The QHY6 CCD camera and CCDCap v2.6.2
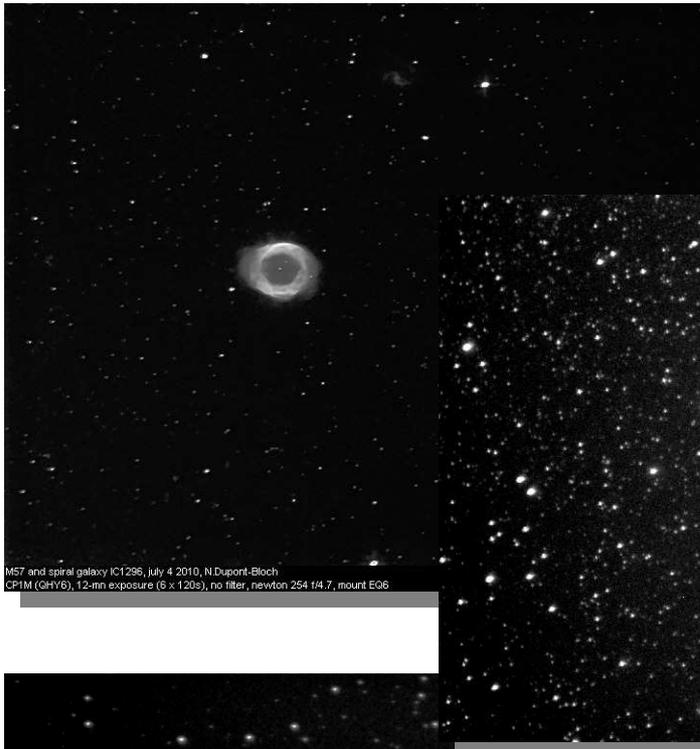
Messier 57 with Newton 10" f/4.7, 6x120 sec

M57 and spiral galaxy IC1296, july 4 2010, N.Dupont-Bloch
CP1M (QHY6), 12-mn exposure (6 x 120s), no filter, newton 254 f/4.7, mount EQ6

Messier 36 with vintage Pentacon 135mm f/2.8 photolens, 1 x 120 sec
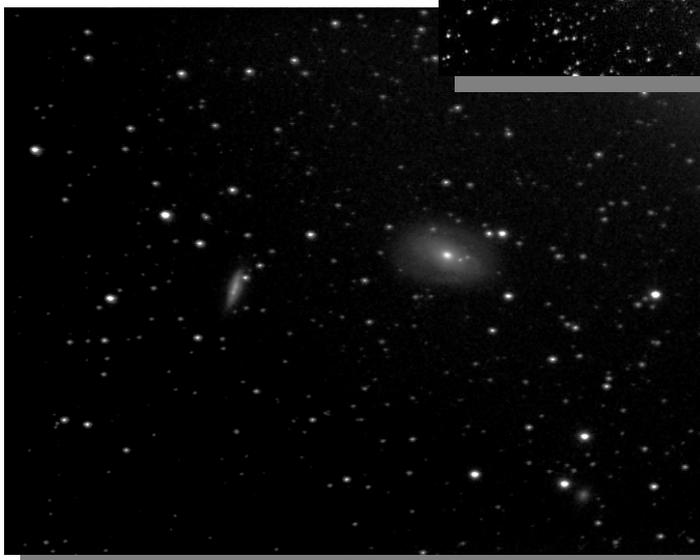
Messier 82 and 81, 135mm f/2.8, 3 x 120 sec

Version 1.2, 11 mars 2011
Text and photos: Nicolas Dupont-Bloch, France (http://nicolas.dupontbloch.free.fr)
This is an amateur contribution under General Public Licence.
🇫🇷 *This document is available in french*

I apologize for my english !
Please report mistakes and improvements to n.dupontbloch (at) free.fr
The ruler on 1st page is in centimeters

1 Summary

This cooled, 16-bit CCD camera is suited for long-exposure, deep-sky imaging on a budget, and for autoguiding with its in-built ST-4™ port. The sensor has a low noise and a good sensitivy to H-Alpha. Since this camera and its associated acquisition software are delivered with little documentation, here is a basic user's manual about the hardware, setup basics, software, and some tips.

2 Specifications

- Sensor Sony™ ICX 259 AL monochrome, interline, interlaced, EXView HAD CCD™
- 0.4 Mpixels (752 x 582), pixel size 6.5 x 6.25 µm, chip size 6x4.96mm
- Quantum efficiency 65% at 560nm, 55% at 650nm
- binning 1x1, 2x2
- anti-blooming –115dB
- exposure from 1/1000 sec, unlimited, electronic shutter
- 16-bit converter
- noise 7-10 electrons (at normal speed 600kpixels/sec)
- Peltier cooling, Δ = -25℃
- USB 2.0, image transfer 600kpixels/sec (< 1 second), 6Mp/s for preview
- in-built ST-4™ autoguider port
- size 60x60x45mm
- weight 275g
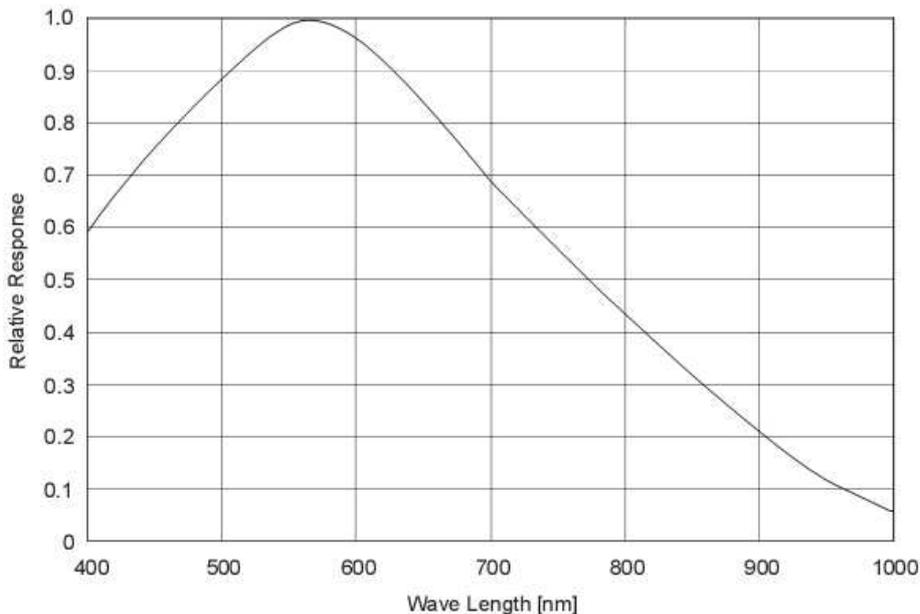
Spectral sensitivity (source: Sony datasheet)

Note the well-balanced curve of the spectral sensivity and a good response at the red, Halpha wavelength (656 nm) emitted by nebulae. In addition, it has a small but non-neglictible near-infrared (NIR) imaging capability.

3 Software installation

The driver, image acquisition software (CCDCap) and plugins for other softwares, are delivered with the camera, or available at astrosoft.be and qhyccd.com. The driver must be

installed prior to connecting the camera. I noticed no trouble at all during this very simple installation.

4 Power supplies

- 12V, from 0.65 to 2 amperes for fan and cooling, if long exposures are planned.
- USB for the sensor and to transfer images to the computer, with or without cooling.

5 Connectors and adaptors

1 = cooling power supply (AC adaptor delivered with the camera)
2 = USB to transfer images to the computer
3 = RJ12 cable to autoguider port of the mount
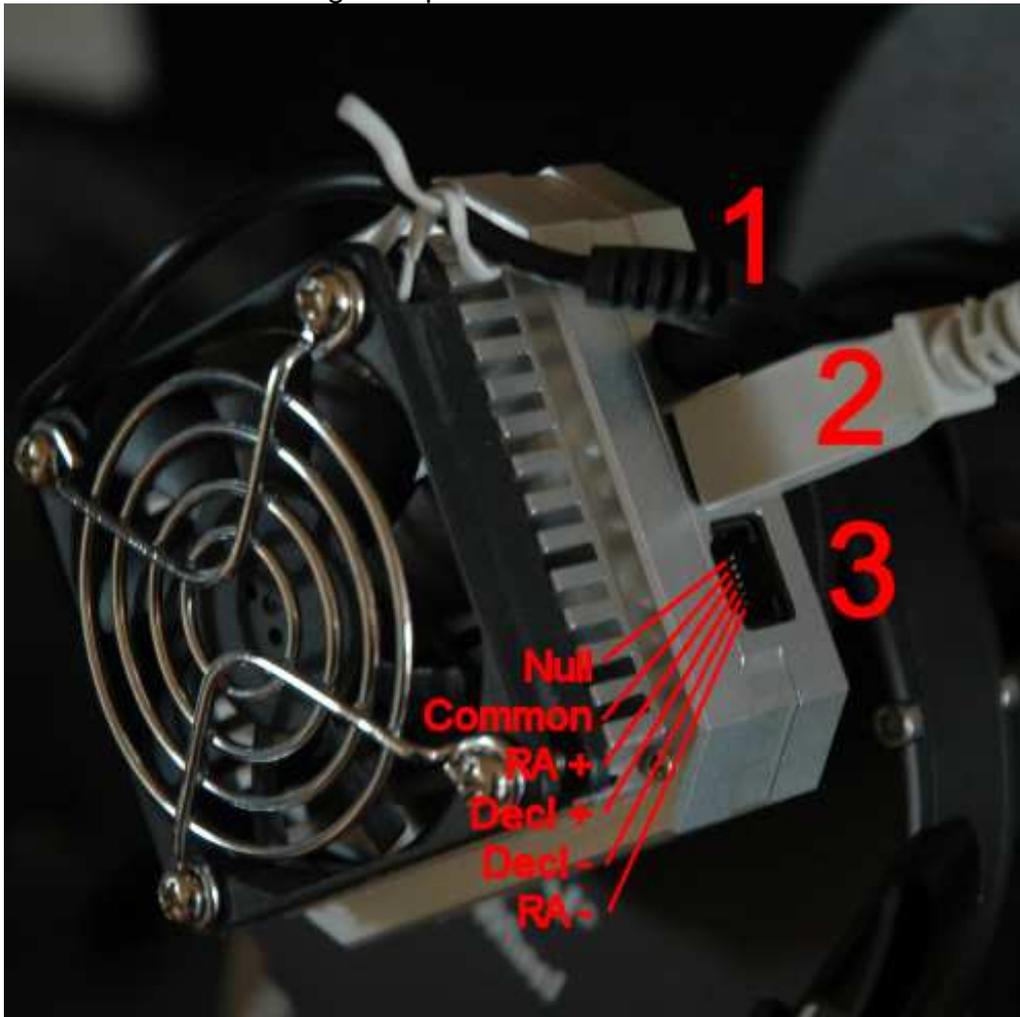
A green LED indicates wether the camera is beeing acquiring an image. The cooler power supply cable is rather rigid and tend to unplug, therefore it has to be secured by a wire attached to one of the screws of the fan grid.

The camera also comes with:
- a removable 1¼-inch adaptor
- a T2 thread (M42 x 0.75)
- a filter thread (M28.5 x 0.5)
An optional 2-inch adaptor is available.

6 CCDCap V2.6.2 acquisition software

This software is delivered with the camera, or can be downloaded freely from qhyccd.com and astrosoft.be.

6.1 Camera selection

Select "0.4 Mpix Camera".

Then click on the "Preview button":

The exposure duration can be set with the cursor. The unit is ms (milliseconds).

A right click on the circled, "+" symbol displays a list of maximum durations:
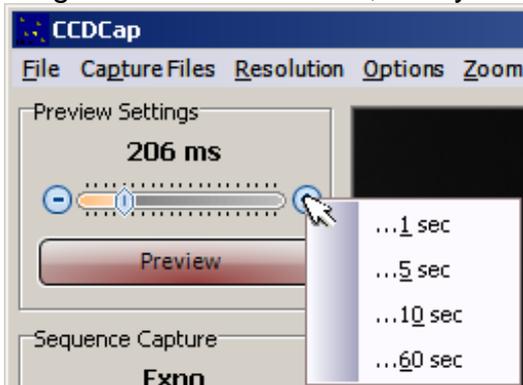
At the bottom right of the main window, a progress bar indicates the preview / acquisition progress:

When completed (or with exposures of less than a second), it becomes red.

6.2 Resolution, binning, VBE/NVBE, High Speed

Select the resolution and binning:
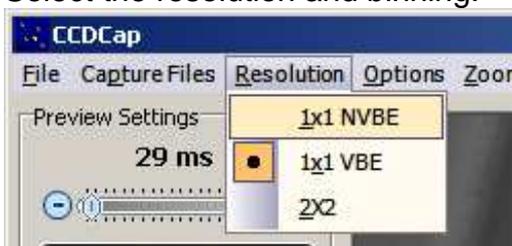
"2x2" is the binning mode: pixels (photosites) are grouped by 4 (2x2) and act as a single, 4x more sensitive pixel. The resolution and the image size are divided by 4, the field of view is unchanged. This is extremely usefull to detect and center a faint object like a galaxy. The 2x2 binning can also been used to quickly acquire color images with RGB filters (or other filters) to add the colors to a black and white, full resolution ("1x1") image.

When the object is in the field, select "1x1" for full resolution and nominal sensitivity. Here is the first mystery: VBE means "Venetian Blind Effect". VBE and NVBE refer to different modes of image processing between its reading and its displaying in CCDCap, because the sensor is "interline".

This cropped image is in "1x1 VBE":	This one is in "1x1 NVBE":
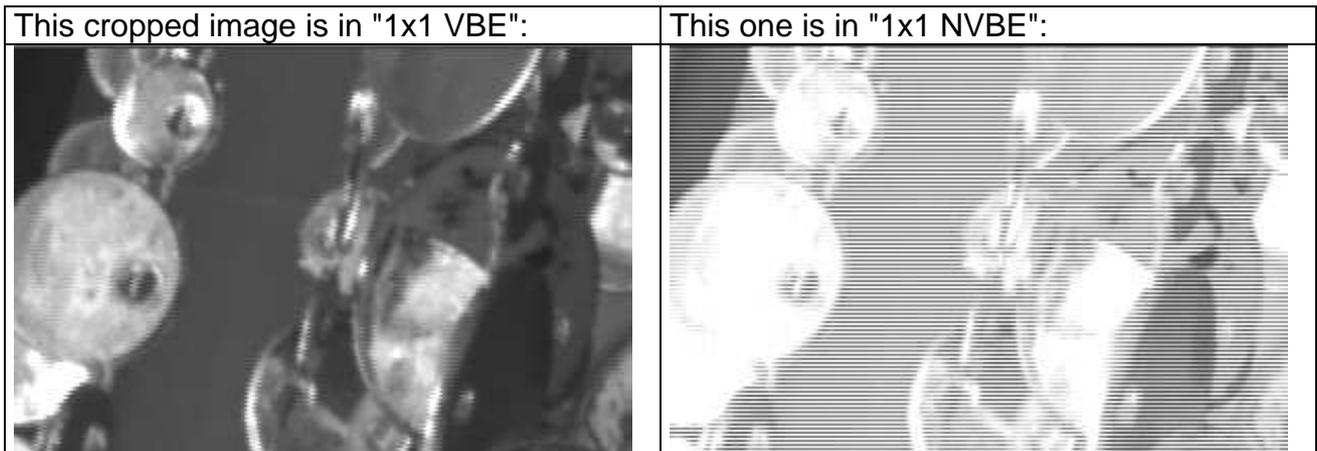
The sensitivity seems to be greater in "NVBE", but a grid of lines is superimposed to the image. Note that this artifact depends on the brightness and can be fixed during processing (e.g. "deinterlace" function) with an external software like Fitswork, Iris, PhotoShop™… The images above are taken at daylight.

The appearance of the image and its artifacts highly depend on the brightness (exposure time, brightness of the subject, f/d ratio). With low brightness, at the evening, the images become closer:

Left: VBE, right: NVBE. The NVBE image is slightly finest:: this is an unaltered, raw image.

In addition to VBE/NVBE/Binning, the option "High Speed" has a noticeable effect on previewing the image and image acquisition, especially in NVBE mode.
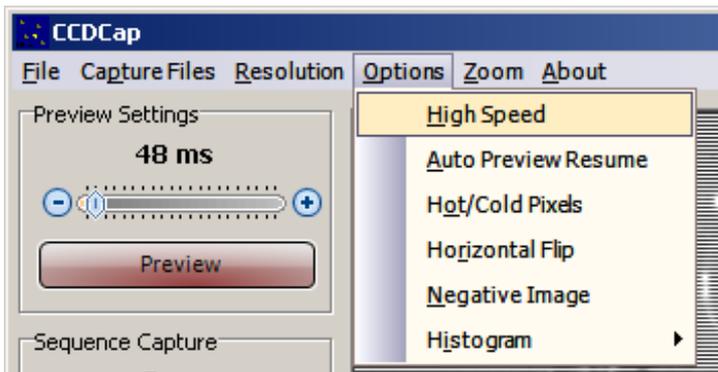
Left: NVBE and High speed checked, right: NVBE and High Speed unchecked.

It is convenient to select High Speed for focusing, but this requires more system ressources of the computer. The image quality is (supposed to be) better with "high speed" UNCHECKED. Nevertheless, interline artifact has to be processed after acquisition.

To conclude, the combination of VBE + High Speed is convenient for (relatively) high speed applications. To begin deep-sky imaging, uncheck High Speed and select VBE. To obtain beter deep-sky images, uncheck High Speed and select NVBE.

7 Histogram

This tool is the reference to adjust the acquisition parameters.
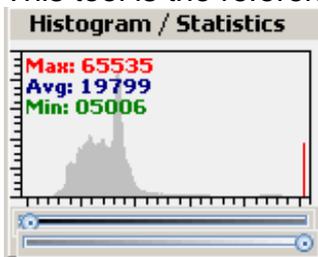
Three values are displayed in the histogram if the button is pressed.

- Max: maximum value of enlightment. The A/D converter of this camera is 16 bits, that means 2^{16} = 65535 is the maximum value before overexposure. This value should never been reached, but if a bright star is in the field.
- Avg: average value, not very usefull because the distribution of the enlightment may vary a lot in deep-sky images.

- Min: minimum value, should be more than 0 to ensure that the weakest values are above noise and detection threshold level.

At the bottom right of the plot, the vertical red line, if any, indicates that the sensor is overexposed. Furthermore, the Max value is displayed in red. One can ignore it if a bright star is in the field, but most values should be located near the center of the plot.

Since the sensor is interline and has an efficient antiblooming (ABG) capability, an overexposure will not propagate to next pixels. The ABG is extremely useful to obtain good images if aesthetics is the goal, but is not a good choice at all for photometry (the values are uncertain). The ABG cannot be set off (due to the hardware design), so this camera can not be used to seriously study light curves of variable stars, exoplanets or novae.

If the menu option "Option / Histogram / Autocontrast" is unchecked, the horizontal cursors reduce or expand the levels; this is to adapt the contrast to the subject. A strong reduction is equivalent to reducing the resolution (number of bits) of the A/D converter.

Soft image:

Max: 65535
Avg: 16367
Min: 04205

Strongly contrasted image:

Max: 65535
Avg: 15754
Min: 04165
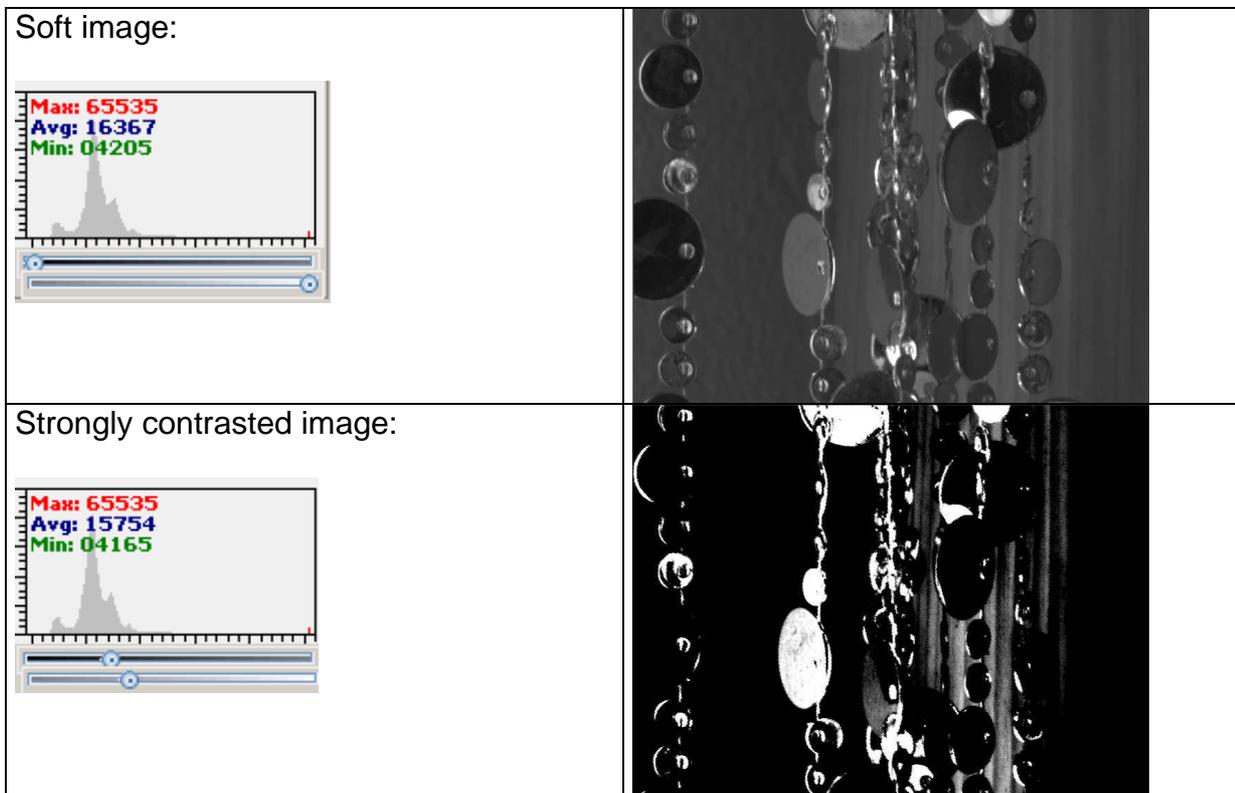
Note that the values distribution plot, the Max, Avg and Min values are poorly affected, or unaffected, by the cursors settings.

A (technically) perfect exposure is achieved when the Min is a little number, but greater than 0, and the Max is slightly less than 65565, like that:

Max: 56789
Avg: 06807
Min: 02531
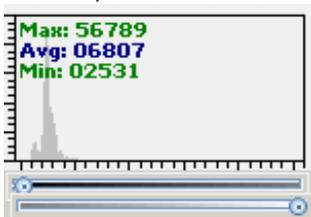
The Max value is now displayed in green. In such conditions, the cursors may be used to conveniently adapt the contrast of the image displayed to the contrast of the subject.

These settings affects both the saved image and the displayed image.

8   Oher options

Click on the menu options:

8.1   High Speed

This has been previously discussed; it is usefull while previewing but should be unchecked for acquisitions.

8.2   Auto Preview Resume

If checked, returns to the preview mode after acquisition.

8.3   Hot/Cold Pixels

If checked, removes hot and cold pixels. Usefull in some cases, but perhaps not very reliable. Nevertheless, hot and cold pixels can be correctly removed are cleanly removed with an external software (e.g. DeepSkyStacker) with dark subtraction and median stacking. This processing, which is standard for all CCD cameras, is not explained in this document.

8.4   Horizontal Flip and Vertical Flip

Help to center the field when compared to a sky map. Simultaneous H and V flip can simulate a rotation of the camera when adjusting the field of view.

8.5   Negative Image

Inverts black and white. Human eye is more able to distinguish black faint shades on a white background. Very usefull to detect galaxies and nebulae while previewing and centering. This operates on both preview and saved images.

8.6   Histogram / Autocontrast and Histogram / Stretch Histogram

Expand, in two slightly different ways, the distribution of low and high values. They act on both displayed and saved BMP images, but very few on saved FIT images. These two options can be combined. They are usefull to detect a faint object in preview, and to ensure that most values are above noise and below saturation. The "Autocontrast" disables the cursors of the "Histogram / Statistics" plot of the main windows.

9 Gain and Offset
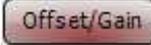
This button [Offset/Gain] displays a little window with two cursors:

GAIN: 100% ⊖ ▭▭▭▭◇ ⊕
OFFSET: 100 ⊖ ▭◇▭▭▭ ⊕
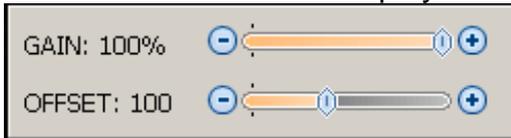
Adjust the GAIN cursor to 60, then perfectly cover the camera / optics with a cap so the sensor receives no light. Uncheck the menu "Option" / "High speed" and select the menu "Resolution" / "1x1 NVBE".

The OFFSET is a constant value added to the signal. It garantees that the lowest values of the image are not concealed in the noise. The offset setting depends on each sensor because of tiny dispersion while building the sensors (on the wafer). Start the cooling, wait 10mn, then increase the offset from 0 until very little light appear in the image (a kind of "light black"). After the dealers, the offset is said to be correct between 100 and 120 (for this camera); mine is set to 100. The GAIN can be adjusted during acquisition; 60 is a good value to start.

10 Square pixels
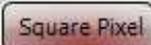
The button [Square Pixel] resizes the image because the sensor has ALMOST square pixels (6.5 x 6.25 µm). This affects only the aspect of the displayed image. During post-processing, the aspect can to be corrected by multiplying the vertical size by 1.04.

11 Focus
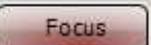
The button [Focus] creates a windows which greatly helps to focus during preview:
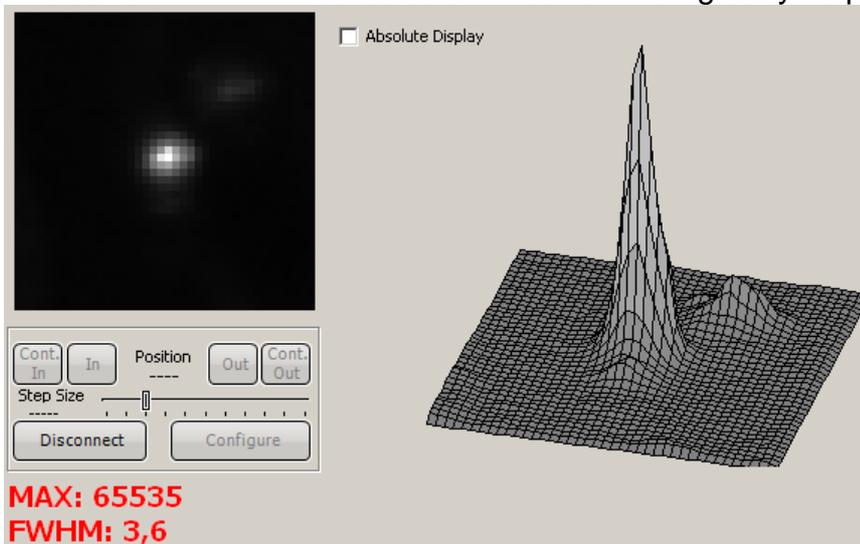
A left click in the image sets the area zoomed in the Focus window. Max is the value of the brightest pixel of this area. The 3D plot at right represents the brightness of the area. The goal is to have a tall, thin peak corresponding to a star. If Max is 65535, the sensor is overexposed, the peak is truncated and the FWHM has no meaning. In such a case, select a fainter star or decrease the exposure duration.

If the check box "Absolute display" is unchecked, the peak height is not proportional to the MAX, but it is more visible if the star is rather faint.

The FWHM (for Full Width at Half Maximum) is the measurement of the peak width at half its height; that is an extremely convenient way to know how a star is in focus. The unit is pixels. The FWHM should be as small as possible. For deep-sky imaging with usual turbulence, a FWHM of 4 is normal for an intermediatly bright star.

A fine image depends on both the FWHM and the sampling (in arcseconds per pixel). With a small telelens, e.g. 135mm, a star with a FWHM of 3 is rather quare. With a 1000mm focal length, a star with a FWHM of 4 is rounded, more natural.

If an electric focuser is connected, the software can remotly control it through the ASCOM protocol. If no ASCOM motofocuser is connected, theses buttons remain effectless (grayed).

12 Reticles

These buttons display two kinds of mutually exclusive reticles. The first may help to manually center a star if the camera is used as a manual autoguider, i.e. it acts like a reticled eyepiece. The second helps to center the subject in the field. The reticles are only visible on the screen, not in the saved images.

13 Image acquisition

13.1 Image format

CCDCap is able to save an image in two flavours:
- BMP (for BitMaP) is a Windows™ image file format. It contains 255 gray levels since this camera is black and white, but a BMP can contains color information in 3x8 bits for Red, Green and Blue.
- FIT (= FITS, for Flexible Image Transport System), a file format designed by the NASA and Goddard Space Flight Center for astronomical purposes. Extremely pregnant, it can contain multidimensional arrays, information on row and columns, and a text description. The FITS format is used for institutional equipments (Hubble Space Telescope, Subaru, Spitzer space telescope…) and amateur astronomy. Numerous softwares et freewares can manipulate FIT files (DeepSkyStacker, Fitswork, Iris…). The NASA provides viewers, manipulation software and extensions for Windows™, Unix, PhotoShop™... See http://fits.gsfc.nasa.gov.

13.2 BMP image acquisition

This is the simpliest way to save an image, either a preview or a long-exposure acquisition. Select the menu File / Save as BMP:
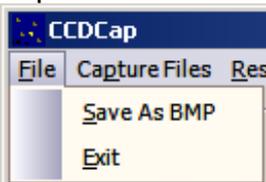
Then choose a directory and enter the file name.

13.3 FIT image acquisition

This option does not work with a preview image. The first setting is the exposure duration in the "sequence capture" frame:

A left click on ms/sec display a list of duration units: milliseconds or seconds.
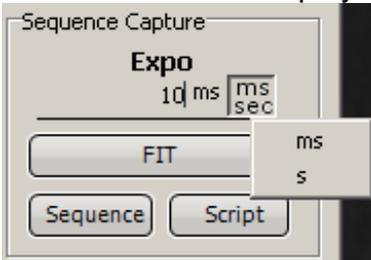
Then click on the value ("10" here) and enter a new one if necessary.

A right click on the little ms/sec button displays a liste of maximum durations.
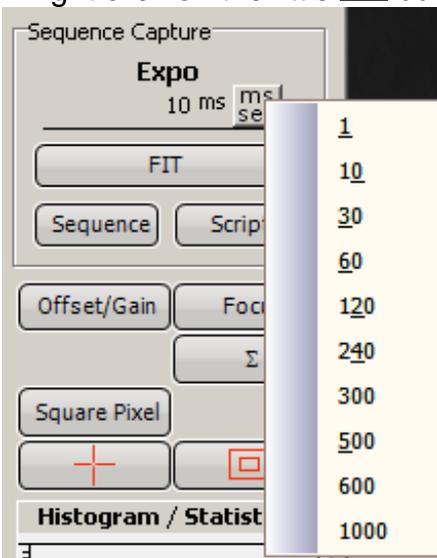
The combination of the unit and maximum duration allow to choose between 1ms and 10,000 seconds. A deep-sky, long exposure requires the cooling device and the fan to be active (with A/C adaptor plugged) in order to reduce the noise in the image.
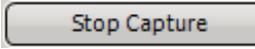
Now click on FIT which becomes Stop Capture when the image is beeing acquiring. At the bottom of the main window, a progress bar indicates the completion: 26%.
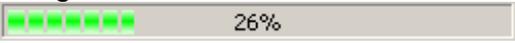
When completed, the image can be saved with menu option "Capture Files" / "Snapshot (FIT)":
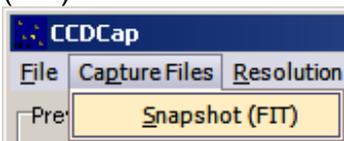
13.4 Sequence capture

CCDCap is able to automatize a sequence of captures. Although this feature is not documented, it is simple and usefull. Click on Sequence and an array is displayed:
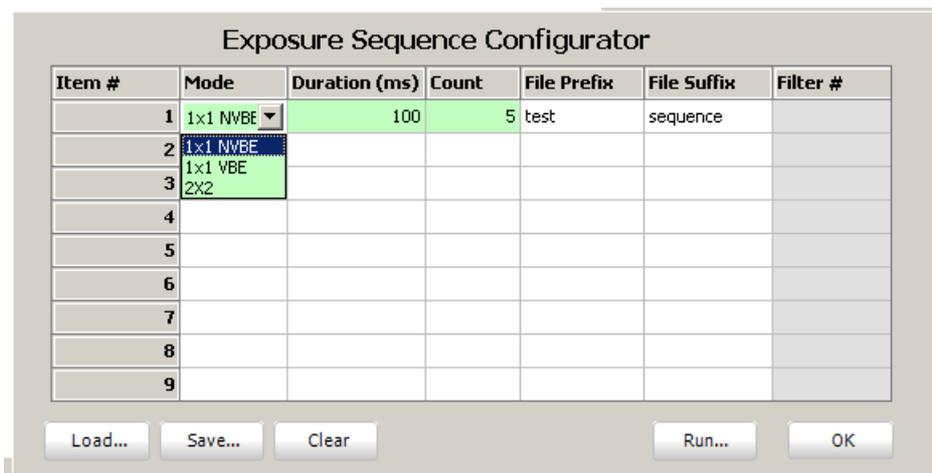
- Mode: a clickable list to chose the acquisition mode and binning.
- duration: exposure duration in milliseconds.
- Count: the number of images to automatically acquire while the astronomer is in the living room, drinking liters of coffee.
- File prefix: the beginning of the images files names.
- File suffix: the end of the images files names.
- Filter: seems to be related to an ASCOM motorized filter wheel. Not tested, mine is manual.

If necessary, Use the arrows keys of the keyboard to shift the array in its window.

When the array is completed, click on [Run...], on [Sequence] to cancel. A sequence can be saved, loaded and cleared with the appropriate buttons.
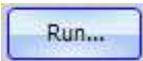
Here is another mystery: [OK] displays an error message, and does not seem to be very usefull.
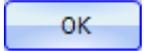
While acquiring a sequence, the progress bar indicates the completion of each image (if the duration of the exposures exceed 1 second). The images are, of course, automatically saved.

The file names are built with five elements:
- the file name entered in menu option "Capture Files / Snapshot (FIT)"
- the prefix in the sequence array
- the suffix in the sequence array
- an automatically incremented number
- the extension .FIT

The result will be : prefix + file name + suffix + automatic number + ".FIT".

13.5 Script

CCDCap is able to interpret scripts to control the camera. Absolutely no documentation is provided at this time, but qhyccd.com has a forum which includes some entries about it. Scripts are close to BASIC language and include, of course, specific commands and parameters for each camera.

14 Humidity and cleaning

In case of EXTREME humidity, insert a silicagel bag through the hole on the side of the camera. This hole is closed by a rubber cap. Appropriate silicagel bags can be purchased from the camera's dealer.

The sensor is protected by a glass window. If grease is on the window, Sony™ recommend to gently clean it with ethyl alcohol and a cotton bud. The sensor is surrounded by a piece of foam which hangs the cotton. Teezers and a brush can help to remove the remaining cotton fluff, but this is tedious.

Dust can be removed with an air blower.

Never touch the electric parts because they are very sensitive to static discharges.

15 Can this camera be used for planetary imaging?

Since the ICX 259 AL sensor is "interlaced", it reads odd then even lines. This takes a while, wherein the atmospheric turbulence (and the telescope vibrations) can result in a little motion or geometric disturbance of the subject. Therefore, the first and second half images, acquired in two passes, are slightly different. In other terms, an interlaced sensor is unable to acquire fast motion images, like a planet with a long focal length.

Note: "interlaced" is not to be confused with "interline". Interline refers to the insertion, betwen the photosensitive lines, of lines dedicated to fast transfer of the image lines to the converter. This is in opposition to reading all the matrix (Full Frame Transfer). Interline is used by both "interlaced" sensors (for broadcast video cameras), and "progressive scan" sensors (for high velocity images and TVHD). "Progressive scan" sensors are able to transfer the image quickly; each pixel can be adressed separately, and, most important, the lines are read in the correct order.

For example, the Sony™ ICX 285 AL is "interline progressive scan" while the ICX 259 AL is simply "interline". What is not said in the datasheet (technical reference documentation from the manufacturer) is that the ICX 259 AL is interlaced, because it is primarily intended for non-TVHD, CCIR video cameras which are always interlaced. Nevertheless, regarding its qualities, using it in a deep-sky camera is absolutely relevant.
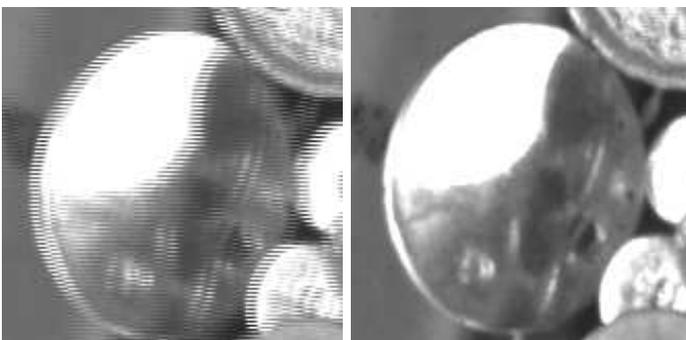
Left: shaky camera, right, steady camera. These images clearly show the undesirable effect of an interlaced sensor with short exposures on high motion subjects.
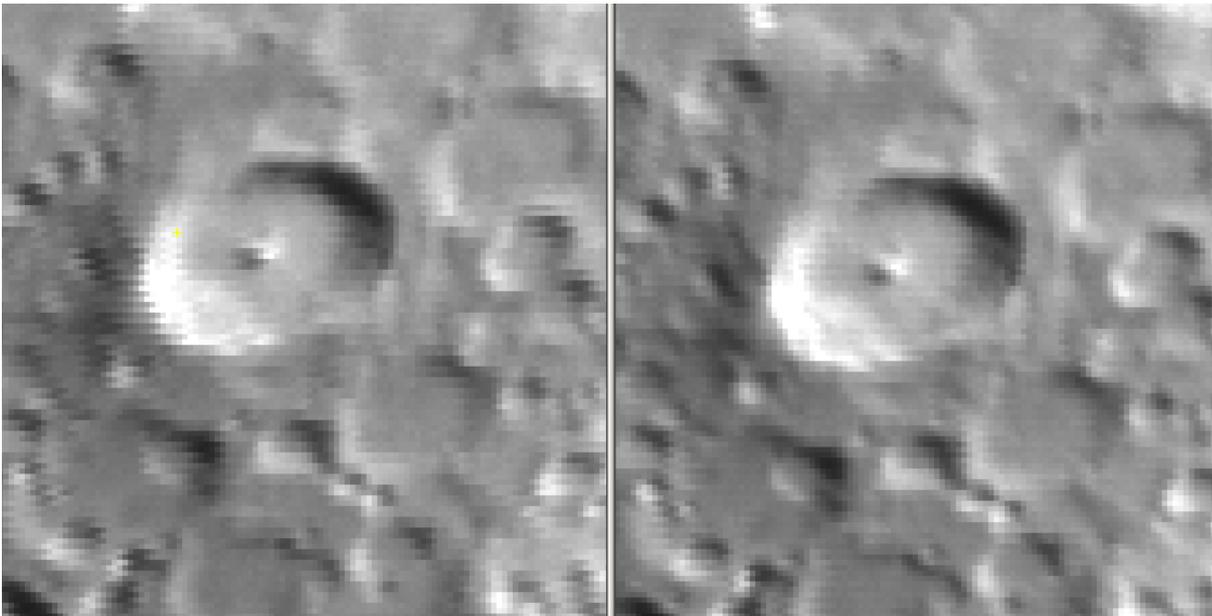
These images (high magnification, zoomed) are separated by a few seconds. At left, the turbulence is more important. The turbulence shifted odd and even lines during the two-time reading process of the interlaced sensor.

This can also affect deep-sky, long exposure images if the telescope is not perfectly steady (shaky tripod, weak mount, wind), if the focal is too long, or if there is noticeable turbulence. But, in this case, this undesirable phenomena is wiped out by the blurring effect of the light accumulation on neighbour pixels.

To conclude, such a camera is not suited for planetary imaging, except for some peculiar applications:
-   short-exposure, medium focal length, wide-field imaging of the Moon, with limited resolution (but high contrast).
-   large solar prominences with limited magnification.
-   Near infra-red, medium exposure duration imaging, with limited magnification and a rock-stable mount, for Jupiter and Saturn which generously span 40 to 45 arcseconds.
-   short-focal and wide-field imaging of the satellites of a planet.

16 Interesting links and softwares

www.m42optic.fr (importer and dealer with active support)
www.qhyccd.com (manufacturer / support forum)
astrosoft.be (CCDcap, drivers and plugins)
qhy.narod.ru (QHY6capture)
freenet-homepage.de/JDierks/ (FitsWork)
deepskystacker.free.fr/ (DeepSkyStacker)
www.astrosurf.com/~buil/iris/iris.htm (Iris)
fits.gsfc.nasa.gov (FITS info, plugins, softwares)
www.stark-labs.com/ (PHDGuiding)
www.guidemaster.de/ (GuideMaster)

17 Conclusion

17.1 Advantages

With a conveniently balanced spectral sensivity, this camera is suited to imaging galaxies, compact clusters, planetary nebulae, and details in diffuse nebulae.

The NIR sensitivity allow to begin the exploration of new views of deep-sky objects (carbon stars, multispectral imaging), mid-duration exposures at limited magnification of Jupiter and Saturn in invisible wavelentghs.

The small, 1/3 inch matrix allow the use of any low F/D telescope, even without field corrector. Coma or vignetting does not appear.

It provides soft, aesthetic images with very little pre- and post-processing (16-bit converter, cooled, interline and antiblooming sensor).

With its in-built ST-4™ autoguider port, this camera can be used as a high-performance autoguider, without re-centering the guiding optics. Therefore this camera can have a second life wether it is replaced by a bigger one.

The power supply is reasonable: USB for the sensor, 12V @ less then 2A for cooling.

17.2 Drawbacks

Due to its interlaced, non-progressive-scan sensor, this camera is weakly convenient for high-speed imaging of the planets, Moon and Sun.

The antiblooming forbids serious photometric studies.

The interlaced sensor create noticeable (but fixable) artifacts.

The small matrix is not suited to wide-field imaging, so large nebulae and some large open clusters are out of range (in high resolution).

Very little documentation.

17.3 In a few words

This camera is a unique bargain to try, or to begin deep-sky CCD imaging on a budget. It is also an very reliable autoguider.

*The CP1M / QHY6 with a 135 f/2.8
photolens and a manuel filter wheel.*