Getting Started with MaxIm DL 6

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Chapter 1. Welcome

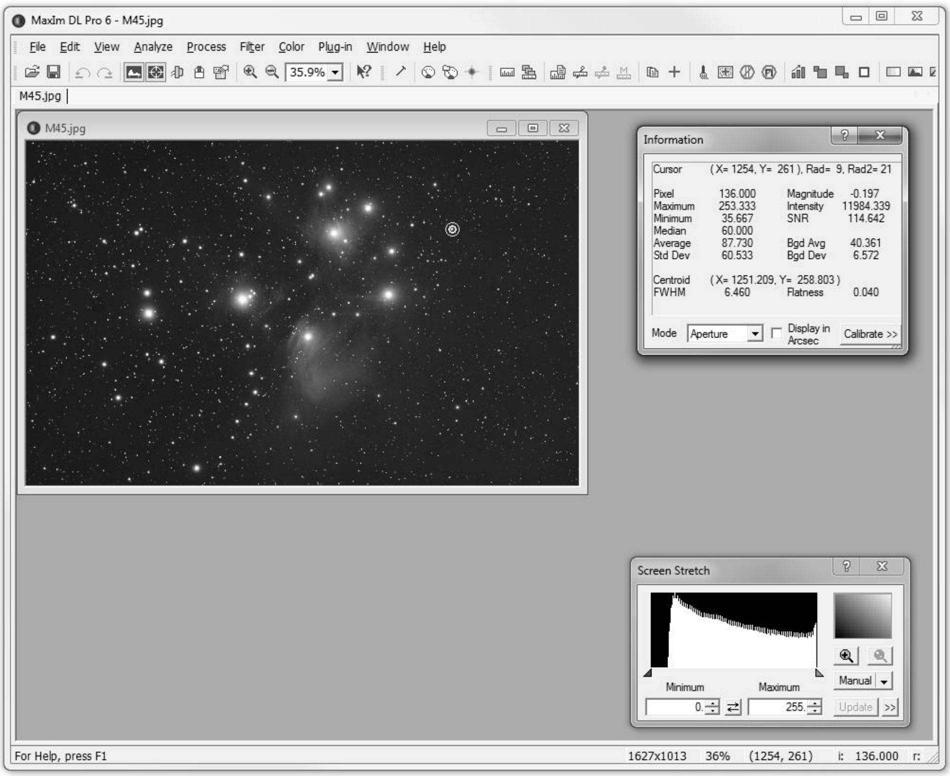
Congratulations, and thanks for choosing MaxIm DL Version 6 for all of your astro-imaging needs! MaxIm DL supports the acquisition of image data with CCD, DSLR, and streaming cameras through a wide variety of proprietary plug-in drivers, third party plug-in drivers, and ASCOM drivers. MaxIm DL also controls a variety of imaging related hardware (telescopes, focusers, etc.) supported by ASCOM drivers. Also included are many powerful image processing and analysis features.

This Getting Started Guide will get you up and running, with a focus on 'pretty picture' deep-sky imaging, in no time at all. Full documentation, including advanced subjects such as scientific imaging, can be found in the Help Topics document available through the program's Help menu. Let's begin with an overview of MaxIm DL 6.

Chapter 2. Overview

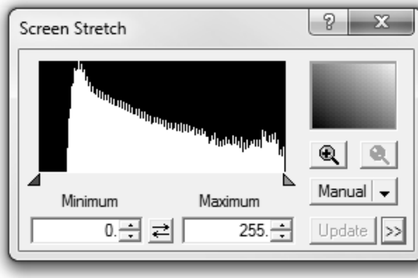
The Workspace

Let's familiarize ourselves with MaxIm DL's user interface. Note the dropdown menus and customizable toolbars up top, providing handy shortcuts to many tools via the colorful icons. We recommend leaving the Screen Stretch and Information windows (View menu) open most of the time.



Screen Stretch

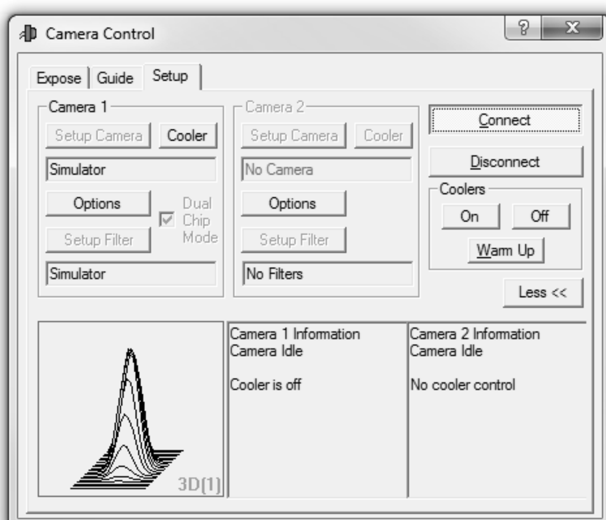
Un-manipulated images are 'linear' by nature. This means that the brightness value of each pixel is the same as originally recorded by the camera. Since this translates to a very dark image, it must be 'stretched' in order to view it effectively. The Screen Stretch Window applies a *temporary* brightening of the image so that various repairs may be performed on it, before permanently altering its linearity. As you observe Screen Stretch's Histogram (pixel graph), experiment with the red and green sliders and drop down menu selections to dial in the temporary visualization. Perhaps the easiest way to do this is with the Quick Stretch feature. Placing the mouse cursor in the gray box at upper right of the Screen Stretch window, hold the left mouse button down while dragging up-down/left-right.



You can also accomplish this directly in the image window, by holding down the Shift key while dragging the mouse.

Acquisition

Astrophotography tasks begin with acquiring image data, and you'll use the Camera Control window to operate your camera. The Setup tab is where you'll connect to the camera during imaging sessions. The Guide tab presents flexible settings for fine-tuning the autoguiding process. The Expose tab controls image acquisition. With your system properly setup and running smoothly, you'll collect sharply focused pictures with tight, round stars.



Stacking

Artful astro-images require multiple subexposures to be calibrated, aligned, and combined into master frames. MaxIm DL automates this task with two powerful yet easy to use features – the Process menu's Calibration Wizard, and Stack.

Linear Processing

As noted, repairing an image while still linear can be very effective. Two tasks that come to mind are the Filter menu's Deconvolve, and Flatten Background. Once applied, master frames are ready for permanent stretches.

Nonlinear Processing

MaxIm DL offers a variety of post-processing tools for turning image data into beautiful pictures. Once nonlinear stretches are applied, you can reduce noise, saturate color, and sharpen fine detail to enhance your images.

Chapter 3. Close-Up

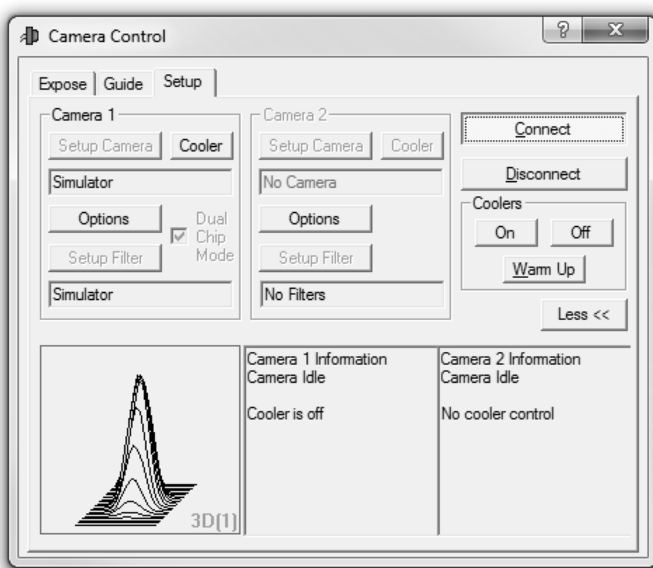
Now that we've seen a brief overview, let's take a closer look. For the complete picture, remember to refer to the program's Help Topics document, and consider joining our Yahoo user group.

Camera Control

Open the Camera Control Window, using the View menu or the View toolbar's camera icon.

Setup Tab

- Click Setup Camera, and providing the camera is installed correctly, select your model from the dropdown menu.



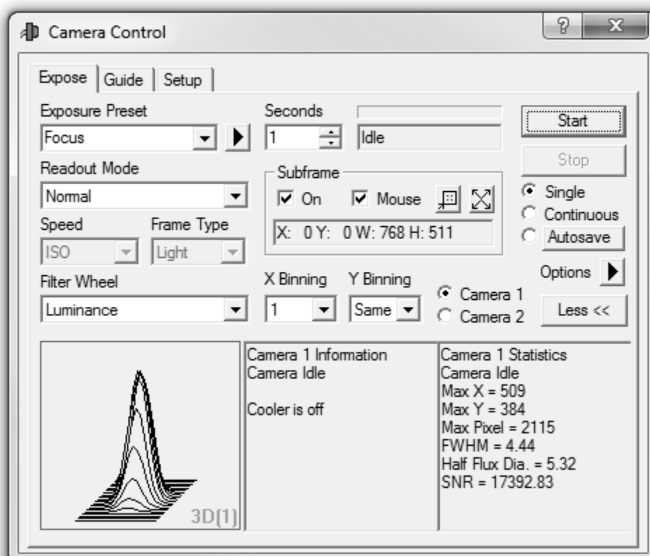
- Camera-specific preferences can be entered in the window.
- When finished, click OK.
- Additional camera settings are available for each camera by clicking the Options button.
- Click Connect. Providing all goes well, MaxIm DL will report status information below.
- If your camera has a thermoelectric cooler, turn it on with the 'Coolers' controls at right. MaxIm DL will report the Setpoint and current temperature of the sensor in Celsius

below.

- To alter the Setpoint, click 'Cooler' at left under Camera 1 or Camera 2.
- At the end of a session you can use the Warm Up button to gradually turn the cooler off, or just turn it 'Off' if you wish. (Only cameras with very high cooling power require gradual warm-up.)
- Don't forget to Disconnect from your camera before closing the program.
- If yours is a monochrome camera, you'll want to set up your filter wheel on this tab as well. Click Setup Filter to select your filter wheel model and enter your specific filter names in the correct order.
- You can practice using most aspects of the Camera Control Window by choosing the camera and filter wheel 'Simulator' for a dry run.

Expose Tab

The Expose tab controls the camera's acquisition of light frames (pictures) and calibration frames through different filters. Depending on your camera type, some options may not be available.



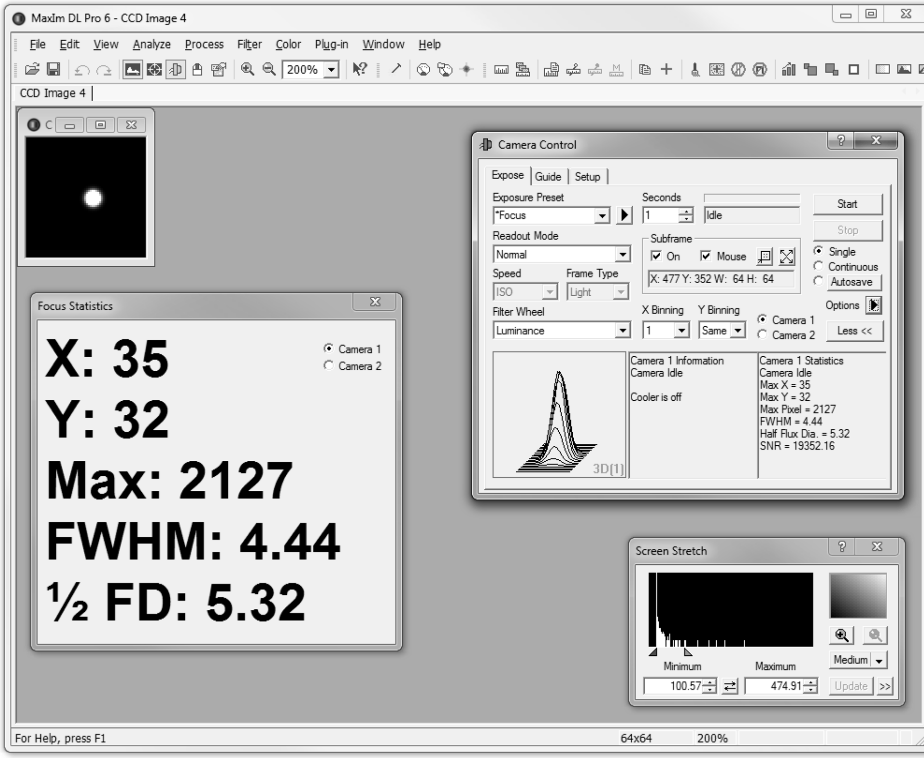
- With the exposure time at the default 1 second, hit Start – as the image downloads, you've just taken your first exposure with MaxIm DL.
- Exposure time is changed via 'Seconds' (i.e. 300s = 5 minutes).

- A 'Single' image will be taken unless you choose 'Continuous'.
- When Continuous is selected, MaxIm DL will continue taking images until you press Stop.
- CCD imaging is generally done at Binning 1, where each pixel works independently of one another. X and Y Binning are typically set to the same value (i.e. 1x1).
- Lower resolution bin modes (i.e. 2x2, 3x3) are often used for specific tasks such as focusing or centering a target. A binning of 2x2 would cause four pixels to be read as a single pixel, resulting in a lower resolution, but slightly more sensitive 'superpixel'.
- Set the specific filter to be used with 'Filter Wheel'.
- Exposure Preset can save, edit, and recall settings you use often. (Tip: the presets available now are merely examples – you can change or replace them entirely.)
- Clicking Autosave opens the Autosave Setup window.
- Typical deep-sky imaging sessions would take advantage of this option, letting you specify the number and type of images desired, and where you want the images to be saved.

Focusing

Focusing the telescope is of critical importance, and the Subframe option is particularly useful for this.

- With 'Single' selected, take a short image.
- Drag the mouse to place a small box around a suitable star in the downloaded image.
- Turn on Subframe to utilize the focus box. Due to the very fast download time required for the subframe, MaxIm DL will be able to report focus changes almost instantaneously below.
- Select Continuous exposures.
- Adjust the exposure time as needed. Shorter exposures will result in faster download speeds and prevent the star from becoming saturated.
- Choose Options/Display Large Statistics to best view the Focus Statistics window.
- As you focus, watch for the highest Max value and the lowest FWHM and 1/2 FD values.
- When you are getting close, watch several images and note the best result – a single focus exposure can be affected by poor seeing so look for the good ones.
- Click Stop when best focus is achieved.



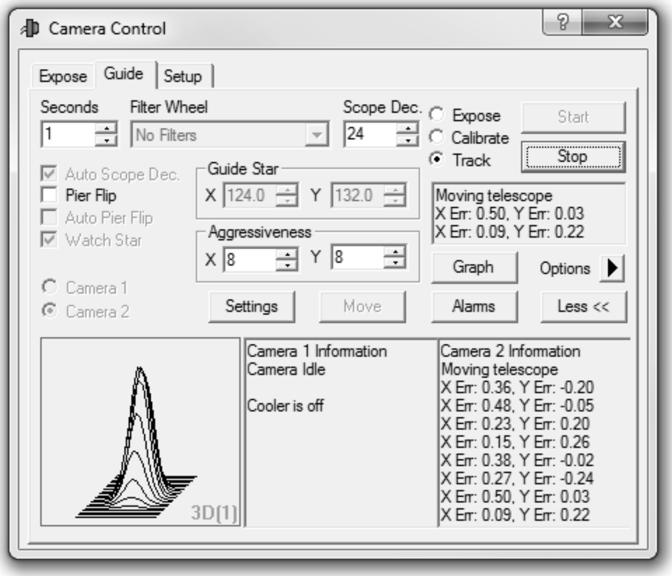
Guide Tab

Long exposure, deep-sky imaging typically requires autoguiding. Maxim DL has been the preeminent software for tackling this challenging task, and the Guide tab offers many flexible settings for fine-tuning the process. Refer to the Autoguiding Tutorial in Help Topics to get started.

The trick is finding a suitable exposure time for a chosen guide star – neither too long, nor too short – and to find the Aggressiveness and other settings that work best with your mount.

- On the Guide tab, choose Expose and click Start to take and download an image.
- Switch to Calibrate and click Start again.
- When the calibration cycle completes successfully, you'll see red lines tracing the star’s motion. If you see an “L” shape then everything worked perfectly.
- Should calibration fail, click the Settings button to open the Guider Settings window.
- Switch the mode to Track and click Start.
- Guide errors in both RA and Dec will be reported below.
- Be sure Autoguider Output/Control Via is set in accordance with your system.

- If successful calibration is not achieved, try increasing the 'Cal. Time'. The star must move a sufficient number of pixels for a given focal length during calibration.
- Tip: there is an Autoguider Troubleshooting section in the Help, see Contents / Imaging with MaxIm DL / Autoguiding.
- To record corrections made to the mount, open a graph by clicking the Graph button.
- Additional options are available under the Options arrow.



Stacking

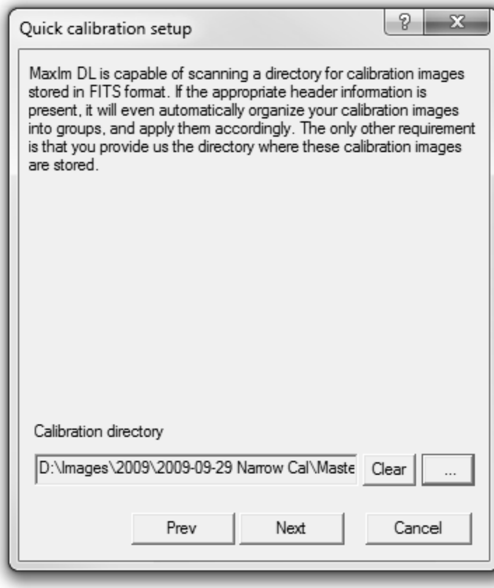
Whether a One-Shot Color (OSC) or monochromatic camera, you'll want to shoot several images. The inherently dim and noisy individual images can then be combined to produce smooth master images, devoid of significant noise – even in background sky and extended wisps of nebulosity. Consider taking a minimum of 9 exposures.

Unfortunately, combining isn't as easy as just adding subexposures together. Read the Help Topics for information on how Calibration Frames, including Darks, Biases, and Flats, can improve your images. When the Light Frames are reduced by these special frames, they can then be 'stacked' for optimal results. MaxIm DL automates this process, with little interaction required from you!

Calibration Wizard

The Process menu's Calibration Wizard automatically finds and groups your calibration frames by type. If you're new to imaging, start with the Wizard. You can switch to Process/Set Calibration later if you wish.

- Simply point the Wizard to the folder containing your Dark, Bias, and Flat frames. There's no need to separate your calibration frames by type. They can even be in the same folder as the Light frames. Click Next, then Finish.
- You may check the View calibration details box beforehand, to see the Wizard's work.



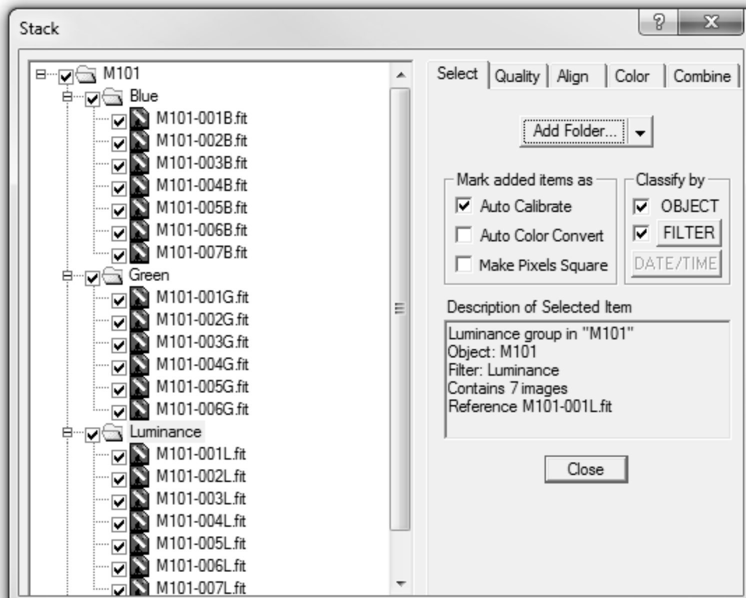
Process/Stack

With calibration frames in place, move on to Stack, also found under the Process menu. Stack is just short of miraculous. Stack can measure the quality (roundness and FWHM) of the stars in your images to weed out poorly guided or defocused subexposures. Using the calibration groups created by the Calibration Wizard (or Set Calibration), Stack will first calibrate the Light frames, and in the case of One-Shot Color, perform a high-quality color conversion (aka: Debayer). Stars will then be accurately aligned to their counterparts in the other subexposures before the images are combined into a final Master (or L, R, G, B, etc. Masters). Let's see how it's done.

Select Tab

- Under 'Mark added items as', select Auto Calibrate. If your images were taken with a One-Shot Color camera, also select Auto Color Convert.*
- On the Select tab, choose Add Files. Shift-Click to include all of your Light frames, and click Open.
- Depending on how many images there are, they may take a moment to load.

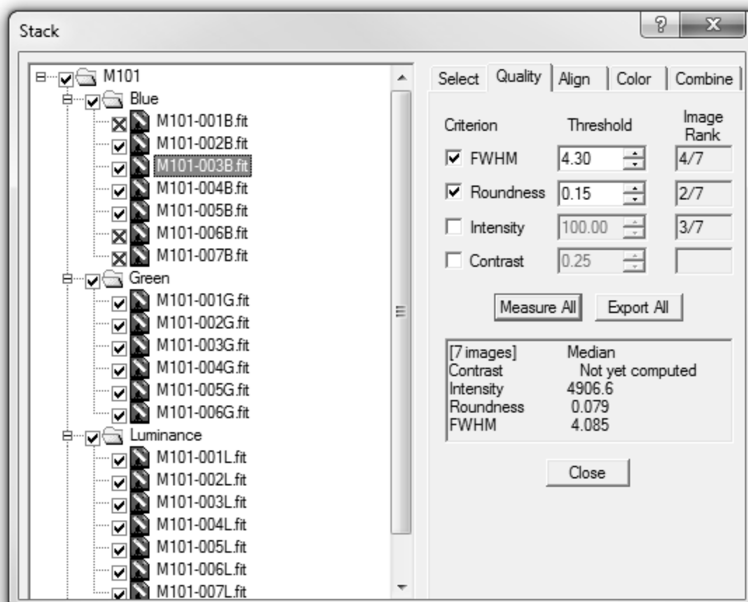
* Before you can use Auto Color Convert, you must set up the color conversion settings using the Color menu's Convert Color command. For OSC Flats be sure to open Set Calibration and set the Flat group's "Flat Norm." setting to "Boxcar Filter" or "Bayer Planes".



Quality Tab

If you'd like to measure the quality of your images, select this tab next.

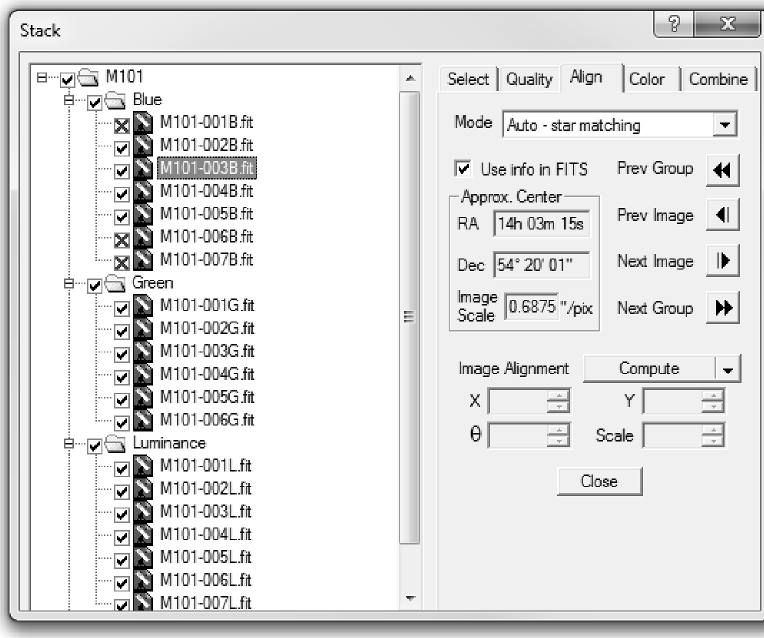
- Open the file tree by clicking the little '+' sign to reveal the individual images – by default, they're all enabled (checked).
- Choose any or all of the four criteria you'd like analyzed, and click Measure All.
- MaxIm DL will rate each image based on the chosen Threshold, and provide an Image Rank of each subexposure with respect to the other images in the list.
- If checkmarks replace the red '?', you're good to go. If, however, a red 'X' appears next to an image, it has failed the Threshold criteria and will not be stacked.
- You can view an image by right-clicking on its file name and choosing Display Image. (Tip: set Auto Display so that any image you click on will display automatically.)
- If you determine that a rejected image looks good enough to include in the stack, simply click the red 'X', changing it to a check mark.



Align Tab

Next comes alignment.

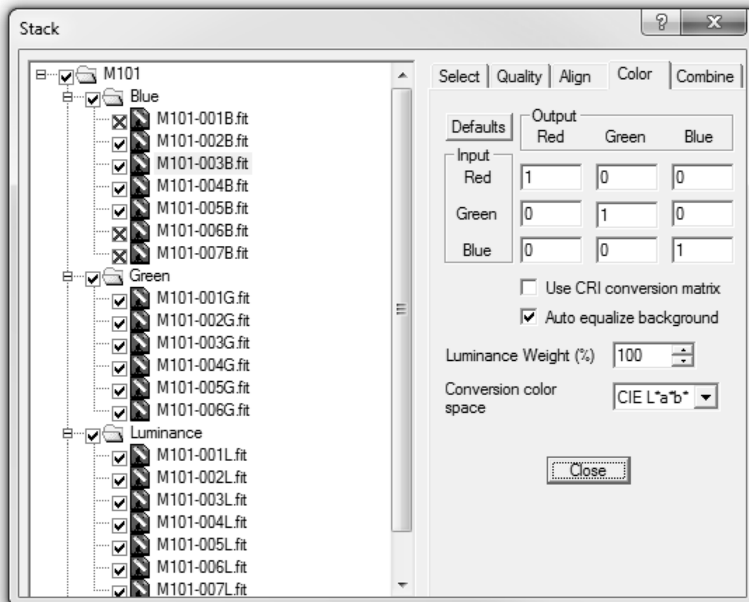
- In most cases, choose Auto – star matching.
- PinPoint Astrometry provides the most accurate and reliable alignment but requires some additional setup.
- For manual or special scenarios, consult the Help Topics.



Color Tab

When working with One-Shot Color cameras, or with monochrome images without filters, this tab will be grayed out.

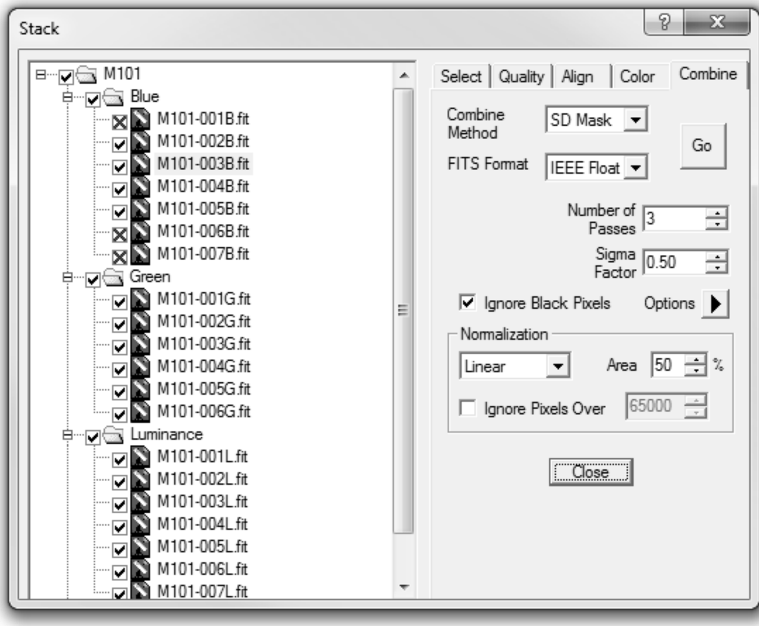
- When Groups of red, green, and blue monochrome exposures are included, MaxIm DL offers the opportunity to alter their ratio here.
- In the presence of Luminance images, the blend of the Luminance master with the Chrominance master may be altered with 'Luminance Weight'.



Combine Tab

Several combine schemes are offered here. Read the Help Topics to compare all six methods.

- Use SD Mask to arrive at the best signal to noise ratio while rejecting unwanted artifacts such as cosmic ray strikes, airplane, and satellite trails.
- Sigma Clip will produce a faster result when stacking a very large number of images.
- Take at least seven exposures to benefit from Sigma Clip or SD Mask.
- We recommend beginning with the default settings of either method.
- Additional Options are available under the black arrow.
- SD Mask or Sigma Clip combined with 'dither' (see Camera Control/Expose Tab/Autosave Setup) is the most effective way to suppress hot pixels.
- Hit Go, and have a cup of coffee or tea. You should return to a beautiful, combined master file(s).
- Tip: Once you have all your settings dialed in, you have the option of jumping directly to the Combine tab and clicking Go. Assuming the settings are okay all your images will stack with no additional effort on your part!



Post-Processing

Linear repair

As mentioned, Screen Stretch's temporary visualization facilitates repair of a master file while still in its linear state. Two common processes used at this stage are the Filter menu's Deconvolve, and Flatten Background (or Auto Flatten Background).

Deconvolve

Earthbound observers view ancient light through many layers of atmosphere. Despite being well focused and guided, our images are affected by the movement of the air over the course of an exposure. This translates to a blurring effect that is especially evident in the stars and fine detail. Filter/Deconvolve is a powerful, yet easy to use algorithm that restores much of the sharpness lost. In-depth deconvolution instructions are found in the Help Topics.

Flatten Background

Another real-world challenge that degrades the quality of images is Light Pollution. Be it from town, a neighbor's security light, or even an uncovered LED in the observatory, our images can be awash in light gradients, leading to Uneven Field Illumination (UFI). Gradients wreak havoc, especially in the color components, and should be dealt with early on in processing.

MaxIm DL provides several filters, including Auto Remove Gradient, to correct ('flatten') the unevenness of the field. Consult the Help file on their use.

With sharpness restored and gradients repaired, it's time to take things down the nonlinear road.

Stretching

In the Overview, we used the Screen Stretch Window to temporarily redistribute our image's pixel values to reveal its hidden data. Just as this raw data is linear, Screen Stretch applies a linear stretch. That is why all brightness levels increase or decrease equally, and this is fine for scientific imaging where linearity is critical to accurate results.

But, for pretty pictures, a more sophisticated type of stretch called nonlinear is required. When permanently applied your pictures will begin to take on the full-range tonality and contrast that terrestrial images possess. Think about it – we expect background sky to be quite dark, with dim wisps of nebulosity or galactic halos just visible above it. Depending on the object, there may also be a fairly bright component such as a galactic or nebular core, and in nearly all cases, bright stars to preserve.

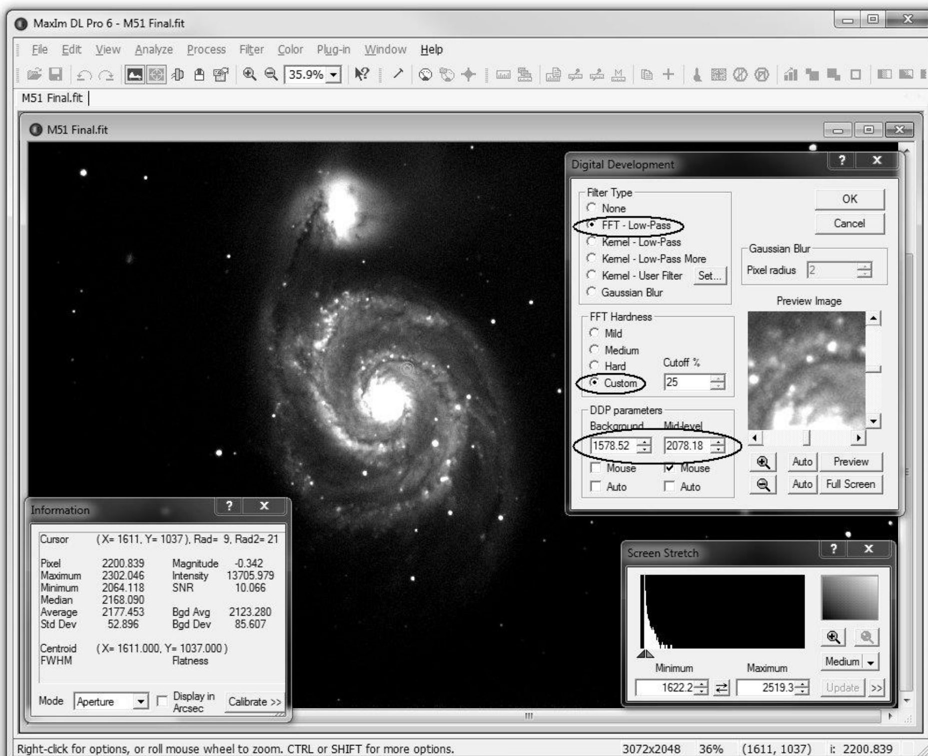
Recall what happened when we temporarily brightened the image with Screen Stretch. Dimmer detail was revealed, but at the expense of star cores and highlights becoming saturated (burned out). Nonlinear stretches avoid this. You can preserve color and detail in bright areas and keep the background sky from becoming too bright, while boosting the all-important midrange data. Useful commands include Filter/Digital Development, Process/Stretch, or, for more experienced imagers, Process/Curves.

Once a nonlinear stretch has been applied to the image, it loses its scientific validity (astrometry/photometry), but finds its artistic soul. It is nonlinear histogram manipulation that is at the heart of every stunning astro-image.

Helpful Hint – On your image processing journey, you'll soon learn that no two images behave the same. Tool settings that worked for one image may not work well for another. With that in mind, let's see some examples of how it's done.

Digital Development

Better known as DDP, this is a quick and easy way to a good-looking image. Digital Development is especially useful with subjects such as our M101 example (you can download the image from www.cyanogen.com/images/M101.zip), where bright cores and stars are present. While there are many ways to use it, here's my preferred method.



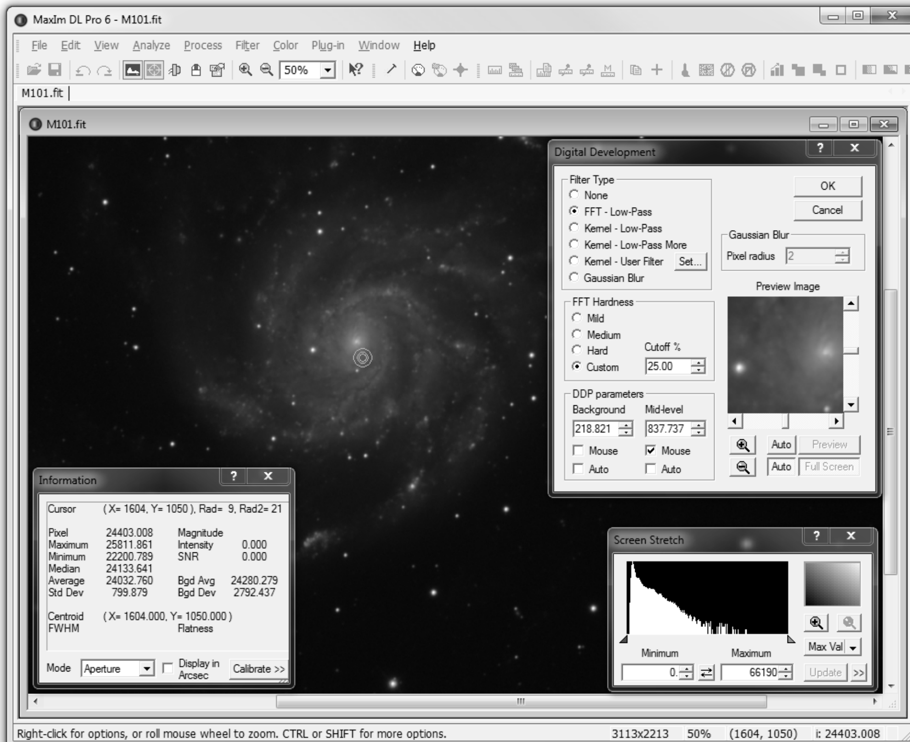
- Set the Screen Stretch to High.
- Open DDP. By default, no Filter Type is selected. This allows you to apply DDP with no sharpening.

- As DDP by definition includes some sharpening, I choose FFT - Low-Pass where appropriate (monochrome chrominance is typically not sharpened).
- Next is FFT Hardness. Try the default 5% Cutoff of the Mild setting.
- In this example, I found Mild to be too harsh, and doubled the Cutoff to 10% (higher percentage = less sharpening).
- The DDP parameters are very important. By default, they are both Auto; but in most cases, you'll change these.
- Uncheck Background's Auto box and lower the estimated value by at least 100.
- Next comes the Mid-level setting. Inspect the object and select a region that is "in the middle" of the brightness range of the object. Some people like to select a pixel just outside the saturated area of the nucleus; others prefer selecting a bright area in the spiral arms.
- Click OK, and let DDP do its thing. This may take some time, so be patient.

With DDP complete, the image still appears somewhat dark but is now nonlinear. Note two things:

- the 'stretched' appearance of the histogram
- the preservation of the details in the bright core

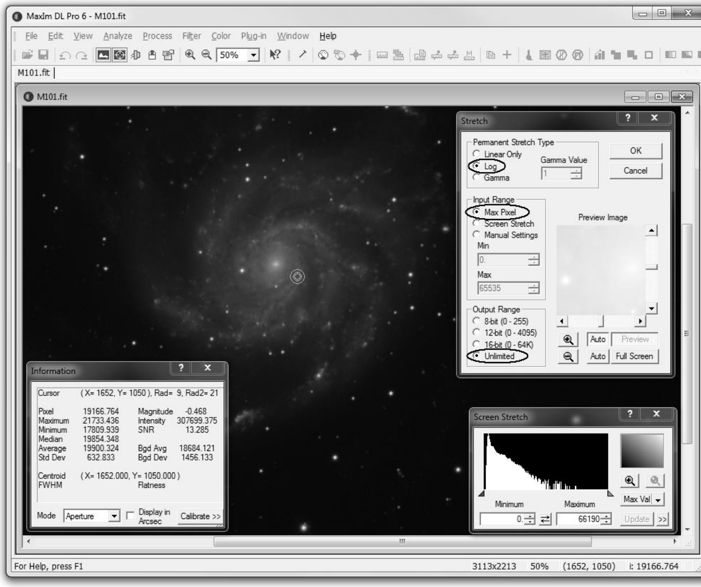
I gauge these positive results against the appearance of the stars, going back and redoing DDP with milder settings if the stars exhibit 'ringing', and are negatively impacted by over-sharpening.

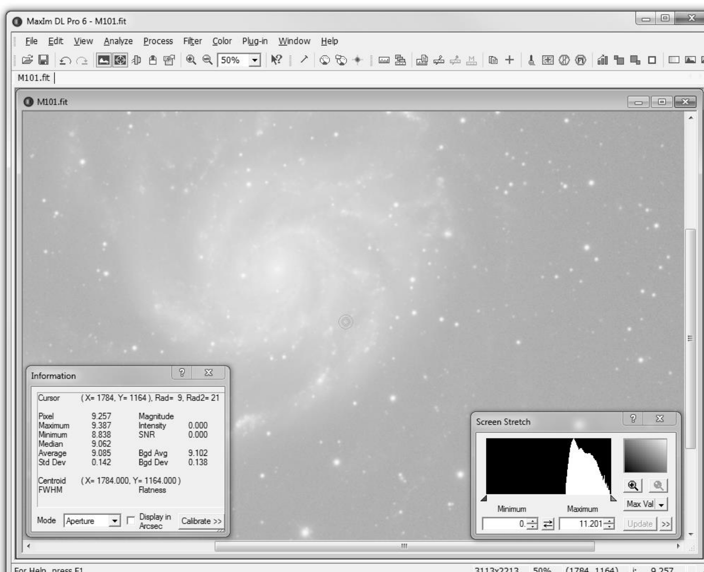


Process Stretch

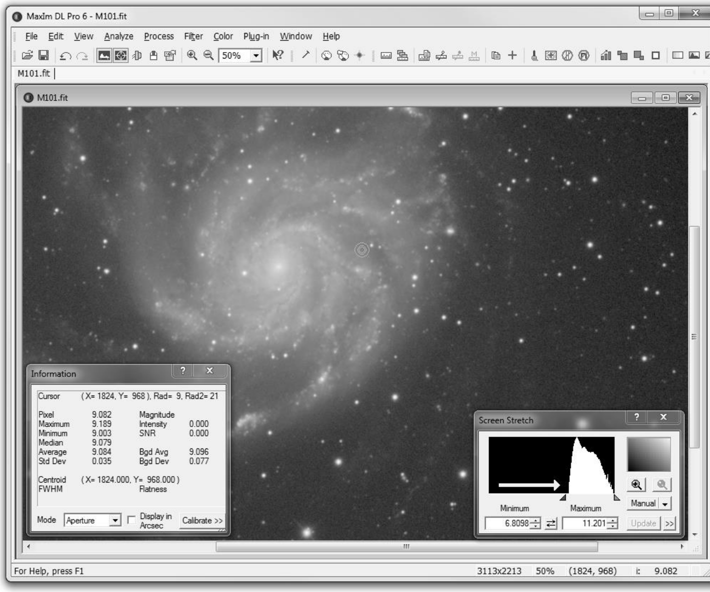
Next, move on to the Process menu's Stretch. While this tool has multiple uses, we'll use it here to do an additional nonlinear stretch to brighten an image.

- With Log selected, choose Max Pixel as the Input Range, and Unlimited for the Output Range.
- Click OK.





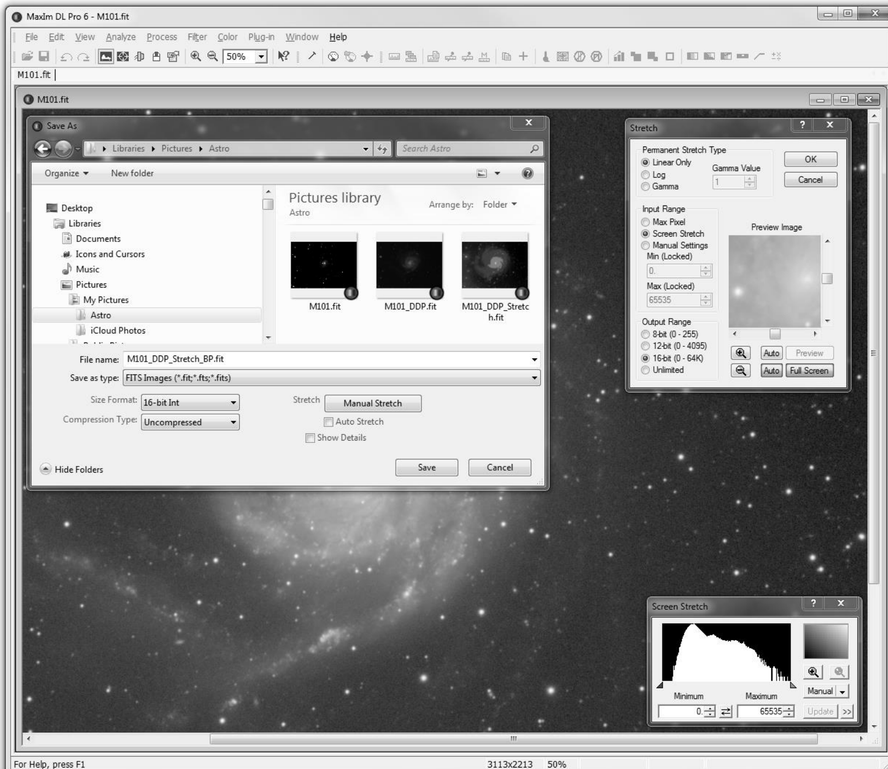
- While the result appears too bright, note the beauty revealed.
- Dragging Screen Stretch's red slider to the right, stop just short of the 'toe' of the histogram as shown.



- This ensures that no good detail on the left side of the graph (shadows) is lost. With the 'black point' reset in this way, look how good our image looks.

Saving

At various times during the workflow it is advisable to save different versions of an image. In this way, you can return to earlier states if you're unhappy with any of your adjustments. Always be certain not to alter the original, pristine master file(s). Recall that Screen Stretch by itself does not permanently modify an image. We need a way to preserve the black point adjustment made in the last step.



- Go to File/Save As. Begin by assigning the file a unique name. I'd call this version M101_DDP_Stretch_BlackPoint.
- Your next steps are critical to good results.
- Clicking Manual Stretch opens the Stretch dialog from the previous step.
- This time choose Linear Only, Screen Stretch, and 16-bit.
- Cross-reference the Preview Image window as you go.
- When ready, click OK, then Save to complete.

If you're heading for a graphics editor such as Photoshop, choose TIFF Images for the Save as type. If you have a Photoshop FITS reader add-on such as FITSPlug you can stay in the FITS format for further processing.

What we've done here is to save the image just as it appears based on the Screen Stretch setting. We also truncated the data to 16-bit, facilitating further processing outside of MaxIm DL.

Noise Reduction

Earlier, we discussed the importance of acquiring sufficient signal to defeat the noise inherent in long-exposure, low-light photography. Expose as long as your mount and conditions permit. At average focal ratios (f/6-8), twelve 10-minute subexposures will produce better results than forty 3-minute ones will. The law of diminishing returns impacts the number of subexposures taken, but not the additional time put into collecting good photons in each subexposure.

Obviously, bright star clusters will require infinitely less integration time than will dusty van den Bergh regions. When imaging dimmer objects, rarely can we hope to accumulate enough signal to keep all regions of the image free of unattractive, 'grainy' noise (caused by phenomenon such as read noise, dark current noise, sky background photon shot noise, etc.). As we applied nonlinear stretches to reveal the hidden detail, the noise was exposed.

Color channels tend to be noisier than does Luminance, because the filter in front of the sensor reduces its quantum efficiency. The same is true for One-Shot Color devices, because each pixel is permanently covered with either a red, green, or blue broadband filter.

MaxIm DL provides several Noise Reduction filters to diminish this problem. Once small-scale noise is 'smoothed', further enhancements such as detail sharpening are facilitated. Let's see one example of noise reduction in action.

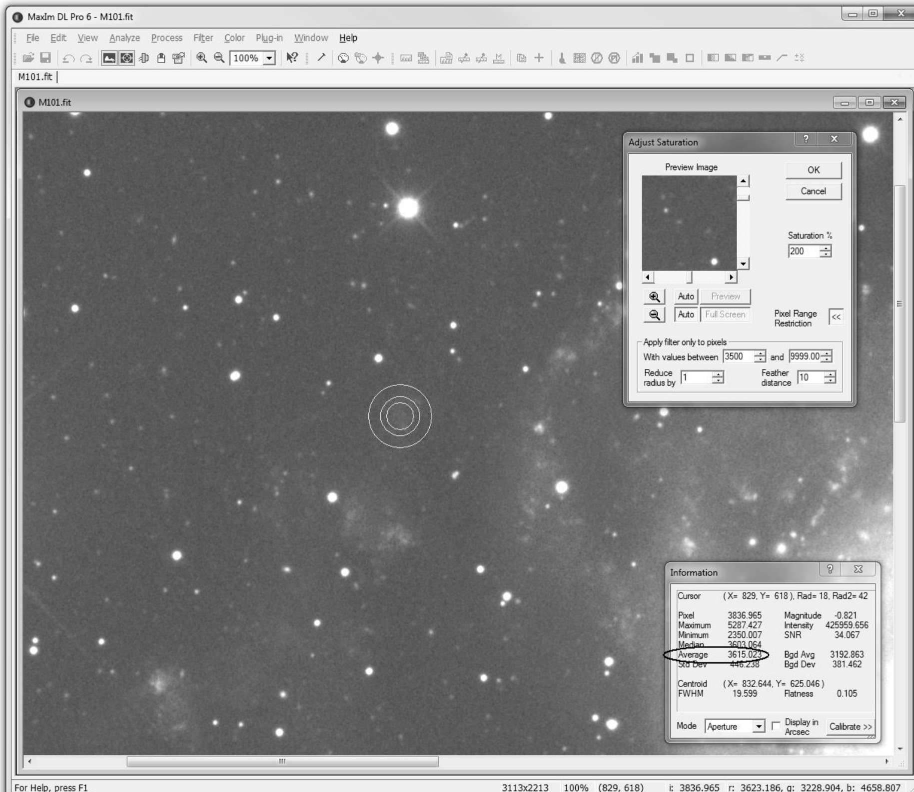
As M101 is a One-Shot Color image, the Color menu's Color Smoothing is a good choice. This filter will desaturate and smooth chrominance noise, without affecting the sharpness of the lightness component of the image.

- Open Color Smoothing.
- With FFT Low Pass selected, apply the default settings for a nice result.
- Alternatively, or in concert with Color Smoothing, try the Filter menu's Kernel Filters.
- Experiment with the Low-Pass filter, or Gaussian Blur at a Radius of 0.5 - 1.0.

Saturation

While few images are more striking than grayscale (black and white) Hydrogen Alpha shots, RGB astrophotos, alive with color, excite the senses as few subjects can. MaxIm DL offers a variety of tools in the Color menu for color enhancement.

As mentioned, color can be noisy, and is also more negatively impacted by light gradients than is Luminance. Even with a background-flattening filter applied in the linear state, the relationship of the R, G, and B components to one another may still need to be adjusted. MaxIm DL's Color Balance or White Balance commands are powerful ways to do this, and are explained in the Help Topics document. Once color noise is reduced, and the colors balanced, saturation may be increased to make your images pop!



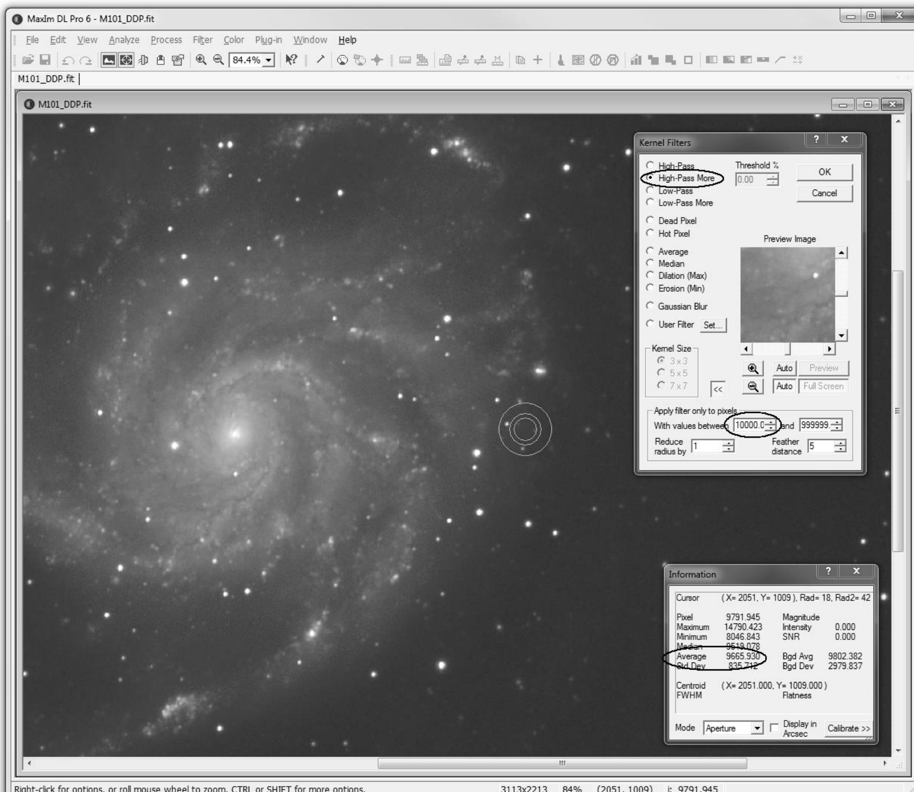
- Open Color/Adjust Saturation.
- I begin by increasing Saturation to 200%, making it easier to fine-tune the settings.
- 200% is double the color intensity. A setting of 100% means no change.
- Clicking on the preview's Full Screen button, I can see the result of the boost in the image.
- Looking at the image close-up, I note an undesired artifact – along with the galaxy and stars, the saturation of the background sky has also increased.
- The Pixel Range Restriction feature of this and several other filters allows us to control this.
- Before we can make use of it, we need some information – recall when we suggested leaving the Information Window open. Here's an instance when it comes in handy.
- Use the cursor to get a measurement of neutral background sky. The Average pixel intensity at the location pictured is about 3,000.
- Now measure the 'Average' brightness value of the dimmest portion of galaxy with reasonably strong signal. I find this to be about 4,000.
- Entering 3,500 in the left hand window, I tell MaxIm DL to only apply saturation to pixel values above it.

- Play with 'Reduce radius by' and 'Feather distance' to ensure that there's no hard cutoff line between saturated and unsaturated regions.
- Lastly, dial back the percentage of saturation to taste, and click OK. I'm generally in the range of 150 - 175%.

Sharpening

While blurring was partially eliminated by the Deconvolve process, we often wish to further increase the sharpness of an image's details. As you've come to expect, we offer several filters to accomplish this. Read the Help Topics on Kernel, FFT, Unsharp Mask, and Wavelet filters.

While these filters increase edge sharpness, the overall contrast between light and dark features is also important. This contrast can be well accomplished using an 'S'-shaped Curve (Process menu) as you gain experience. Let's look at an example of sharpening.



I found the Kernel Filter to be the most effective for this particular image.

- Opening the filter, I chose the 'High-Pass More' setting.

- While the galaxy was nicely sharpened, the noisier background sky exhibited an unattractive 'orange peel' look.
- As with Saturation, use the Pixel Range Restriction feature of this filter as well, to target the strong signal of the midrange only.
- This time I target values 10,000 and above, as pictured.
- As I found the stars negatively impacted by further sharpening, I restricted the high-side sharpening as well by entering 35,000 (as determined with the cursor) in the right side box.

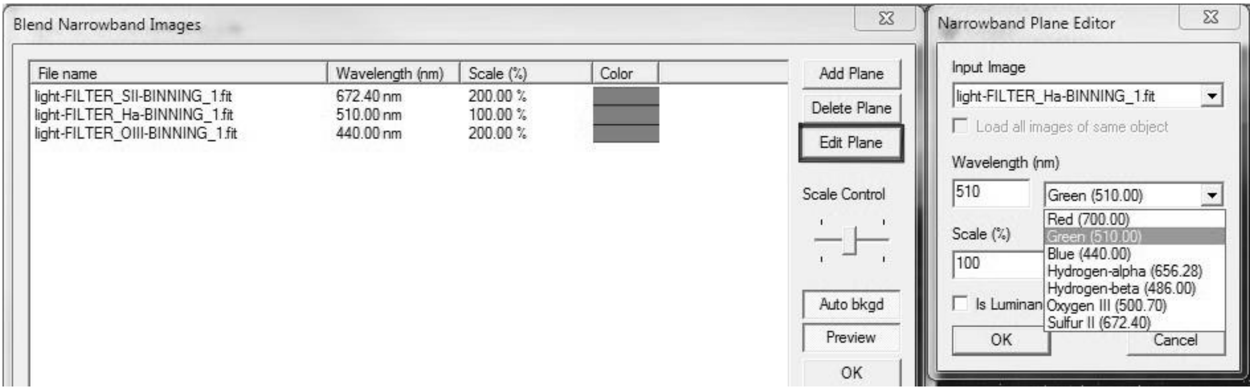
When well-calibrated and stacked images are stretched, smoothed, saturated, and sharpened using MaxIm DL with an artistic eye, your first NASA APOD may be just around the corner!

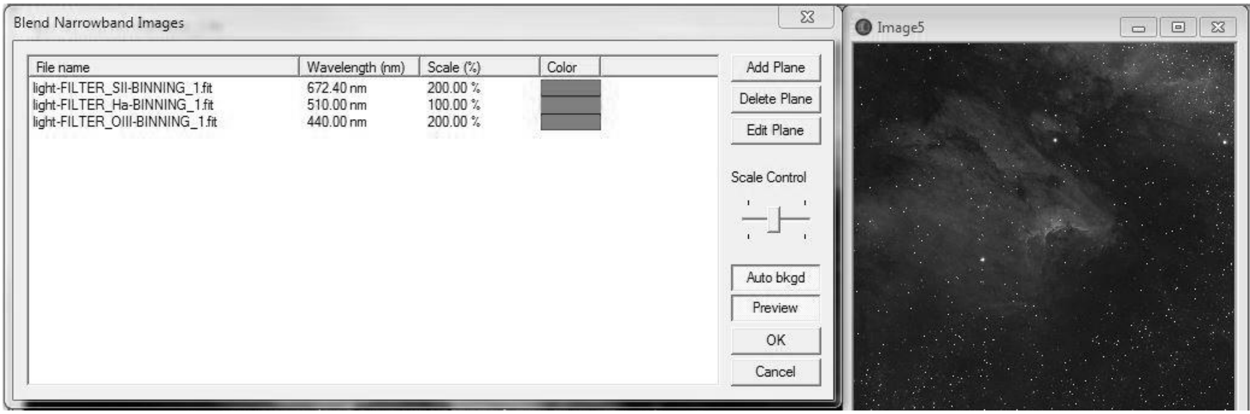
Narrowband

Narrowband imaging has become very popular for several reasons, not least of which is that you can shoot with Hydrogen Alpha (Ha), Oxygen III (OIII), and Sulfur II (SII) filters under a full-moon or profoundly light-polluted sky. These can additionally be blended with more traditional LRGB images for stunning results.

Brand new to version 6.0 is the Color menu's Blend Narrowband Images. It allows you to create color masters mapped to either the Hubble, CFHT, or the naturalistic HOO palette, quickly and easily. We believe this new tool may revolutionize Narrowband processing, saving you many steps with other graphics editing software. Let's see an example of how it works. Consult the Help file for more information.

- Open an aligned Ha, OIII, and SII narrowband image.
- Invoke Blend Narrowband Images found under the Color menu, and click on Add Plane.
- Select an Input Image. Here, SII is chosen. The process will automatically assign a Wavelength and a default Scale of 100%, unless altered. Click OK.
- Clicking Add Plane again, I chose Ha, this time overriding the assigned Wavelength to Green.
- Repeating the process, I assigned OIII to the Blue Channel, thereby completing the 'Hubble Palette'.
- With Auto bkgd engaged to automatically equalize the background levels of the images, select Preview to display the result.
- If unsatisfied, select a channel and raise or lower its brightness level in increments from 1 - 20 with the Scale Control.
- You can also perform this and other changes by selecting Edit Plane.
- In this example, boosting both SII and OIII's contribution to 200% yields a pleasing result.
- Click OK when finished.



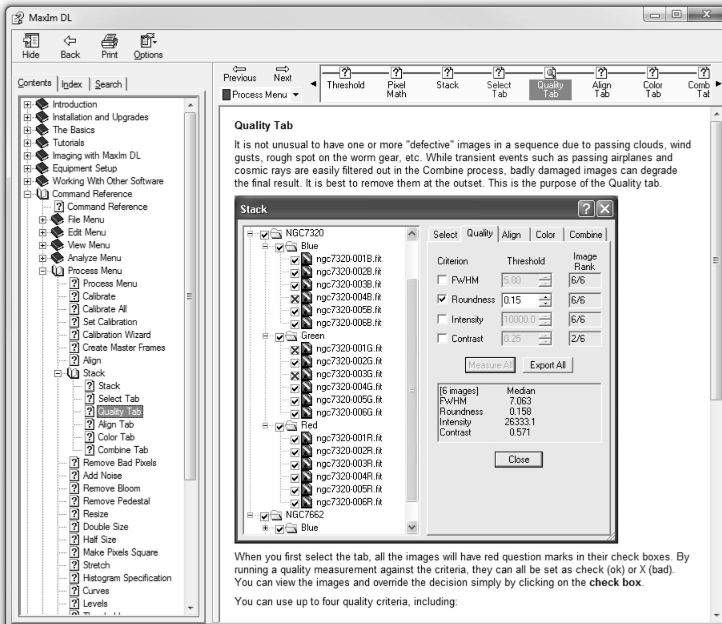


Science

While we've concentrated on artful imaging in this guide, know that MaxIm DL continues to be a leader in the science of astrometry and photometry. Visit the Analyze menu and the Help Topics to get started.

Chapter 4. Getting More Help

A frequently overlooked feature of MaxIm DL is the extensive and comprehensive built-in Help. While many programs have very limited Help information, we have put a lot of effort into explaining all of the functions and capabilities of the software.



Some tips on using Help:

- The Contents tab is the quickest and easiest way to find things:
    - Most importantly the Command Reference section lists all of the features of the software in the same order as they appear in the menus. The Camera Control, Observatory Control, and Adaptive Optics chapters are at the bottom of the section.
    - A Tutorials section is included – a great place to continue learning MaxIm DL. You can use the simulators to try things out at your desk before going under the stars.
    - Working with Other Software helps you understand how you can connect MaxIm DL to other programs, to allow you to build a complete observing system.
    - Imaging with MaxIm DL includes a lot of useful information on imaging in general, and using MaxIm DL in particular.

  - Equipment Setup tells you how to connect and configure your hardware, with a particular emphasis on cameras and filter wheels. Please note that ASCOM drivers and third-party plug-in drivers may not be listed; consult the manufacturer's documentation for more information.
  - For advanced users, the Scripting section describes how to control MaxIm DL from another program, script, or plug-in. Many users have created amazing tools using MaxIm DL's scripting interface. Many of these have been made available online, and a large number are linked from the Extras section of our web site.

- If you have trouble finding something, also try the Search or Index tabs.
- You can download a printable PDF version of the Help, if you prefer reading offline. Simply use the Help menu PDF Manual command. The first time you use it you need to have an internet connection. Once the file is downloaded it is stored on your hard drive under My Documents\MaxIm DL 6\Downloads.

Chapter 5. Thanks

Thanks again for choosing MaxIm DL imaging software. We hope you found this Getting Started Guide helpful and easy to follow. We've put a lot of time into the Help Topics, and we believe that answers to most of your remaining questions will be found there. Remember too, that the MaxIm DL Yahoo user group is a great resource for sharing information, and getting answers. Enjoy astro-imaging with MaxIm DL Version 6!

Chapter 6. Tutorials

The following tutorials are also available in the MaxIm DL built-in and online Help.

Image Processing Tutorials

These tutorials provide a basic introduction to image processing, including opening an image file, adjusting brightness and contrast, filtering, stretching, histogram specification, and saving.

The Adjust Brightness and Contrast tutorial is particularly important. Since MaxIm DL handles high bit depth images that your computer screen is incapable of displaying fully, knowing how to adjust the image appearance is critical to using the software effectively.

Open File Tutorial

The first and most basic step is to open and display an image file.

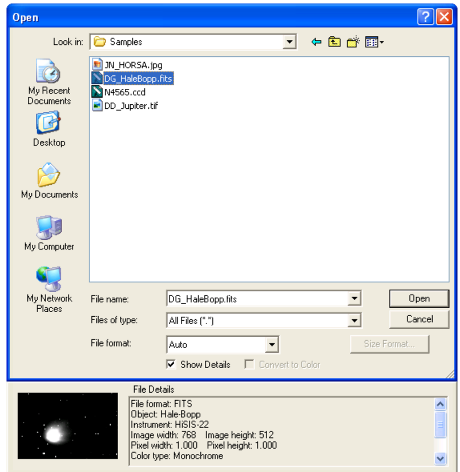
Click on the **Open** button on the **Toolbar** to bring up the **Open** dialog.

Set **Files Of Type** to **All Files (*.*)**.

Use the **Look In** control to select the **Samples** folder under the **MaxIm DL V6** program directory. If you used the default installation directory, the samples will be located at C:\Program Files\Diffraction Limited\MaxIm DL 6\Samples on 32-bit machines, and C:\Program Files (x86)\Diffraction Limited\MaxIm DL 6\Samples on 64-bit machines.

Click once on the file named "**DG_HaleBopp.fits**". This is a CCD image of Comet Hale-Bopp taken while it was still far from the sun.

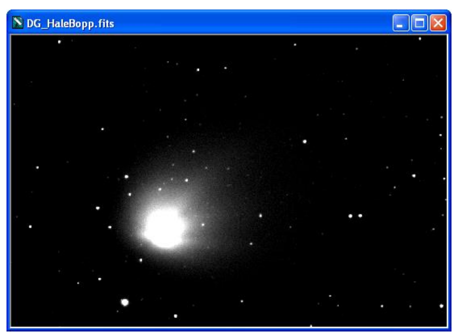
The **File Details** box should now display information on the file format, object, instrument, pixel width and height, and color type.



Click Open to open the file.

If the image does not fit within the screen area, **click** the **Zoom Out** button on the **Toolbar**.

The image will appear as follows:

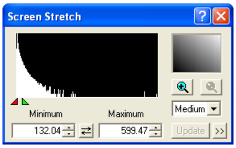


Adjust Brightness and Contrast Tutorial

1. If you have not already done so, open the **DG_HaleBopp.fits** file in the Samples directory. (For help on opening files see the Open a File Tutorial).

2. Make sure the **Screen Stretch** window is visible. If it is not, **click** the **Toggle Screen Stretch** button on the **Toolbar**.

3. The **Screen Stretch** window should look something like this:



4. The large histogram graph at upper left shows the relative number of pixels (vertical scale) at each intensity level (horizontal scale) in the image. The graph shows that most of the pixels are grouped on the left (dark) side of the histogram, and that the number of pixels drops off rapidly at brighter levels (right side).

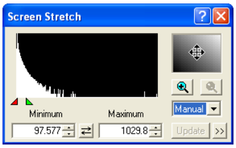
5. The red caret (pointer) indicates the brightness level that is displayed as black on the screen. The brightness level of the red caret is indicated in **Minimum**. Similarly, the green caret indicates the brightness level that is displayed as white on the screen; this brightness level is indicated in **Maximum**.

6. **Click** on the drop-down list with the mouse and select **Low**. The image should change as follows:

7. The **Low Stretch** setting makes the image darker, allowing details in the brighter part of the comet to be visible. Try selecting the **High Stretch** setting and see what happens. Each of the three views reveals different parts of the comet. Note that selecting the stretch mode has no effect on how the image is stored; it only changes how it is displayed.

Quick Stretch

The fastest way to adjust the image brightness and contrast is to use the **Quick Stretch** control. This method gives instant updates as the mouse is dragged, and is particularly fast for monochrome images. The **Quick Stretch** control is the shaded box at the upper right of the Screen Stretch dialog box.



Point the mouse at the **Quick Stretch** box and **press** and **hold** the **left** mouse button down. The mouse cursor changes to a "four arrows" shape. You can now adjust the image contrast and brightness as follows:

- Move the mouse upwards to increase brightness
- Move the mouse downwards to decrease brightness

- Move the mouse right to increase contrast
- Move the mouse left to decrease contrast

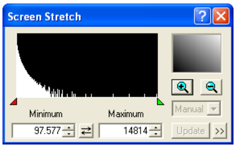
This function is also available without using the **Screen Stretch** window. Simply point the mouse at any image window. Hold down the **shift** key, then **press** and **hold** the **left** mouse button down. You can now make the same adjustments described above.

Manual Controls

Adjustments can also be made by adjusting the position of the pointers along the bottom of the histogram.

1. **Click** and drag the **Green** caret (pointer) under the histogram image. This controls the brightness level that corresponds to full **white** on the screen; i.e., the maximum output level. Drag it right or left; when it is dropped, the image will update with the new settings. The **Maximum** field also updates to show you the corresponding brightness level in the image.

2. The **Red** caret controls the **black** or **background** level. Try adjusting it and see what the effect is. The **Minimum** field updates as you adjust the setting.



3. Placing the **Red** and **Green** carets close together produces a high contrast; conversely placing them far apart produces a low contrast. Reversing the positions of the two carets (**Red** to the right of **Green**) will produce a negative image.

4. When moving the carets with the mouse, experiment with holding down either the **SHIFT** or **CTRL** keys. The **SHIFT** key makes the carets move together, keeping the contrast constant but changing the brightness. The **CTRL** key makes the carets move in opposite directions.

5. You can also modify the **Maximum** and **Minimum** fields directly by typing in a new number and then pressing **Enter**. **Note:** if you type in the numeric entry fields, you *must* press **Enter** or click **Update** for the new value to take effect.

Notes

Remember, these functions only affect the image *display*. They have no effect on the image buffer itself. This allows you to conveniently change the stretch at any time without affecting any later image processing operations.

Tip: The **Screen Stretch** window is normally left turned on, and can be accessed at almost any time – even while a dialog box is active. When a dialog box is active, you can adjust the stretch of the **Preview Image** using the **Screen Stretch** window. In most cases, if the **Preview** button is depressed, the **Preview Image** has separate stretch settings. You can stretch it by clicking on the dialog box, then adjusting the **Screen Stretch** window settings.

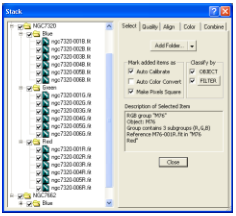
If the **Preview** button is not depressed, the **Preview Image** and main **image** window **share** the same stretch settings.

Stacking Tutorial

For this tutorial, you will need a folder of raw images to stack. We will demonstrate stacking LRGB images; however, a similar process works for monochrome, one-shot color, and RGB image sets.

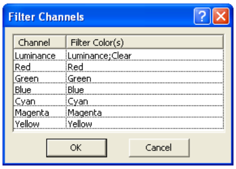
1. For best results, capture the images using MaxIm DL, so that the FITS headers include important information including the filter selection and object name.

2. Select the **Process** menu **Stack** command.



3. On the Select tab, turn on Classify by OBJECT and FILTER.

4. Click the FILTER button to set up the filter mapping. This will determine what filters are mapped into which LRGB color channels. To change a row, click once on the row, then click once on the Filter Color item, and enter a new value. This will make sure that your filters are automatically assigned to the correct group.



5. If your images have not yet been calibrated, turn on **Mark added images as Auto Calibrate**. Each image will automatically be calibrated as it is needed, using the settings from the Set Calibration command.

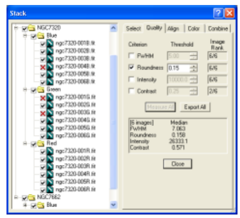
6. Click the **drop list** on the multi-function button and select **Add Folder**. Browse to a folder on disk where your images are located. This folder may contain images of several different targets, as long as the OBJECT FITS keyword is set in each image (during imaging, this is automatically obtained from the Observatory Control window if a telescope is connected).

7. The **Tree View** on the left side of the Stack dialog will now show all the image files you have selected, arranged into groups according to their FITS header. You can open the groups to view the files by clicking on the + sign. If you would like to view an individual file, **right-click** it and select **Display Image**. Alternatively, using the right-click menu

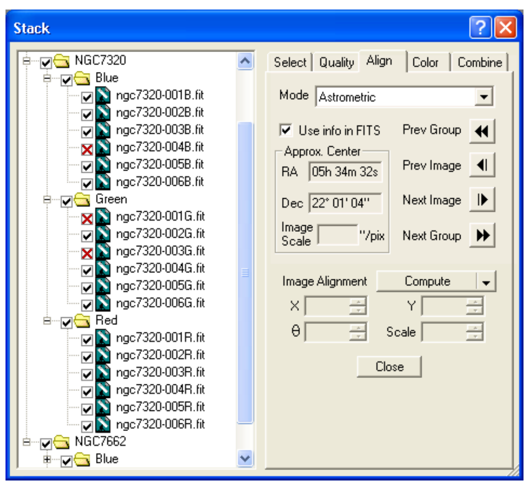
select **Auto Display**, and any image you click on will be automatically displayed.

8. If necessary, you can move images or entire groups by **dragging** them. You can set properties for groups or individual files using the **right-click** menu.

9. Select the **Quality** tab. If you would like to eliminate images with out-of-round stars caused by bad tracking, turn on the **Roundness** check box. The **Threshold** should be set to limit how far out of round the star can be; for example, 0.1 will throw out any image with stars that are more than 10% out of round. Click the **Measure All** button, and any bad images will automatically receive an X in the enable box. You can manually override this decision if you like, by changing the enable box.

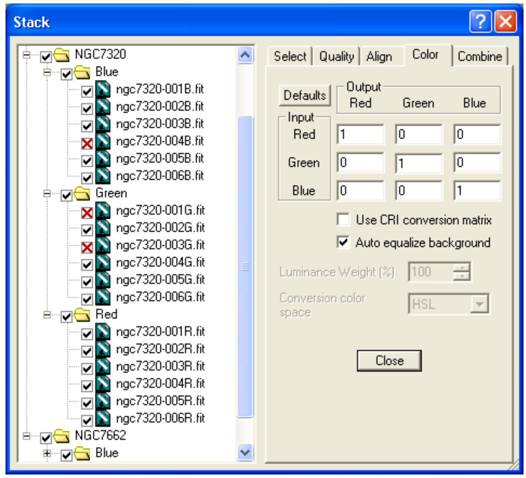


10. Select the **Align** tab. If your images have been solved using PinPoint Astrometry you may wish to use the **Astrometric** align mode, which is extremely accurate. Alternatively, the **Auto Star Matching** mode is fully automatic and quite accurate. There are a variety of other alignment modes available, including manual alignment.

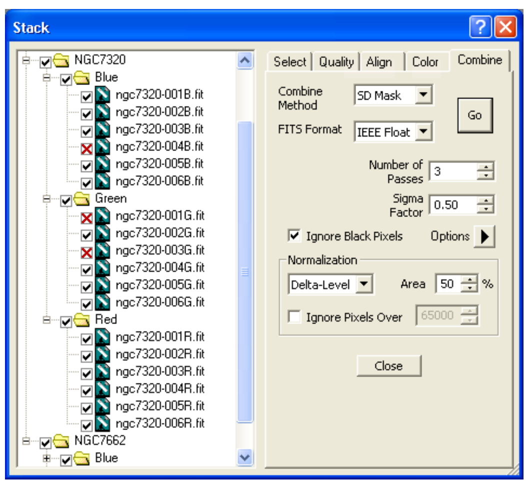


11. You can select one of the images to be the **Reference Image**, using the **right-click** menu. This image will not be shifted during alignment; all other images will be aligned to it. If you do not select the reference image, the first image in the list will be used.

12. Select the **Color** tab. If you wish to customize the color balance settings you may do so; otherwise click the **Defaults** button, which assumes 1:1:1 color balance. Also turn on **Auto equalize background** to remove any background color cast due to sky glow.



13. Select the **Combine** tab and set the **Combine Method**. For large numbers of images we recommend using **Sigma Clip**; a **Sigma Factor** of **3** is a good starting point. If you have a modest number of images the SD Mask mode will produce a better result (but will take more time); a good starting point for the settings is a **Sigma Factor** of **0.5** and a **Number of Passes** of **3**.



14. Be sure to turn on **Ignore Black Pixels**. If there are any areas where the images do not completely overlap, this will ignore the contribution from the missing data. Otherwise you may get strips across the edges of the image that look dimmer.

15. Set Normalization to **Linear** and set **Area** to **50%**. This setting assumes that any changes in intensity between the images are due to extinction rather than changes in background level. If you have strong background level changes you may want to use **Delta-Level**

instead.

16. Select whether you want the results created as new images or written to a disk folder using the commands in the **Options** menu.

17. Click **Go** to start the stacking process. This may take some time; you can interrupt and restart the process if needed. If you have multiple image groups, they will be stacked separately. Color sets will automatically be color combined. To view results written to a folder, you must close the Stack command before opening them with the Open command. Alternatively, you can simply drag and drop them from Windows Explorer onto the MaxIm DL window.

Tip: Once you have all the settings the way you like them, you can simply dump in the images and click the **Go** button.

Tip: You can also drag-and-drop images onto the **Tree View** from the **Windows Explorer**, or select files individually.

Tip: When you use the **Add Folder** option calibration files are automatically ignored; the other methods for adding files will include them. Usually you don't want to stack the calibration files automatically, since the Set Calibration command does that for you with proper normalization, etc.

Tip: This tutorial has barely scratched the surface; this command has many more capabilities. For more information, please refer to the Help.

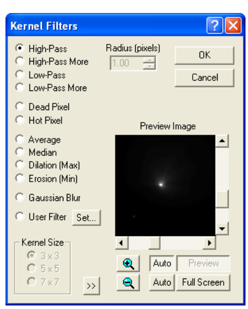
Filtering Tutorial

Filtering allows you to smooth or sharpen an image. There are several types of filters, including FFT, Kernel, Unsharp Mask, and Digital Development. The latter two commands are particularly useful for enhancing astronomical images.

1. We will demonstrate the **Kernel Filters** command.

2. If you have not already done so, open the **DG_HaleBopp.fits** file in the Samples directory. (For help on opening files see the Open a File Tutorial).

3. **Click** on the **Kernel Filters** button on the **Toolbar**. This will activate the **Kernel Filters** dialog.



4. Using the **left** mouse button and holding down the **CTRL** key, **click and drag** the

Preview Image until the brightest part of the comet is visible, holding the button down while dragging. Then turn on the **Auto Preview** control, and select **High Pass More**. A high-pass filter sharpens the image; in this case, the image is fairly sharp already and the filter just increases the noise, making the image "grainy".

5. Now select **Low Pass More**. The **Preview Image** will appear smoother. **Click** on **Average**. The image will be smoothed slightly more. In this mode, the **Kernel Size** function is available. Select **7 x 7**, the strongest filter, and the preview image will become much blurrier.

6. Switch back to **High Pass More** and click **OK**. After a few seconds, the entire image will update.

7. If you don’t like this result, you can undo this change by pressing the **Undo** button on the **Toolbar**.

Be sure to try the various other filters mentioned above.

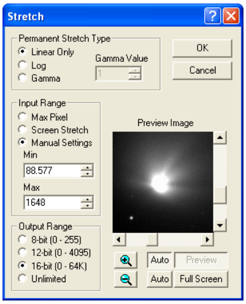
Stretching Tutorial

Although the **Screen Stretch** window allows you to adjust the brightness and contrast of the image on the screen, sometimes you want to change the data in the image buffer. For example, you might want to adjust an image so it will fit in the 8-bit range of a JPEG file. You might also want to try a "non-linear stretch" to compress the dynamic range of the image. These operations are performed with the **Stretch** command.

1. If you have not already done so, open the **DG_HaleBopp.fits** file in the Samples directory. (For help on opening files see the Open a File Tutorial).

2. Press the **Stretch** button on the **Toolbar** to bring up the **Stretch** dialog.

3. Set **Permanent Stretch Type** to **Log**, **Input Range** to **Manual Settings**, and **Output Range** to **16 bit (0 - 64K)**. Turn on **Auto Preview**. As you can see in the **Preview Image**, these settings will dramatically compress the dynamic range of the image so that the brightest and faintest parts of the comet are both visible at once.



4. Perhaps this setting is a bit harsh. We can better control the amount of dynamic range compression by changing the **Permanent Stretch Type** to **Gamma**. Set **Gamma Value** to **0.2** and click **OK**.

5. Now set the screen stretch to **Low** using the **Screen Stretch** window. You can toggle back and forth between the processed and original version of the image using the **Undo** and **Redo** buttons on the **Toolbar**. Notice how the faint outer details in the comet are enhanced, but the brighter details are still visible.

6. Various effects can be achieved with the **Stretch** command; the following are some suggestions you can try:

   - To prepare a file for export to a **JPEG**, **BMP**, **8-bit PNG**, or **8-bit TIFF** format, set **Permanent Stretch Type** to **Linear Only**, **Input Range** to **Screen Stretch**, and **Output Range** to **8 bit**. In this mode, you can adjust the **Screen Stretch** of the **image window** to change the **Input Range** settings; the **Min** and **Max** fields will update as you adjust the stretch.

   - To greatly compress the dynamic range of an image, set **Permanent Stretch Type** to **Log**, **Input Range** to **Max Pixel**, and **Output Range** to **Unlimited**.

   - To emphasize faint features, set **Permanent Stretch Type** to **Gamma**, **Input Range** to **Max Pixel**, and **Output Range** to **Unlimited**. Reduce the **Gamma Value** to **below 1.0** and adjust until you are happy with the effect in the **Preview Image**.

At this point, some additional explanation of the **Preview Image** is in order. You will notice that the **Screen Stretch** window is still available; if it is not on, you can turn it on using the button on the **Toolbar**. Which image the **Screen Stretch** window affects is determined by the state of the **Auto** (Preview) push button and by where the focus is, that is, on which window you last clicked. If **Auto** is **off**, both the image buffer and the **Preview Image** always adjust together. If **Auto** is **on**, the **Preview Image** actually becomes a different image and is separately adjustable. When you start a command dialog, or after clicking on it, the **Preview Image** has the focus and is therefore adjusted. If you click on the main image window or its title bar, it gets the focus and the **Screen Stretch** window will now adjust it instead. To adjust the **Preview Image** again, click anywhere on the dialog box.

You can also preview the result of the processing on the **Full Screen**. Refer to the documentation of the **Preview Image** in the Command Reference for details of **Full Screen** previewing.

Histogram Specification Tutorial

Histogram Specification is similar to Log or Gamma stretching, but provides additional flexibility by allowing you to specify the exact shape of the desired histogram.

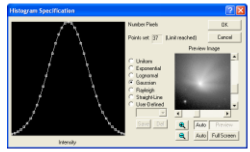
1. If you have not already done so, open the **DG_HaleBopp.fits** file in the Samples directory. (For help on opening files see the Open a File Tutorial).

2. **Click** the **Undo** button on the toolbar to remove the stretch from the previous tutorial.

3. Select the **Histogram Specification** command on the **Process** menu. Select the **Gaussian** option and **click OK**. Since this command can significantly change the dynamic range (min and max values) of the image, you may want to adjust the **Screen Stretch** window settings after processing completes. In this case, setting the mode to

Low gives pleasing results.

4. This processing highlighted the outer tail of the comet, but did not saturate the inner core. Histogram specification is useful for making details visible simultaneously at greatly differing brightness levels.



Try experimenting with different settings, including manually-drawn histogram shapes. When drawing manually, it is often easier to start from the **Straight-Line** or **Uniform** options and then modify the graph: **click** on the graph shape to add a point, or move an existing point by **dragging**. (If you drag a point left or right past its neighbor, the neighbor will be removed automatically.)

Enhancing Details with Curves Tutorial

The Curves command provides a function similar to Log or Gamma stretching, but provides additional flexibility by allowing you to specify the output brightness level for each different input level. You can use it to redistribute pixel brightness and in effect change the shape of the image's histogram.

In this example we are going to reduce the core brightness of the comet and increase that of its tail relative to each other. This makes more detail visible than in a single unprocessed image.

1. If you have not already done so, open the **DG_HaleBopp.fits** file in the Samples directory. (For help on opening files see the Open a File Tutorial).

2. **Click** the **Undo** button on the toolbar to remove the stretch from the previous tutorial.

3. **Right-click** on the image and select **Screen Stretch** > **Max Val** from the context menu. Almost everything except one bright star and the core of the comet dim substantially or disappear altogether.

4. Select the **Curves** command on the **Process** menu. If the graph in the left half of the dialog does not show a straight line from the lower left to the upper right corner, **right-click** in the graph area and select **Curve > Reset** from the context menu. Set the **Curve Type** to **Modified Spline**.

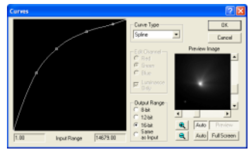
5. The graph controls how the image is stretched. The brightness of pixels in the original image run along the bottom. The corresponding brightness of pixels in the processed image run up the graph.

6. A straight line will have no effect on the image. If you raise the curve in the middle, pixels in the middle brightness range of the image will be boosted. You can fine-tune different parts of the image by adjusting different parts of the graph.

7. To adjust the curve, click to create a new point. The line will adjust to pass through that point. You can drag the point in any direction using the mouse. To remove a point, **right-**

click and select **Delete Point**.

8. Now set the Output Range to **16-bit** and **click** the **Auto** to the left of the **Full Screen** button. The image will show a little more detail but still be mostly dark. That's all right, since we can repeat the process iteratively. Click **OK**, then reactivate the Curves dialog and apply the curve again. Repeat several times until the tail is visible over a significant portion of the image; the inner near-saturation region of the coma remains small.



Here is the recommended "best practice" procedure for boosting faint detail in astronomical images:

1. Set **Max Val** screen stretch mode.

2. Look at the histogram in the **Screen Stretch** window. If there is a large gap at the left hand side, move the lower caret up to the upper end of the gap (but still within the gap). Use **Process** menu **Stretch**, with **Linear Only**, **Screen Stretch**, and **16-bit** settings. Then reset the screen stretch mode to **Max Val**.

3. Run the **Curves** command and moderately boost the curve as shown in the diagram. Click **OK**.

4. Repeat steps 2 and 3 until you are getting close. If **Auto Full Screen** preview is on, you'll see immediately when you try to run the command one too many times.

5. For the last step, run the **Curves** command one last time. **Right-click** and select **Curve > Reset Curve**. Now gently fine-tune the curve to bring out details in interesting parts of the image. For example, if a galaxy has some faint dust lanes, you might want to increase the slope of the curve in the area that emphasizes the dust lanes.

Deconvolution Tutorial

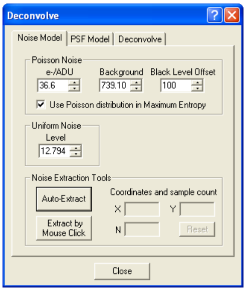
We will now sharpen an image of galaxy NGC4565 using *Deconvolution*. The image was taken with a telescope that was out of alignment (collimation) resulting in a distortion called coma, which makes the stars look like ”V” shapes. We will remove the effects of the collimation error and reduce the effect of atmospheric seeing.

In this tutorial, it is assumed that MaxIm DL has just been started. (To start MaxIm DL, **click** on the program icon under the **Start** button’s **Programs** sub-menu.) It is also assumed that the standard toolbar is visible. If it is not, use the **View** menu **Toolbar** command to switch it on.

1. Open the **N4565.CCD** image in the Samples directory. (For help on opening files see the Open a File Tutorial).

2. **Click** the **Zoom In** button on the **Toolbar** once. Notice how the star images are distorted by the collimation error.

3. Go to the **Filter** menu and select **Deconvolve**. A tabbed dialog box will appear, with **Noise Model**, **PSF Model**, and **Deconvolve** tabs.

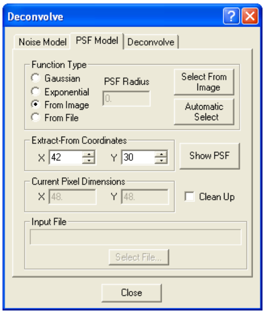


4. First we need to set up the noise model. This helps the deconvolution algorithm account for noise in the image. Enter 36.6 **e-/ADU**, the photoelectrons per ADU or Gain of the CCD camera. This is necessary in order for the noise model to match the actual statistics in the image. The value entered here is for the PC-Lynxx camera; for images from your CCD camera you can use the Photons Wizard to determine the correct value.

5. Next turn on **Use Poisson distribution in Maximum Entropy**.

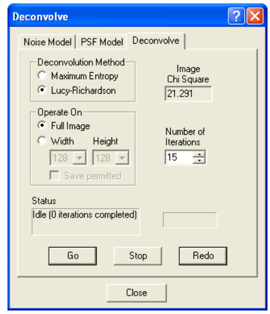
6. To determine the correct background level, click **Auto Extract** under **Noise Extraction Tools**.

7. Next, we will choose a Point-Spread Function (PSF) model. This model tells MaxIm DL how the image was blurred, so that it can try to remove the blur from the image. Click the **PSF Model** tab. Select **From Image** for **Function Type**, turn off **Clean Up**, and click **Select From Image**.



8. Adjust the **circular cursor** to a radius of 8 pixels (as shown in the **Information** window) by **right-clicking** and selecting the appropriate radius. **Click** on the bright star in the lower center of the image (if necessary, you can move the dialog out of the way by dragging the title bar).

9. Click the **Deconvolve** tab. Set **Operate On** to **Full Image**, and **Number of Iterations** to **15**. Choose either **Maximum Entropy or Lucy-Richardson** deconvolution. Click **Go**.

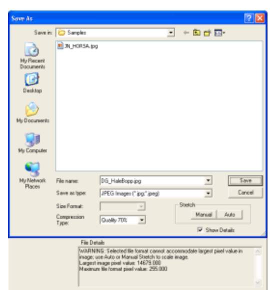


10. Watch the iterations proceed on the image. When the processing is complete, alternately hit **Undo** and **Redo** to see what the effect is on the image.

Saving Images Tutorial

Once you have modified an image, you will naturally want to save it. The high bit depth capability of MaxIm DL means that you have to consider the data range of your image before you save it; otherwise you may lose data.

1. If you have not already done so, open the **DG_HaleBopp.fits** file in the Samples directory. (For help on opening files see the Open a File Tutorial).



2. On the **File** menu, choose the **Save As…** command. Set **File Format** to **JPEG**. Turn **off** the **Auto Stretch** check box.

3. The **File Details** box will now show: *"Warning: Selected file format cannot accommodate largest pixel value in image. Use Auto or Manual Stretch to scale image."*

4. Now turn **on** the **Auto Stretch** check box. The message will change to, "*NOTE: Maximum pixel value exceeded. Auto Stretch will rescale image buffer.*"

5. When **Auto Stretch** is on, any image that will not fit into the range of the file format is automatically adjusted based upon the current **Screen Stretch** settings. This means that any data outside the range displayed on the screen will be lost, so make sure this is what you really want to do.

6. (If you want to adjust the stretch manually, click the **Stretch** button. The **Stretch** dialog will appear. If you set **Permanent Stretch Type** to **Linear Only**, **Input Range** to **Screen Stretch**, and **Output Range** to **8 bit**, you will get the exact same result as **Auto Stretch**.)

7. Now click **Save** to save the file.

CCD Imaging Tutorials

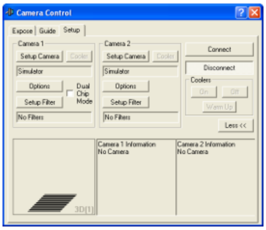
These tutorials provide an introduction to basic camera operations, including equipment setup, focusing, aiming the telescope, taking exposures, and shutdown procedures.

We recommend that the first "imaging session" be done at your desk, rather than under the stars, so that you can become familiar with the operation of the software and your CCD camera.

Before using a CCD camera for the first time, we **strongly recommend** you review the Help section under Camera and Autoguider Setup for your specific model.

CCD Basic Setup

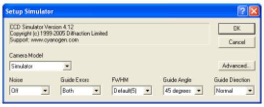
1. Start MaxIm DL and open the **Camera Control** window by clicking on the toolbar button.



2. Move the Camera Control window to a convenient location on the screen. To do this, point the mouse at the **title bar**, **click and hold** the left mouse button, and **drag**.

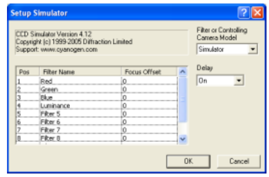
3. The **Setup** tab should appear first; if it is not displayed click on the **Setup** tab near the upper right corner of the window.

4. Select **Camera 1** by clicking on the associated **Setup Camera** button, and picking **Simulator** for the **Camera Model**. You can ignore the remaining settings for now. Click **OK**.

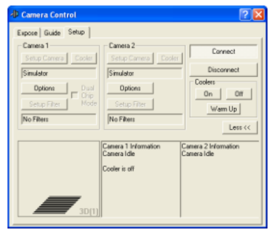


5. Now set up Camera 2, which is usually an autoguider. Click the autoguider Setup button, and set the Camera Model to Simulator. Set Noise to Off, Guide Errors to Both, FWHM to Default (5), Guide Angle to 45 degrees, and Guide Direction to Normal. Click OK.

6. Next set up the filter wheel for Camera 1. Click the Setup Filter button, and set Filter or Controlling Camera Model to Simulator. Type in Red for Filter 1, Green for Filter 2, Blue for Filter 3, and Luminance for Filter 4. Click OK.

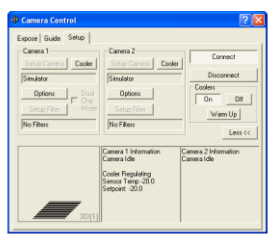


7. Now we are ready to connect to the equipment. Click **Connect**.



8. We now have two "cameras", one for use as the main camera, and the other for use as the autoguider. Normally you would configure your actual imaging and autoguider cameras, but the simulators allow you to try the controls at your desk.

9. The Simulator camera has a programmable temperature. Click **Coolers On** to activate it, and then click the associated **Cooler** button to set the temperature. For each camera, set the temperature setpoint to **–20** degrees C and click **OK**.

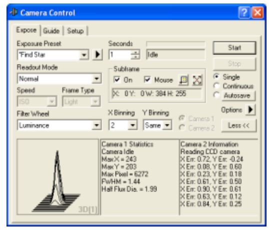


10. Once all of these settings are made they will be remembered. The next time you want to start MaxIm DL, just click the **Connect** button and then Cooler **On**.

CCD Focusing Tutorial

1. Set up the camera as described in the Basic Setup section. If your camera is currently not available, you can use the Simulator to try out the focusing features.

2. Select the **Expose** tab of the Camera Control window. If necessary, click the **More >>** button to display the **Inspect Panel**.



3. Set up dark frame subtraction. If you are using a real camera, open the **Options** menu and check **Simple Auto-dark**. If you are using the simulator, you can select **No Calibration**, which will speed things up slightly. If you use Simple Auto Dark and your camera does not have a shutter, you will be prompted to cover or uncover the telescope as needed.

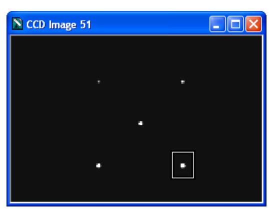
4. In the **Seconds** field, set an exposure time of 1 second. **Tip:** you can use the up/down "spin" control (arrow) buttons to rapidly dial in the exposure. The range of exposure times available depends on the camera model.

5. Select **Single** exposure mode.

6. If your camera has **Readout Mode** options, select a suitable mode. Some cameras have a **Normal** and **Fast** mode; the Fast mode is lower quality but faster readout. If the camera is particularly slow to read out, you may wish to select the faster more. Be sure to use the Normal mode when imaging.

7. If you are using a real camera on a telescope, you should first point the telescope to a moderately bright star; say 5th magnitude.

8. Click **Start** to take an exposure. After a few seconds, an image appears (simulator image shown).



9. Many cameras are too slow for easy full-frame focusing. It can be very difficult to focus if you have to wait a long time between updates. To speed up the process, select a subframe. In the **Subframe** section check **On**, then check **Mouse**. We can now select a subframe on the image using the mouse. **Drag the mouse** to create a box around a star (point the mouse to the top-left of the star, press and hold the left mouse button, and drag to the lower right). You will see the mouse coordinates entered automatically.

10. Click **Start**. Only the selected part of the image will be downloaded. Most CCD cameras will operate much faster if a subframe is selected.

11. If you wish to have the focus display update continuously, select the **Continuous** mode and click **Start**. In some cases you may wish to set a small delay between exposures.

This can be done using the **Options** menu and select **Exposure Delay** option. Click **Stop** to finish imaging.

12. The Inspect panel at bottom shows information on the star. The panels can be configured as you like them. The two text panels can be set show image statistics, including the location and value of the brightest pixel. When focus is sharp the pixel value will be maximized. To select the display mode, simply right-click on the panel.

13. The Full-Width Half Maximum (FWHM) of the brightest object will also be shown. This is the diameter of the star at half of the peak value. The smaller the number, the better the focus. Also shown is the Half-Flux Diameter, which is similar to FWHM but works even if the star is badly out of focus (e.g. a large donut).

14. The left-hand panel is for graphs. It can show a 3D representation of the star, or a graph of the peak value of the brightest star over time, the Full-Width Half Maximum (FWHM) size of the star over time, or the Half Flux Diameter (HFD) size of the star over time. Using the graph you can get an idea of focus trends as you change the focus setting on the telescope. Again, to pick the display mode, simply right-click on the panel.

15. Once you have adjusted focus for the best image, click **Stop** to interrupt the Continuous mode.

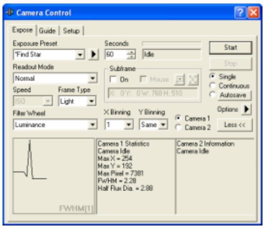
Tip: If you have a computer-controlled focuser, you can adjust the focus position through the **Observatory** control Focus Tab.

Tip: If your computer-controlled focuser is capable of absolute positioning, you can autofocus. Please refer to the Autofocus Tutorial for more information.

CCD Imaging Tutorial – Basics

Now that we have the target object focused and in our camera's field of view, it is time to take some images. CCD cameras can collect a usable image in only 30 or 60 seconds, but the best results are always obtained by taking longer exposures.

1. Open the **Camera Control** window and select the **Expose** tab.



2. Turn **Subframe Off**. This will ensure that you get the entire image.

3. Turn off Binning by setting the **X Binning** value to **1** and the **Y Binning** value (if enabled) to **Same**. This will give you the highest resolution image.

4. Set the **Readout Mode** if enabled. The setting depends on the camera model; however, many cameras have Normal and Fast; for best quality you should select **Normal**. Some

cameras may offer different bit depths; pick the highest setting. If the camera is a one-shot color style it may offer Monochrome and Color options. Usually it is best to select **Monochrome**, because that allows you to perform dark subtraction before color conversion. Please note that raw monochrome one-shot color images will look odd when displayed. They will be monochrome, and they will change appearance when zoomed in and out because of the way Windows displays images on the screen. These images will not look "correct" until the Convert Color command is applied.

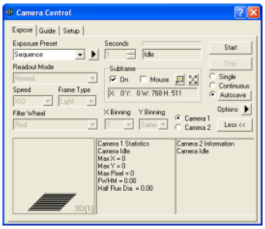
5. Check the **Options** menu to see if additional **Camera Settings** are available; if so you may wish to check the settings for your camera.
6. Under the **Options** menu, select **No Calibration**. If you wish to perform calibration (dark subtraction, flat-fielding, etc.) immediately as each image is taken, you must first set up calibration frames using the Process menu Set Calibration command. Then select **Full Calibration**. **Simple Auto-dark** can also be used; it is particularly handy for "quick images", especially if your camera has a built-in shutter.
7. Set **Frame Type** to **Light** (normal image frame).
8. Dial in the desired exposure time in the **Seconds** field.
9. Click **Expose** and an image will appear. If you like you can save the image to disk.

CCD Imaging Tutorial – Advanced

This tutorial assumes you just completed the DSLR Exposures - Basic tutorial.

We can now proceed to more advanced camera control operations, namely setting up an LRGB color autosave sequence. This assumes you have set up a filter wheel (or simulator) with the necessary filter slots.

1. On the **Expose** tab, open the Options menu and select **Set Image Save Path**. This will open a browse folder window. Select a location to save your images; for example, a folder under My Documents. It is usually a good idea to name the folder with today's date, so that images taken on different days go into their own folder.



2. Make sure the **Subframe** is turned **Off**. This will ensure that you capture the entire frame, rather than just a part of it.
3. Click the **Autosave** button. This will switch the exposure mode to Autosave and open the Autosave Setup dialog box.

4. Enter a base file name that identifies your target, such as ”NGC4565”, in the **Autosave Filename** field. The filenames for Individual exposures taken by the sequence will be composed of this, a unique sequence number, and a suffix. If you have the Observatory Control Window connected to a telescope, click the drop arrow and select **Filename from Observatory Control**. The filename will automatically set based on the last object that was slewed to, or if the telescope was not slewed to a particular object name, then the closest object to the telescope position.

5. Turn **Dither**, **Mosaic Capture**, and **Astrometric Resync Off**.

6. Set **Delay First** and **Delay Between** to **0**. Delay Between can be used to provide some extra time between exposures for the autoguider to settle (by default there is a minimum 5 second delay when the guider is running). You can also set a settling criterion based on the autoguider error using the Guide Tab Options menu.

7. Enable the first four **Slots**, and disable the rest. This is done by clicking the Slot number buttons. Use the scroll bar at the right side to scroll through all the slots and make sure the remaining ones are disabled.

8. In the first Slot, set the following:

   - Set Type to Light
   - Set Filter to Red
   - Set Suffix to R
   - Set Exposure to your desired exposure time, in seconds
   - Set Binning to 2
   - If enabled, set Readout Mode to Normal (or as appropriate for your camera model)
   - Set Repeat to the desired number of exposures
   - Leave Script blank (to clear click the ... button and then click None)

9. Repeat the slot setup for the remaining filters, Red, Green, Blue, and Luminance. You must use a unique Suffix for each. Usually the Luminance exposure is set for no binning and a longer total exposure.

10. Click **OK** (or **Apply** if you want to leave the Autosave Setup window open).

11. Click **Start** on the **Expose Tab** to initiate the exposure sequence.

CCD Shutdown Procedure

Note: Regardless of the advice in this section, we strongly recommend that you follow any manufacturer's recommendations. If they differ from the advice below, the manufacturer's instructions must take precedence.

If your camera has the capability of creating very large temperature deltas (e.g. more than 40 degrees C lower than ambient), then your sensor may be subject to thermal shock if it is warmed up very rapidly. This is usually not as serious as it sounds; many camera models warm up slowly even if the power is cut, it requires a large and rapid temperature change to create thermal shock, and even if the camera is susceptible actual damage will only occur if rapid thermal shock occurs a great many times. An occasional power loss, for example, will not damage the camera. In any case, you should follow the manufacturer's recommendations on the warm-up procedure.

Some cameras have a built-in mechanism to gradually ramp up the CCD chip to the ambient temperature. This can be triggered using the **Warm Up** button on the **Setup** tab. The period of time required for the warm-up depends on the particular camera model; some cameras switch off quickly, while others gently raise the temperature over an extended period of time.

Most camera models allow you to force the cooler to switch off rapidly by clicking **Cooler Off**. Generally speaking, you can safely do this once the temperature is within 20 degrees C of ambient.

DSLR Imaging Tutorials

These tutorials provide an introduction to basic camera operations, including equipment setup, focusing, taking exposures, and autoguiding. It is highly recommended that all users review the tutorials prior to operating a camera with MaxIm DL.

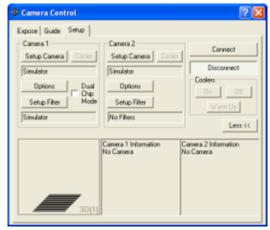
We recommend that the first "imaging session" be done at your desk, rather than under the stars, so that you can become familiar with the operation of the software and your DSLR camera.

Before using a DSLR camera for the first time, we **strongly recommend** you review the Help sections on DSLR Exposure Control and the section under Camera and Autoguider Setup for your specific model.

DSLR Software Setup Tutorial

This tutorial assumes the use of the camera simulator. If you are using an actual DSLR camera instead, be sure to review DSLR Exposure Control and the section for your camera under Camera and Autoguider Setup before proceeding. Otherwise you may not be able to connect to the camera.

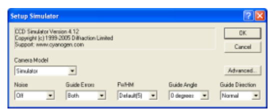
1. Start **MaxIm DL** and open the Camera Control window, then select the Setup tab.



2. Move the **Camera Control** window to a convenient location on the screen. To do this, point the **mouse** at the **title bar**, **click and hold** the **left mouse button**, and **drag**.

3. The **Setup** tab should appear first; if it is not displayed click on the **Setup** tab near the upper right corner of the window.

4. Select **Simulator** for the **Camera 1** by clicking on the associated **Setup** button, and picking **Simulator** for the **Camera Model**. You can ignore the remaining settings for now. Click **OK**.



5. Now set up **Camera 2**, which is usually an autoguider. Click the autoguider **Setup** button, and set the **Camera Model** to **Simulator**. Set **Noise** to **Off**, **Guide Errors** to **Both**, **FWHM** to **Default (5)**, **Guide Angle** to **45 degrees**, and **Guide Direction** to **Normal**. Click **OK**.

6. Now we are ready to connect to the equipment. Click **Connect**.

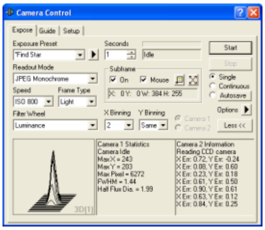
7. We now have two "cameras", one for use as the main camera, and the other for use as the autoguider. Normally you would configure your actual imaging and autoguider cameras, but the simulators allow you to try the controls at your desk.

8. Once all of these settings are made they will be remembered. The next time you want to start imaging, just click the **Connect** button.

DSLR Focusing Tutorial

1. Set up the camera as described in the DSLR Exposure Control and DSLR Software Setup sections. If your camera is currently not available, you can use the Simulator to try out the focusing features.

2. Select the **Expose** tab of the Camera Control window. If necessary, click the **More >>** button to display the **Inspect Panel**.



3. For DSLR cameras, it is usually simplest to turn off dark frame subtraction during focusing. Open the **Options** menu and check **No Calibration**.

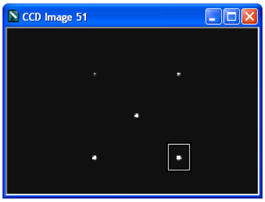
4. In the **Seconds** field, set an exposure time of 1 second. **Tip:** you can use the up/down "spin" control (arrow) buttons to rapidly dial in the exposure. The range of exposure times available depends on the camera model.

5. Select **Single** exposure mode.

6. DSLR cameras always have several **Readout Mode** options. Although it is the best option during imaging, do ***not*** use the **Raw Monochrome** option for focusing, because the color Bayer matrix will make it impossible make proper measurements on the star. You can use the **Raw Color** mode; however, for most cameras the image download time is slow enough to be very inconvenient for focusing. The best option is usually to use the **JPEG Monochrome** mode. The image downloaded is noisier, lower bit depth, and has compression artifacts; however, the image degradation is not bad enough to significantly affect focus measurements.

7. If you are using a real camera on a telescope, you should first point the telescope to a moderately bright star; say 5th magnitude.

8. Click **Start** to take an exposure. After a few seconds, an image appears (simulator image shown).



9. DSLR cameras do not support subframes; however, the plug-in drivers in MaxIm DL can extract subframes from the downloaded images. This does not speed up camera operation; however, it is often helpful to isolate a single star to work on. In the **Subframe** section check **On**, then check **Mouse**. We can now select a subframe on the image using the mouse. **Drag the mouse** to create a box around a star (point the mouse to the top-left of the star, press and hold the left mouse button, and drag to the lower right). You will see the mouse coordinates entered automatically.

10. Click **Start**. Only the selected part of the image will be downloaded.

11. If you wish to have the focus display update continuously, select the **Continuous** mode and click **Start**. In some cases you may wish to set a small delay between exposures. This can be done using the **Options** menu and select **Exposure Delay** option.

12. The Inspect panel at bottom shows information on the star. The panels can be configured as you like them. The two text panels can be set show image statistics, including the location and value of the brightest pixel. When focus is sharp the pixel value will be maximized. To select the display mode, simply right-click on the panel.

13. The Full-Width Half Maximum (FWHM) of the brightest object will also be shown. This is the diameter of the star at half of the peak value. The smaller the number, the better the focus. Also shown is the Half-Flux Diameter, which is similar to FWHM but works even if the star is badly out of focus (e.g. a large donut).

14. The left-hand panel is for graphs. It can show a 3D representation of the star, or a graph of the peak value of the brightest star over time, the Full-Width Half Maximum (FWHM) size of the star over time, or the Half Flux Diameter (HFD) size of the star over time. Using the graph you can get an idea of focus trends as you change the focus setting on the telescope. Again, to pick the display mode, simply right-click on the panel.

15. Once you have adjusted focus for the best image, click **Stop** to interrupt the Continuous mode.

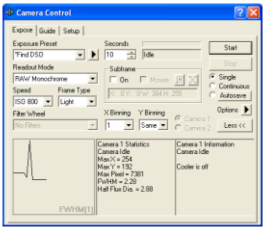
Tip: If you have a computer-controlled focuser, you can adjust the focus position through the **Observatory** control Focus Tab.

Tip: If your computer-controlled focuser is capable of absolute positioning, you can autofocus. Please refer to the Autofocus Tutorial for more information.

DSLR Imaging Tutorial - Basics

Now that we have the target object focused and in our camera's field of view, it is time to take some images. Most DSLR cameras can take an exposure of maximum 30 seconds with the standard cable; using an external bulb cable much longer exposures can be taken. Please see DSLR Exposure Control for more information.

1. Open the **Camera Control** window and select the **Expose** tab.



2. Turn **Subframe Off**. This will ensure that you get the entire image.

3. Turn off Binning by setting the **X Binning** value to **1** and the **Y Binning** value (if enabled) to **Same**. This will give you the highest resolution image, and will also make color imaging possible.

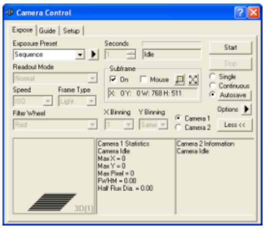
4. Set the **Readout Mode** to **RAW Monochrome**. This provides the best quality final image, because you can perform dark subtraction before color conversion. Please note that RAW images will look odd when displayed. They will be monochrome, and they will change appearance when zoomed in and out because of the way Windows displays images on the screen. These images will not look "correct" until the Convert Color command is applied.
5. **Set Speed** to **ISO 800**. For many cameras, this is the gain setting that results in the best sensitivity and dynamic range. You may need to experiment to find the best setting for your particular camera model.
6. **Options** allows you to adjust advanced camera settings (when supported by the camera), set the camera control window to remain always on top, and to automatically flip or rotate images upon download.
7. Under the **Options** menu, select **No Calibration**. If you wish to perform calibration (dark subtraction, flat-fielding, etc.) immediately as each image is taken, you must first set up calibration frames using the Process menu Set Calibration command. Then select **Full Calibration**. **Simple Auto-dark** can also be used, but you will have to manually cap the telescope for dark frame exposures because the DSLR cameras do not provide a method to take images with the shutter closed (this is a firmware limitation of the camera itself). Some cameras provide a built-in "noise reduction" option that takes dark frames for every exposure; however, this doubles the amount of exposure time required.
8. Set **Frame Type** to **Light** (normal image frame).
9. Dial in the desired exposure time in the **Seconds** field.
10. Click **Expose** and an image will appear. If you like you can save the image to disk.

DSLR Imaging Tutorial - Advanced

This tutorial assumes you just completed the DSLR Exposures - Basic tutorial.

We can now proceed to more advanced camera control operations, namely setting up an autosave image sequence.

1. On the **Expose** tab, open the Options menu and select **Set Image Save Path**. This will open a browse folder window. Select a location to save your images; for example, a folder under My Documents. It is usually a good idea to name the folder with today's date, so that images taken on different days go into their own folder.



2. Make sure the **Subframe** is turned **Off**. This will ensure that you capture the entire frame,

rather than just a part of it.

3. Click the **Autosave** button. This will switch the exposure mode to Autosave and open the Autosave Setup dialog box.

4. Enter a base file name that identifies your target, such as ”NGC4565”, in the **Autosave Filename** field. The filenames for Individual exposures taken by the sequence will be composed of this, a unique sequence number, and a suffix. If you have the Observatory Control Window connected to a telescope, click the drop arrow and select **Filename from Observatory Control**. The filename will automatically set based on the last object that was slewed to, or if the telescope was not slewed to a particular object name, then the closest object to the telescope position.

5. Turn **Dither**, **Mosaic Capture**, and **Astrometric Resync Off**.

6. Set **Delay First** and **Delay Between** to **0**. Delay Between can be used to provide some extra time between exposures for the autoguider to settle (by default there is a minimum 5 second delay when the guider is running). You can also set a settling criterion based on the autoguider error using the Guide Tab Options menu.

7. Enable only the first **Slot**, and disable the rest. This is done by clicking the Slot number buttons. Use the scroll bar at the right side to scroll through all the slots and make sure the remaining ones are disabled.

8. In the first Slot, set the following:

   - Set Type to Light
   - Leave Suffix blank
   - Set Exposure to your desired exposure time, in seconds
   - Set Binning to 1
   - Set ISO Spd to 800
   - Set Readout Mode to RAW Monochrome
   - Set Repeat to the desired number of exposures
   - Leave Script blank (to clear click the ... button and then click None)

9. Click **OK** (or **Apply** if you want to leave the Autosave Setup window open).

10. Click **Start** on the **Expose Tab** to initiate the exposure sequence.

Observatory Control Tutorials

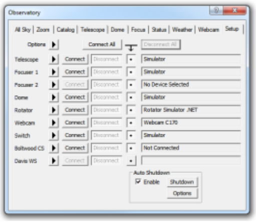
The Observatory Control provides a number of extremely useful functions:

- Go to a catalog object
- Search for nearby catalog objects
- Synchronize telescope to a catalog object
- Synchronize telescope to a PinPoint solution
- Nudge telescope in any direction
- Automatically center telescope on an object in an image
- Park and un-park telescope
- Set telescope real-time clock
- Add telescope coordinates to the image FITS header
- Add object name to the image FITS header

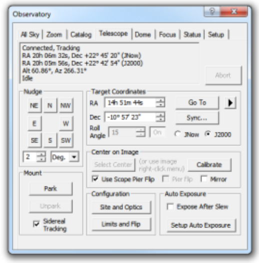
These tutorials introduce you to basic telescope operations and the auto-center function.

Telescope Control Tutorial

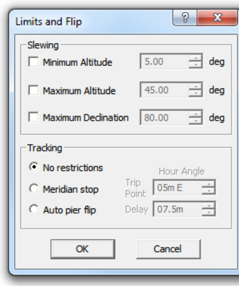
1. The first step is to set up a telescope. For this tutorial we will use the Telescope Simulator. Activate the Telescope using **View** menu **Observatory Control Window**.



2. On the **Setup** tab, under Telescope, click the **Options** button and select **Choose.** Use the chooser to select **Telescope Simulator**. If this is the first time you have selected the simulator you may need to click **Properties** and configure the simulator. Click **OK** to return to the Setup tab and then click **Connect**.
3. The **Scope Simulator** display may appear. Move this to a convenient place on the screen.
4. Switch to the **Telescope** tab.



5. Click **Limits and Flip** button. Make sure that **none** of the check boxes are set, and that **Tracking** is set to **No Restrictions**.



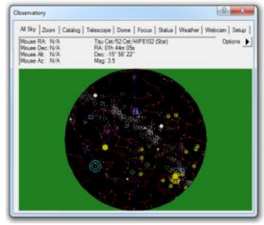
6. Under **Mount**, make sure **Sidereal Tracking** is checked.

7. Click a **Nudge** button to move the telescope in one of the eight available directions. You will see the telescope position change. You can set the distance moved with each nudge.

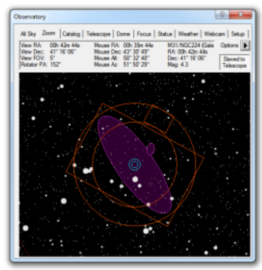
8. After a nudge or move, if the **Take image** check box is on, the **Camera Control** window will also be activated to take a picture of the region of the sky. (If the camera simulator is selected, you will get the test pattern). You can set up exposure settings for these images using the **Exposure** button. Usually this is just set to a quick binned exposure so you can tell whether the telescope is on target.

9. Click the **Site** button, and make sure you have configured the geographical location for the observatory. You can also set up the telescope parameters such as focal length, which is useful later on.

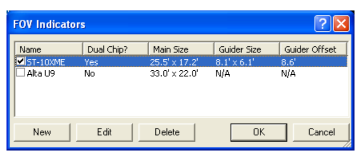
10. Switch to the **All Sky** tab. The sky will be shown as it currently appears. A circular cursor will indicate the position of the telescope. You can move the telescope anywhere in the sky by pointing at the sky and using the **right-click** menu **Slew To Mouse Position** command. You can also zoom in by selecting **Zoom To Mouse Position**, which will switch you to the Zoom tab.



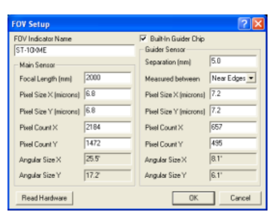
11. In the **Zoom** tab you can move the sky display by **dragging** with the mouse. You can zoom in and out using the **mouse wheel** or **right-click** menu. The Observatory Control window is resizable by dragging the lower right corner with the mouse, so you can get a bigger sky display if you so wish.



12. **Right-click** and select **FOV Indicators**. Click the New button to add a Field of View indicator.

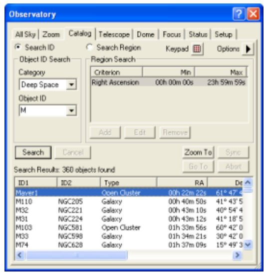


13. Type an **FOV Indicator Name**. If your camera has one, turn on **Built-In Guider Chip** and enter the **Offset**. If your camera is connected, click the **Read Hardware** button to load the fields; otherwise you will have to enter the values from the camera manual. Click **OK**.



14. Now set the **Check Box** beside the name of your FOV indicator, and it will appear on the **Zoom Tab** display. You can orient the FOV indicator by grabbing it with the mouse and rotating it. If you have an instrument rotator attached, the rotator will turn to match.

15. Now switch to the **Catalog** tab.



16. Set **Category** to **Deep Space**, and click the **Object ID** drop-down list arrow. Pick **M** and type **3** in the Object Name. All Messier objects starting with M3 will be displayed.

17. You can sort the list by any field by clicking on the title bar. You may wish to resize the window, in order to better see all the fields in the search list. You can also control and sort the columns using the **right-click** menu.

18. Click on an object and select **Go To** to slew the telescope, or **Zoom To** to display it on the Zoom tab.

The Observatory Control window has many more capabilities, including Dome, Focuser and Rotator control, image overlays, and much more. Please refer to Observatory Control Window in the Command Reference for more information.

Aiming Your Telescope

Aiming a telescope cannot be illustrated easily in simulation, but a few pointers are in order.

Once the telescope is in focus, the biggest challenge can be finding your the target. CCD cameras do not have a viewfinder, and it can be very frustrating to aim if the images take more than about 20 seconds to appear. It can also slow things down if you have to keep changing exposure settings. There are a number of things you can do to greatly speed up the process.

1. Most cameras will be faster and more sensitive if operated **Binned**. Binning combines adjacent pixels together to make a bigger "super-pixel". Most cameras download more quickly, and the sensitivity increases for a given exposure time. In most cases, faint deep sky objects can be seen with only 5-10 seconds of exposure time with a Binning of 2. This makes centering much easier.

2. Define a set of **Presets** containing your favorite find, focus, and Autosave sequence exposure settings. This allows you to switch back and forth quickly.

3. Calibrate your focus images; at the very least use the **Simple Auto-dark** mode. The Camera Control window remembers previously-used auto-dark frames, so you can switch back and forth quickly without reshooting for different exposures or binning.

4. The PinPoint Astrometry feature can be used as a **digital finderscope**. Slew to the approximate position of your target, take an image, and PinPoint solve it. You now know the exact center of your image to a fraction of an arc-second. Next Sync the telescope to that position. Now a second GOTO command will bring the telescope to the exact correct coordinates. PinPoint now has the capability to perform an all-sky solve through

Astrometry.net, if an internet connection is available; this means you do not even need to roughly know where your telescope is pointing.

5. You can ***automate*** the above process of using PinPoint to refine your telescope position, using the **Slew Refinement** feature. In the **Telescope** tab **Target Coordinates** section, click the **Options** menu. Turn on **Refine via Sync** or **Refine via delta RA, delta Dec**. You will also want to set up the **Refinement Exposure**, and the **Auto-Reset Distance**. Now whenever your telescope has to move more than the Refinement Distance, it will automatically take a pointing refinement exposure, solve it, and use that as a reference point for a final slew to the correct position.

6. Consider using MaxPoint, which can improve your pointing accuracy to one or two arc-minutes over the whole sky. This will ensure that your target is in the field after a slew.

7. Overlay your image on the Observatory control window Zoom Tab. This will show you the position and orientation of your image on the real sky.

8. Use the Auto-Center feature, available on the Observatory Control window Telescope Tab, or the image buffer right-click menu. You simply point the mouse to the position you want centered, and the telescope is automatically moved to center that point.

Auto Center Tutorial

Auto Center permits extremely rapid object centering. This tutorial will require a real telescope and camera operating under the night sky. We will assume that the **Observatory Control** window is already linked to a telescope, and the **Camera Control** window is linked to a camera.

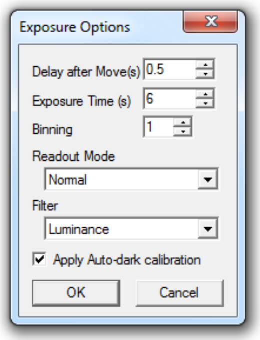
Tip: If you are using a **German Equatorial** mount, switch to the **Status Tab** and make sure that the display indicates German Equatorial. If not, then your telescope's ASCOM driver does not report back the type of mount. Switch to the **Setup Tab**, disconnect the telescope, and on the **Options** menu click **Mount Type** and select **German Equatorial**. Reconnect the telescope. This is important because pier flipping affects Auto Center.

1. Make sure the Telescope is synchronized on the sky so that the Right Ascension and Declination matches the telescope position. Make sure the camera is focused, and take an image of the star field in the area.

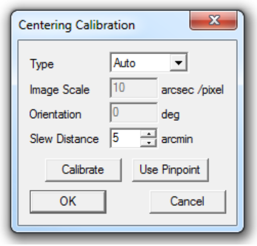
2. Select the **Telescope** tab.

3. Click the **Setup Auto Exposure** button, and configure a short (typically 10 seconds is sufficient) binned exposure. If there is some slop in your drive gears, you may want to set

a brief **Delay After Move**. Click **OK**.



4. Click the **Calibrate** button, and set the **Type** to **Auto**.



5. You have two options: calibrate by moving the telescope, or calibrate using PinPoint Astrometry. If you have already set up to use PinPoint, this is the best option. Simply PinPoint solve the image, then click the **Use PinPoint** button.

6. If you do not want to use PinPoint, then make sure a reasonably bright (e.g. 5th magnitude), isolated star is visible in the image. Set **Slew Distance** to 1/8 to 1/4 of the field size for your camera (in most cases you can use 5-10 arc minutes). Click **Calibrate**.

7. The camera will take a picture, using the settings configured under the **Setup Auto Exposure** button. The telescope will then slew West, and a second picture will be taken. The telescope will then move back to the original position. The distance the star moved will be used to determine the scale and rotation angle of the camera view.

8. If you are using a **German Equatorial** mount, turn on the **Use Scope Pier Flip** check box; otherwise turn it off. Also turn off the **Mirror** check box unless your telescope has an odd number of mirrors.

9. Now you can rapidly center any object on the image. Simply **right-click** on it and select **Point Telescope Here** from the right-click menu. The telescope will slew a short distance to center the object.

10. If **Expose After Slew** is checked (recommended), a quick exposure will be taken after each centering movement, so you can see the results. For convenience, you may wish to **right-click** on the image and turn on **Crosshairs**.

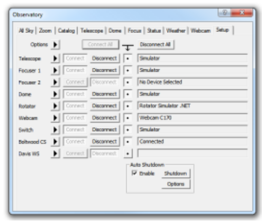
Once set up properly, Auto Center will work anywhere in the sky. You will only need to recalibrate if you change equipment or rotate the camera.

Autofocus Tutorial

Autofocus requires a compatible digital focuser with absolute positioning, i.e. it uses a stepper or servo motor. If you are using an open-loop DC motor (relative focuser) then we recommend using FocusMax, available from http://focusmax.org.

This tutorial assumes you have your telescope and camera operating.

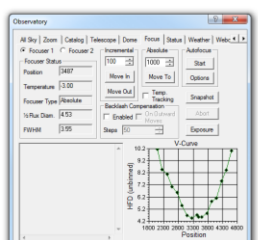
1. The first step is to set up the focuser. Select **View** menu **Observatory Control Window** and select the **Setup Tab**.



2. Under **Focuser 1**, click the **Options** menu and click **Choose**. The **ASCOM Chooser** will appear. Select the focuser model you are using, and click **Properties** to set it up. The exact settings depend on the model of focuser you are using, and how it is connected to the telescope. Please consult the manufacturer's instructions for more information. When you are done click **OK**.

3. If you have a computer-controllable telescope you can set it up and connect it as well. This is convenient for adjusting the telescope pointing but not required.

4. Switch to the **Focus** tab.



5. Check that you can adjust the position of the focuser. Change the **Absolute** position value and click **Move To**. The focuser should move to the new position. You can also adjust incrementally; set the **Incremental** step size to 50 and click **Move In** or **Move Out**. Take an image with the camera to verify that the focuser is actually moving and the focus is changing.

6. Under **Autofocus** click the **Options** button. There are several parameters that must be set

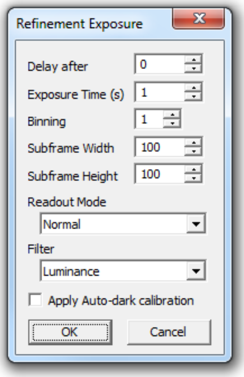
up correctly for autofocus to work.

7. The **Telescope Focal Ratio** is essential. It determines the depth of focus, and therefore the step size that is used when hunting for best focus. The focal ratio is often found in the telescope manual; it can also be calculated by dividing the focal length by the aperture.

8. Also essential is the **Focuser Step Size**. Some digital focusers know what this is inherently; you can click the **Auto** button to fill in the information. Other digital focusers do not have this information; they are just motors hooked up to focusers from other manufacturers. In this case, take out a ruler! Move the focuser 1000 steps, measure the distance it moves, and divide that by 1000. Enter that into the Focuser Step Size (be sure to set **Microinches** or **Microns** as appropriate). (Tip: if you cannot see the focuser move, as for a Schmidt-Cassegrain telescope, focus the telescope with an eyepiece, move the focus out 1000 steps, and then pull the eyepiece out of the focuser until the image is sharp. Measure the distance the eyepiece is moved.)

9. You also need to set the **Target 1/2 Flux Dia**. The Half Flux Diameter is a measure of how large the star images are, in pixels; obviously we want them to be as small as possible. The target needs to be set somewhat higher than the optimum; typically by 2 pixels. This is required because the measurements are made on either side of focus, not right at focus. Typical values are 5 to 7, but it depends on how small your star images are at best focus.

10. Once you are done, click **OK** to return to the **Focus Tab**, then click **Exposure**. Set **Delay after Move** to **0**, **Exposure Time** to **1** second, **Binning** to **1**, Subframe Width and Subframe Height to 100. If your camera has a shutter turn on **Apply Auto-dark calibration**. If your camera is very slow or is one-shot color, turn on **Use Fast Download if available**. Click **OK**.



11. Point the telescope at an isolated star, approximately 5th magnitude. You want the star to be bright enough to give a good signal-to-noise ratio, but not have it saturate when you are near focus. If the star is too bright then autofocus will not work properly.

12. Now click the **Start** button. Focusing takes a minute or two as MaxIm DL first performs coarse focusing, then switches to fine focus mode and determines the change in star image size on both sides of the region of best focus, and finally computes and moves to the optimum focus position.

13. Watch the log and the V-Curve. During fine focus, the Half Flux measurement should change about 1.5 pixels every time the focuser moves (anywhere between 1 and 1.5 is okay). If it moves too quickly, open the **Options** and **increase** the **Focuser Step Size**. If it moves too slowly, decrease the **Focuser Step Size**. This will provide optimum focus speed and accuracy.

14. The V-Curve will continue past best focus for a bit. If it keeps right on going without detecting best focus, check the **Target 1/2 Flux Dia** setting. This number **must be bigger** than the best focus achieved by approximately 2 pixels.

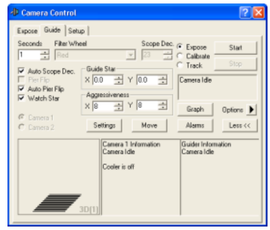
15. Once the V-Curve has traced out both sides of focus far enough, it will be able to calculate the position of best focus, i.e. at the center of the V. The focuser will be commanded to go to the optimum position, and a last image will be taken so you can see the results. The focus will now be spot-on; often more accurate than you could achieve manually.

Autoguiding Tutorial

Autoguiding appears at first to be a rather complex task. However, the autoguider controls in MaxIm DL are actually quite easy to operate.

For most camera models, you must have a separate autoguider camera for this purpose (usually selected as Camera 2).

1. Switch to the **Guide** tab.



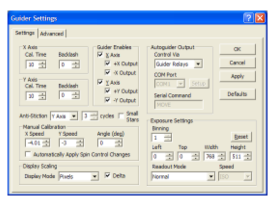
2. If you have a telescope connected to the Observatory Control Window then turn on **Auto Scope Dec** and **Auto Pier Flip**. If these are enabled, you will not have to recalibrate the autoguider after moving the telescope. If you do not have a telescope connected, you can control **Scope Dec** and **Pier Flip** manually. If you plan to recalibrate for each target, leave **Scope Dec** at **0**.

3. Turn on the **Watch Star** check box. This will display the guide star continuously during guiding.

4. If your guider has a shutter, click the **Options** button and select **Simple Auto-dark**. This will automatically create a dark frame and then dark subtract each image from the camera. If you do not have a shutter select **No Calibration** for now.

5. Set the exposure time to **0.5 Seconds**.

6. Click the **Settings** button.



7. Click the **Defaults** button and click **Yes** to confirm that you want to set all fields to their recommended initial values. (The **Manual Calibration** and **Exposure Settings** controls are excluded.) Among these are:

- The **Cal Time** controls specify how long MaxIm DL will "hold the button down" (i.e., actuate the telescope guiding motors) during guider calibration. This will determine how far the star moves between calibration steps. Calibration is an essential step to determine how fast the guiding motors move the telescope and thus how much correction to apply for a particular measured position error. (Note: if there is a speed control on your mount, it is recommended to set it between 0.5X and 0.1X for guiding purposes.) **Cal Time** is measured in seconds and can be specified independently for each axis.

- The six check boxes in the **Guider Enables** group are all turned on, enabling guiding in each axis, and enabling guiding motor operation in each direction.

- **Control Via** is set to **Guider Relays**. This setting informs MaxIm DL how the guiding motors (or in this case simulator) are controlled. If you are using a different device to send commands to the mount, you will need to configure this differently. Please refer to the Guide Tab section for more information.

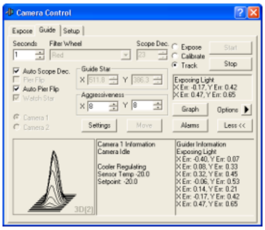
- Set **Display Mode** to **Pixels**. Also turn on the **Delta** check box. This causes the guider position to be reported in pixels, or fractions of pixels, and displayed as an offset from the correct position.

8. In most cases, you can set **Binning** to **2** or **3**. Binning 1 is only required when you are using a separate guide scope that is a much shorter focal length than the main scope. The guide camera can have 1/10th the resolution of the main camera and still guide very well, since the software can measure the centroid of a star to a tiny fraction of a pixel.

9. Click the **Reset** button to reset the subframe settings to include the entire guide sensor.

10. Select the **Advanced** tab of the **Guider Settings** dialog, click its **Defaults** button and confirm that you want to set all fields to their recommended initial values. If a filename appears under **Offset Tracking**, click **Clear**.

11. **Click OK** to return to the **Guide** tab. Once you have these settings configured the way you want them, they will be remembered the next time you start the software.



12. On the **Guide Tab**, make sure the **Expose** mode is selected and click **Start**. A single image will be displayed.

13. The brightest star will automatically be selected as the guide star. You can optionally pick the guide star by **clicking on a star** in the image. *Do not draw a box around it.* Just click on it.

14. Now switch the mode to **Calibrate**, and click the **Start** button again. The camera will take a series of pictures; each time moving the telescope mount (if you are using the simulator, the "mount" and "stars" are of course simulated).

15. The calibration cycle will take five pictures, moving the star in +X, -X, +Y and -Y directions. Usually X refers to RA and Y to Declination, but depending on the mount wiring this may be different. The star may also move in a different direction, because the camera may not be aligned with North at the top. (The camera simulator has a setting that allows you to adjust how the camera is "rotated".)

16. Once the calibration cycle is complete, the star should be approximately back where it started. A red line is drawn to trace the path of the star; this should look like an "L". The

sides of the "L" need to be long enough to get a good measurement of the star movement. If the movement is too short (less than 20 pixels or so), increase the appropriate **Cal Time** setting and start the calibration cycle again.

17. We are now ready to guide. Switch the guider mode to **Track**. Set the **X** and **Y Aggressiveness** settings to **8**. Click **Start**.
18. The image will shrink to a small subframe. This is done to speed up camera download during guiding. You may wish to zoom in the window to see it better. The star should be in the center, and should remain there during tracking. (If the simulator was set up to emulate guider errors, you will see the star bounce around a bit because the simulated "mount" has very rough tracking. Hopefully in the real world your tracking will be smoother!)
19. You can now switch to the **Expose** tab and start an exposure. By default, a five second pause is inserted before each exposure, to make sure that the guider is tracked in before the next exposure starts. Guiding is not performed during main camera readout (to prevent readout artifacts due to CPU loading, and because some cameras use one shutter for both sensors); if the telescope drifts during readout the delay allows it to be tracked in.

Some guiding tips:

- If the guider needs more settling time between exposures, go to the **Autosave Setup** and increase the **Delay Between** to more than 5 seconds. Alternatively, you can set up a **Guider Settling Criterion** on the Guide Tab's **Options** menu.
- The calibration settings change if you move the telescope in declination. To avoid having to recalibrate for every image, you can use declination compensation. Set the **Declination** field to the declination of your calibration star before you calibrate. Then reset the **Declination** value whenever you change guide stars. You can use **Auto Scope Dec** to retrieve this information from the Observatory Control Window.
- If you are using a German Equatorial mount, pier flipping will also affect the guider calibration. The **Auto Pier Flip** will retrieve the necessary information from the Observatory Control Window.
- If you have a large amount of backlash in your mount, you might want to adjust the **Backlash** settings. Be careful not to set them too high, or it will make things worse instead of better.
- If you have stiction on the declination axis of your telescope, you may wish to avoid reversing the corrections in declination. To do this, note the direction of drift and in the **Settings** turn off the autoguider output that pushes in the direction of the drift. That will prevent the declination axis from ever reversing direction.
- It is usually best to balance the telescope *slightly* heavier on the East side, so the main drive gear is lifting the scope. Otherwise any slop in the gears will result in them bouncing back and forth between the teeth, which makes proper guiding impossible. If this is very bad you may need to adjust the gears.

- If you have trouble getting good results, please refer to the Autoguider Troubleshooting section.

Chapter 7. Index