NATIONAL OBSERVATORY OF ATHENS

Institute for Astronomy, Astrophysics Space Applications and Remote Sensing

HELMOS OBSERVATORY

COOKBOOK

for

Rapid Imaging Search for Exoplanets 2

(RISE2)

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Contents

1. Starting up the system

1. Turn on RISE2 PC on the telescope (Fig. 1).

2. Turn SFM to position for RISE2 (port number: 2, instrument: empty)

For Linux or Mac OS

3a. Open 4 terminal windows

4a. In the 3 terminals: ssh rise@rise2.astro.noa.gr
password: rise2user

5a. In the 4th terminal: sftp rise@rise2.astro.noa.gr
password: rise2user

For Windows OS

3b. Open 3 terminal windows using the "SSH Secure Shell" software

4b. In these 3 terminals create profile using:

HOST: rise2.astro.noa.gr
Password: rise2user

5b. In the 3rd terminal select the “New file transfer window” option and the "SSH Secure File transfer" terminal will appear. Create profile using:

Set SFTP HOST: rise2.astro.noa.gr
Password: rise2user

Common steps

6. **1st terminal**: go to: /home/rise/testing

run: *./rise2d*

7. **2nd terminal**: go to: /home/rise/bin

run: *./rise2log*

Wait until the temperature goes down to the requested temp or close approximation.
Check the CCD temperature setup to -40°C (or -45°C). If not, go to:
"/home/rise/rise2conf" and change the temperature to that value.

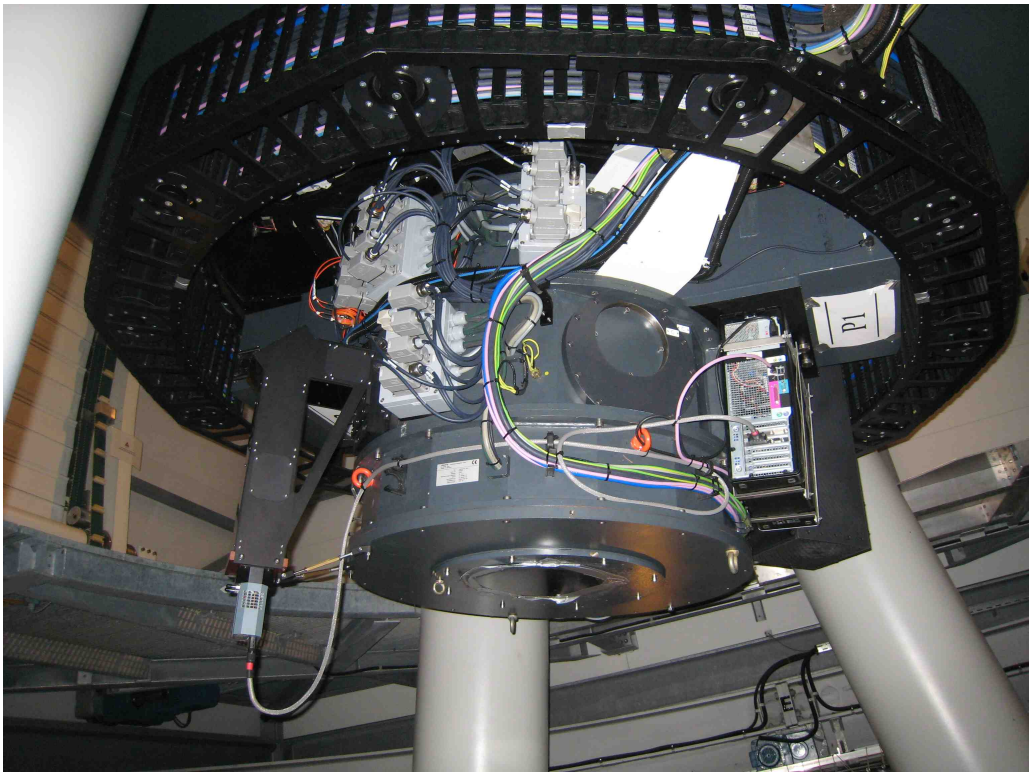

Fig.1. The RISE2 camera mounted on the Aristarchos telescope.

2. Observations in default binning mode (2×2)

For Linux or Mac OS

1a. **1st terminal**: run: *./rise2client --nimages 1 --exposure 10.0 --bin 2 --type object [--c "test"]*
The above command takes 1 image of 10 sec, binned 2×2 and is a test image of the object.

2a. **3rd terminal**: go to: /data/rise2
This is the area where the data will be stored. We have created directories by year. For each day of observations we create the appropriate directory. At the end of the night we transfer all data to this directory in order to clear /data/rise2 area.

3a. **4th terminal:** go to: /data/rise2
During the observing night, you can transfer the data (tests, biases, flats objects etc.) to your PC and check the images using DS9.

For Windows OS

1b. **1st terminal**: run: *./rise2client --nimages 1 --exposure 10.0 --bin 2 --type object [--c "test"]*
The above command takes 1 image of 10 sec, binned 2×2 and is a test image of the object.

2b. **SSH Secure File transfer" terminal**: go to: /data/rise2
This is the area where the data will be stored. We have created directories by year. For each day of observations we create the appropriate directory. At the end of the night we transfer all data to this directory in order to clear /data/rise2 area. During the observing night, you can sftp the data (tests, biases, flats objects etc.) to your PC and check the images using DS9.

Common steps

4. Take bias frames

1st terminal: run: *./rise2client --nimages 100 -- exposure 0.0 --bin 2 --type bias [--c "bias first set"]*

ATTENTION: Since there is no shutter on the CCD, it can be difficult to acquire bias images. This must be achieved manually by taking zero second exposures with the light path to the CCD obstructed. It is recommended to close the dome shutter, the primary mirror shutter and also to change the SFM position (e.g. port number 1).

For exoplanet transit observations, at least 300 biases are needed, typically 100 are taken before and another 100 after the transit and the remaining 100 before the start or after the end of the observations (e.g. before or after flats). In order to obtain good quality biases, the CCD must be covered with a black cloth, which is a manual and time-consuming task.

5. Take flats (near sunset or sunrise).

1st terminal: run: *./rise2client --nimages 50 -- exposure XX.X --bin 2 --type flat [--c "flat first set"]*
Or, you can run: *./rise2client --nimages 300 --bin 2 --type flat [--c "flat"]*
where the exposure time is set automatically by checking the CCD counts. This procedure is easier to do. Exoplanet transit observations need around 200 flats so we take sets of 50 and then check the exposure time. We must get between 20000-40000 counts (the camera becomes non-linear above that value).
We must rotate the telescope a bit each time (Cassegrain rotation by 45°) to create a master flat at the end, which corrects the different illumination pattern in the field.

6. Take test images by running:

1st terminal: run: *./rise2client --nimages 1 --exposure 10.0 --bin 2 --type object [--c "test"]*

For Linux or Mac OS

4th terminal: /data/rise2

For Windows OS

SSH Secure File transfer" terminal: go to: /data/rise2

You can transfer the test images to your PC and check them using DS9 for the following parameters:
(a) position of the object compared to the centre of the field
(b) telescope focus: exoplanet targets should be defocused
(c) object counts: 20000-30000 counts are optimal for defocused exoplanet targets. We suggest to keep exposure times above 3 sec and below 30 sec in order to get these count levels (e.g. for HAT-P-19 at V=12.9 mag, 10 sec exposures suffice).

(d) guiding: autoguiders need to be set up before starting the observations. High-precision photometry of transiting exoplanets requires movement of the target on the chip of less than 5 pixels during the transit.

7. Observe your target:

1st terminal: run: *./rise2client --nimages XXXX --exposure XX.X --bin 2 --type object [--c "name of the object"]*
The number of images (XXXX) depends on the duration of the transit and the exposure time (XX.X), so you have to calculate it each time.

8. Obtain another set of biases by running (see also step 2.4):
1st terminal: run: *./rise2client --nimages 100 -- exposure 0.0 --bin 2 --type bias [--c "bias second set"]*

3. Observations in other binning modes

The steps for observing in other binning modes is almost identical to observing with binning 2×2.

If you perform observations in other binning modes then you must pay attention to the following:

- Flats and bias frames should be acquired in the same binning mode as the mode used for the object observations
- The automatic procedure for flats described in step 5 (Section 2) works ONLY for 2×2 binned images. For other binning modes, it is recommended to use the manual procedure by checking the median of the frames. Take a few test images, check the median and then choose the appropriate exposure time for the flats (ATT: The camera is linear up to 40,000 counts)

A quick guide for the observations is the following:

For object frames:

1st terminal: run: *./rise2client --nimages **NN** -- exposure **XX.X** --bin **B** --type object [--c **"NAME"**]*
Where **NN**=number of images, **XX.X**=exposure time (sec), **B**=Binning mode, **NAME**=name of the image

For flat frames:

1st terminal: run: *./rise2client --nimages **NN** -- exposure **XX.X** --bin **B** --type flat [--c **"Flat"**]*
Where **NN**=number of images, **XX.X**=exposure time (sec), **B**=Binning mode

For bias frames:

1st terminal: run: *./rise2client --nimages **NN** -- exposure **XX.X** --bin **B** --type bias [--c **"Bias"**]*
Where **NN**=number of images, **XX.X**=exposure time (sec), **B**=Binning mode

4. Shutdown Procedure

In order to shutdown the CCD camera, run the following:
1st terminal: run: *./rise2client killd*

2nd terminal:
Wait until the temperature reaches approximately 2°C and the message “shutting down RC” appears.

Exit from all terminals

5. System specification

- Single fixed "V+R" filter comprising 3mm OG515 + 2mm KG3
- Pixel Scale: 0.594´´/pixel (unbinned), 1.188´´/pixel (binned 2×2)
- Field of view: 10.13´×10.13´
- Minimum exposure Time: 1.2 seconds (1×1 binning)
- Minimum exposure Time: 0.6 seconds (2×2 binning)
- No readout overhead
- Gain: 2.3 electrons/count (2×2 binning)
- Read noise: 10 electrons (2×2 binning)
- Mean dark current: 0.0143 counts/sec (2×2 binning)
- Saturation Limit: 20,000 counts (1×1 binning); 40,000 counts (2×2 binning)
- The orientation of the images is EN to the top (N is to the right by about 55° from the vertical position)

6. Important information

- If you want to check the status you run:
  1st terminal: run: *./rise2client status*
- If you want to abort an exposure or an exposure sequence you run:
  1st terminal: run: *./rise2client abort*
- The ULTRACAM pipeline is available at https://github.com/trmrsh