

70 CM TELESKOP

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REVISION HISTORY

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3.1	2.10.2020	CONCHI CARDENAS	Sections update: 5.2, 5.6, 5.7 and 6.3.

Attention: All the green emphasized text is under revision!!

**You can help to improve this document. Please, don't be shy and contribute!
Contact Conchi Cardenas for this.**

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REFERENCES

REFERENCE DOCUMENTS

Table 0-1: List of reference documents

RD	TITLE	AUTHOR	ISSUE
RD01	Instructions to fill with LN2 the CCD's dewar - KING-MPIA-MAN-002 URL https://svn.mpia.de/trac/gulli/king/attachment/wiki/WikiStart/Instructions-LN2/002-1.0-Instructions_to_fill_with_LN2_the_CCD's_dewar.pdf	C. Cardenas	1.0
RD02	Astralux, high angular resolution astrometry with an electron multiplying CCD Diploma thesis, Max Planck Institute of Astronomy. URL http://www.mpia.de/ASTRALUX/Papers/AstraLux_Diploma_Thesis_2007.pdf	F. Hormuth	2007
RD03	General analytical telescope pointing model URL https://www.boulder.swri.edu/~buie/idl/downloads/pointing/pointing.pdf	M. W. Buie	2003
RD04	RoCon Software Manual - KING-MPIA-DOC-DET-004 URL http://www.mpia.de/~mathar/public/KING-MPIA-DOC-DET-004.pdf	R. J. Mathar	1.279

ABBREVIATIONS AND ACRONYMS

CCD: Charge Coupled Device

ESO European Southern Observatory

FoV: Field of View

KING: Königstuhl Instrument zum in den Nachthimmel Gucken

LN₂: Liquid Nitrogen

MPIA: Max-Planck-Institut für Astronomie

TMP: Turbo Molecular Pump

1 INTRODUCTION

The KING telescope was designed and built at MPIA. The project started in 1981 and the telescope was erected in the Eastern dome of the Elsässer lab in May 1986, first light in June 1986. The first presentation to the public at the open-house day in July 1986. It started operation in 1988.

The KING telescope is a 70 cm f/8 Cassegrain telescope currently equipped with a scientific grade 2kx2k back-illuminated, nitrogen-cooled SITe CCD. With a pixel size of 15 μ m x 15 μ m, it provides a field of view of 18.8x18.8 arcmin.

The KING telescope can be used by any staff member from MPIA.

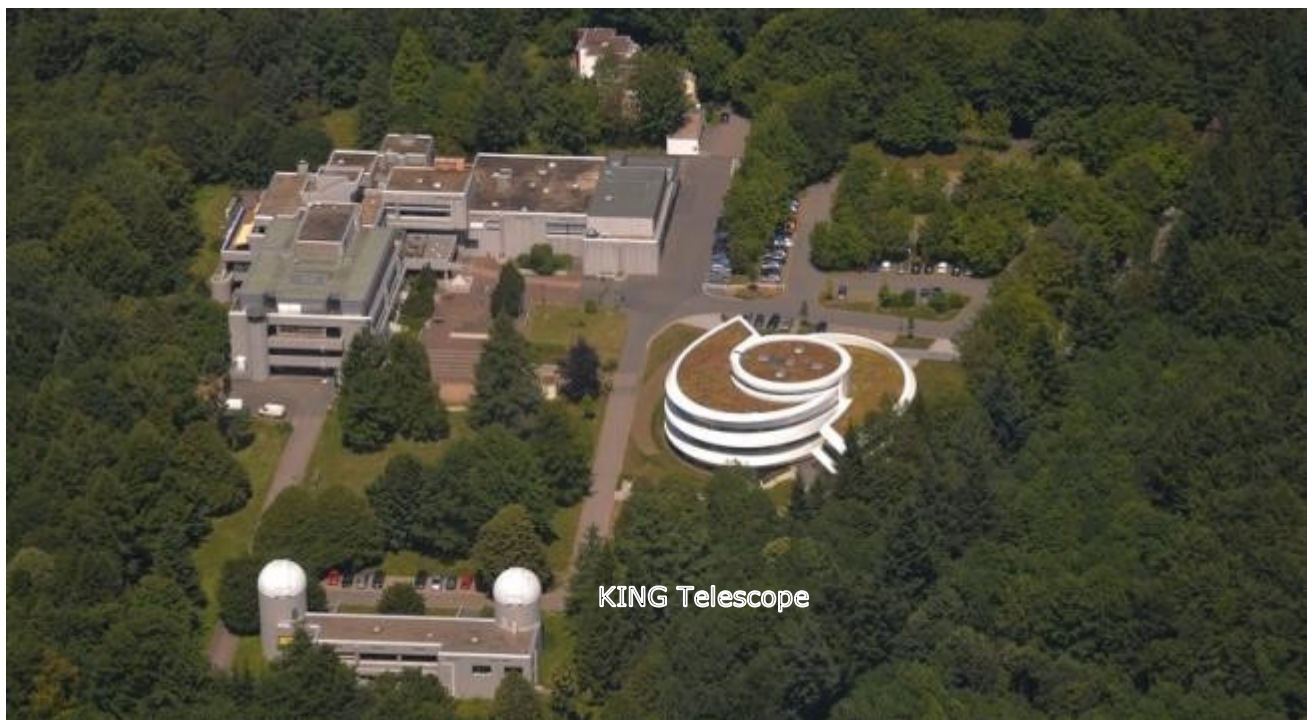


Figure 1-1: The Telescope is located in the eastern dome of the Elsässer Lab

2 SAFETY

Physical access to the telescope is currently granted after having done the cryostat safety and operations training (contact Werner Laun: <mailto:laun@mpia.de>)

For operating and observing with KING telescope, you should do a first run together with trained personnel, please contact our mailing list for coordination: <mailto:king@mpia.de>

3 KING 70 CM TELESCOPE

- **Location**

Name MPIA, Heidelberg

Latitude N 49° 23' 44"

Longitude E 08° 43' 25"

Altitude 560 m

- **Mechanical Characteristics**

Mounting German Equatorial mount¹ (49° 23^m)

Structure

Right ascension axis

Declination axis

- **Optical Characteristics**

Aperture 70 cm

F# 8

Focal distance 5600 mm

Plate scale 27 μm/arcsec (37 arcsec/mm)

Field of View (without coma) 11.7 arcmin = 18.95 mm (without corrector)

Field of View (maximum usable) 20 arcmin = 32.4 mm

Configuration **xx**

Focal station Cassegrain

Focus mechanism Secondary mirror

Focus range

- **Other Characteristics**

Speeds GROB (meaning 'rough') ~ 90 deg/min

MITTEL(meaning 'medium/average') ~ 30 deg/min

FEIN (meaning 'fine') ~ 1 deg/min

Pointing accuracy without correction 10-20 arcmin

Pointing accuracy with correction < 1 arcmin

Tracking 15 arcsec/sec

Unguided observations up to 180 s

¹ https://de.wikipedia.org/wiki/Deutsche_Montierung

4 DOME

Attention: Take care of the weather when you open the dome slit!

Do not open during heavy winds, storms, any rain or high humidity outside.

Only open a little slit for demonstrations if it is snowing or raining! No water drops or snowflakes should fall on the mirror at any time.

In winter, make sure no snow is lying on the dome itself, which could fall into the dome, if you open the slit.

To rotate and open/close the dome use the **manual control** hanging at the telescope (see Figure 4-1). You can remove the control from its hook and walk around with it.

Next to the manual control of the dome, you can see another - similar looking control – hanging at the telescope. This additional manual control can be used to move the telescope manually (see section 5).

To **rotate the dome**, push the green button “**Ein**” AND one of the two top buttons “**Rotation**” together.

You can choose to rotate the dome to the left or the right by pressing the appropriate white button.

To **open or close the dome slit**, press the green button “**Ein**” AND one of the lower buttons “**Spalt**” together.

Notice that the “Klappe” does not work. It is always closed.



Figure 4-1: Left: position of the manual control for the telescope dome hanging at the telescope. Right: control itself.

5 TELESCOPE OPERATION

The telescope can be operated with two different controls: a manual control (section 5.2) and the telescope console.

Attention: To move manually the telescope, the console must be ON and the “ANTRIEBE” “EIN”, that is the gears activated so the motors can actually move the telescope (see section 5.2).

Attention: For observations and always when the telescope tracking is needed, the telescope shall be moved using its control console.

5.1 THE TELESCOPE’S CONSOLE

The electrical and electronic components for the drives and control of the telescope are located in a control **cabinet** (in the room on the first floor of the telescope – half way up to the dome) and in a control panel, the **console** at the dome (Figure 5-1).

The cabinet is a control box from which the lines go out or end. It includes the current supply, power supplies, output power amplifiers, DCF clock, relay control and most of the electronics.

The clock can be set via the **time signal transmitter DCF77** and sends the data serially to the displays in the console. It also provides the timing for tracking and slow speeds.

At the console, the control panel contains the operating elements, the displays and the required control electronics.

Using the manual buttons of the control panel, the CCD electronics and the telescope electronics is power on, and the telescope can be moved in both axes at three different speeds.

This is the explanation of the different buttons that you can find on the control panel of the console. The numbers in the following list correlate with the numbers of the buttons in Figure 5-1:

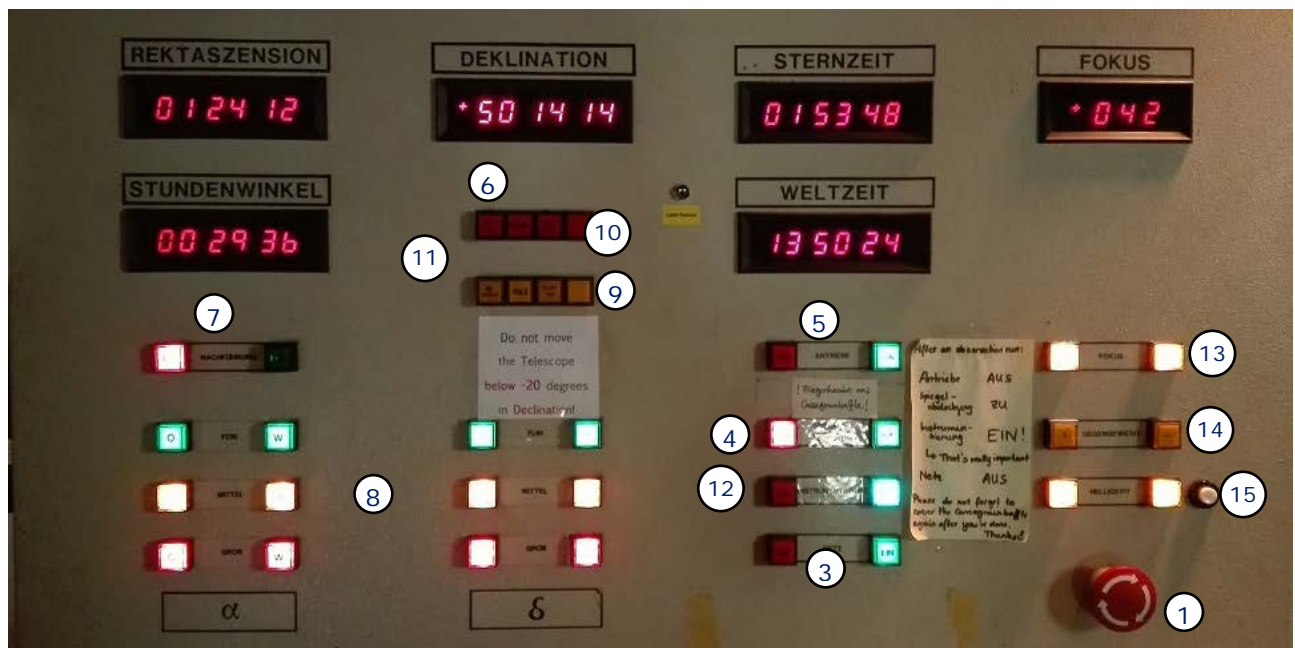


Figure 5-1: The Control Panel of the KING telescope’s Console.

- (1) **NOT AUS - Emergency shutdown.**
Push the button to shut down the complete console.
Attention: Use only in the case of a real emergency!
To unlock the button, turn it clockwise.
- (2) Key switch that activates the console (see Figure 5-3).
- (3) **"NETZ" "EIN"** turns on / **"NETZ" "AUS"** turns off the electronic of the telescope.
If turned on, the buttons for brightness **"HELLIGKEIT"**, focus **"FOKUS"**, mirror covers **"SPIEGELABDECKUNG"** and gears **"ANTRIEBE"** should brighten up.
The instrumentation **"INSTRUMENTIERUNG"** can be turned on and switched off independently from the telescope electronic.
- (4) **"SPIEGELABDECKUNG" "AUF"** to open / **"SPIEGELABDECKUNG" "ZU"** to close the mirror covers, which protect the mirror from dust and dirt.
Press the button until the motors stop automatically. One half of the hatch is opened after the other, so it takes a while.
Don't forget to close the hatch after you finish the observation.
- (5) **"ANTRIEBE" "EIN"** turn on / **"ANTRIEBE" "AUS"** turn off the gear of the telescope.
Only with activated gears, you can move the telescope around.
- (6) **" α BLOCK"** and **" δ BLOCK"** - These buttons signal a blocking of the corresponding axes.
If one of them is enlightened, the manual blocking of the corresponding axis is active and the telescope cannot be moved.
This should never be the case as the manual blocking is only used during maintenance work.
- (7) **"NACHFÜHRUNG" "EIN"**- activates / **"NACHFÜHRUNG" "AUS"**- deactivates the α , the Right ascension **autotracking**.
- (8) **"GROB" / "MITTEL" / "FEIN"** - These buttons are available for both axes and allow moving the telescope (keep pushing the button).

You can adjust how fast you want to rotate the telescope around the corresponding axis:

GROB = fast ~ 90 deg/min

MITTEL = medium ~ 30 deg/min

FEIN = slow ~ 1 deg/min

Attention: These motions are overlaid to the motion of the autotracking.

For α , the Right ascension, the button **"O"** means you are moving the telescope to the **East**, and **"W"**, to the **West**.

For δ , the Declination, the button **"+"** indicates you are moving the telescope towards the **North** (a rise of the telescope), whereas **"-"** to the **South** (lowers the telescope).

- (9) **"Hg I"**: The Hg I button enlightens if the telescope is moved to a horizon distance of 10 degrees.
This indicates that the telescope is reaching its limits.
How to recover the telescope in this case is explained in section 5.6.
Attention: The velocities fast "GROB" and medium "MITTEL", for the declination movement, are no longer available.
- (10) **"Hg II"**: The Hg II button enlightens if the telescope is moved to a horizon distance of less than 5 degrees.
This indicates that the telescope is out of limits. How to recover the telescope in this case is explained in section 5.6.
Attention: This should never happen! If this is the case, the gears of the telescope do no longer work!
- (11) **" α GRENZ"** : This lamp indicates that the range limits in the hour axis (Stundenachse or Rekasziensachse) have been reached.
How to recover the telescope in this case is explained in section 5.6.
- (12) **"INSTRUMENTIERUNG" "EIN"** turns on / **"INSTRUMENTIERUNG" "AUS"** - turns off the instrumentation.
This power supply can be switched off and on independently of the electronics of the telescope (button "NETZ").
Attention: The instrumentation should always be turned on. Don't switch it off.
If the instrumentation is switched off, "INTRUMENTIERUNG AUS", the periodic reading of the CCD temperature and also the dewar temperature control will not work.
- (13) **"FOKUS" "+" / "-"** : Using these buttons the focus can be adjusted.
The focus position can be read in the upper screen labelled "FOKUS".
- (14) **"GEGENGEWICHT"**: These buttons adjust the balance weight.
Adjustments should only be made after instruments have been added or removed from the telescope.
Attention: Do not touch this button during observations or the guided tours!
- (15) **"HELLIGKEIT"** - These buttons control the brightness of all buttons on the panel.
To restore them to auto press the "AUTO" button located just on their right.

5.2 THE TELESCOPE'S MANUAL CONTROL

To operate manually the telescope use the manual control hanging at the telescope. This control is next to the other manual control to move the dome.



Figure 5-2: Left: position of the manual control for the telescope hanging at the telescope. Right: control itself.

Attention: To move manually the telescope, the console must be ON and the "ANTRIEBE" "EIN", that is the gears activated so the motors can actually move the telescope (see section 5.2). In case of any doubt, please read the next section "Turning on the KING Telescope"-

1. NOT AUS, emergency button must be unpushed. To activate if, turn the button to the right.
2. To switch the telescope on, press the green button "NETZ EIN".
3. Turn on the gear of the telescope "ANTRIEBE" "EIN".
4. At the manual control, the switch marked with "F", "M" and "S" is to select the speed of the movement, those stand for "Fein", "Mittel" and "Grob".

There are those speeds for both axis of the telescope.

5. To move in α , Right ascension, select the desired speed and then press the appropriate button marked with α to move West or East.
6. To move in δ , Declination, select the desired speed and then press the appropriate button marked with $+\delta$ or $-\delta$.
7. To move the secondary mirror to focus the telescope, use the the appropriate button marked with "Fokus".

The change in the coordinates of the telescope and the focus can be seen at the control console display.

5.3 TURNING ON THE KING TELESCOPE

Attention: The telescope shall be in the parking position, that is:

- looking to Zenith (declination $\sim 49^\circ 23'$) and
- with right ascension in the meridian ("STUNDENWINKEL" to $0^h 0^m 0^s$).

1. NOT AUS, emergency button must be unpushed. To activate it, turn the button to the right.
2. To switch the telescope on, press the green button "NETZ EIN".

The console itself now shows the position of the telescope (see Figure 5-1):

- "REKTASZENSION": Right ascension
- "STUNDENWINKEL": Hour angle
- "DEKLINATION": Declination
- "STERNZEIT": Star time, Local Sidereal Time (LST)²
- "WELTZEIT": World time, UTC (Universal Time Coordinated)
- "FOKUS": Focus

Attention: The telescope shall be in the parking position, that is:

- looking to Zenith (declination $\sim 49^\circ 23'$) and
- with right ascension in the meridian ("STUNDENWINKEL" to $0^h 0^m 0^s$).

Now you can move the telescope using the buttons α and δ .

If the button "NETZ" "EIN" is not working, the console has to be activated first: it can be activated by the key on the right side of the console (see Figure 5-3). Turn it completely towards you (counter clockwise) until you hear a soft *click* and keep it then in the middle position.

3. To **open the covers** of the primary mirror keep the button "SPIEGELABDECKUNG AUF" pressed until the motor stops automatically, then the both covers should be fully open.

One half of the hatch is opened after the other, so it takes a while.

Don't forget to close the hatch after you finish the observation.

4. Turn on the gear of the telescope "ANTRIEBE" "EIN".
5. The warm lamps α BLOCK and δ BLOCK indicate the blocking of the respective axis. As long as the blocking is good (the telescope is within its limits), the corresponding driver remains switched off.
6. Turn on the tracking in right ascension, "NACHFÜHRUNG" "EIN".
7. Use "**GROB**" / "**MITTEL**" / "**FEIN**" buttons to position the telescope and can be overlaid on the tracking speed.

There are those speeds for both axis of the telescope.

8. At a horizon distance of less than 10 degrees, the lamp Hgl lights up and the speeds GROB and MITTEL are inoperative.

How to recover the telescope in this case is explain in section 5.6.

² The sum of the "STUNDENWINKEL" and "REKTASZENSION" equals "STERNZEIT"

9. If you move closer to the horizon, the HgII lamp will also light up and the drives will be switched off.

How to recover the telescope in this case is explain in section 5.6.

10. If you reach the limit in the hour axis, the " **α GRENZ**" lamp will light up and the drives will be switched off.

How to recover the telescope in this case is explain in section 5.6.

11. Make sure that the power of the CCD electronics is on "INSTRUMENTIERUNG" "EIN".

Attention: The instrumentation should always be turned on. Don't switch it off.

12. To focus the telescope between the different filters use "FOKUS" buttons.

To **operate the dome** use the manual control hanging at the telescope (see section 4).



Figure 5-3: Key of the Control Console of the KING telescope.

5.4 HOW TO RECALIBRATE RIGHT ASCENSION AND DECLINATION

A) Declination, δ .

1. Move the telescope in α until the hour angle "STUNDENWINKEL" is close to $0^h 0^m 0^s$.
2. If the telescope is not pointing to the Zenith, then move the telescope to the parking position, towards the Zenith.
3. If the "DEKLINATION" displays $\sim +49^\circ 23'$, the telescope electronics is displaying the correct coordinates.

Then, you can trust the display.

4. If the reading is any other number, a recalibration is needed by restoring the limit-switch sensor in declination that is installed to in the declination axis (red circle in Figure 5-4).

Two persons are needed for this operation.

- a) One person moves the declination, δ , to the South, by pressing "-" until it is crossing the equatorial plane ($\delta = 0$).

Remember: the numbers on the "DEKLINATION" display are wrong!!

Use the "GROB" speed at the beginning, and then "MITTEL" until the pin is close to the limit-switch.

- b) A second person using the leader will watch that the pin (red arrow in Figure 5-4) is approaching the black limit-switch sensor (yellow arrow in Figure 5-4).

- c) The first person then shall use the "FEIN" speed and let the pin pass through the limit-switch sensor completely.

The numbers on the "DEKLINATION" display will restore automatically to zero. Now the declination is set.

- d) Now, the first person can return the telescope to the North, using the δ "+" and "FEIN" speed at the beginning (while passing through the sensor), and then "MITTEL" or "GROB", and return the telescope to the parking position.

B) Right ascension, α .

1. Switch off the automatic tracking, "**NACHFÜHRUNG AUS**".
2. Move the telescope in α until the hour angle "STUNDENWINKEL" is close to $0^h 0^m 0^s$.
3. To check if the right ascension is properly set or to recalibrate it, you shall restore the limit-switch sensor in right ascension that is installed to in the right ascension axis (red circle in Figure 5-5). The operation is just to pass through the meridian without tracking!! Two persons are needed for this operation.

- a) One person will watch the pin (red arrow in Figure 5-5) is approaching the black limit-switch sensor (yellow arrow in Figure 5-5).

If the telescope is in the parking position, the pin should be very close to the sensor.

- b) A second person moves the right ascension, α , from negative (23 h) to positive (0 h), or viceversa, using the "FEIN" speed and let the pin pass through the limit-switch sensor completely.

The numbers on the "REKTASZENSION" display will restore automatically to zero. Now the right ascension is set.

4. Switch on the automatic tracking, "**NACHFÜHRUNG EIN**".

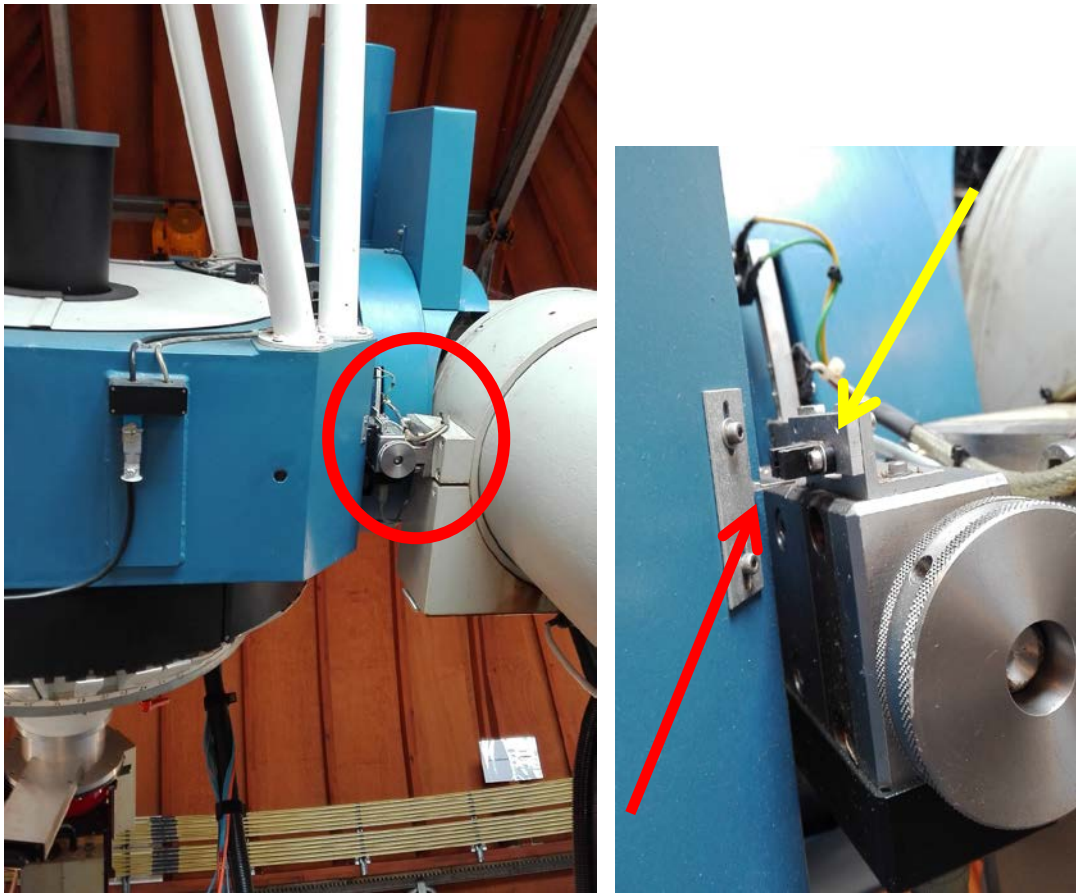


Figure 5-4: Limit-switch sensor of the declination axis.

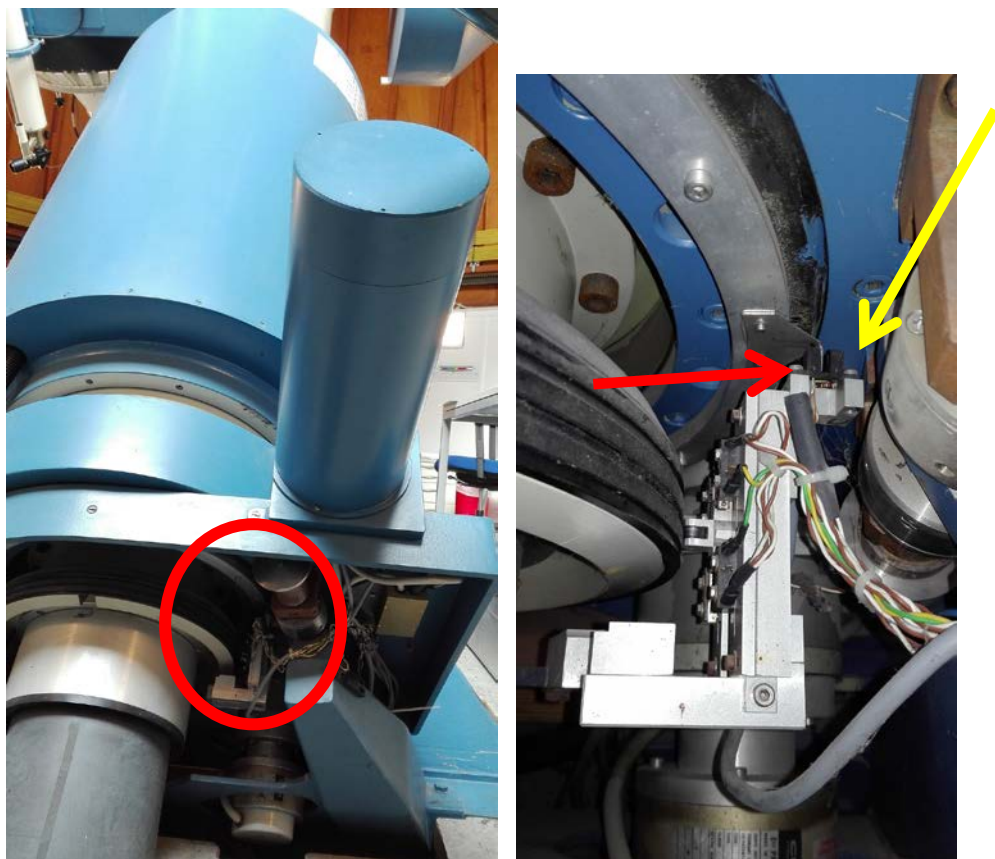


Figure 5-5: Limit-switch sensor of the Right ascension axis.

5.5 SHUTTING OFF KING TELESCOPE

2. To switch the telescope off first bring it in to the vertical position, which is the parking position.
3. Then turn the gears off, "ANTRIEBE AUS".
4. Close the mirror covers, "SPIEGELABDECKUNG ZU".
5. Make sure the instruments are still on, "INSTRUMENTIERUNG EIN".
6. Turn the electricity off, "NETZ AUS" off.
7. Of course, the dome slit should be closed.
8. When you leave the dome, make sure that you switch off the lights and you lock the door using the transponder key.

5.6 HOW TO RECOVER THE TELESCOPE WHEN IS OUT OF LIMITS

The telescope has two mercury sensors to detect when the declination axis is close (Hg I) or passed (Hg II) its limits.

Attention: Always switch off the gears during observation breaks! "ANTRIEBE" "AUS".

- A) "Hg I": The Hg I button enlightens when the telescope is moved to a horizon distance of **10 degrees**, which indicates that the telescope is close to its declination limit.

The "DEKLINATION" display should be ~ **-27°**.

Do not move the telescope further away!!

Attention: The velocities fast "GROB" and medium "MITTEL", for the declination movement, are no longer available.

To recover the telescope from this position, press the button "Hg I" **and** the "δ +" with "MITTEL" or "FEIN" speed, at the same time. Take care of the direction in which you move the telescope! Shall be "δ +".

- B) "Hg II": The Hg II button enlightens if the telescope is moved to a horizon distance of less than **5 degrees**.

This indicates that the telescope is out of limits.

Attention: This should never happen! If this is the case, the gears of the telescope do no longer work!

To make the telescope operable again you need a second person to help.

1. Then turn the gears off, "ANTRIEBE AUS".
2. One person has to go the first floor of the telescope - half way up to the dome (Figure 5-6 left); and open the **back door** of the control cabinet (Figure 5-6 right). The control cabinet key should be in.
Locate the button in the fuse box labelled in yellow with "**3K1 HgII**" (Figure 5-7).
3. Press the button of the relay "3K1 HgII" (that allows to switch the gears on) and keep pushing it meanwhile a second person is at the same time turning the gears back on "ANTRIEBE EIN".

4. Then, the person at the control console can push the button "Hgl" and the "δ +" with "MITTEL" speed to leave the blocked position.
Take care of the direction.
5. The button of the relay at the control cabinet has to be released again as soon as the telescope has a distance to the horizon of more than 10 degrees!



- Figure 5-6: Left: Entrance to the room at the first floor of the telescope – half way up to the dome. Right: Telescope control cabinet located in the room.



- Figure 5-7: Fuse box **3K1 HgII**, located on the back side of the control cabinet.

- C) " **α GRENZ**" button enlightens if the telescope is moved out of the range limits in the hour axis (Stundenachse or Rekaszensionsachse).

To recover the telescope from this position, press the button " **α GRENZ**" **and** the corresponding " **α +/-**" with "MITTEL" or "FEIN" speed, at the same time. In this way, you can move away from the range limit again.

Take care of the direction in which you move the telescope!

5.7 HOW TO RESET THE TELESCOPE CLOCK

The clock can be set via the **time signal transmitter DCF77** and sends the data serially to the displays in the console. It also provides the timing for tracking and slow speeds.

The signal may temporarily not be distributed by the 200 m high antennas near Frankfurt under stormy winds. The clock may need up to 2 minutes after disruption to synchronize to the signal.

The clock is lost when the displays on the "STERNZEIT" and "WELTZEIT" displays show only zeros.

It usually implies that the display does not react to moving the telescope; then simple reboot is not enough, but you need to reset the system clock manually.

To reset the clock:

1. Go to the to go the first floor of the telescope - half way up to the dome (Figure 5-6 left), and open the **front door** of the control cabinet (Figure 5-6 right). The control cabinet key should be in.
2. Locate the module labelled "DIOCUST-2-DCF" (Figure 5-8 and Figure 5-9).



- Figure 5-8: Left: Telescope control cabinet located in the room. Right: Cabinet front door opened.



- Figure 5-9: DIQCUST-2-DCF module.

3. The red led on the left side of the red numbers should be blinking. That means the clock is synchronized and working.

If the red led is ON, and not blinking, then the clock is not synchronized, there is a discrepancy. Therefore the clock must be set manually.

4. Turn the key labelled "**70 cm Telescope DCF77**" to "SET" (clockwise) and then to "START" (counter clockwise), we keep it in the "START" position for the next steps.
5. Obtain the current information of the UT you can use the linux computer. In the terminal use the command: "**date --utc +%H %M %S %d%m%y' "**
6. Press the button "**DT**" and next set the date in the following format: "day/month/year", 2 digits per each field (e.g. "080917" for 08th Sep, 2017).
Confirm with "**ENT**".
7. Press the button "**UT**" and maintain it pressed while you set the time in the following format: "Hour/Minutes/Seconds", 2 digits per each field (e.g. "132044" for 13 h, 20 min, 44 s).
Realise the "UT" button and press "**ENT**" once more to confirm.
8. Turn back key to its central position. Notice that now the clock should run.

6 CCD OPERATION

Camera: CCD LOR #130

- **Working parameters at the 70 cm telescope**

Pixel scale (0.554 ± 0.003) arcsec/px

Field of View (18.85 x 18.85) arcmin = 18.95 mm (without corrector)

Installed at Cassegrain focal station

Orientation North-Up, East-Left

- **Technical specifications**

Manufacturer Loral / Lesser

Chip Manufacturer SITe

Chip Model n2k2eb BI

Characteristics MPP, thinned, AR-coated

Operating temperature 163 K

Dewar labelled Dewar #23

Chip size (pixel) 2048 x 2048

Pixel size (μ) 15 x 15

Chip size (mm) 30.72 x 30.72

Measured QE See figure 'Efficiency'

Reading time xx Hz ~ 120 s (binning 1x1); ~30 s (binning 2x2)

Gain xx e⁻ /ADU

Read noise xx e⁻ rms

Dark current xx e⁻ /pixel/hr (~ -120 °C)

Linearity xx

Binning capability Yes

Windowing capability Yes

- **Efficiency**

- o <http://www.eso.org/sci/php/optdet/instruments/CCDsystems/40/40.html>
- o [RoCon Software Manual \(KING-MPIA-DOC-DET-004\)](#)

6.1 SETTING UP THE SYSTEM

- ✓ 30-45 min setup time.
- ✓ **Pumping the cryostat** and **Liquid nitrogen filling** in the afternoon (only be trained personal!)

The LN2 typically lasts for one night.

There is a printed document at the dome with the instructions to pumping the CCD's dewar and to fill it with LN2. You can also find it in this link (RD01):

<https://svn.mpia.de/trac/gulli/king/wiki/WikiStart/Instructions-LN2>

6.2 FILTERS

The filters are switching manually with screwdrivers. There is not any automatic mechanics to change filters.

The filters are installed for operation in a slide with a maximum of 5 positions (Figure 6-1). This slide is inside the aluminium box shown in Figure 6-2.

Do NOT loose the small screws to fix the cover!!

In case you see a filter should be cleaned, please contact the telescope manager: conchi@mpia.de



Figure 6-1: Aluminium box where the filters are installed: Opened.

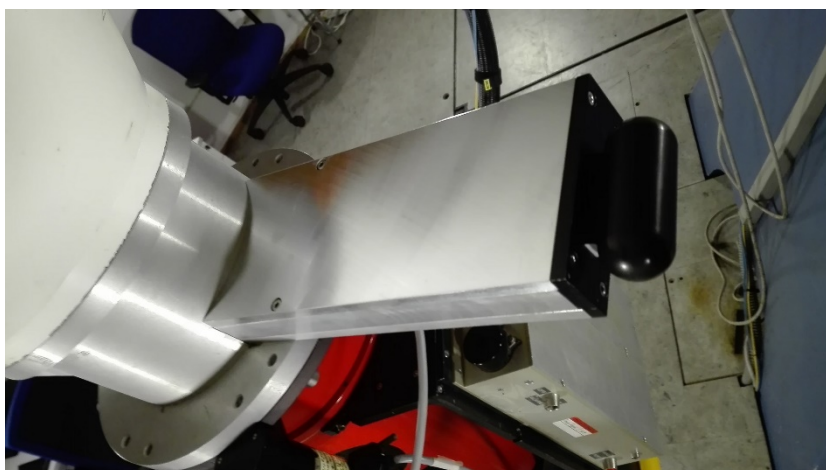


Figure 6-2: Aluminium box where the filters are installed: Closed.

The complete set of filters are normally stored in a big box just underneath the telescope structure on the dome.

The complete list of the available filters and their characteristics can be found here bellow in this table and in the following link, where you will have also access to their transmission data: <https://svn.mpia.de/trac/gulli/king/wiki/WikiStart/FilterSpecs>.

# Filter Slide / Pos	Name	Filter	Size / Thickness [mm]	Type	λ_c / FWHM (*) [nm]	Curve	Comments
#1 /p1	J1	Johnson U	50x50/4	shortpass	365/60	--	UG1/1mm + BG40/3mm; short $\lambda_{\text{cut-off}}$ defined by CCD
#1 /p2	J2	Johnson B	50x50/4	bandpass	430/80	--	GG395/1mm + BG25/1mm + BG39/2mm
#1 /p3	J3	Johnson V	50x50/4	bandpass	541.6/67.6	Plot (#)	GG495/2mm + BG39/2mm, Roeser V
#1 /p4	J4	Johnson R	50x50/4	bandpass	648.3/139.8	Plot (#)	OG570/2mm + KG3/2mm, Cousins R
#1 /p5	J5	Johnson I	50x50/3	longpass	846.1/241.7	Plot (#)	RG9/3mm; long $\lambda_{\text{cut-off}}$ defined by CCD
--							
#2 /p1	E6	H α (wide)	50x50/	interference	657.7/6.7	Plot(#)	
#2 /p2	E9	SII continuum	50x50/	interference	702.7/41.1	Plot (#)	
#2 /p3	E8	SII	50x50/	interference	672.6/6.8	Plot (#)	
#2 /p4	E3	OIII	50x50/	interference	501 / 14	--	
#2 /p5	E1	OII	50x50/	interference	372 / 8	--	
--							
#3 /p1							
#3 /p2							
#3 /p3							
#3 /p4							
#3 /p5							
--							
#4 /p1	Grating1	G300	50x50/	Transmission grating	-		300 grooves/mm, blazed for 600 nm
#4 /p2							
#4 /p3							
#4 /p4							
#4 /p5							
--							
#5 /p1							

#5 /p2							
#5 /p3							
#5 /p4							
#5 /p5							
--							
#6 /p1	DS1	Deep Sky 1	50x50/	interference	Several lines	Plot(#)	
#6 /p2							
#6 /p3							
--							
--	E2	H β	50x50/	interference	486.7 / 9.7	--	
--		Roeser BV	50x50/	bandpass	497.7/155.9	--	BG39/xmm ; long λ cut-off defined by CCD
--	E4	OIII	50x50/	interference	500 / 10	--	
--	E5	H α (wide)	50x50/	interference	656.7/8.4	Plot(#)	
--	E7	H α redshifted	50x50/	interference	672.7/3.8	Plot(#)	Very low transmission
--	E10	CI 8727	50x50/	interference	871.6/5.1	Plot(#)	
--	E11	CI continuum	50x50/	interference	916.2/23.7	Plot(#)	
--	G1	Gunn z	50x50/	longpass	835.3	Plot	RG830/3mm ; long λ cut-off defined by CCD
--	G2	Gunn z	50x50/	longpass	840.8	Plot	RG830/3mm ; long λ cut-off defined by CCD
--	DS2	Deep Sky 2	50x50/	interference	Several lines	Plot(#)	
--	DS3	Deep Sky 3	50x50/	interference	Several lines	Plot(#)	

(*) Given as Central Wavelength/ Full Width Half Maximum or cut-on wavelength only for longpass filters or cutoff for shortpass filters.

Long wavelength cut-off defined by CCD properties ($\sim 1050\text{nm}$).

(#) Derived from actual measurements where transmission curve is linked, otherwise design values are given.

Transmission curves made in 10.2018 by **Maximilian Häberle**, Master student at MPIA.

6.3 DOME FLAT FIELD OPERATION

Inside the dome there is a white screen installed that can be used to take flat-fields with the telescope.

1. There is a power supply on top of the telescope control console (Figure 6-3) that feeds the lamp besides it.

Switch on the power supply using the black switch "EIN ON".

By default the voltage is set to 7 V, and the electricity intensity to 2.4 A.

The electricity intensity must not be changed, just keep it as it is set up. To increase the light intensity you should increase the voltage only.

Attention: The electricity intensity must be always smaller than 2.5 A, and the voltage smaller than 12 V.

2. Orientate the lamp in such a way that the white screen is almost homogeneous illuminated.
3. Move the telescope (see section 5 to learn how to move the telescope) to look to the white screen too.
4. Take the flats with the different filters.



Figure 6-3: Power supply of the lamp use for the dome flat field.

6.4 CCD SOFTWARE

The complete manual of the software of the readout electronics of the CCD camera in RD04, which can be also found as a printed document at the dome and in this link:

<http://www.mpia.de/~mathar/public/KING-MPIA-DOC-DET-004.pdf>

6.4.1 COMPUTER INFORMATION

The computer in the dome is called *king.mpia.de* (current IP: 149.217.45.16)

- Software:
 - OpenSuse 15.2
 - ds9
 - pyRAF
 - idl
 - The users@king are:
 - **staff**: default user to login and do something, also for observations.
 - **ccd**: CCD engineering account
 - **praktikum**: to do F30 advanced lab course
- (check <http://www.linfo.org/uid.html> if you need to know about linux users)

6.4.2 IMPORTANT COMMANDS OF THE CCD SOFTWARE

Attention: The exhaustive lists of the command and how to use them are in the mentioned CCD software manual and are also available under the command "info king".

- **ccdstart**: Switches on the relay box and set up readout electronics
- **ccdstop**: Powers down all four DAC channels and switches off the relay box at the CCD.
- **ccdread**: without any arguments: will get a full frame (incl. overscan), 2x2 binned bias with gain 5 and save as test.fits.

Note: the readout of an unbinned full frame takes ~110 s, and ~30 s with binning 2x2.

"ccdread -h" gets the usage information with more details about parameter formats.

IMPORTANT: Interrupt the *ccdread* process with Ctrl-C is NOT a good idea.

Hitting Ctrl-C is handled by a local signal handler such that the exposure time is shortcut, the shutter is closed, the current readout is finished, and the current read-loop of "*ccdread -r*" is ended. Therefore, this does not work as fast as just killing some standalone software program usually does. This ensures that the readout electronics is not in a limbo state afterwards. This usually also means that no FITS files are produced, because the software only produces files for data that have trustworthily arrived at the computer.

If you do this nevertheless, you should at least take a test image afterwards to verify that it is properly working.

- **ccdtemp**: Reads the temperature of the W&T 57710 module, which is the CCD temperature measured by a PT100 sensor, via the Ethernet. The number in units of Celsius is printed on standard output.

Notice: Temperature will always be added to the FITS header.

The CCD temperature is also available in these two locations:

→ <http://wut70cm.mpia.de>

→ <ftp://ftp.mpia.de/pub/ccd/king70cmTemp.pdf>

Some users may need to set the ftp proxy in the browser to 'web-proxy.mpia-hd.mpg.de' (port: 3128) to be able to visualize/download the pdf file.

6.4.3 READ THE DETECTOR

1. Check that the CCD electronics is ON:

The green button on the console labelled "INSTRUMENTIERUNG" "EIN" shall be illuminated (see section 5.1 of this document).

If not, then proceed to step 6.

2. Take a test image: "ccdread -w 100x100".

This gets a bias frame of the central 100x100 pixel, and it is very quick.

Save it as "test.fits".

Check the image content, by opening it in ds9 and looking at the data statistics.

If it is all zeroes, you need to reset the CCD.

If not, you're fine and may proceed to step 9.

3. Use the command "ccdstop" to power down the relay box and readout electronics of the CCD.
4. Switch off "INSTRUMENTIERUNG" "AUS", on the control console.
5. Wait 5 seconds.
6. Switch on "INSTRUMENTIERUNG" "EIN", on the control console.
7. Use the command "ccdstart" to power on the relay box.
8. Get a new test image, see step 2 for instructions.
9. All should be well now. Clear skies and good observing!
10. If there is still a problem: go to the Troubleshooting (section 7.5).

7 TROUBLESHOOTING

7.1 IF "NETZ EIN" BUTTON IS NOT WORKING.

If the button "NETZ EIN" is not working, the console has to be activated first: it can be activated by the key on the right side of the console (see Figure 5-3).

Turn it completely towards you (counter clockwise) and keep it then in the middle position.

7.2 THE CONTROL PANEL SEEMS COMPLETELY DEAD, NOTHING BLINKS OR REACTS.

- You probably hit by accident the emergency button in the console. DO NOT DO IT AGAIN!!
- To recover (see Figure 5-3):
 1. Release the emergency button by twisting it in the direction of the arrows.
 2. The key to activate the console is usually in its place, on the right side of the console. If not find it in the first drawer of the chest of drawers(The key is marked with a label: "70 cm Telescope Control Console")
 3. Turn it completely towards you, counter clockwise (a soft *click* will usually be heard) and release it such that it will settle in the middle position (similar to a car's start key).
 4. Start the console by pressing the usual "NETZ EIN" button.

7.3 IF "INSTRUMENTIERUNG" "EIN"/"AUS" BUTTON IS NOT ILLUMINATED, ALTHOUGH YOU THINK IT SHOULD BE.

- This usually does *not* mean that the button is not working (the bulb behind the button could be broken and need to be replaced)
 - Check commands like `$ccdread` and `$cctemp`.
 - If for instance you get a useful chip temperature, then *Instrumentierung* is ON, since the temperature read and the instrumentation use the same power.
- If you notice that any bulb is broken, please inform the telescope manager who will take care of restore it. It is a standard piece that can be provided by the MPIA Electronics department.

7.4 IF *CCDREAD* DISPLAYS THE ERROR MESSAGE "ERROR: No FITS FILE PRODUCED"

If you hit Ctrl-C is before all data have arrived, no FITS files are produced. This is the expected outcome then.

You need to initialize the camera as follows:

- In the terminal: `ccdstop`
- In the console: Check if the is turned on: "INSTRUMENTIERUNG" "EIN" illuminated
- In the terminal: `ccdstart`

7.5 IF CCDREAD PRODUCES A FITS IMAGE WHERE ALL VALUES ARE ZEROS.

- There was probably a problem with the initialization of the CCD
- You need to do a complete reset cycle of the CCD electronics. It is performed as follows:
 1. In the terminal: `ccdstop`
 2. In the console: "INSTRUMENTIERUNG" button to Off ("AUS")
 3. Wait ~10 seconds
 4. In the console: set the "INSTRUMENTIERUNG" button to On ("EIN")
 5. In the terminal: `ccdstart`
 6. In the terminal: read again, "`ccdread -w 100x100`".
 7. If the CCD does not produce valid images afterwards, you most likely will have to unlock the CCD first.

In the console: using "`ccdunlock`" and typing "YES" (in capitals!) at the prompt when asked for it.
 8. If there is still a problem after the step 7, you will have to include also the console in the reset.
 - Follow the steps 1-3.
 - In the console: switch off the power by pressing "NETZ AUS".
 - In the console: Turn the key on the right side of the console (see Figure 5-3it completely towards you (counter clockwise) until you hear a soft *click*.
 - Wait a few seconds.
 - In the console: Return the key to the middle position.
 - In the console: restart the power by pressing the "NETZ EIN" button.
 - Continue following the steps 4-7.
 9. If there is still a problem: notify someone, e.g. write a mail to king@mpia.de, call Conchi Cardenas, but don't just ignore it.).
- **REMEMBER**
 - If you need to initialize the camera, do a `ccdstop` followed by a `ccdstart`.
 - If you want to power off the CCD electronics, always do a `ccdstop` first.
 - If you are not sure in which state the CCD is when you start working, you can just do `ccdstop` followed by `ccdstart` and it should be fine.
 - Interrupting the `ccdread` process with Ctrl-C is NOT a good idea.
 - If you do this nevertheless, you should at least take a test image afterwards to verify that it is still working.
 - You most likely will have to do a complete reset of the CCD electronics (as explained before in this section).

8 NIGHT OBSERVATIONS

8.1 STAR CHART

To get the coordinates of the objects you plan to observe you can use an astrometric catalogue.

- From the ESO archive you can find in this link an **Astrometric Catalogues Server**:
<http://archive.eso.org/ASTROM/ASTROM>

For bright stars you can use “Tycho-2” Catalogue.

- More catalogues are available from: <http://vizier.u-strasbg.fr/>

For example, here you can have access to the “UCAC4” catalogue.

8.2 PREPARING FOR THE OBSERVATION

The quickest way to obtain an overview of which RA/DEC regions are available (plus a cursor-based calculator for conversions of ALT/AZ/HA to RA/DEC/LST coordinates) is to call “*xephem &*” in the terminal. This command has the “Tycho-2” catalogue locally installed.

Here you can find a tool to find out the observability of objects for a particular night:
<https://www.osn.iaa.csic.es/en/observing/staralt>

8.3 FIELD SIMPLE IDENTIFICATION

The pointing accuracy of the 70 cm telescope is typically on the order of 10–20 arcmin.

This can be sufficient to reliably acquire targets with the 2k×2k CCD which is usually mounted at this telescope. In case you want to improve the default pointing accuracy see section 8.4.

To quickly identify the field, you can use astrometry.net:

1. Move the telescope to your target.
2. Get an image with CCD.
3. use <http://astrometry.net/> to get the actual location and calculate the offset.
4. Move to updated location and check again to be.

Attention: When the corrections calculated by “astronet” are suspicious or too big, it can be necessary to recalibrate the Right ascension and Declination of the telescope. To do that, follow the procedure described in 5.4 in this document.

8.4 THE 70 CM TELESCOPE POINTING MODEL

In the Felix Hormuth’s Diploma Thesis (RD02) was made an **analytic pointing model** using a total of 65 calibration images with uniform distribution on the sky. The pointing model was implemented at the telescope in 2006. That model is based on Buie’s model (RD03) and reduces the pointing residuals to ~ 4 arcsec, in any case, smaller than 1 arcmin.

The analytic model fits a high-order polynomial to the differences between apparent coordinates and the positions where the telescope was pointed to, without any experimental knowledge of the pointing error sources. This method can work remarkably well, as demonstrated by Hormuth. It requires a large amount of calibration data to allow a stable fit.

This model can be accessed directly through the command interface of the KING’s computer, with the routine “*kingPoint*” (please see RD04, sections 2.1 and 2.7).

9 SCIENCE CASES

Section in progress...

9.1 NOVAE HUNTING IN M31 (OR SIMILAR)

By Trifon Trifonov (<mailto:trifonov@mpia.de>)

The rate of Novae in M31 is about 30-50 per year! That means that one has very good chances to spot a Novae at maximum brightness. Once with students we discovered one in M31 and even had an astronomical telegram. It is a fun project and many professional and amateur astronomers are hunting for Novae in M31 (even supernovae ...).

Actually to hunt Novae one must be very fast to announce a discovery since many other people around the globe are also observing even with robotic telescopes.

This project would require someone to develop a fast pipeline that crosscheck for new objects in the field and performs photometry on them. It should not be so complicated to be done. [...]

Alternatively, [<http://diffractionlimited.com/product/maxim-dl/> MaximDL] is a handy amateur tool for that and LSW has some experience with this software.

Particularly for science, any data from the Novae light curve helps to better understand the Maximum magnitude vs. rate of decline (MMRD), which has a potential to be used as a distance indicator.

The FOV of the KING telescope (~19arcmin diameter) is a bit small, but still it can be used for the central part of M31 (where most of the Novae occur if I am not mistaken).

What I can recall is that Novae in M31 typically have apparent magnitude in R about 16 mag.

The exposures usually about 900 sec for a good S/N but often I take several (about three) in BVR and only from time to time in H+alpha.

So 900sec = 15 min + overhead ~ 5 min equal to ~ 20 in filter. If we take 3 exposures in each filter = 1 h.

BVR = 3 h/ night

Alternatively, if this time is too much then only images in R are sufficient to discover Novae.

9.2 MAPPING ANDROMEDA

With our 19 arcmin (FoV) we can do a mosaic of pictures for Andromeda. One can later combine all the images and reconstruct the Andromeda galaxy with very high signal to noise image. That might be a cool to project for a student. In addition, M51 is a good object of interest (the supernovae rate there is very high!).

=====End of document=====