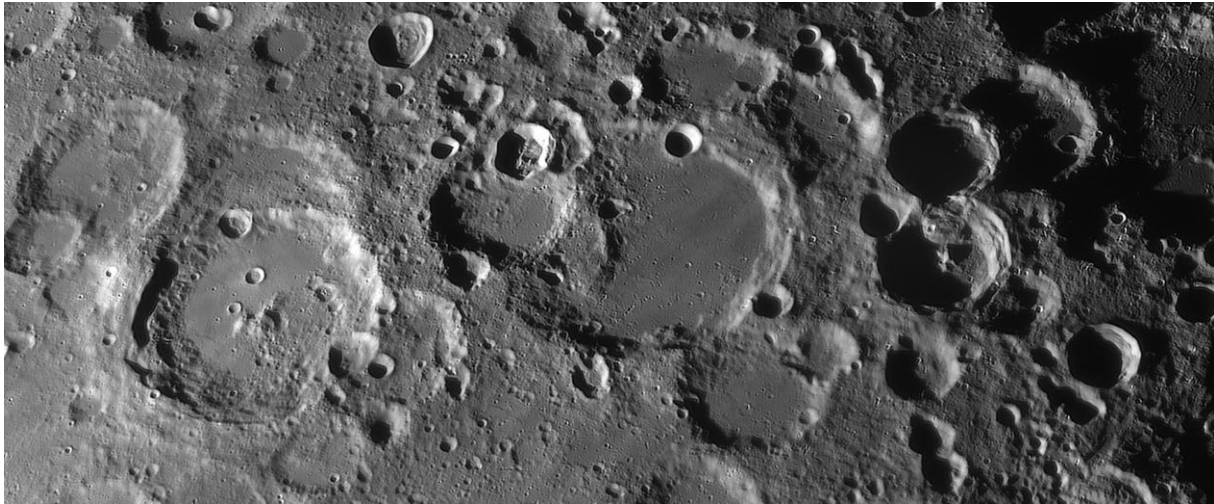


Hints + tricks for high-resolution lunar and planetary photography with "lucky imaging technique" and a video camera - a short workflow for Schmidt Cassegrain telescopes and Baader Planetarium accessories)

Pictures often say more than a thousand words ...



... again and again I am asked how I make my high-resolution lunar and planetary shots. Therefore, here is a brief description of the equipment and following a few hints + tricks to the "workflow" for shooting and image processing.



What Do You need ?

- ✓ A [Schmidt Cassegrain telescope](#) (SC) with large opening, here an older Celestron 14 (purchased in the year 2001)
- ✓ a video module, in my case a [Celestron SkyRis 445 Mono](#)
- ✓ a Barlow lens, in my case the Baader [Q-Turret Barlow](#)
- ✓ Filters, in my case a Baader [UV/IR Cut](#), but mostly a Baader [IR Passfilter](#) and
- ✓ mechanical components, in my case an older [Baader Crayford manual focuser](#) and some mechanical adapter.

Short comments on the used telescope and its observing location

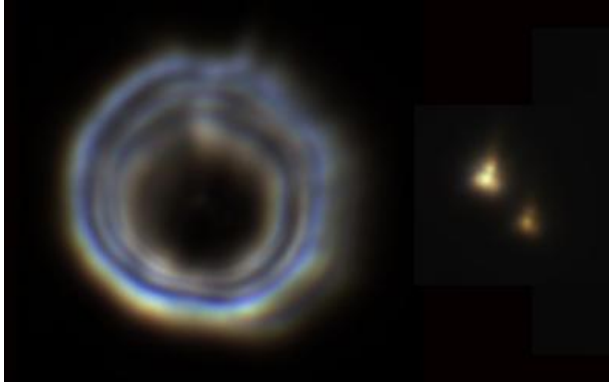
In May 2013, an older Celestron C14 (purchased in 2001) was reactivated by me in Namibia and was reset at the Guest Lodge Onjala near the international airport close to Windhoek. The telescope is mainly used in "public star gazing" for the guests of the lodge.

large aperture and the long focal length of the C 14 is predestined for lunar and planetary observations and so in 2014 first test images of the moon were taken, and their quality was excellent.

The imaging telescope ...

should have a good to very good image quality. I mainly use the C14 in its primary focal length at 3,900 mm. If the seeing conditions are excellent - which is relatively rare at my observing location - the focal length is extended to about 6 meters with the Baader Q - Turret Barlow lens. For reducing seeing problems the [Baader IR Passfilter](#) is often used. More about the last two points later.

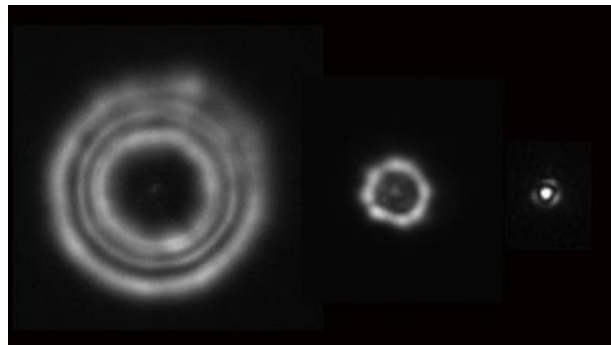
The **Alpha and the Omega** for the telescope optics is a perfectly collimated secondary mirror (sm). Smallest tilts of the sm against the main mirror (mm) immediately result in blurred images at the edges in the image field, despite the small field of view (in my case about 5.4 x 4 arc minutes), even if the center of the image is still somewhat sharply displayed.



< The image on the left shows a decollimated SC system, and the secondary mirror shade is clearly asymmetrical to the main mirror. To the right is the resulting image of the double star alpha Centauri.

For a stationary mounted instrument, it is sufficient to check the collimation of the sm from time to time, for equipment that is frequently transported and set up and dismantled, the collimation should be checked before **EACH** recording sequence.

> The picture on the right shows the SC system after collimation. From left to right: the star Altair extrafocal blurred, just before focus and finally focused at right (note the first diffraction ring).



With some experience you can see immediately if the seeing is reasonably good and stable, whether the collimation is OK. First times I had to adjust an SC telescope, I used a small public domain software called "Astroraster". The link for the download can be found in the appendix off this small paper.



The second important point is that SC telescopes have a so-called "mirror shift," meaning that when the image is focused on the normal spindle focus, the main mirror tilts slightly back and forth on its guide.

Therefore, I also used an older, [manual Baader Crayford focuser](#) with a 1:10 reduction, which is bolted to the back of the 3.3 male thread of the tube termination plate. For raw focussing I use the normal spindle, final focus is then done with the Crayford.

Slight tilting of the main mirror (mirror shift) via the spindle focussing can have immediately negatively influence to the collimation of the secondary mirror.

Therefore the following personal tip: whenever you

move the main mirror with the spindle focus, select the final direction of rotation COUNTER CLOKEWISE. In this direction of rotation you pinch the main mirror in a defined tilt fixed position.

- **So ALWAYS select the counterclockwise direction of both the collimation and later in the pre-focusing**

And a last tip to the recording telescope. Make sure that the SC plate is clean and dust-free. Dirt generates stray light, which quickly reduces the recording quality. Of particular

importance is a clean optic for the acquisition of planets, e.g. of Jupiter, whose fine, relatively contrastless cloud structures otherwise are lost in scattered light.

For me, unfortunately, it is often the case that due to special circumstances, the SC plate is completely polluted when I come back to Namibia. I only use the cleaning fluid Optical Wonder from Baader Planetarium to clean the SC plate.

The video module

I started with various video modules of the company "The Imaging Source" (TIS), a German based company in the city of Bremen. These video cameras were expensive, but technically well engineered and easy to use with the stable running control software IC Capture. After a veritable boom of TIS cameras, which were actually designed for industrial applications, TIS developed several video modules for the company Celestron, which were designed specifically for amateur astronomy. To control the recording functions of the modules, the ICap software was developed.



I currently use the [Celestron SkyRis 445 M camera](#) with a pixel size of 3.75 microns for monochrome lunar and planetary video sequences. The control software ICap is almost intuitive to use and runs extremely stable.

In the prime focus of the C14 at 3,900 mm focal length results in the red wavelength range at the pixel size of 3.75 microns, a theoretical resolution at average lunar distance of about 400 meters, which I also achieve at good and stable Seeing conditions (see also links in the appendix).

The Baader Q-Turret Barlow lens

If my seeing conditions allow, I use a [Baader Q-Turret Barlow lens](#) to extend the focal length of the C14. **Why I select the Baader Q-Turret barlow lens ?**



- For its low price (€ 49.- price at January 2018) it offers a brilliant, outstanding image quality,
- the Barlow is divisible, the actual Barlow element can be separated from the socket and screwed directly into the 1¼" socket with the C-mount thread for the SkyRis module. The advantage is that, depending on the choice of the socket the adjustable extension factor lies between 1.5 and 1.8 times.

The picture above shows the separated Q-Turret Barlow. On the left the optical element, on the bottom the unscrewed sleeve and on the top the SkyRis module with a short [Baader 1¼" socket \(# 295 8515\)](#). Here the optics of the Q-Turret is directly screwed in and the factor of the focal length extension is then approximately 1.5 times.

The usual focal length extensions of 2 to 3 times of normal Barlow lenses are just too much for the C14 and my seeing conditions. As soon as possible - when Seeing

conditions allow - I work with the Q-Barlow at a factor of about 1.5 times and thus give a secondary focal length of about 6 meters.

Filter

The time window at my observation site with very good seeing conditions is usually short (max. 45 minutes) and often starts BEFORE sunset, so the sky background is still bright. An indispensable tool in many of my recordings is therefore the Baader IR pass filter. On the one hand, it significantly improves the seeing conditions during the phases of good seeing. On the other hand it darkens the sky background far enough in the twilight. The filter opens at about 680 nanometers, which indeed reduces the image resolution, which depends on the wavelength, but the resulting better Seeing conditions brings more benefits than the higher image resolution.



The filter even allows - if the sky is very transparent and the optics is clean - moon shots in high sun daylight. This can be helpful if you want to record special lighting situations of specific lunar structures (for example, shadows of crater walls or crater central mountains).

< The picture on the left shows the Baader 2 inch IR pass filter, which is screwed into the 2"-1¼" adapter and the SkyRis with the Barlow element in the short plug (# 295 8515).

Tests by me have clearly shown that further shifting of the recording wavelength to the infrared spectral range with other filters does not improve the seeing conditions. On the other hand, a noticeable extension of the exposure time for taking the individual pictures is noticeable. See also the weblink in the appendix.

In the rare cases where I record "single shot" color raw video sequences with a color video module of planets, I always have a Baader UV / IR blocking filter in the optical path.

Mechanical components

> The picture on the right shows the complete recording unit with the IR pass filter and on the right with a corresponding dust cover.

As already mentioned above, I used an older Baader Crayford for final focusing. The 2" entry of the focusing unit is reduced by an adapter from 2" to 1¼". On the telescope side the 2" UV / IR blocking filter or the 2" IR pass filter is screwed in. The video module is then connected via a 1¼" socket with C-Mount thread realized. I make sure that ALWAYS a filter is screwed into the adapter. This protects the recording chip from dust, which - once it is on the chip - is very difficult to remove. That's why I always leave the camera, adapter and filter as a complete unit together.



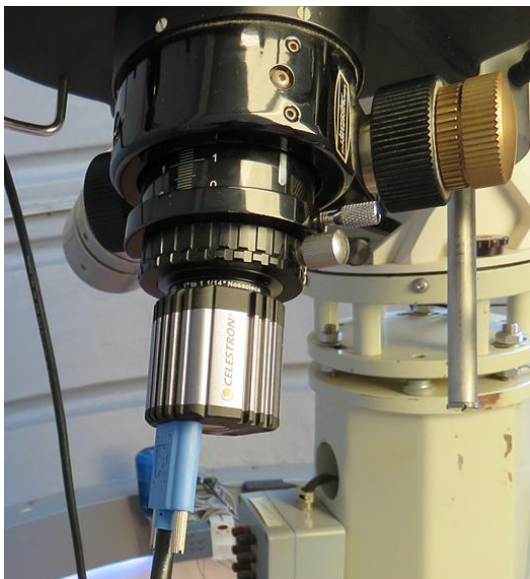
This concludes the description of the imaging components. In the following, I describe the workflow for imaging the raw video files.

Shooting preparation

EVERY observation site has its own best Seeing window, which you should know. It makes little sense to take raw avi files in bad seeing. The free available software packages for stacking the raw images (AviStack, RegiStax and AutoStackard) work brilliantly, but they can not perform magic.

If possible, have your recording telescope temper approx. 1 hour before the start of the recordings. My best Seeing window in Namibia is round about sunset and the telescope is mounted in a 4m dome, which I open about 30 minutes before starting the recordings. The Sun is then still above the horizon and the telescope is not yet tempered very well when I start the avi shots. That's why I often have to refocus at the beginning of my imaging sessions.

I mount the camera into the Crayford focuser and then align it by rotating to the axis Right Ascension (RA) and Declination (DE) with the Lunar Terminator. Thus, the lunar section which I want to image shifts up/down when adjusting the declination and right/left when shifting into right ascension. This saves a lot of time in setting moon formations to the field of view, especially when the Seeing window is short in time. If the moon image somehow moves diagonally when moving in RA or DE, it takes a long time to adjust the desired image detail.



Focussing ...

... is one of the most important points for record good raw avi files. With very good and stable seeing conditions, focusing is easy. Here, in the live view, focus is set at the smallest visible structures. Things are different when the seeing conditions are anything other but stable.

< The picture on the left shows the individual components for recording the avi files on the Crayford focuser.

Local Seeing generally consists of two components:

- **image motion** - the image stays sharp but shows strong displacements in the field of view
- **blurring** - the image is stable, but the focal sharpness changes constantly.

Both components usually overlap, unless you have an extremely favorable observing location. Here are some tips on image focusing for normal Seeing conditions.

- ✓ Increase the image brightness of the live image with the control software either with changing the exposure time or with the electronic gain higher than you later expose the single images. A bright picture can be focused more safely. For planetary shoots, make sure the exposure time is not less than 1/30 second. Jerky live images do not allow good focus.

- ✓ !!! Do the pre-focusing counter-clockwise with the spindle focus. The collimation of the secondary mirror will be preserved !!!
- ✓ Use a manual focus unit for final focussing. It's IMPORTANT to be able quickly change between extra- and intrafocal images to find the best possible focus position. Electronic focus units are far too slow under normal seeing conditions for quick changes.
- ✓ Image Motion reduces significantly near the best focus position.

If the telescope is not perfectly tempered to the surrounding temperature, re-focus EACH new avi file.

- Ultimately however, everyone has to find their own way for themselves and their instrumental equipment.

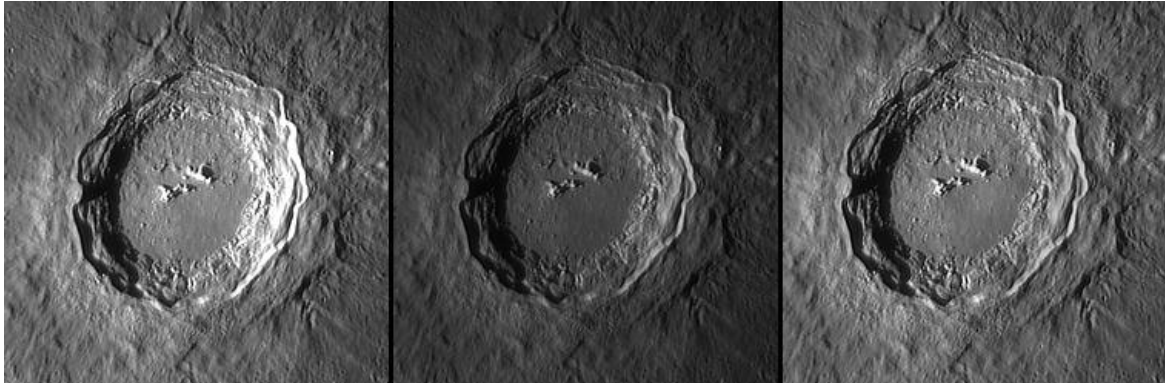
Settings at the control software for imaging the raw avis

Here I can only give tips for **ICap**, the recording control software for Celestron SkyRis video modules, but in general the tips can be transformed to other software packages.

- ✓ **Absolutely important:** Be sure to check - BEFORE you start the first Avi - recording - the BASIC settings of your control software, especially the video codec settings. NOTHING is more annoying than having taken a lot of good avi streams and the stacking software can not handle the movies, because of incompatible settings between the video module and the stacking software,
- ✓ the brightness changes for the single frames - especially in moon shots - are often too rough by changing the exposure times, so I regulate the final image brightness usually with the electronic gain. This allows a much more sensitive adjustment of the image brightness,
- ✓ my basic settings for GAIN is at + 10 db for sun, moon and planets. I try to avoid reinforcements higher than + 13 db, because the image noise of the single raw images is then very strong and a correspondingly higher percentage of single images must be stacked,
- ✓ depending on the conditions of seeing, I record between 1,200 and 1,800 individual single raw images of the moon, of which I stack between 10 and 12% for the final raw sum image (average approx. between 150 and 180 single raw images). In planetary shots, I take a maximum of 3,000 frames, of which I generally stack 10% for the raw sum image. This usually results in noise-free raw sum which are extremely easy to sharpen via sharpening filters in the final image processing,
- ✓ set the frame rate (frs, frames per second) so that you can record as many frames per second as the USB speed, the speed of your laptop's hard disc and the video module allow. However, make sure that the frame rate and exposure times of the individual images match. As an example, it will not work e.g. shooting Jupiter so set a frame rate of 60 frames per second when the exposure time is only 1/30 second. On the contrary, it could happen that the stacking software can not read these avi files,
- ✓ when imaging Jupiter and Saturn, make sure that the complete recording time of the raw avi does not take too long, as both planets rotate very fast. As a reference value for the C14 in the primary focus, the recording time of a single Avi file should not take longer than about 2 minutes, otherwise small atmospheric

structures rotate by a larger angle than the theoretical resolution of the telescope and thus generate image blurring.

Especially "young" lunar craters, such as Copernicus, Tycho and others show extremely bright crater walls near the terminator, which burn out completely after stacking and sharpening when the exposure time is set to the surroundings landscape and thus appears very unattractive (see illustration below). In such cases, I take TWO files, one exposed accurately on the crater wall and one exposed precisely to the environment. Both sharpened raw sum images are then superimposed in the final image processing in layers (exposure for the crater wall down, surrounding up) and then - in the simplest case - with the "eraser function" in Photoshop the overexposed crater wall is edited.



The picture above shows as an example the crater Copernicus. Left: exposed for the surrounding, middle exposed to the crater walls and right the assembled, final processed image as described above.

... and one last hint:

a good stacked raw image is crucial for the subsequent image sharpening, whatever filter functions are used (I use only the wavelet filtering), and for the subsequent effort in the final image processing.

[Dipl.-Ing Wolfgang Paech in January 2018](#)

Appendix

Two complete online Lunar Atlantes, whose images were taken ALL as described above, can be found at this URL:

<http://www.chamaeleon-observatory-onjala.de/en/chamaeleon-observatory/project-htm/projekt-mondatlanten.htm>

A more detailed description of image acquisition and image processing of these lunar images can be found at this URL:

<http://www.chamaeleon-observatory-onjala.de/mondAtlas-en/bildverarbeitung/bildverarbeitung.htm>

Remarks on the theoretically and practically achievable image resolution of a Celestron 14 at this URL:

<http://www.chamaeleon-observatory-onjala.de/mondAtlas-en/bildaufloesung/bildaufloesung.htm>

At the moment only available in German language

Example images of the moon taken with C14 and Baader Q-Turret Barlow element

http://www.chamaeleon-observatory-onjala.de/de/chamaeleon-observatory/moon-images/mond_web_2017/mond_start_2017.htm

The Baader IR pass filter in practical use

<http://www.baader-planetarium.com/de/blog/baader-ir-passfilter-im-praktischen-einsatz/>

IR pass filter in comparison

<http://www.baader-planetarium.com/de/blog/ir-pass-filtervergleich-planetenfotografie/>

Moon photography in daylight and high sun

<http://www.baader-planetarium.com/de/blog/mondbilder-am-tage/>

Cleaning an Schmidt Cassegrain Telescope

<https://www.baader-planetarium.com/en/blog/baader-optical-wonder-a-real-optical-wonder/>

About Barlow lenses

<http://www.baader-planetarium.com/de/blog/zu-den-brennweiten-verlaengernden-faktoren-von-barlowlinsen/>

Tutorial for video planet photography

<https://www.celestron-deutschland.de/brands.php?BrandID=108>

Tutorial for the video photography of the moon and the ISS

<https://www.celestron-deutschland.de/brands.php?BrandID=108>

Software for collimation of SC telescopes

Note: *The software is written by Mr. Bernd Marquard and creates a transparent image window, which in the foreground e.g. above the live image of a video module. The software has not been modified since 2007 and runs on Windows 7 (I have not tested Windows 10). If the program is installed and started, an HELP window opens when the <F1> key is pressed. Among many other functions there is also a routine for collimation of an SC system.*

<http://www.gosky.de/Software1.htm>