiding cycles to let the guider center the star image on the pinhole.

— When observing a faint star (magnitude 9.2 or more), you may need to enhance the counts received in each pixel for proper guiding (this is relevant when you get too often “star faded” message from the guider). This enhancement is done by “binning” which means that we sum



Figure 6.10: Autoguider on a star with the pinhole in the middle.

the counts of several neighboring pixels. Binning of 2x2 means that we sum a  $2 \times 2$  box of pixels. This of course reduces the size of the image by factor of 2 in both x and y axes. This means that the coordinates of the pinhole in the “binned” image will be half their original value.

— In the MaximDL program, go to the guide tab and press Settings. There, change the Binning option from 1 to 2. Press Ok.

— Change the pinhole coordinates to half of what they were (for example, if the pinhole coordinates are 404/284, change them to 204/142).

— When moving to the next star, don’t forget to change/check the binning. Press reset and then change the binning.

— Once the guider is running press the ”Fetch remote info” button in the AuDela and the exposure information will be transferred from the “Remote Wise” to the AuDela. Verify the information and start the exposure from the AuDela window.

### Notes:

1. In order to change stars (via Wise Commander) make sure that the “slew” button in the Telescope agent (in the Dome PC) is pressed. Otherwise the telescope will not move.

2. If the guide is too slow you can increase the aggressiveness to larger values, if it ”overshoots” reduce the aggressiveness to smaller values.

— Take a short calibration sequence (It is a predefined calibration procedure in the eShell menu as “Intercal”. “Intercal” contains:

3 images of ThAr 10sec exposure

3 images of FLAT 10sec exposure

3 images Tungsten 10sec exposure

- Make sure that the guider keeps tracking the star during the exposure.
  - **Important - perform "Intercal" procedure before and after each exposure!**
  - When finished stop the guiding and go to your next object.
- It is recommended that the last exposure of the night should not continue beyond the time when the sun is 12 degrees below the horizon.

## 6.4 End of night

- Stop the guiding by pressing "stop" in the "Guide" tab.
  - Take a final calibration sequence (eShel/Intercal). If Pre-Observation calibration was not done in the evening then do it in the morning.
  - In the "Camera Control" window on the "setup" press "Disconnect".
  - Close the "MaximDL" window.
  - Using the "Remote Wise Commander" tool position the dome to the east by pressing the "Sky Flat" button and "Go To" – the dome will move the east and the telescope to the zenith.
  - Then disconnect the Dome Track by pressing its "off" button, and move the telescope to declination of 50 (this way when you'll close the dome the hazard of things falling into the telescope is minimized).
  - Close the dome using the "Shutter" button on the "Remote Wise Commander" tool.
  - Turn OFF the RA tracking in the "Remote Wise Commander".
  - In the "Remote Wise Commander" disconnect all sockets by using "Sockets-Disconnect All" from the menu.
  - Exit the "Remote Wise Commander" program.
  - Turn off the dome ventilation and close the dome's openings around the dome using the "Dome Vent" button in the "Telescope Agent" window. Wait for two seconds to allow it to respond.
  - Exit all VNC windows that are opened on mizpe-cdr.
- Backup the the current session image files from the eShel computer to the mizpe-cdr computer and to the mizpe-bck, using a simple "Total Commander" copy procedure on the eShel computer. Verify that the files were copied correctly, i.e. check the image sizes in kb (see section 2.4.3).
- It is also the responsibility of the principal investigator (PI) of the night to make sure

that all files were backed up correctly.

- Go up to the dome and cover the telescope and position it to a DEC of about 50.
- Switch off the relay box and the focus switch behind the blue console.
- Turn on the air conditioners.
- Make sure the platform is all the way down.
- This is the time to set up and run a long calibration that will include darks with the length of the exposures that were taken during the night. This calibration can take place while you are asleep. Be sure to leave the dome dark for this calibration.
- Before leaving on the last day - be sure to turn off the eShel calibration unit and the eShel SBIG camera using the switch on its power supply.
- Switch off all lights in the dome.
- On the way down switch off the three circuit breakers (CB2, CB3, CB4).
- Fill out the nightly log in: <http://wise-obs.tau.ac.il/observatory/log.html>
- Check that all the books are back at their place, the kitchen is clean and all lights are off.
- Lock the observatory up and go to sleep.

## 6.5 eShel image processing

(This part maybe done in the next morning as part of the data processing – a detailed description of data processing is given in the *eShel Pipeline Manual*).

Return to the eShel main window and press the **Process spectra** button. **eShel Processing** window will open. Press the **Generate and start processing** button. The software will locate all the relevant files and calculate the calibration. After it finishes - go to the “Reference” folder and inspect the CALIB and FLAT images. Put tick marks in “ord” “calc” “obs”. If the process was successful you will see that the software identified all the required orders and identified the ThAr lines. In the HDU dropdown list you can inspect each order and at the bottom you will find a table: “ORDERS Binary” which gives a list of the order and results of the wavelength calibration. Check the “rms\_cal” values for the quality of the fit. Values should be below 0.1. For more details refer to the *eShel Pipeline Manual* . If there are no apparent problems with the calibration, you are ready for the night.



# Appendix A

## Observing Conditions at the Wise Observatory

*This appendix is part of a paper with the same title (Brosch 1992).*

The quality of the nights at the Wise Observatory, in terms of cloudiness and fraction of useful time, has been collected from the interim observing reports filled by the astronomers at the end of each observing night for 17 consecutive years. This report is based on 11 years of operating the observatory that were processed manually and six years when the interim reports were processed by computer. The fraction of nights when no clouds were reported is typically about 70%. The best season, when practically no clouds are observed, is June to August, while the highest chance for clouds are in the period January to April. The actual breakdown of cloudiness percentage for individual months is given in Table A.1.

Table A.1: Clear nights 1972 to 1983

Month	Percent clear
January	52 [10]
February	56 [17]
March	55 [12]
April	51 [10]
May	77 [10]
June	89 [10]
July	92 [06]
August	90 [05]
September	76 [16]
October	67 [19]
November	60 [12]
December	64 [13]
Yearly mean	69 [15]

Note: The standard deviation of the mean is given in square brackets.

## A.1 Extinction

Since 1975 extinction coefficients are measured at the Wise Observatory on a fairly regular basis. Their collection gives an idea about the character of the site and may be useful to observers if no measurement of the extinction was obtained for a certain observation. The results presented here combine about 100 observing nights when at least UBV standard photometry with adequate standards was done. We include among them results presented by Vidal *et al.* (1978) from the preliminary test of the photometric qualities of the site. The photoelectric system used at the Wise Observatory is based on Landolt (1973) UBV standards with the RI extension based on stars from Moffett and Barnes (1979). Table A.2 shows the median value of the extinction coefficients for different years and the number of different nights from which the median values were derived.

Table A.2: Median extinction coefficients for the Wise Observatory

Period	$k_V$	$k_{B-V}$	$k_{U-B}$	$k_{V-R}$	$k_{R-I}$	$N_{measurements}$
1975-80	0.26	0.15	0.33	-	-	5
1981-82	0.26	0.17	0.31	-	-	20
1984	0.45	0.07	0.14	0.01	0.02	9
1986-87	0.24	0.14	0.23	0.05	0.06	23
1988	0.24	0.14	0.22	0.05	0.07	26
1989	0.22	0.14	0.24	0.08	0.04	14

Notes: The measurements before 1984 used the bi-alkali photomultiplier and were limited to the UBV bands. We find no ready explanation for the anomalous extinction coefficients measured in 1984.

The typical extinction at zenith, taken as the median value over all the measurements, is 0.24 at V. The color-dependent terms are  $k_{B-V}=0.14$ ,  $k_{U-B}=0.22$ ,  $k_{V-R}=0.05$  and  $k_{R-I}=0.07$ . For comparison, the typical extinction at La Silla, as given in the ESO User's Manual, is 0.11 at V and the color-dependent terms are  $k_{B-V}=0.09$ ,  $k_{U-B}=0.26$ ,  $k_{V-R}=0.08$  and  $k_{R-I}=0.02$ . Similar values can be derived for the CFHT. At Mauna Kea Krisciunas *et al.* (1987) measured  $k_V=0.113$  and  $k_{B-V}=0.082$  at the mountain peak and  $k_V=0.149$ ,  $k_{B-V}=0.158$  at 2800 m altitude. The extinction at Wise is slightly worse than at ESO or at the CFHT, by about 0.13 mag at zenith. This is to be expected, considering the altitude difference between Wise Observatory and ESO/La Silla (2400m) or the CFHT (4204m).

## A.2 Sky Brightness

The sky brightness is measured on a star-free sky patch one arcminute in diameter. In 1976 November-December the zenith sky brightness toward the Perseus cluster of galaxies yielded "U"=23.0 (see note about the definition of the U-band in Vidal *et al.*, 1978), B=22.7 and

V=21.6 mag/square arcsec. In 1979 July the sky brightness during a dark night was measured at U=21.7, B=22.2 and V=21.6 mag./square arcsec. In March 1989 the measurement was repeated towards the Coma region with a different photomultiplier and filter combination. The results are comparable with those of 1979, implying no worsening of the sky conditions.

Table A.3: Sky brightness in mag/square arcsec

Period/Band	U	B	V	R	I	Notes
Nov-Dec 1976	23.0	22.7	21.6	-	-	from Vidal <i>et al.</i> (1978)
July 1979	21.7	22.2	21.6	-	-	Bi-li tube
Mar 1989	21.5	22.2	21.7	21.2	20.4	Ga-As tube
AAT	-	22.5	21.5	20.8	19.3	AAO Newsletter
CFHT	21.6	22.3	21.1	20.3	19.2	User's manual
ESO	22.0	23.0	21.9	21.1	20.2	User's manual
KPNO	-	22.9	21.9	-	-	Garstang
CTIO	-	22.5	21.6	-	-	Garstang
DDO	-	19.9	19.2	-	-	Garstang
Palomar	-	22.9	21.5	-	-	Garstang

A summary of sky brightness measurements is given in Table A.3, together with representative values for CFHT (CFHT User's manual, 1990 edition, p. 5-2), for ESO (ESO User's manual), and for the AAT (AAO Newsletter No. 56, 1991). A location in California, with dark skies, was reported to have a typical sky brightness of B=22.3–23.1 and V=21.2–22.1, depending on solar activity (Walker, 1988). From all these we conclude that in the late 1970s and 1980s the Wise Observatory has a similar sky brightness as other observatories.

### A.3 Seeing

The typical seeing reported by various observers at the Wise Observatory ranges from 2'' to 3''. Rare nights exhibit 1'' seeing or less; these are only a few per year and occur mainly in winter, after the passage of a storm front. This determination is based on individual, visual estimates of various observers, sometimes by observing double stars with known separation, and is confirmed by measurements of stellar integrated profiles obtained with the photometer and a large aperture, while the star is drifting at the sidereal rate through the field of view.

The seeing evaluation is also based on many hundreds of CCD exposures obtained since 1986 that were analyzed at the Wise Observatory. The average FWHM of stellar images is 3.5''. Bad seeing produces images of 7'' FWHM; worse images are not recorded. In general, the seeing improves after midnight, following the reduced wind speed mentioned by Vidal and Feldman (1974).

# Appendix B

## The Automation of The Observatory

A presentation given by Peter Ibbetson at the First Joint Egypt-Israel Astrophysical Workshop: The National Research Institute of Astronomy and Geophysics (Helwan, Cairo, Egypt) and The Wise Observatory of Tel-Aviv University (Tel-Aviv, Israel), which took place at Taba, Egypt, February 27-29 1996. Refers to Fig. B.1.

Written by:

Peter Ibbetson - Electronics Engineer.

Ezra Mashal - Technical Director.

### ABSTRACT

The successive stages in automation of the observatory are discussed. The automatic setting of the telescope is described. The insertion of positional information into image files follows. It is shown how the precise positioning of an object is achieved. A description of the motorized filter wheel is given followed by a description of the automation of the dome. Automatic guiding is touched on. Finally further items which may need automating are listed.

The automation of the Wise Observatory has proceeded over a number of years. Each stage has been accompanied by an experimental period followed by a shake down period. During the shake down period each system has been exhaustively used by the observing astronomers. Their comments and requests have been heeded by the electronic, computing and technical staff.

This method has lead to the current system. It cannot be said to be flawless but it does work consistently. Furthermore it has been designed to make the pattern of observing as simple as possible. Thought has also been given to assisting the astronomers in their subsequent reduction by ensuring that all peripheral data required in the reduction is recorded in an accessible form at the time of observation without the intervention of the astronomer. It should be noted that this can only be achieved consequent upon each stage of automation.

Automation is an open ended process. With the accomplishment of each stage the as-

tronomer's life becomes easier. Then there follow, from those who are never satisfied, suggestions as to what must be the next step.

## OBSERVATORY AUTOMATION

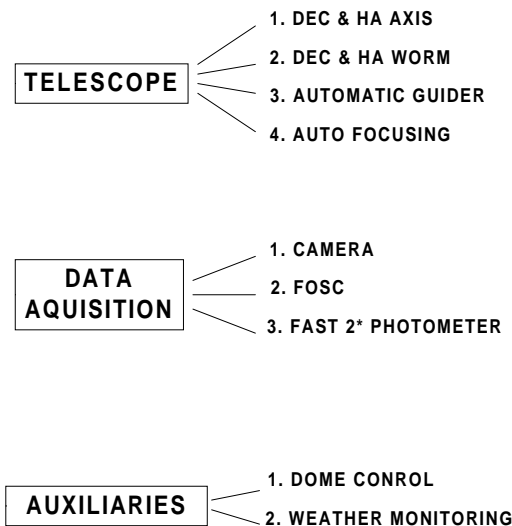


Figure B.1: Automation Scheme.

## DETAILED DISCUSSION

The automation of the dome was to have been the last piece of the puzzle. Naturally it has not turned out to be this way. A policy of automating the observing routines at the Wise Observatory was initiated in earnest some two years ago. There had been an expensive but half hearted attempt in the early days of the observatory back in the middle seventies. This was abandoned because the electrical noise in the dome spelt doom for the incremental encoders and consequently the telescope when the first attempt was made to set it automatically. It was clear from these early efforts that incremental encoders would never work with the large currents powering the heavy motors used in this somewhat vintage observatory. Unfortunately having already spent a lot of money unwisely there was a natural unwillingness to spend a great deal more in order to do it right.

As the years passed and the equipment used for observations with the telescope was itself computerized and to some extent automated there became increasing pressure to automate the telescope itself. Many of the current observations are repeated on a monthly routine basis. They are often of a short duration and each observation is in a different filter. Moreover the series of observations can cover a large number of stars spread all over the sky. Because of this it was found that a great deal of the time was spent each night setting the telescope, moving the dome, finding and positioning the star and rotating the filter wheel.

The second attempt to add a digital indicator for the telescope's position followed a suggestion by the first electronic's engineer employed in the observatory. He observed that

the synchros used for the dial setting could be electronically digitized. This was done with the three synchros associated with each axis some thirteen years ago. The system worked as an indicator but the locking points between two of the three synchros associated with a given axis was not wholly reliable. Moreover, because of all the computation involved the time taken to make any given reading precluded the possibility of making the whole scheme automatic and reliable.

Meanwhile computers became cheaper, smaller, more powerful and more reliable.

The next attempt involved placing potentiometers as inexpensive encoders directly on the telescope axes and on the worm wheels. The cost of a single absolute encoder with sufficient resolution on a given axis was seen to be prohibitively expensive. This system proved a great deal more reliable than the triple synchro system previously employed. It was now felt that an attempt ought to be made to automate the telescope setting. A PC AT computer was more than man enough for the job and now readily available so the first real automatic setting was undertaken. It proved immediately ninety five per cent successful. It was very popular.

This attempt showed the way forward to the next step. Two absolute optical digital encoders would be used for each pair of axis and worm. The cost of these items had also dropped as the years had passed. Having already placed potentiometer encoders on the axes, replacing these with the optical variety was a straightforward task. The setting program developed for the potentiometers was easily adapted to the new encoders. It was immediately found to work more reliably with them.

That would seem to be the end of the road but of course it was not. Resettability to any given position over the whole sky was within perhaps 10 or 15 seconds of arc but due to various telescope errors that did not necessarily correspond to the required stellar position. A star position mapping program over the whole sky was undertaken and correction values found. These were added into the setting program which was then found to achieve an accuracy of better than one minute of arc over the whole sky.

The widely embraced optical video medium adopted by the astronomical community was now the CCD. PC's had grown in stature to nurture the new devices. The file interface transfer system originally proposed by astronomers some years ago for archived storage of astronomical images on magnetic tape had become ubiquitous. There was an increasing demand that a whole set of fields be correctly defined and entered into each file header. A number of these were associated with the telescope setting but the computer used for setting and guiding could not also be used for image acquisition. Frequently from the point of view of time considerations telescope setting had to be undertaken whilst the CCD image was being read out. A simple and elegant solution was found - let the CCD PC read the encoders.

Everything is digital and the encoders can easily drive a number of reading devices. There are rather a lot of lines but that difficulty was overcome.

There was a specific demand for precise telescope positioning to within plus or minus five seconds of arc in one particular application. This was in connection with long slit spectroscopy of two objects observed simultaneously with the faint object spectrographic camera used on the Wise 40" telescope. In order to accommodate a star and a quasar in the slit at the same time the instrument on the telescope has to be rotated. Subsequently the two objects have to be moved onto the slit. A manual setting method using repeated imaging was first employed. Because of the curious orientation of the instrument on the telescope this could sometimes take rather a long time. It was clear that the CCD ought to be made into its own positioning device. The pair of objects could be found on the CCD. The position of the slit onto which these objects had to be moved was known. Unfortunately the rotation of the telescope has to be made manually and this orientation must be entered manually into the CCD PC. The field scale and pixel dimensions are known so the CCD PC can compute the exact motions required in right ascension and declination to move the stellar object pair onto the slit. It simply has to make the correct pushes on the settings buttons. This sort of task is well adapted to the capacity of a PC. A procedure which used to take between 10 and 15 minutes was reduced to 30 seconds.

Naturally once the CCD PC could accurately position the telescope a variety of other applications for this ability were found. Small telescope motion between sky flat fields was automated. Precise positioning on a given pixel can be achieved. On occasions telescope rotation is used with the direct camera in which case positioning the object correctly is greatly simplified.

A filter wheel which holds eight two inch filters was constructed. It is rotated by a stepping motor with a direct mesh gear. One rotation of the stepping motor corresponds to the motion required to move between any pair of adjacent filters. A disk with a single slit was mounted on the motor shaft together with the gear. The disk passes through an optical switch. The precise detent position for each filter can thus be checked. The system does not depend entirely on motor step counting. It is known that stepping motors sometimes get out of step in the harsh electrical environment of an observatory. If the motor positioning fails the observer is warned and the automated procedure halts until the error has been corrected. With this filter wheel serial observations in several filters can be smoothly undertaken and if required automated.

Precise positioning of an archaic American telescope was not the simplest task but it was achieved. Positioning a particularly recalcitrant and awkward Israeli dome both to a given telescope setting and to follow the telescope tracking had yet to be implemented. Now

following a wise Egyptian suggestion two Israel residents of Iraqi and English origin have achieved this too.

A potentiometer once used on the telescope axis was mounted with a gear reduction head and a pressure wheel in contact with the rotation track of the dome. The reduction gear was chosen so that a single rotation of the dome would correspond to a single rotation of the potentiometer. It was a matter of half a day to have a computer set table dome once the encoding device was mounted. But there were weak spots the potentiometer has a three degree dead region. Having tasted this particular mouthful of vinegar before, once having shown the feasibility, no attempt was made to pursue the matter until an absolute optical encoder was available. A very reasonably priced 10 bit encoder of Swedish manufacture was purchased. It proved to use a grey code rather than a binary coded decimal scheme so a fast conversion array had to be created. A collection of unused PC AT's were lying around the observatory. One of these was pressed into service. Sufficiently accurate dome positioning over the full revolution of the dome was quickly accomplished. A connection had now to be made between the telescope setting PC and the dome positioning PC. A dome mapping array returning a dome position for any combination of hour angle and declination was found experimentally. The main problem here was craning ones neck in seldom used telescope configurations and then bumping ones head. A hard hat was worn.

The setting PC tells the dome PC ahead of making a setting where the dome must go. Whilst the telescope is setting the dome is also in motion. The setting PC doubles as the guiding PC but continues to send out the current required dome setting every five minutes whilst the telescope is tracking. The dome PC then determines whether it should update the dome's position or not dependent upon the amount of the required correction.

The automation of almost everything required for remote operation has now been implemented. It is now possible for an observer to keep his cool whilst he keeps himself warm in the observatory's control room (previously the library) during a winter observing run. What are the remaining items. Telescope focusing has yet to be encoded. In principle encoding is not required for remote focusing. In practice if an observer requires filters of different thickness these will have different foci. These must be determined at the beginning of the night and the telescope refocused each time the filter is changed. For this an encoded focus indicator is required.

The automatic guider requires observer intervention. The observer must find a guide star and set the guider's focus according to the telescope focus. It is hoped to bring a new guider based on a more sensitive larger CCD chip into operation with which it should be possible to acquire and focus a suitable guide star remotely.

It is open to speculation what will be the final chapter in the tale.



# Appendix C

## Additional Information

### C.1 Troubleshooting, Warnings, Notes, and Tips

— When the dome gets stuck you will see in the "Remote Wise Commander" window two red exclamation points (!!). Then, either use the "dome agent" window in the dome-pc or the sub-window called "Dome AZ." in the "Remote Wise Commander" and move the dome a little clockwise (CW) or counter clockwise (CCW) to get it free from its stuck place and get back to normal operation.

— If the "Remote Wise Commander" is not able to connect to the "dome agent" then go into the dome-computer and in the "dome agent" window press "Configure" → "Setting..". Enter the current dome position in the "Dome Azimuth". Then press the "Sockets" tab and check mark the first check-box to allow sockets communication to this software. Then go back to the "Calibration" tab and press "ok". Then press "Configure" → "Save Settings" to save the settings. Now close the "dome agent" window and open it again from the desktop icon. Now socket communication should work well.

— If the number of the focus position in the "Focus Agent" programs is not as it should be for the instrument you are using (PI-CCD and eShel around 980, Laiwo around 1320, FOSC around 1230) then there might something has gone wrong with "turns" that are counted by the software. In the "Focus Agent" window on the dome-pc go to "Configure" → "Setting..". Go to the "Hardware" tab and check the numbers of turns that are there. For PI-CCD and eShel it should be around 7, for Laiwo around 10, and for FOSC around 9. You can change the number of turns and press "Apply" to see the effect on the number of the focus position. Once you get the right number of turns for your instrument press "ok". Then press "Configure" → "Save Settings" to save the settings.

— If the telescope drifts slowly in the Dec direction (usually to South) then the "South" black button on the big blue console is stuck. You need to free it with a small push to jump it out of its stuck place.

— When doing a large movements of the telescope from one position to the other it is best to do this when lights are on in the dome and you are watching the telescope with the “dome-cam”.

If the telescope runs to a direction that is different than the direction you specified then stop the movement and move the telescope that you want with the buttons of the “telescope Agent” window on dome-pc. Once you are close to the coordinates you want you can safely send the telescope automatically to that position.

— If the telescope run below the horizon-limit, a buzzer starts and a red light appears on the lower-right side of the console. Press the red-light button to stop the buzzer and move the telescope above the horizon limit in order to turn-off the red light.

— When using VNC to mipze-cdr one cannot see the second (right) screen of the computer. Sometimes there are windows that appear on that right side and the user looking through VNC cannot see these windows. To move a window in Windows7 (mizpe-cdr for example) from one screen to the other without using the mouse you need to choose the window on the task bar. Then press “alt+space”, release it and than press “m”. You just chose the Move mode. Now you move the window with the arrows to the left side. Though, there is a problem to use this method from VNC that runs on a Windows machine since it will move the VNC window and not the destination window. However when using VNC or remote-desktop from linux it works fine.

— When using the “Telescope Agent” in the dome-pc, if the pointing of the telescope is not calibrated and it is far from the requested coordinates, there might have been some problem in the file that calibrations are written in or that the calibration was not done properly and the file was messed up. The calibrations are written on dome-pc in the file: C:\Documents and Settings\mizpe\Desktop\Teleparams.ini . The parameters should be around HA=0.003 and Dec=0.0001 . If they differ by much from these you can put the parameters in the file by hand and then do a calibration to the telescope. Also you can see some history parameters in the file: C:\Documents and Settings\mizpe\Desktop\Teleparams\_org.ini .

— It is advised to observe when the Sun is more than 12 degrees below the horizon (or even 15 degrees for galaxies and faint objects).

— Try to observe at airmass less then 2.5. In case a photometric standard observations are done try to observe at airmass less than 2.0

— Make sure the temperature on of the instrument is at it should be (-110 degrees for the PI and around -104 for LAIWO).

— If you could not take sky flats at dusk or dawn (e.g. it’s raining, or you missed the twilight due to some malfunction), take flats at dusk or take dome flats in the same way.

— If the system crashes and nothing respond on the screen to the keyboard or the mouse

action, then reset everything and start from a softboot – alt+ctrl+del , and the whole starting procedure of the computer. Sometimes a hardboot is needed (press the reset button in the PC or turn it off and on again).

— Nitrogen should be filled every 12 hours for about 3 minutes in the PI, and once a day for LAIWO.

— You can use the Total commander window to erase the last file you wrote or to look in the observing list. Remember that if you minimize it and then restore it from an icon it does not update automatically. You need to do something in it so that it will get updated (like pressing the update button, or going a directory up and than back to the images directory).

— Keep the door to dome (from staircase) closed. This will improve seeing by reducing influx of hot air in the dome.

— Remember to take enough arc spectra to calibrate your observations! Although the attempt was made to make the FOSC very rigid, flexure at various telescope positions and small motions of the various elements are still possible. The only way to guard against these is to take your calibration spectra at the same telescope orientation as the actual observations.

— In spectrophotometry, beware of differential refraction effects.

— The FOSC shutter is fairly large and may take a time to fully open. As it is mounted just below of the field lens, behind the apertures, this opening delay may cause extra vignetting. Such an effect will **not** flat-field well. Exposure times should probably be longer than one second to minimize this effect.

— If on the right-bottom corner of the console the small orange button is light, it indicates that an electricity break down took place.

— The “DEC track” button on the console should be always on “off” position.

— If the telescope fails to set and slew check that the console reset switch on the lower right is not glowing red. If it is, press it and reset the three main breakers downstairs.

— If the telescope does not move look at the right-bottom corner of the console: if the lights indicating “mash” are on than the mashes were probably forgotten in out position and they need to be pushed back to their positions. Probably best that Sami will do that.

— If the dome fails to rotate, it may be because it is stuck, in which case the motors will be laboring in their attempt to turn it. It may be because one of the phases powering the motors has failed. In the first case try sending it to the right and then to the left in an attempt to unstuck it. In the second case, Sami is your only recourse.

## C.2 Exposure Time and Limiting Magnitude

No thorough study was done on the limiting magnitude and exposure times required by the different instruments. Based on our experience we can estimate the above quantities.

### CAMERA

— Typical exposure time with the camera are:

$\sim V$ Magnitude (point source)	Exposure Time (sec)	
	R filter	B filter
$\sim 13$	50	80
$\sim 14 - 15$	120	180
$\sim 15 - 16$	180	240
$\sim 16 - 17$	250	300
$\sim 17 - 18$	300	400

### FOSC

— Exposure time of 1 hour is considered to be the highest exposure time due to the many cosmic ray that are gathered in that time, hence spectra for point-like objects with magnitude above  $\sim 15.5$  magnitude.

— The resolution of the  $2''$  slit wedge3 and 600 grism can fully separate two lines that their separation is  $15\text{\AA}$ . This means that separation of peaks can be done for peaks with separation of  $8\text{\AA}$ . Also this means that the echelle with  $2''$  aperture can fully separate lines with separation of  $7\text{\AA}$ , and can separate only peaks of about  $4\text{\AA}$ .

— Using the  $10''$  slit Wedge3 and 600 grism the typical exposure times to get spectra from point-like objects are:

$\sim V$ Magnitude (point source)	Exposure Time (sec)
$\sim 10 - 11$	400
$\sim 12 - 13$	900
$\sim 13 - 14$	1800
$\sim 14 - 15$	3600

## C.3 Rotating the Instruments on the Telescope

All instruments are mounted under the telescope on a disk that can be rotated relative to the telescope. Rotating the instrument is easy: unscrew the two holding screws, and rotate the handle near the rotator dial to the angle you want.

The rotating facility makes the use of the telescope much more flexible and convenient. For example this enables to rotate the FOSC in order to have two (or more) objects aligned

in the spectrograph's slit to get simultaneously spectra. For this purpose there is also the "rotnangl" macro for the FOSC, where one can edit the rotator angle value in the image header. Another use for the rotator is when doing deep-imaging and some CCD pixels become saturated and start to pour electrons along the rows. If your object is on such row your in troubles, however, rotating the instrument in 90° will cause the saturation not to pour on the desired object.

*EXTRA CAUTION should be paid when rotating the instrument so that its many wires won't be caught and ripped.*

When rotating the instrument pay attention that north as appear in the focal plane is not in the direction it usually is, i.e., the image on the screen will not have north at the top and east to the left, but it will be rotated, so be careful to rotate your finding chart as well. Also for the same reason the autoguider CCD needs to be rotated to about to the same angle that the rotator was rotate. This is done by unscrewing the brass screw, and rotating the periscope by hand to the appropriate angle. This angle is read on the aluminum ring of the periscope housing, and it should be positioned so that the angle that correspond to the rotator dial should be pointing to the mark on the periscope.

Two rules of thumb for aligning the objects in the FOSC slit:

- 1) If the line between them is tilted to the right (west) and you want to turn it to the left (east) you need to enlarge the rotator angle. If the line between them is tilted to the left (east) and you want to turn it to the right (west) you need to make the rotator angle smaller.
- 2) If you want the image to be aligned to a specific *Position\_Angle* (measured from north through east), then:  $Rotator\_Angle = Instrument\_Angle - Position\_Angle$  , where *Instrument\_Angle* is the angle when the instrument is aligned to the north (i.e., 353.4 for the FOSC, 82.4 for the PI CAMERA, and 3.7 for the LAIWO).

With the current ST7 guider one also needs to change the guider angle when rotating the instrument. For each instrument there is a *Guider\_angle* in the Guider tab→Options→Guider Settings of the MAXIM CCD window (When the image is aligned to the north for the PI camera *Guider\_angle* = 1 and for the FOSC it is *Guider\_angle* = -179. When rotating the instrument the new *Guider\_angle* should be:  $Instrument\_Angle - Rotator\_Angle + Guider\_angle$ , i.e., for the FOSC it is  $175 - Rotator\_Angle$ .

## C.4 Emergency Power Generator

The Wise Observatory is equipped with a Peugeot generator (Fig. C.1) to allow working ability during electricity breakdowns. Here we outlined the operating instruction of the generator.

### Starting up the system

1. Open the external door of the generator room (it must be so as long as the generator is in operation);
2. Check oil in engine and water in its radiator and fill up if necessary;
3. Check fuel and fill up if necessary (see Fig. C.1);
4. Make sure that the main connector of the generator (3) is in the **A** position (OFF);
5. Turn keyswitch (1) clockwise and hold it like that until pilot light (2) turns on red;
6. Release keyswitch (1) and immediately press and turn clockwise again until engine starts;
7. Wait 5 minutes until engine warms up (the red warning lights **WATER** and **OIL** should turn off);
8. Turn the main connector (3) to position **M** (ON);
9. On the main electrical board, in the “Automatic Changeover Unit” that is on the top right side of the board, change the switch from “AUT” to “MAN”, and then press on the “Close I” button that is on the left side (under the title “electric company” in Hebrew) until a green light will appear in that button.

### To turn off the system

1. On the main electrical board in the in the “Automatic Changeover Unit” that is on the top left side of the board, change the switch from “MAN” to “AUT”.
2. Turn the main connector of the generator (3) to position **A** (OFF);
3. Pull handle (4) until engine stops;
4. Turn off keyswitch (1) anticlockwise.

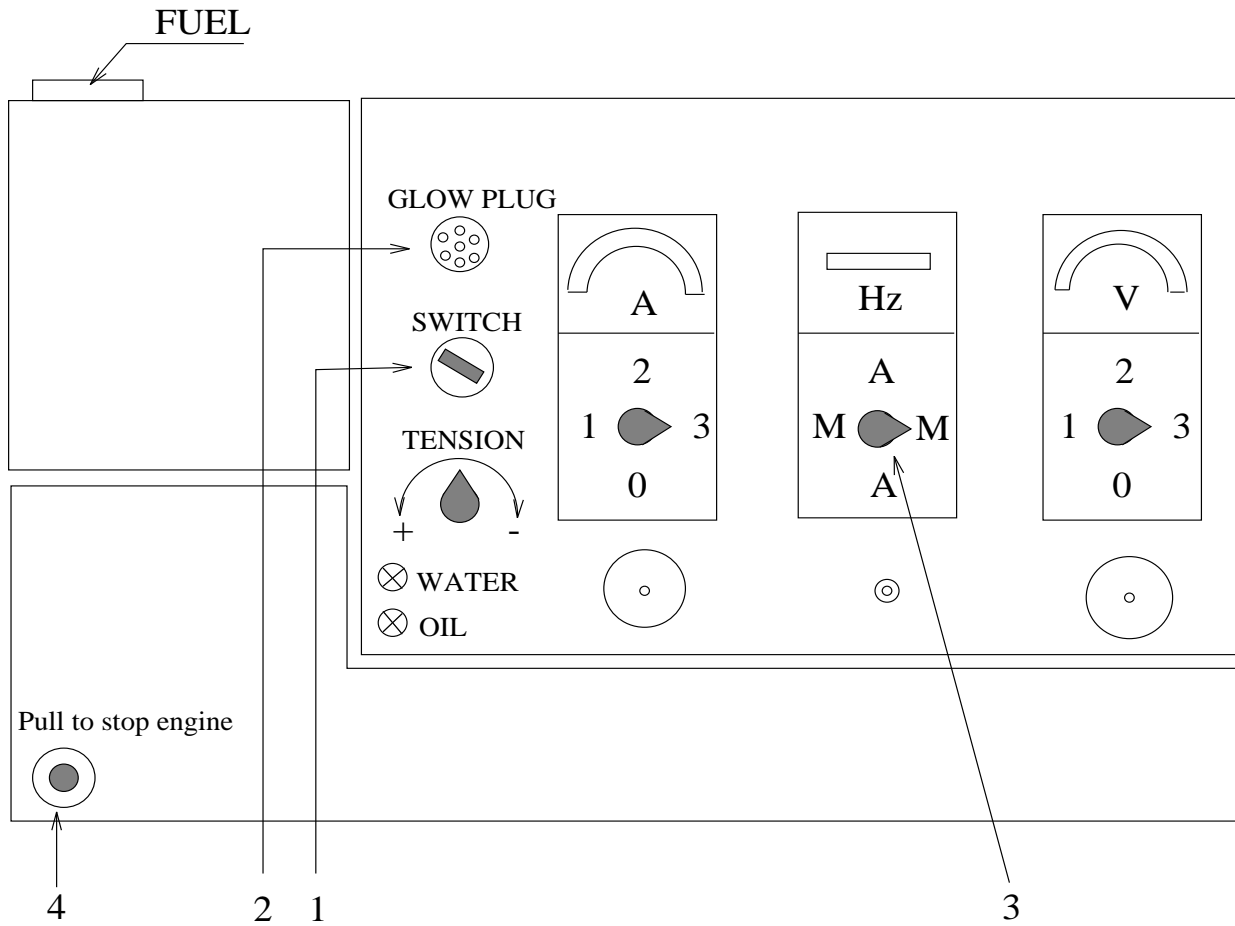


Figure C.1: Generator's console schematic diagram.

## C.5 Data Reduction

Images from the CCD camera, LAIWO, and from the FOSC can be reduced with the IRAF image reduction packages installed on the network at the Tel-Aviv headquarters (and in the LAIWO computer at the observatory).

Standard UBVRI photometry (and spectroscopy) is done in a semi-automatic mode. The pre-requisite for this option is choosing the standard stars from an approved standard list based on Landolt equatorial stars.

## C.6 Standard Stars

**Photometry:** The observatory is equipped with the three Landolt standard stars catalogs: Landolt (1973), Landolt (1983), and Landolt (1992). They are placed in a green folder on the telescope console, and can be used for Standard UBVRI photometry.

**Spectrophotometry:** In order to transform the spectroscopic observations to absolute fluxes, at least one, and preferably more, spectrophotometric standard stars should be observed. There are few lists of such stars in the observatory (in a red file on the telescope console). Those lists include the IRS standard star manual (1984), and the IIDS standard star manual (1977), both of Kitt Peak National Observatory, which are included in the spectrophotometry routines within IRAF and VISTA. Also there are some private lists based on information from IRAF. The spectral energy distributions can be found also in Stone (1977) or Oke (1974).

## C.7 Computing Zenith Distance

To compute the angle of an object from the zenith (zenith distance) one uses the formula:

$$\cos Z = \sin \phi \sin \delta + \cos \phi \cos \delta \cos H, \quad \text{where:}$$

$Z$  = the Zenith Distance;  $(90^\circ - Z)$  is the angle above the horizon.

$H$  = the hour angle of the object ( $HA = RA - ST$ ).

$\phi$  = the latitude of the observatory; at Wise  $\phi = 30.5^\circ$ .

$\delta$  = the Declination of the object.

Air Mass =  $\sec Z - 0.0018167(\sec Z - 1) - 0.002875(\sec Z - 1)^2 - 0.0008083(\sec Z - 1)^3 \approx \frac{1}{\cos Z}$   
(Hardie's formulae) where,  $\sec Z \equiv \frac{1}{\cos Z}$ .

## C.8 Dome air conditioners

The dome has been fitted with two air-conditioners. Their purpose is to keep the day time dome temperature as low as possible so as to maintain the mirror throughout any 24 hour period at a temperature lower than or about equal to the lowest night time temperature. In practice this cannot be achieved and in any case it might cause dewing on the mirror but this is nevertheless the aim.

The air conditioners should be turned on just after the dome is closed in the morning and they should be turned off just after the dome is opened in the evening.

They should always be operated in a mode to achieve maximum cooling.

They are controlled remotely with the Electra remote panel.

The red button turns the air conditioners on and off.

Point the remote panel at each air conditioner in turn and press the red button.

The remote panel should indicate the following:

- There are six grey buttons.
- Left hand top grey button controls the fan speed. The lower right hand display indicates



the fan speed setting. This should be set to six horizontal bars. This is the maximum fan speed setting.

— The center top grey button controls the air conditioner mode. The top left display indicates the mode. The mode should be set for maximum cooling. This is indicated by the six pointed frilly star. This is in position two of the five selectable modes.

— The two right hand grey buttons inscribed + and – select the desired temperature. The lower right display indicates the selected temperature. This should always be set to the minimum setting of 16 degrees. Press the minus button repeatedly until 16 degrees is indicated.

## C.9 Dome ventilations openings

In order to improve the dome seeing openings were cut on the dome sides. Those openings are open/close using a remote control that is places on the old telescope console.

A common problem with operation of the openings used to be that their power supply switch is often turns off - and the green lights on the power box on the dome goes off. In order to turn it on again the dome needs to be rotated so that the power box is near the stairs inside the dome, where it will be reachable. Then the green button needs to be pressed. Only then the remote control will be able to operate the shutters of the openings. This problem is now overcome by using a safety socket for this device.

To open/close the openings one should use the "Dome Vent" button on the "Telescope Agent" window which is on the dome-pc computer. After you click the button wait for two seconds to allow it to respond.

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