StellaImage 3 User's Guide

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Overview

StellaImage 3 is a third-generation image processing program developed by AstroArts, Inc. in cooperation with the Japanese amateur and professional astronomy community. It is a full-function, astronomically oriented image processing package with features designed to fulfill the needs of beginners as well as advanced amateur astronomers. These features include:

- CCD image processing support -- dark frame, flat field, blooming trail removal
- Multi-format file support -- TIFF, JPEG, FITS, and BMP as well as most CCD manufacturer formats
- TWAIN scanner interface support
- Color support -- tri-color (RGB and CMY) or quad-color (LRGB and WCMY)
- 32-bit floating point internal operations
- Standard digital filters -- Blur, Sharpen, Unsharp Mask, etc.
- Advanced signal processing - Wiener filter, Maximum entropy, and Lucy-Richardson deconvolution
- Vignetting correction function
- Digital Development Processing (DDP) with Color Enhancement
- Star Sharpening function
- Special operations -- 2D and 3D intensity plots, planetary surface projections, blink comparator

System Requirements

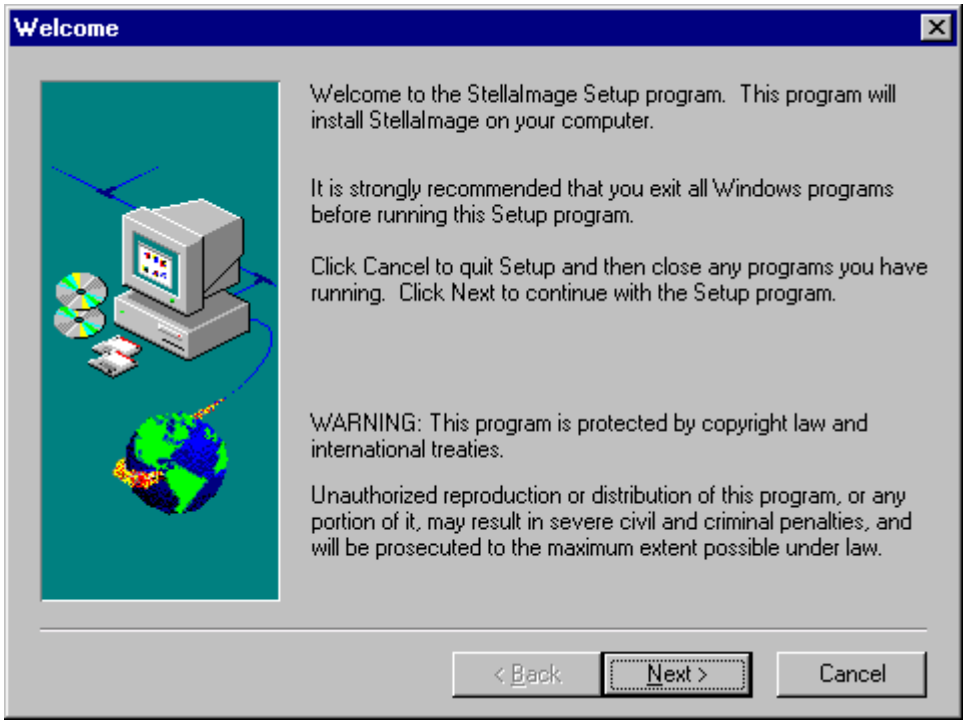
StellaImage 3 is a Windows application for Windows 95, Windows 98, Windows NT 4.0 or later operating systems. Minimum hardware requirements are a Pentium processor, 32MB memory, 4MB hard disk space for the installed program, but many image processing operations are considerably faster on more capable systems. A CD-ROM drive is required for installation of the full version of StellaImage, but is not required for operation once installation has completed.

A color display and graphics card capable of operating at a resolution of 800x600 pixels and 16-bit color is also required. True color (24-bit color) is recommended.

Installation

To install StellaImage, insert the CD-ROM into your drive. If you have your system's auto-start function enabled, the CD-ROM installation program will automatically start. If it does not start automatically, use Windows Explorer or the **[Start] [Run…]** menu to start **SETUP.EXE** in the CD-ROM root directory.

Once the setup program starts with the Welcome screen, follow the prompts to select the hard disk location for installation and to optionally create a shortcut icon on the desktop.



Sample Files

Also included on the StellaImage CD-ROM in the "Image" directory are sample image files which may be used to become familiar with the operation of StellaImage functions. You may open these directly from the CD-ROM when you wish to use them or copy these to your hard disk first for faster access.

General Recommendations for Getting Started

When getting started with StellaImage, it is best to use small files for test cases. Some functions are computationally intensive, so processing may take a significant amount of time on slower processors or limited-memory systems.

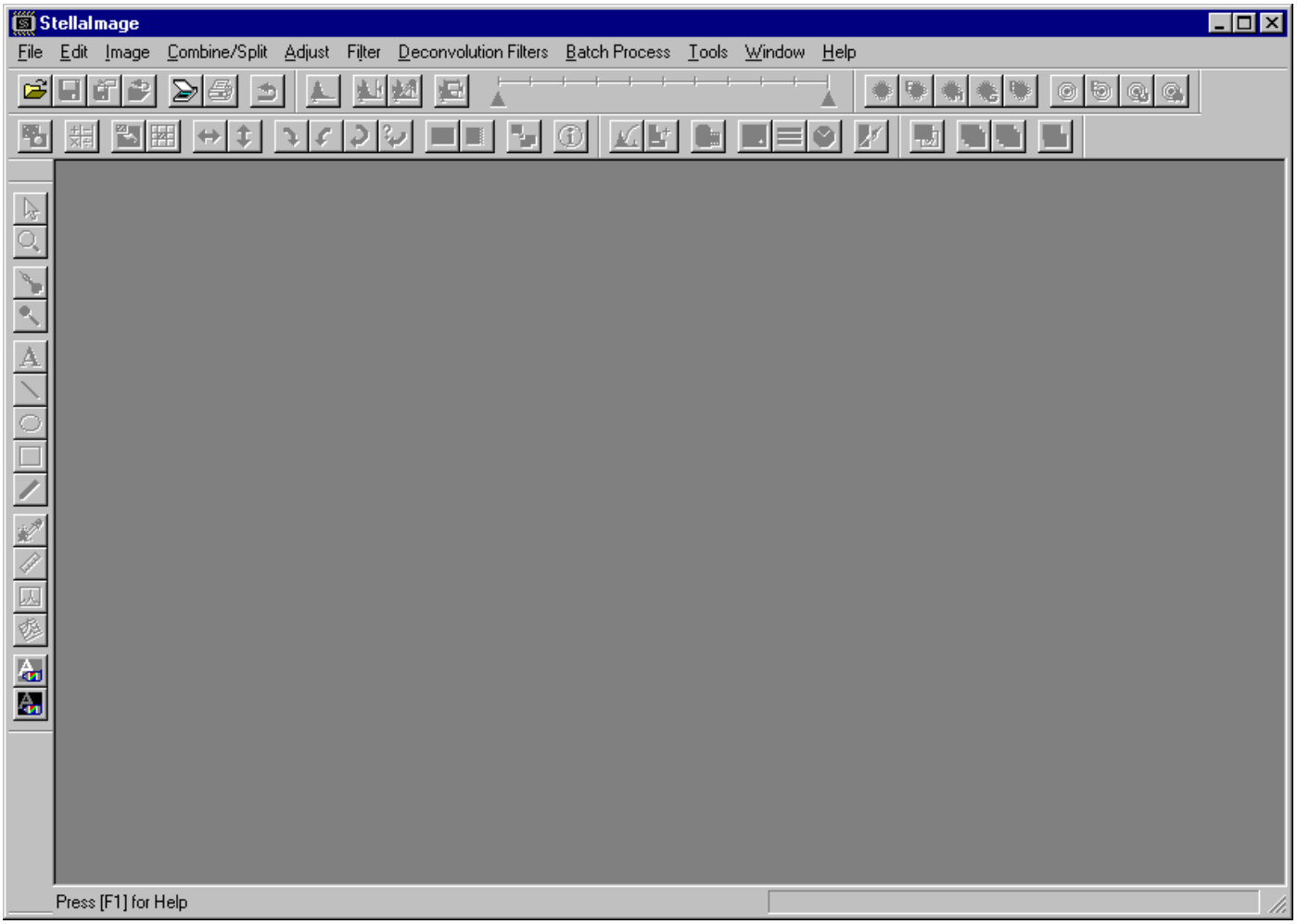
Many functions also have a great deal of user control flexibility and may seem counter-intuitive when starting out or switching from another image processing program. When familiarizing yourself with a new function, use the sample and settings provided to get a feel for what to expect and the behavior of the controls.

Running StellaImage

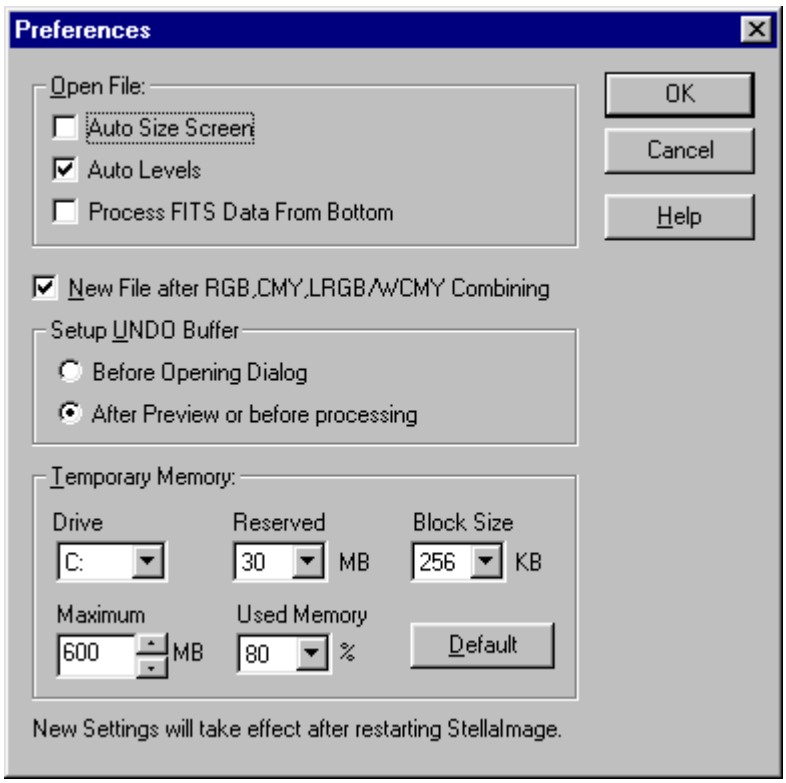
Starting and Stopping StellaImage

To start StellaImage, the fastest method is to click on the icon created on the desktop if you selected this option during installation. Otherwise, use the **[Start] [Program]** windows method to select the StellaImage folder and click on the StellaImage icon to start the program. Note that repeatedly starting StellaImage will cause a window to open for each invocation of the program.

When StellaImage starts running the window will look as shown below. Basic functions are available via familiar Windows pull-down menus. To close a StellaImage session, use **[File] [Exit]** pull-down menu function or click on the StellaImage window's close button. If any files have been processed but not yet saved, a dialog will pop up to ask whether the modified files are to be saved or discarded.



Setting Preferences



Many of the actions in StellaImage have default behaviors which may not be in accordance with your preferences. To set these default actions use the **[File] [Preferences…]** menu. All settings take effect the next time StellaImage is restarted. A pop up window (right) will appear which allows the following behaviors to be set:

Open File:

Auto Size Screen: yes/no - allows StellaImage to automatically adjust the window size depending on your system desktop size.

Auto Levels: yes/no - allows StellaImage to automatically adjust levels when opening an image if required.

Process FITS Data From Bottom: yes/no - sets the direction which StellaImage interprets FITS data. If FITS images are being opened flipped vertically, change this setting. Alternatively the image flip function may be used to fix specific images.

New File after RGB, CMY, LRGB, WCMY Combining:

yes/no - selects whether or not a new image window is created each time a tri-color or quad-color image is created by combining component images. Selecting "no" will place the result in the active window.

Setup UNDO Buffer:

This sets the point at which the UNDO buffer is created:

Before Opening Dialog: - causes the pop-up dialog to be slower but previewing is faster.

After Preview or before processing: - makes the pop-up dialog faster but previewing slower

Temporary Memory:

Drive: Select the letter of the drive to be used for temporary files during processing.

Reserved: Set the space reserved for Windows and other applications.

Block Size: Set the block size for allocating temporary memory.

Maximum: Set the maximum amount to be used by StellaImage.

Used Memory: Set the maximum percentage of available space (excluding reserved space) that StellaImage may use.

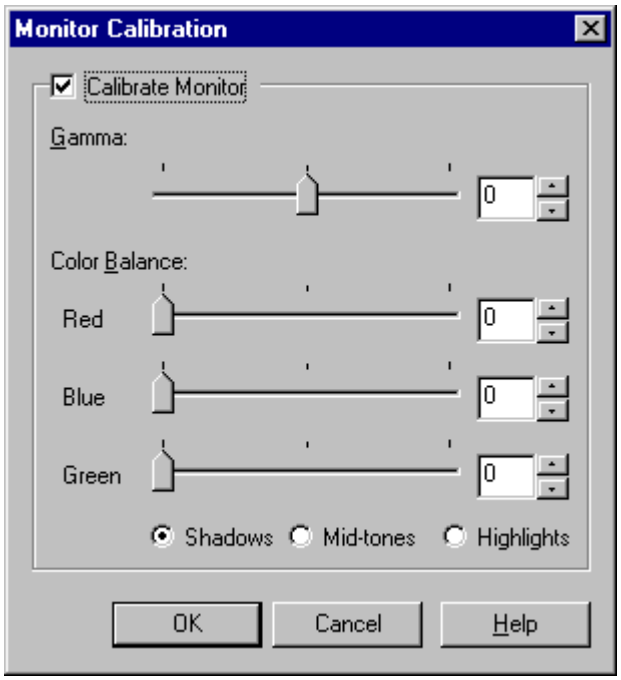
Hints:

1. Decreasing the reserved memory and increasing the percentage of memory which StellaImage may use speeds StellaImage up at the expense of other applications.

2. Setting the block size larger decreases the time required when StellaImage must swap data to disk, but when many small image files are processed at the same time, using a larger block size may waste memory capacity.

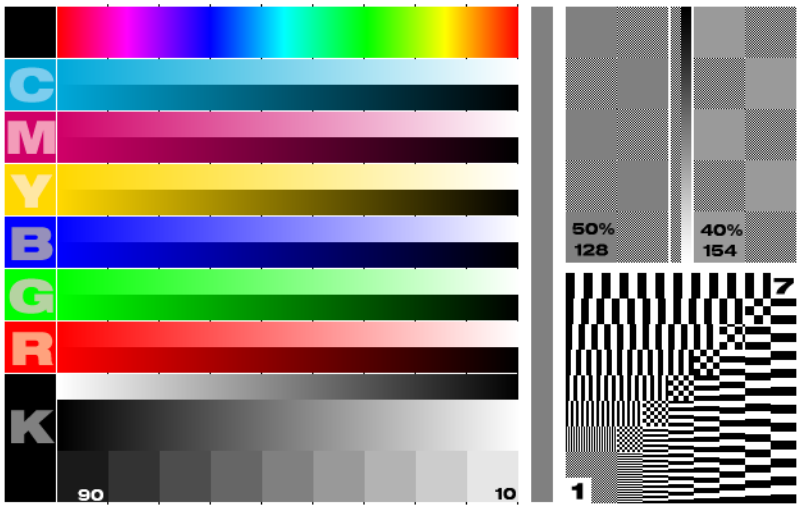
Monitor Calibration

For proper viewing of images, your monitor can be adjusted using the compensation provided by StellaImage. However, if your system hardware and software provides this function, all calibration should be done outside StellaImage. StellaImage's calibration can be used to fine tune the matching if necessary. To enable or disable StellaImage's color correction, use the checkbox (**[Calibrate Monitor]**) at the top left corner of the calibration dialog box.



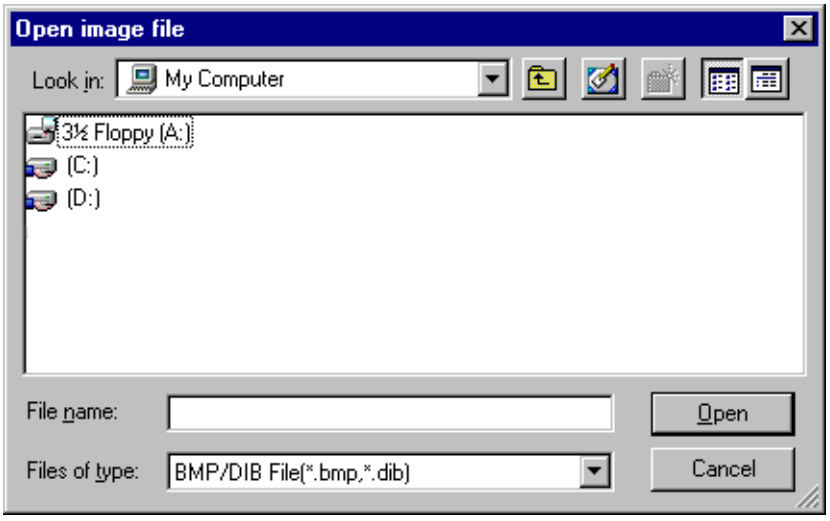
To adjust the luminosity gamma, use the **[Gamma]** slider control which controls the midtone point (positive values lighten midtones). Open the file CHART.BMP found on the StellaImage CD-ROM (use **[File] [Open]**) and view the checkered pattern at upper right. Adjust the "Gamma" slider until the pattern matches the adjacent gray patches.

The color balance controls are used for print color matching. Refer to the printing section of this manual for the print calibration and printing procedure.



File: CHART.BMP

Opening Files



Opening files for processing follows standard Windows procedure. Use the **[File] [Open]** pull-down menu function.

When the file selection dialog opens, select the appropriate file type from the list (refer to the **[File] [Open]** description in the command reference section for a full list of supported formats) and select one or more of the files.

Each file selected will be opened in a separate window. Files which have been recently processed in a StellaImage session may be recalled in one step from near the bottom of the **[File]** menu list.

Images in special formats may be read by using the **[File][Import]** pull-down function and selecting **[Unsigned FITS]**, **[RAW]**, or **[PhotoCD]**. A dialog window will open to allow the specific file information to be entered for proper interpretation of the data format.

Images may also be scanned directly into StellaImage by using the **[File][Import][Import TWAIN…]** function which calls a scanner driver supplied by the manufacturer of the scanner. A dialog window specific to the installed scanner will open to allow setting the appropriate scanner controls. If multiple scanners have been installed in a system, the **[File][Import][TWAIN source…]** function should be used to first select the scanner to be used.

Closing and Saving Files

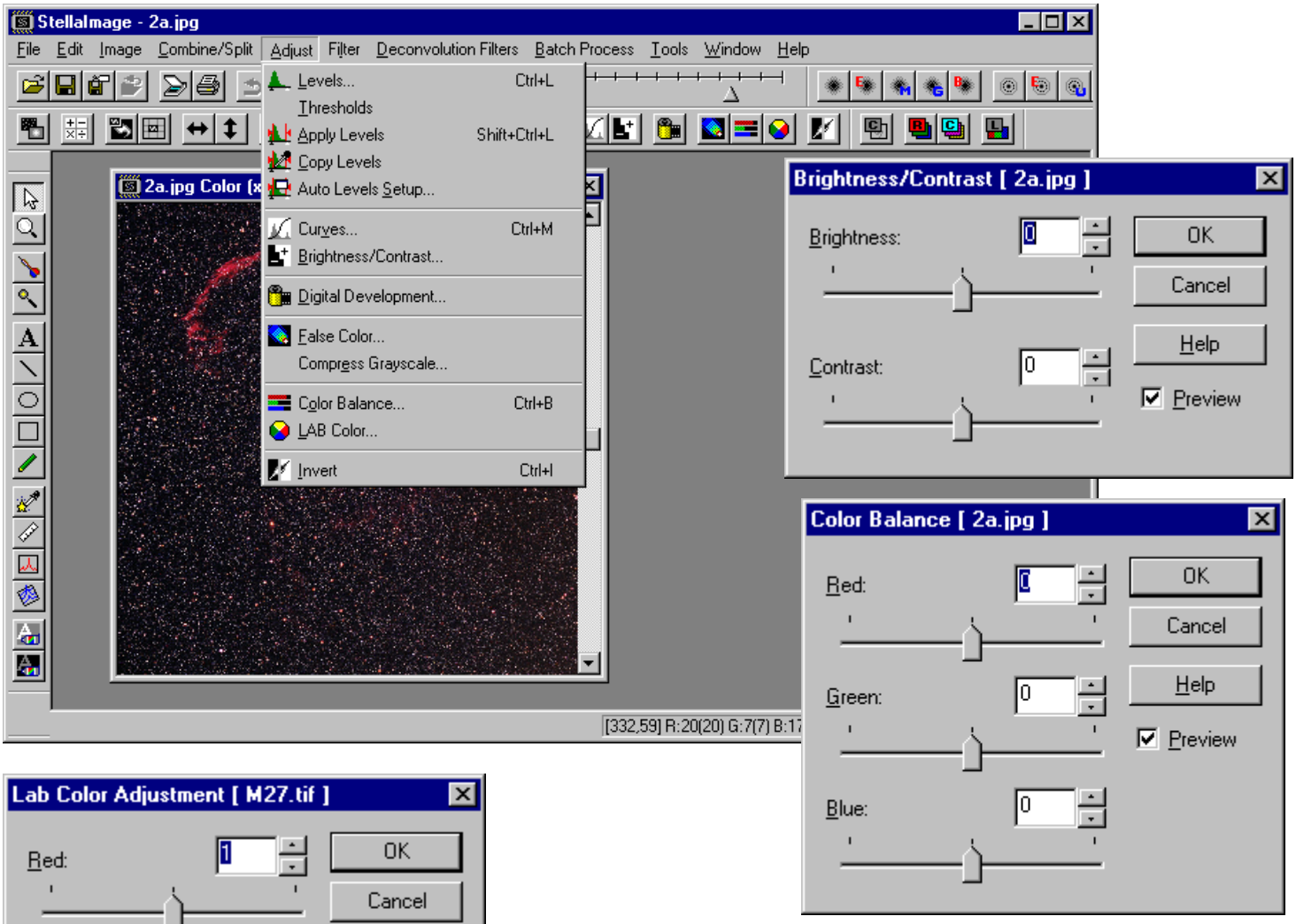
To close files, click on the close box at the upper right of the file's window, or with its window active, select **[File] [Close]** from the pull-down menus. If the file has been modified a dialog window will appear to ask whether or not the modifications should be saved first.

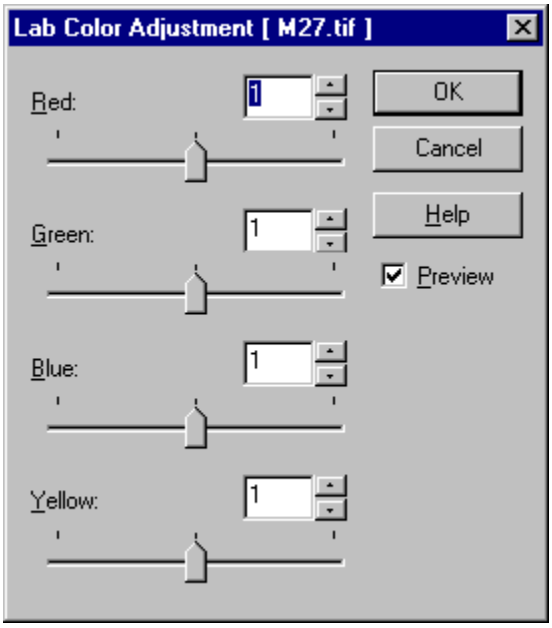
To save a file without closing its window, use the **[File] [Save]** or **[File] [Save As…]** pull-down functions. If the **[Save As…]** function is used, a dialog will open allowing you to specify the file name, directory, and graphic file format. The **[Save]** function will simply replace the original version of the file if it previously existed. Otherwise the **[Save As...]** dialog will appear, requiring you to specify the file name and format.

When saving a file for further processing, FITS format (32-bit floating point option) is recommended as this preserves the full dynamic range of the image and thus avoids compromising the fidelity of the image. Other output options are available for compatibility with other applications or when saving a "final" image for web display or printing. Refer to the StellaImage Command Reference section for full details.

Basic Image Adjustments

Basic adjustments to an image may be made using some of the functions found under the **[Adjust]** pull-down menu (see screen image below). As in the case of most sophisticated image processing programs, there are several methods with overlapping functionality provided to allow adjustment of the appearance of an image. At the simplest level, use the **[Levels…]**, **[Brightness/Contrast …]** and **[Color Balance…]** controls.

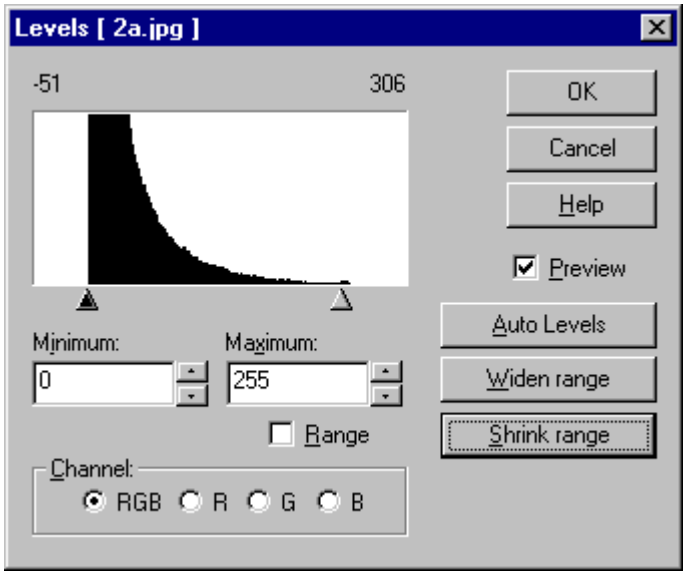


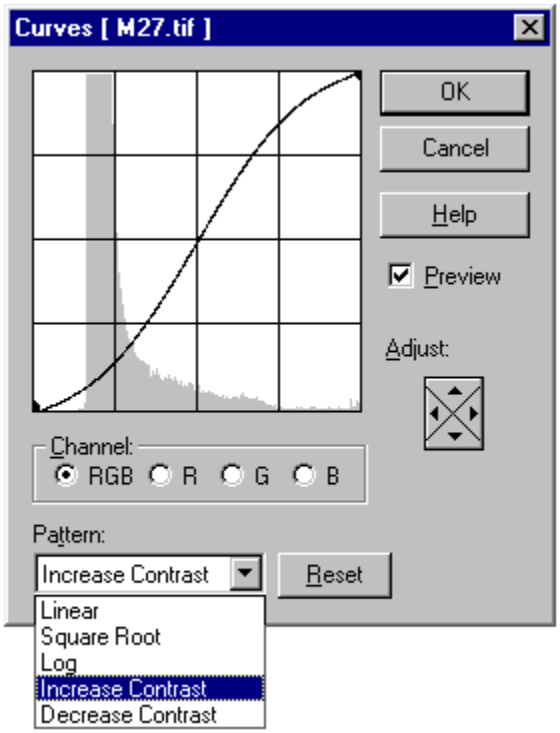


Color balance may also be adjusted by use of the **[Adjust] [Lab Color…]** controls (left). This method of adjustment is often easier to use because white objects such as stars are not affected by the controls.

The **[Levels…]** function displays a histogram of the image in the active window and allows the shadow and highlight points (dark and light triangles, respectively) to be set using the mouse to click and drag, or by typing values into the "Minimum" and "Maximum" parameter boxes. Note that the overall luminosity may be adjusted by selecting "RGB" or individual color channels may be adjusted by selecting "R", "G", or "B".

The "Auto Levels" button sets the shadow and highlight points automatically according to predetermined criteria. To set the auto levels criteria, use the **[Adjust][Auto Levels Setup]** pull-down function.

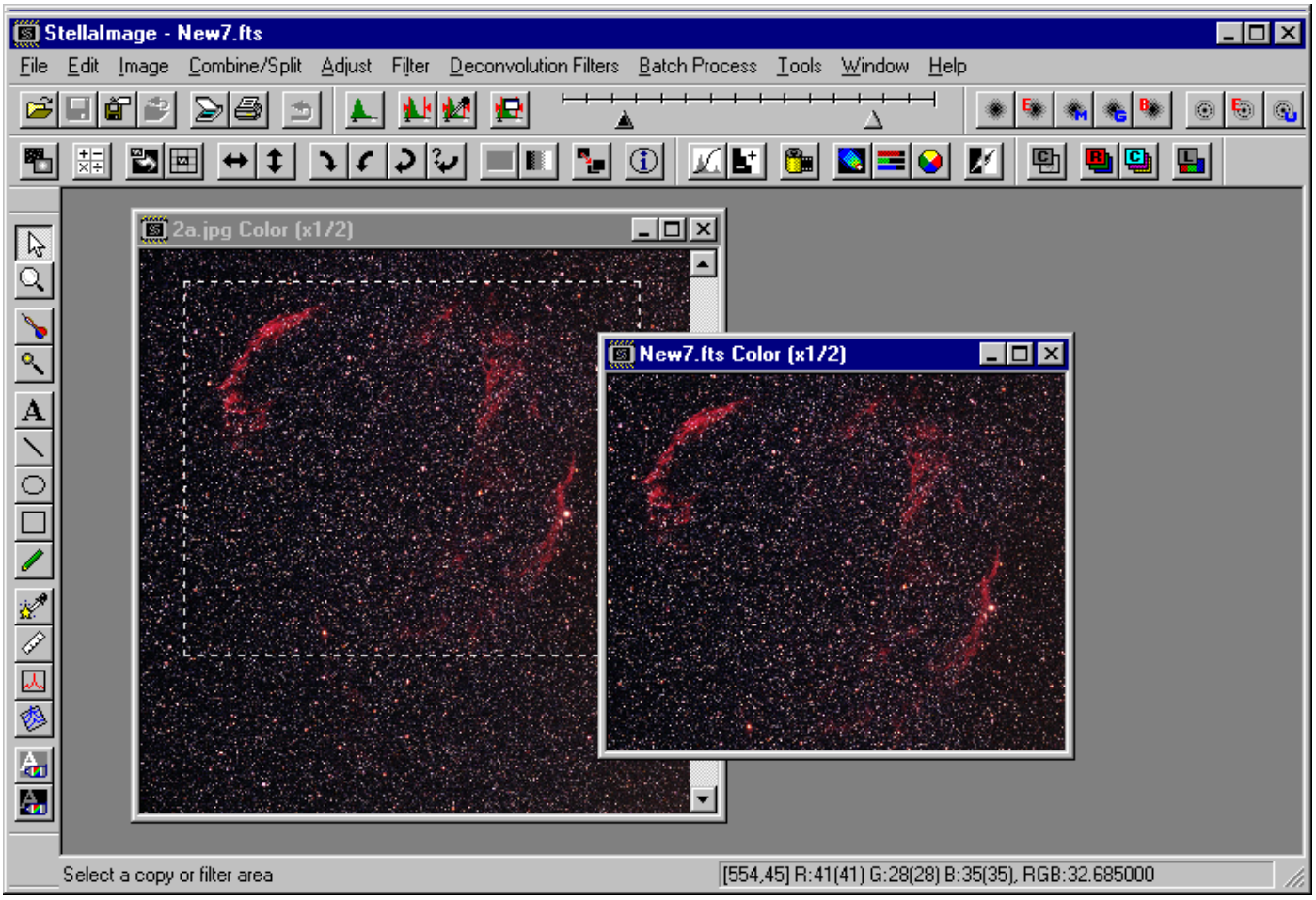




At an even higher level of control flexibility, once the overall tonal range has been set using the **[Levels…]** function as described above, use the **[Curves…]** function. Like the **[Levels…]** the adjustments may be made to the overall luminosity (select "RGB") or on individual color channels. The default linear gamma curve overlaid on the image histogram may be changed to one of the other preprogrammed curves by selecting a basic curve shape ("Linear", "Square Root", "Log", "Increase Contrast", or "Decrease Contrast"). The resulting curve may then be arbitrarily modified by clicking on any point of the curve to create control points, which may be selected and dragged with the mouse. To remove control points, right click on them with the mouse.

Cropping (or Duplicating) an Image

To crop an image, open the file so that it is visible within a window. Use the selection pointer (arrow) to select an area by clicking and dragging mouse pointer as shown below. Then use the **[Edit] [Copy]** function to copy the selected portion of the original image into the image buffer followed by the **[Edit] [Paste]** function to create a new window containing only the selection desired. Note that the entire original image may be copied into a new window by using the **[Ctrl-A]** key combination to select the whole image in the initial step.



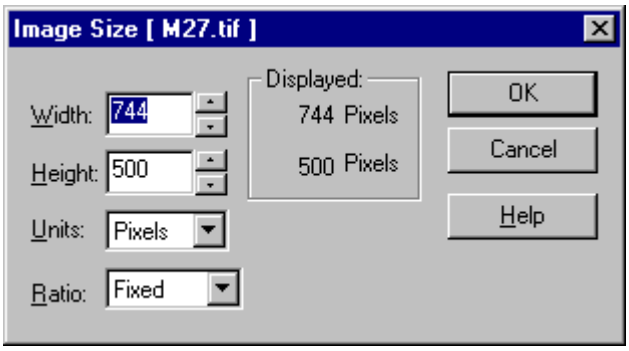
An image may also be duplicated by using the **[Image] [Duplicate]** menu operation or with the short-cut key combination **[Ctrl-Alt-D]**.

Image Transformations

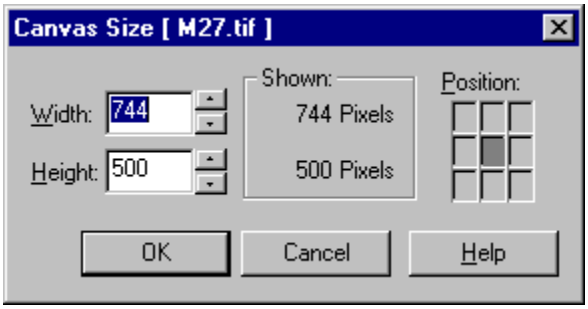
Image transformation functions (found under the **[Image]** menu) which are provided in StellaImage include:

- Image Size…
- Canvas Size…
- Soft Binning

- Flip Horizontal
- Flip Vertical
- Rotate

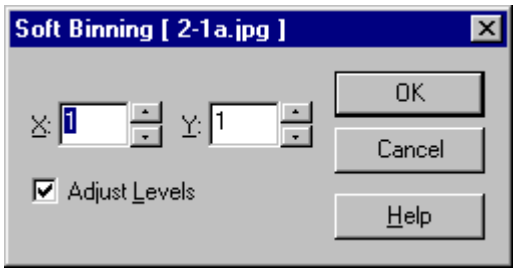


The **[Image Size…]** function allows the size of the image to be modified in a pop-up dialog window (right). The height and width may be specified in pixels or percentage, and the aspect ratio may be fixed, or the two axes may be scaled independently.



The **[Canvas Size…]** function allows modification of the size of the image without modifying the resolution of the original image, cropping or adding pixels as necessary to fit the desired size. When pixels are added, the current background color is used for the new pixels.

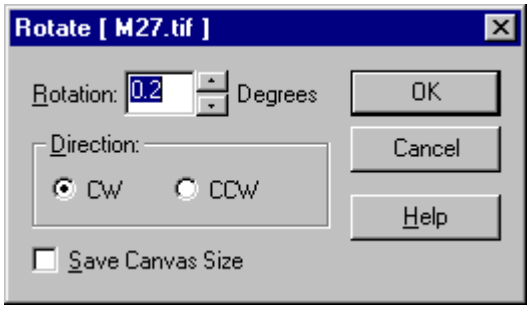
The "Position" grid allows the position of the original image to be specified when the new canvas size is larger than the original image.



[Soft Binning] simulates the binning operation of a CCD camera. Adjacent pixels are added in the directions specified and the resolution reduced correspondingly. Since levels are affected, if the "Level Adjustment" option is not checked, the appearance of the image will change.

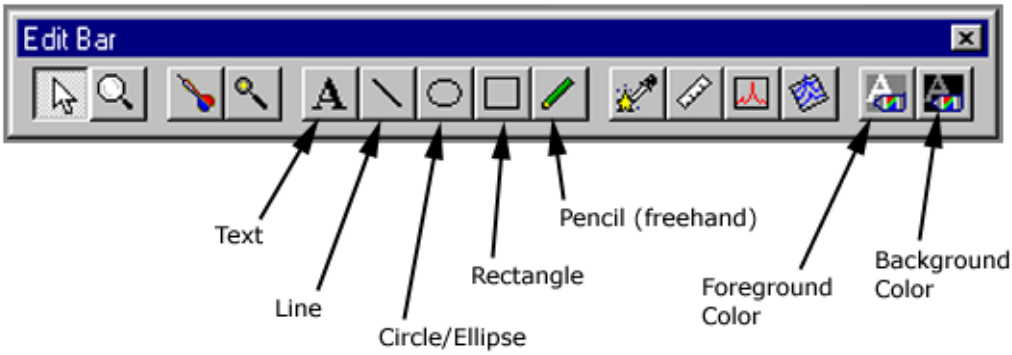
Images may also be mirror flipped using the **[Flip Horizontal]** and **[Flip Vertical]** operations. Rotations are available under a submenu under **[Rotate]** as **[90 degrees CW]**, **[90 degrees CCW]**, and **[180 degrees]**.

[Rotate] [Arbitrary] brings up a dialog window which allows specifying rotations in either direction to a fraction of a degree. Unless the "Save Canvas Size" option is checked, the canvas will be enlarged to accommodate the entire rotated image, with pixels of the current background color used to fill in as necessary. If the option is checked, the original canvas size is retained and corners of the original image may be chopped off. Pixels of the current background color are used to fill in as necessary.



Annotating Images

While it is not intended to be a full-featured drawing package, StellaImage does provide a suite of basic tools for annotating images so that objects of interest may be highlighted or copyright notices may be added to images. These functions are accessed via the Edit Toolbar as indicated below:

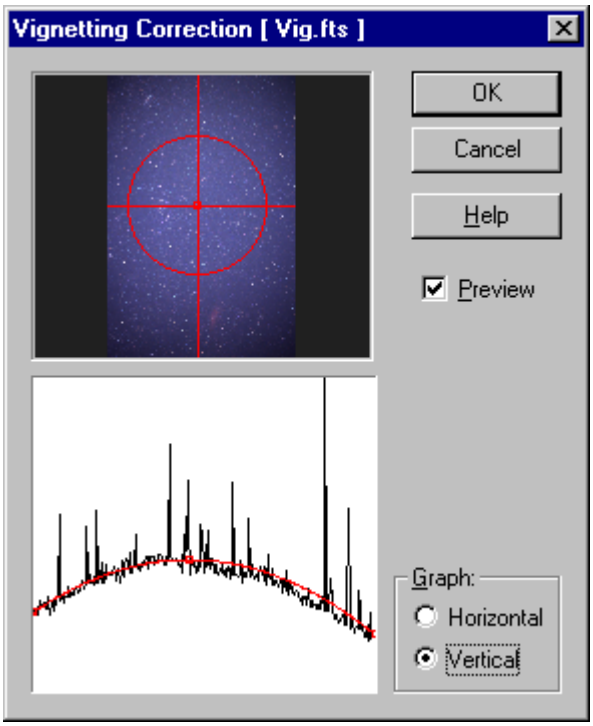


The five annotation tools operate like most Windows-type drawing tools, with the mouse used to click and drag from one endpoint to another, or to designate the start of a block of text for the Text entry tool. The results are turned into bitmaps and merged with the image. Each of these tools uses the foreground color that was last set using the "Foreground Color" button on the Edit Toolbar. The background color is used by other functions which need to fill in pixels as a result of an operation (such as enlarging the canvas).

Use the **[Edit] [Undo]** pull-down menu function or the **[Ctrl-Z]** shortcut key to undo the last action.

Correcting Vignetting

A common problem in astroimaging is the vignetting effect of a constriction in the optical path of a telescope/camera system. To correct for vignetting use the function **[Tools] [Vignetting Correction…]**. This brings up the dialog window at right.



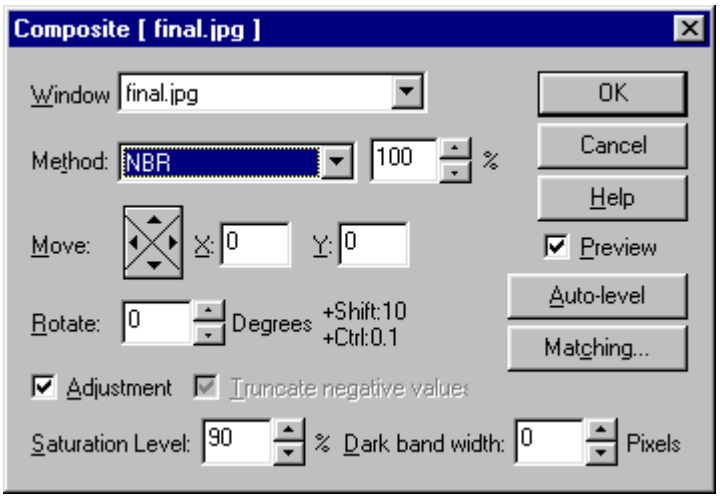
The vignetting profile is assumed by default to be radially symmetrical and centered on the center of the frame. If this is not the case, click and drag the center point in the upper frame until the cross-hairs are centered on the center of the vignetting.

Next select "Horizontal" or "Vertical" to choose which of the intensity profiles to use (shown in the lower frame). Generally, the longer of the two profiles is better.

Finally, grab the left or right handle of the red line in the lower frame until the curvature matches the intensity profile shape and use the center handle to move the curve up or down to match the profile. If the preview box is enabled, the corrected image should now look uniform. Click "OK" to complete the process when the vignetting is minimized.

Compositing Images

Combining multiple images is a commonly used way to increase contrast and/or decrease noise in astronomical images. For contrast/noise control, "Add", "Sum and Average", and "Stack and Average" are available. The "Add" computes an output based on simply adding the active image to the image in the window specified. Note that since floating point numbers are used internally, there is essentially no limit to the number of images which may be added without a danger of saturation.

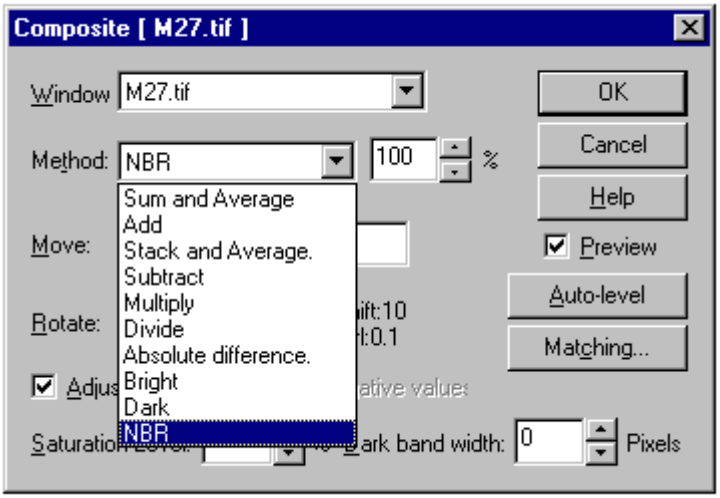


Note that controls are provided for positioning the second image manually, or automatically (use the "Image…" button). If reference points have been previously selected (see below) for each of the images to be combined, they are used to align the images prior to compositing.

The "Sum and Average" weights both images equally and divides by two for decreased noise. When the number of images to be combined is a power of two, pairs of images should be processed this way, and then pairs of results processed, and so on, so that the resulting image contains and equal weighting of each image. If the number of images is not a power of two, the "Stack and Average" option may be used. This method allows the weighting of the second image to be explicitly specified.

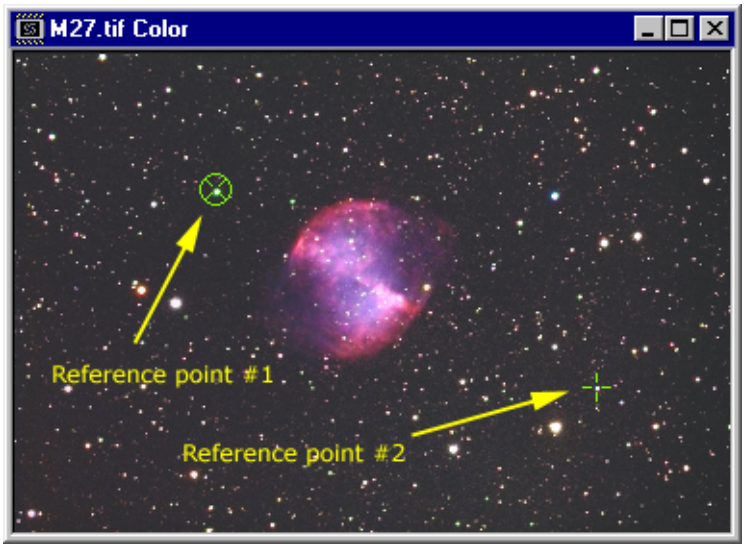
Other compositing methods available include:

- Subtract
- Multiply
- Divide
- Absolute difference
- Bright (use brighter of two images)
- Dark (use darker of two images)
- NBR (non-blooming rotated) composite



Specifying Reference Points for Compositing Images

Reference points may be set so that StellaImage aligns images before combining them. Specifying a single reference point on each image will force alignment by translation only, while specifying a second point will allow rotation to also be used for image alignment.



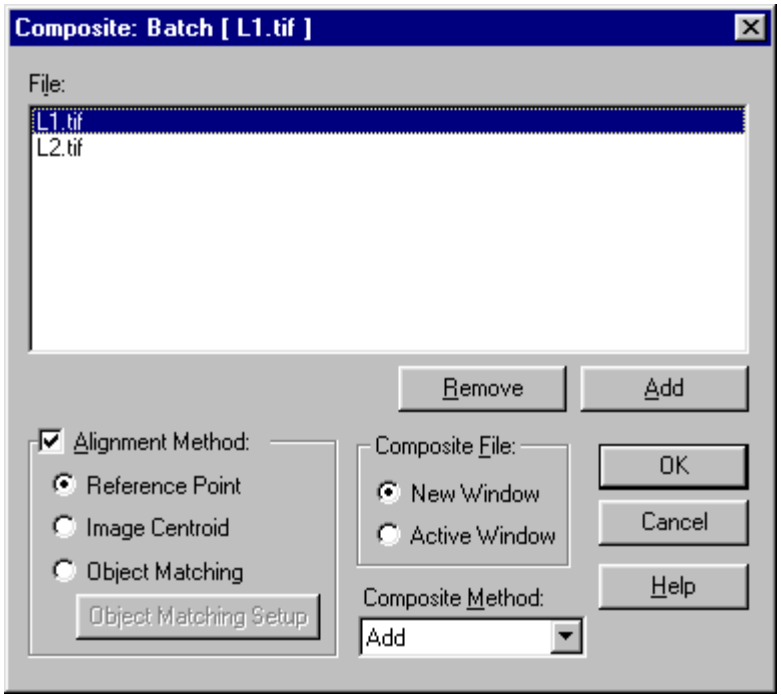
Select the first reference point by clicking and dragging to create a box which encompasses the target star. A green "X" within a circle will be placed at the peak value point which is selected as the reference point.

Pressing the **[Shift]** key while repeating the selection sequence (click and drag the target box) allows the second reference point to be assigned on an image.

To remove a reference point, right click on it and use the pop-up menu function **[Clear]**.

Batch Compositing

Compositing may also be done as a batch process to reduce manual effort. The dialog window is activated by using the **[Batch Process] [Composite…]**, which opens the window shown at right.



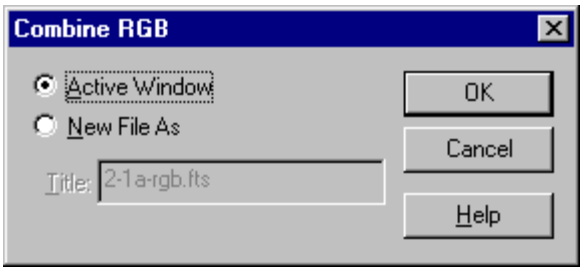
Files to be processed can be added or removed from the list using the "Add" and "Remove" buttons below the list window.

Alignment of images can be accomplished using a manually specified reference point in each image. To use reference point matching, designate 1 or 2 reference points on each image by using the "Ref. Point" tool (on the Edit menu bar) as specified above.

StellaImage may also be used to automatically match images using the "Image Centroid" (matching the calculated centroid of each image) or with its automatic "Object Matching" (image correlation) function. Alternatively, the matching can be disabled if the images are already aligned.

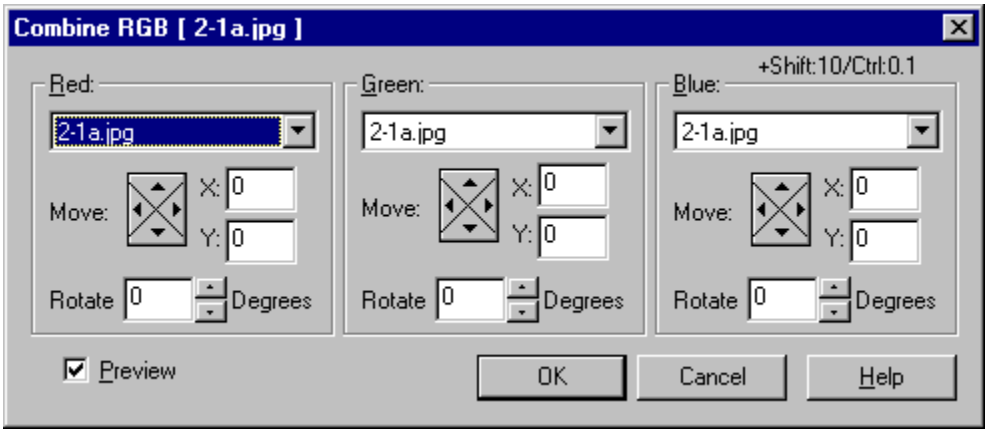
The combining method function may be selected from add, add and average, or median. The output may be specified to overwrite the currently active window, or to go to a new window.

RGB or CMY Composite Images



To create color images using red/green/blue or cyan/magenta/yellow filtered monochrome images (either CCD or black-and-white film), StellaImage supports tri-color compositing.

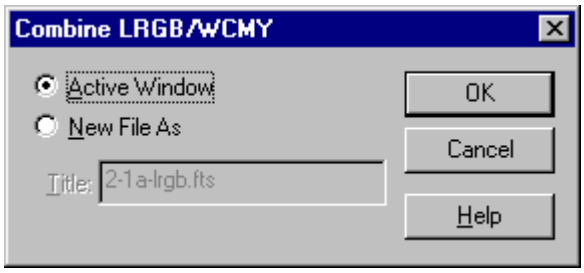
To use this function, first open the R, G, and B component files, and then select **[Combine/Split][Combine RGB…]**. The dialog window at right will open so that the output window/file can be specified. You have the option of overwriting the active window or creating a new window for the output.



Once the output window has been specified, the input components must be specified. Each file may be manually adjusted using the controls in the dialog window, or if reference points have been previously specified, the images will be automatically aligned. Note that if the exposures are not balanced due to differences in sensitivity in the channels or mismatched exposures, the individual component images should be multiplied by the appropriate factor before compositing or the color balance will not be correct.

CMY compositing is done in the same manner as RGB compositing as described above using the **[Combine/Split] [Combine CMY…]** selections.

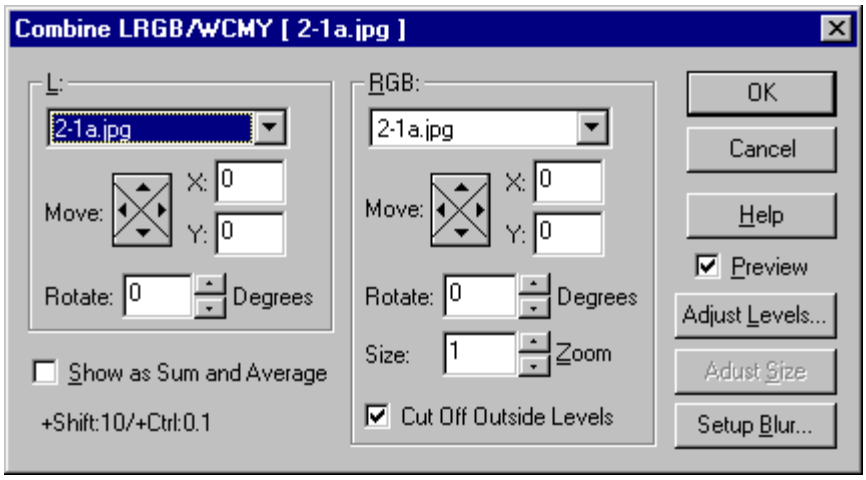
LRGB/WCMY Composite Images



When tri-color compositing is not feasible due to excessively long exposures for the component images, a compromise is possible using LRGB (luminance/red/green/blue) or WCMY (white/cyan/magenta/yellow) quad-color compositing. This procedure is similar to tri-color compositing, except a high-resolution monochrome image is combined with color filtered images which are usually shot at lower resolution to shorten exposures.

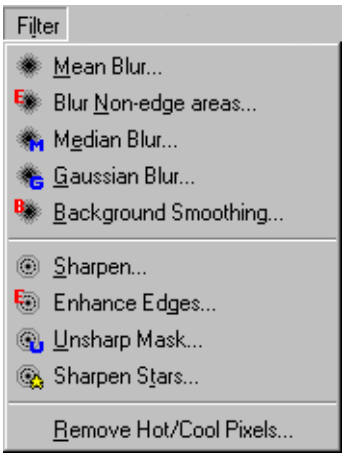
The first step is to combine the R/G/B (or C/M/Y) components in the procedure described previously to create a color image. Next the L and color files can be combined using the **[Combine/Split] [Combine LRGB/LCMY]** function which opens the dialog shown above so that the output file/window may be specified.

Next, the dialog at right opens to allow the L and color components to be specified, registered, and sized to match. Additional controls allow the L-component levels to be adjusted to control color saturation.



Filtering Images

StellaImage offers a full suite of filtering functions divided into low pass (blurring or smoothing) filters:

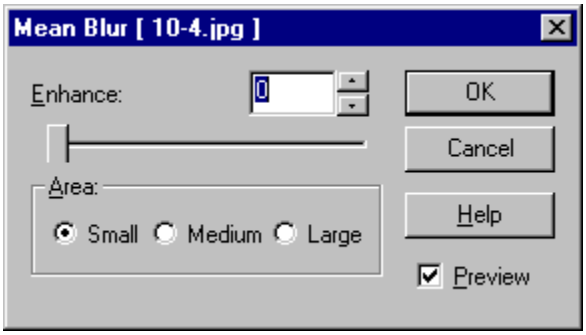


- Mean Blur
- Blur Non-edge Areas
- Median Blur
- Gaussian Blur
- Background Smoothing

and high-pass filters, including:

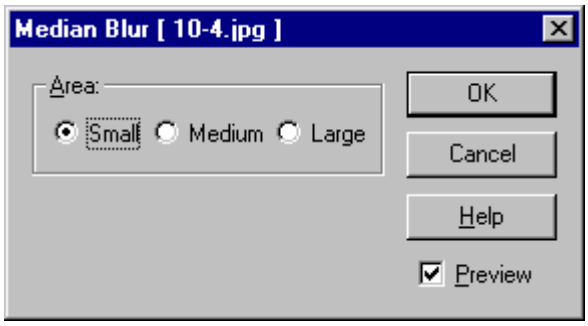
- Sharpen
- Enhance Edges
- Unsharp Mask
- Sharpen Stars

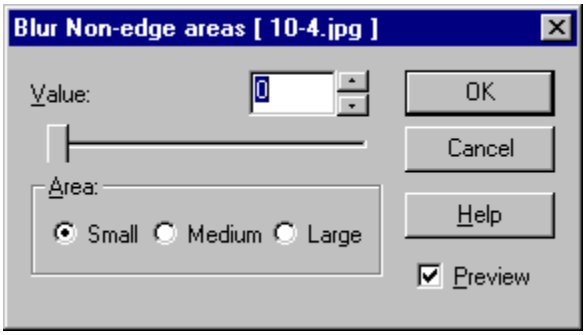
Low Pass Filters



The Mean Blur filter is a "traditional" low pass filter which, like many other StellaImage filters, is implemented with an option of 3 kernels – small (5 pixels), medium (9 pixels), or large (21 pixels). The pixel processed is computed by a weighted average of the pixels in the selected kernel.

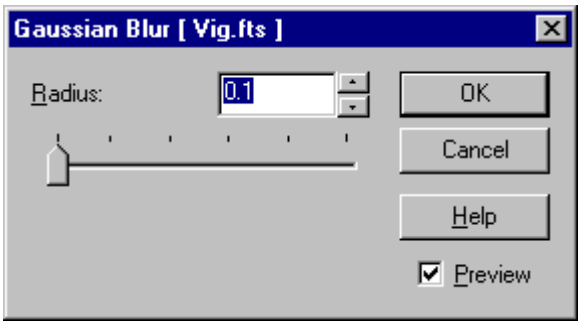
The Median Blur filter (right) similarly computes each pixel based on the median value of the kernel pixels.

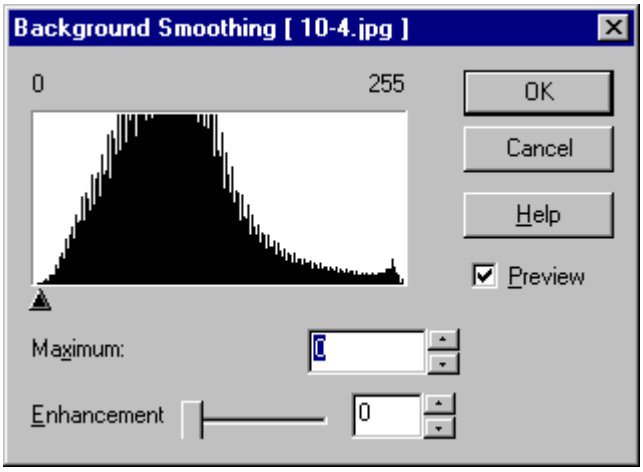




The "Blur Non-edge Area" function (left) applies a low pass filter to areas which do not have a rapid change in pixel value, thus avoiding sharp edges in the image. One application of this filter is to smooth the background of an image.

An alternative to the average blur function is the Gaussian Blur filter (right). The kernel of this filter is controlled via the radius parameter which is in units of pixels.

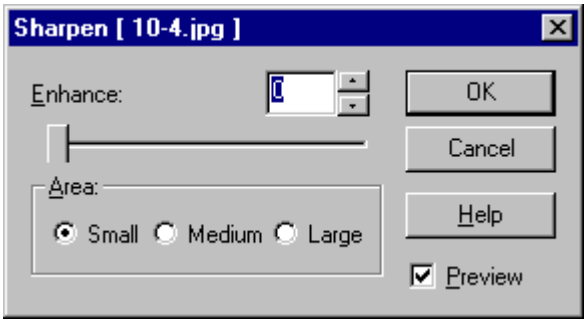




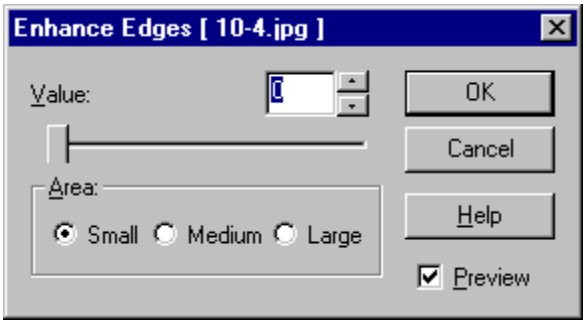
The Background Smoothing filter applies a smoothing filter to areas of an image below a specified threshold value. A histogram is shown as an aid to setting the threshold value.

High Pass Filters

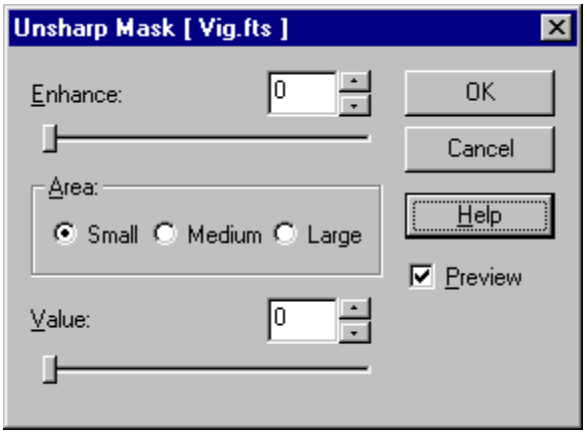
The high pass filters, which tend to emphasize fine details in an image, include the standard sharpening filter (right). As is the case for many of the low pass filters, there are 3 options for the size of the kernel – small (5 pixels), medium (9 pixels), or large (21 pixels). This filter is applied to the entire image uniformly.

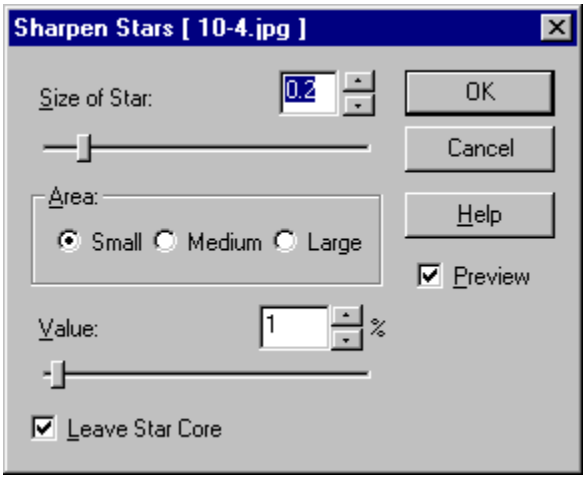


The Edge enhancement filter (below), however, is applied only where the pixel values are rapidly changing (edges).



The Unsharp Mask filter (right) is the digital analog of the photographic technique of creating a defocused version of an image to act as a mask for the original image to enhance fine details. The "Enhance" parameter controls the strength of the filtering effect while the "Area" allows selection of the kernel size. The additional "Value" parameter added in the StellaImage implementation allows control of the threshold below which the filter is not applied. This keeps the sharpening from being applied to the background pixels.





Another specialized filter implemented in the StellaImage suite of filters is the Star Sharpening filter. The "Size of Star" parameter controls the enhancement applied. A smaller value increases the enhancement (decreases the sizes of stars).

The "Area" selection allows choice of the kernel size. **[Small]** corresponds to 5 pixels, **[Medium]** corresponds to 9 pixels, and **[Large]** corresponds to a 21 pixel kernel.

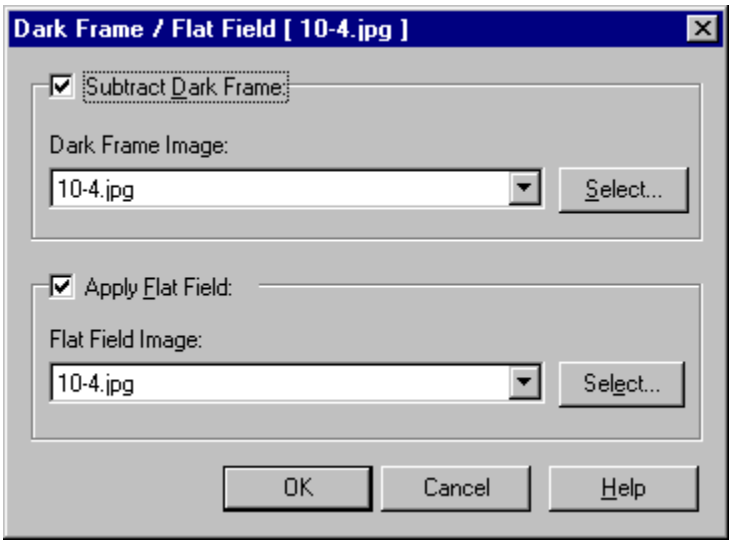
The "Value" slide control adjusts the strength of the sharpening effect. Changing this control allows stars to be sharpened without affecting diffuse objects such as nebulae.

See Appendix A for an example of the use of this filter.

Processing CCD Images

Applying Dark Frames and Flat Field Frames

CCD images may be processed like film images, but to get the most out of them generally requires some special steps specific to CCD imagers. To utilize this processing requires that dark frames (exposures with the CCD covered) and flat field frames (exposures through the same optical train imaging a uniformly illuminated field of view) be taken along with the actual images. The basic processing uses the **[Image] [Dark Frame / Flat Field]** (dialog window shown at right) is as follows:



1. Since the flat field image itself needs to be corrected with the dark frame data, the first step is to subtract the dark frame from the flat field frame using the **[Image] [Dark Frame / Flat Field]** function. In this case, the "Apply Flat Field" check box should be off because the flat field frame itself is being processed.

2. Apply the corrected flat field frame and the dark frame to the image frame by using the **[Image] [Dark Frame / Flat Field]** function again, this time with the flat field processing enabled.

Batch Processing with Same Dark Frame / Flat Field

The dark frame / flat fielding procedures may be applied to multiple images in a batch procedure to simplify processing when many images have been taken which depend on the same dark frame and flat field image. The batch dialog window is accessed from **[Batch] [Dark Frame / Flat Field 2]** as shown at right.

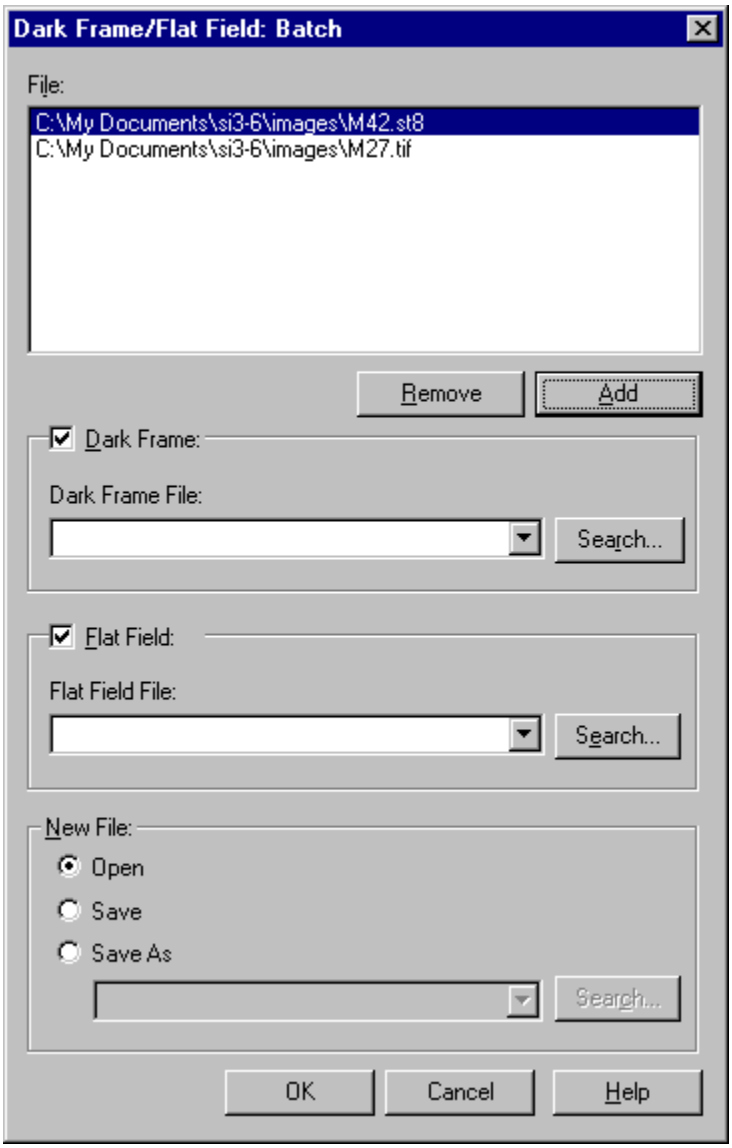


Image files to be processed are specified in the top "File" area. Click "Add" to specify an additional file, or highlight one of the listed files and click "Remove" to remove a file from the processing list.

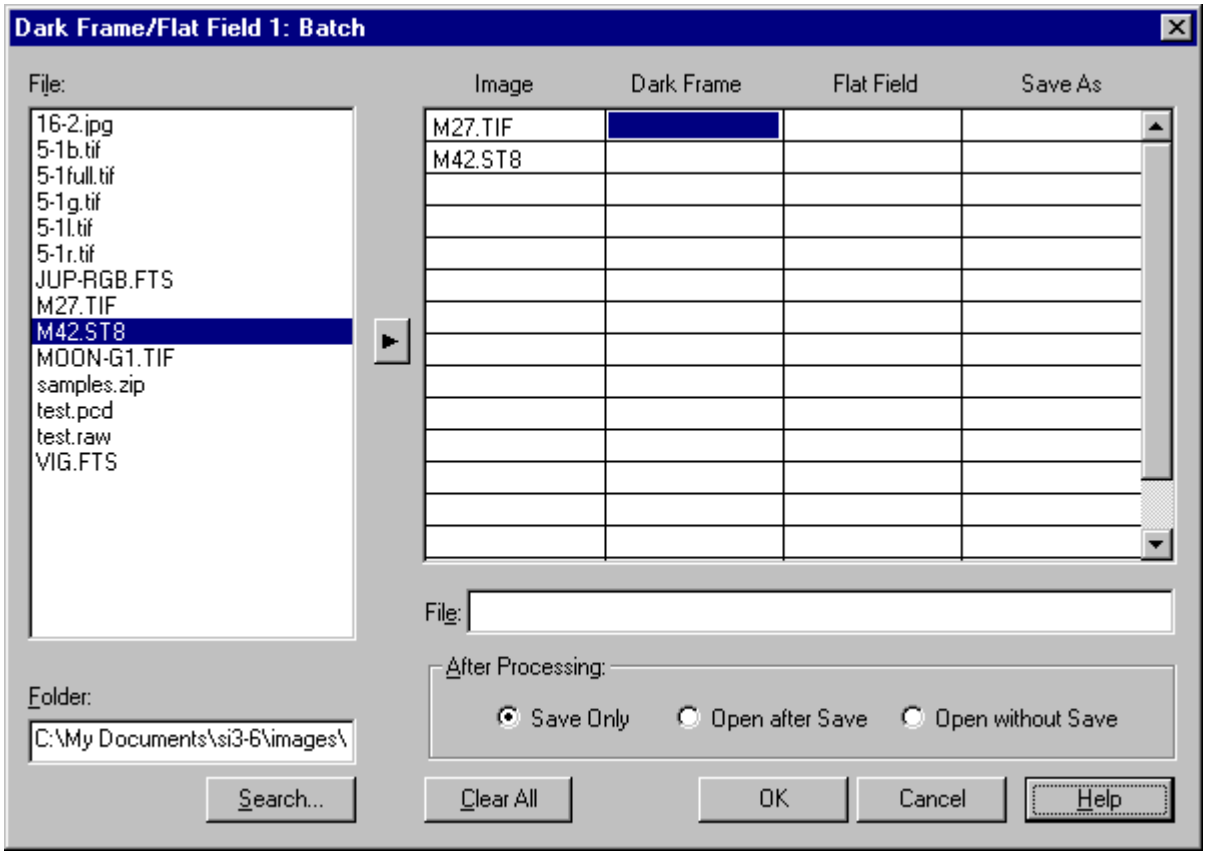
For the dark frame and flat field files, click the check box and select the file using the "Search" button.

Finally, specify the output as "Open" for a new window, "Save" to overwrite the original image file, or "Save As" to create a new file by the same name (in a different directory).

Batch Processing with Different Dark Frames / Flat Fields

If the images depend on different dark frames and/or flat field images, the alternate **[Batch] [Dark Frame / Flat Field 1]** may be used (below) to specify each set of images for processing. Highlight each cell in the "spreadsheet" and select the file using the "File" and "Folder" windows selection windows and the "Search…" button, or directly type the file name into the editing box below the processing matrix.

For the output, select whether the result should be saved, overwriting the original file ("Save Only"), saved and opened into a new window ("Open after Save"), or just opened in a new window ("Open without Save").



Note that levels adjustments may be made prior to dark frame / flat field processing since the level settings affect only the displayed image and not the underlying data. Optional steps such as averaging flat field frames must of course be done prior to the dark frame / flat field processing. However, dark frame / flat field processing should be done before most other functions.

Removing Hot/Cool Pixels

Another processing function specific to the removal of CCD imaging defects is the hot/cool pixel removal "filter." This function compares pixels in a 5x5 array around the target pixel and replaces it with the median value if the pixel differs from the computed median by the value specified.

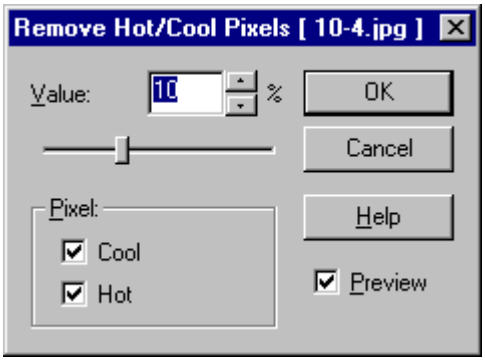
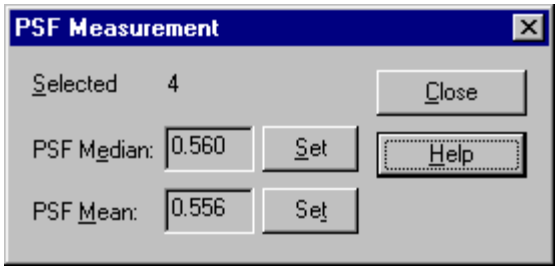


Image Restoration Functions

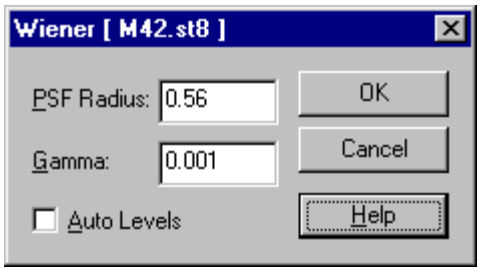
Image restoration is also possible with CCD images which have the properties of linearity and wide dynamic range. StellaImage provides the following advanced image restoration functions which may be found under the **[Deconvolution Filters]** menu:

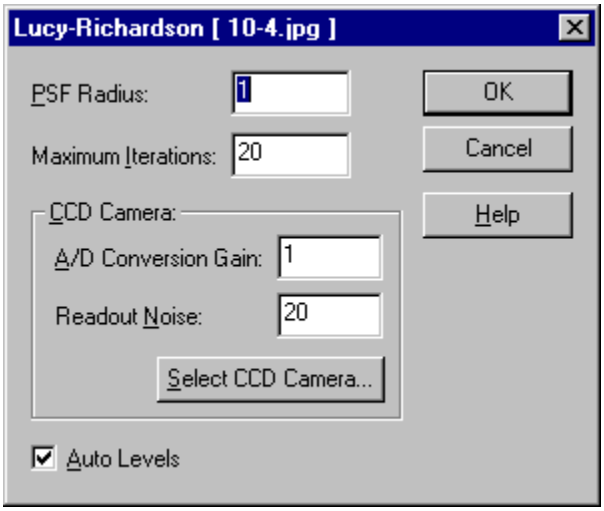
- Wiener
- Maximum Entropy
- Lucy-Richardson

These functions are dependent on knowledge of the point-spread function (PSF), a measure of the blurring caused by the atmosphere and optical system. To estimate this value, reference stars should be selected and StellaImage can be used to compute a PSF value. To do this, use the PSF tool on the Edit tool bar to designate stars in the image to be processed, then use the **[Deconvolution Filters] [PSF Measurement]** function to calculate a mean and median value for the PSF. These values should be close to each other for best results. Press "Set" on either value to enter it for subsequent processing.

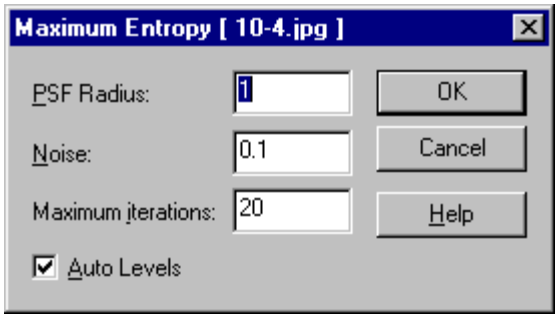


Once the PSF value has been calculated, any of the 3 filters under the **[Deconvolution Filters]** menu may be selected. Each will pop up a dialog window with controls for the specific filter, which must be adjusted until the image looks acceptable.





Since extensive experimentation may be necessary to find an optimal adjustment and these processes are very computationally intensive, using a small piece of the target image for testing is advisable until the correct settings have been found.

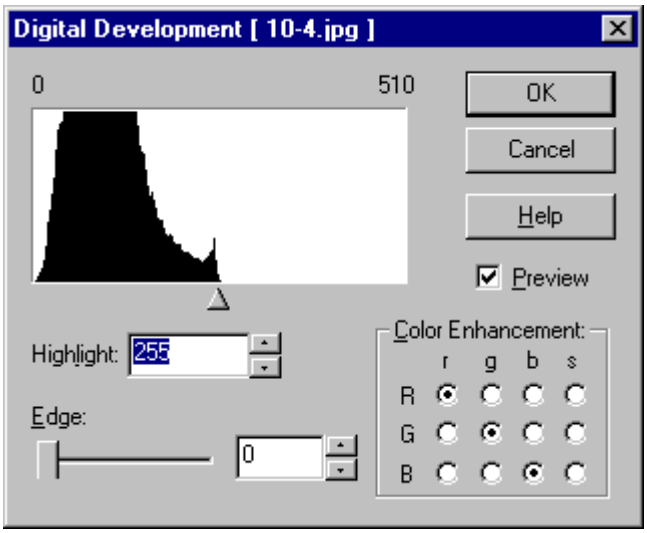


Digital Development Processing

As a final stage in the creation of a presentable image from a CCD imager, it is usually necessary to compress the wide dynamic range, linear image into a narrower range. This can be done using DDP processing which not only accomplishes the dynamic range compression, but also applies some edge enhancement. The net effect simulates the chemical processing effects inherent in film-based photography.

To begin processing an image, first, using the **[Adjust] [Levels]** function, set the minimum and maximum levels, taking care that the image has maximum detail in the shadow and midrange regions. Do not be concerned if the highlight areas become saturated. It will be adjusted in the DDP processing step.

Next, activate the DDP function by selecting the **[Adjust] [Digital Development…]** menu. This pops up the DDP dialog window. If the image is a monochrome image, the color controls will be disable.



With preview enabled, change the highlight value using the triangular control under the histogram, or directly type a value into the Highlight parameter box, or use the up/down arrow controls on the side of the Highlight value box. This controls the saturation point of the image and must be set interactively for each image.

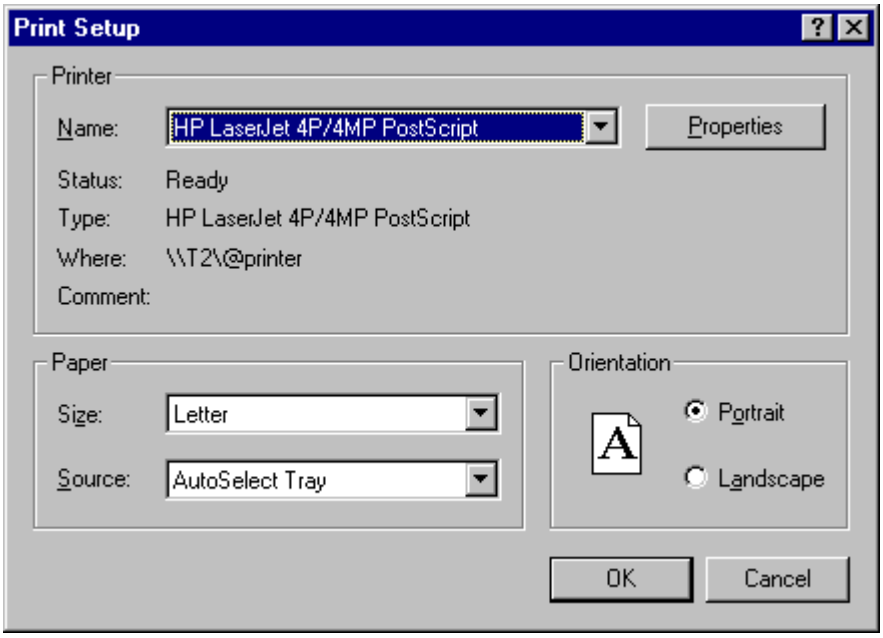
Use the "Edge" slider to control the edge enhancement feature of DDP, which is accomplished through unsharp masking. Excessive application of this will cause artifacts around edges. This is most visible when stars and light nebulosity are superimposed.

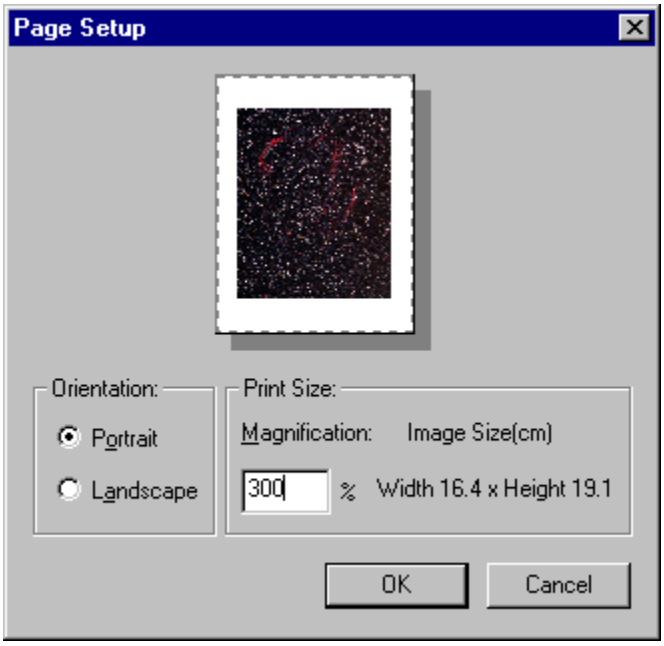
For color images, the "Color Enhancement" matrix at the lower right of the DDP dialog window will be enabled. When processing each color channel (R/G/B), this allows the flexibility of using a different mask generated by using a different color layer (r/g/b), or an average value (s), computed from an average of all channels.

For further details on the DDP algorithm, refer to the StellaImage Command Reference Section.

Printing Images

Before printing an image, the appropriate printer should be selected from the **[File] [Print Setup…]** pull-down menu. Depending on the printer and driver, properties for the printer may need to be set. Typical properties for a color printer may be the type of paper to be used, orientation, and paper size.





Once printer-specific properties have been set, the image to be printed should be opened in a window, and the page layout properties adjusted for the image. Use the magnification percentage controls to enlarge or reduce the image to fit properly on the output page. Click on OK when the settings are set satisfactorily.

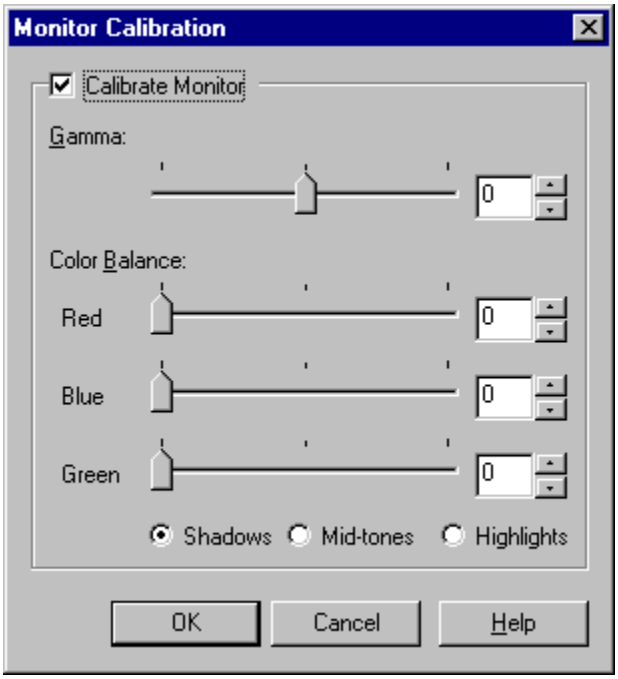
If desired, a detailed preview may now be examined using the **[File] [Print Preview]** function.

Once all printer adjustments have been made, use the **[File] [Print…]** pull-down menu to initiate printing.

Fine Tuning Color Printing

To fine-tune the color reproduction of prints, the StellaImage monitor calibration function should be used. To do this, print a test image on your printer. Next select **[File] [Monitor Calibration]** from the StellaImage pull-down menu and enable monitor calibration by clicking on the check box if it has not already been enabled during initial setup of StellaImage.

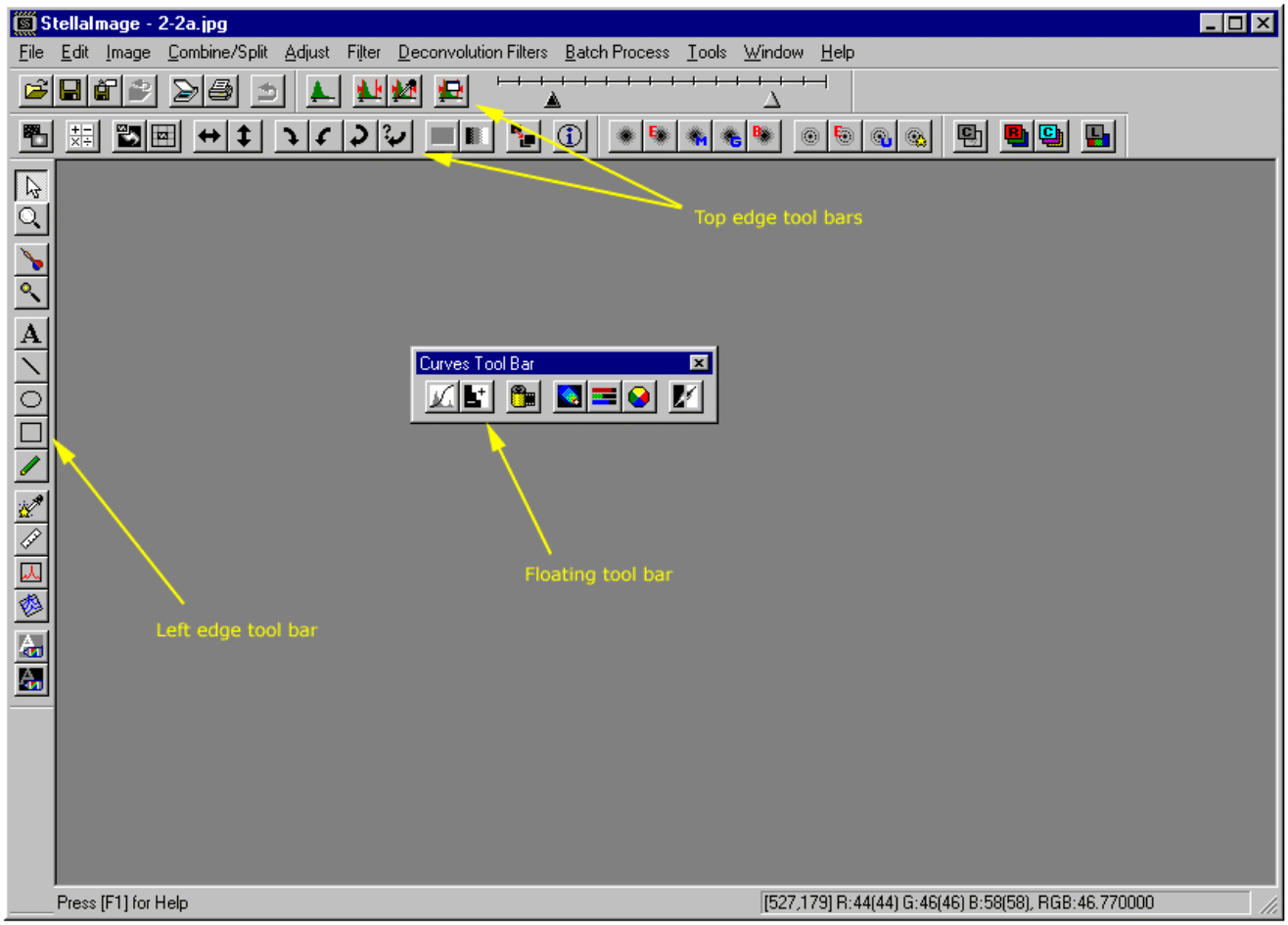
While viewing the test print under the lighting which will normally be used for viewing your prints, adjust the monitor hardware controls and the StellaImage software calibration controls until the screen view of the test image matches the printed sample. With monitor calibration set and enabled, prints made now should now closely match their appearance on your monitor when displayed by StellaImage. For consistent results, always use the same room lighting and monitor control settings used during calibration when processing images with StellaImage.



Tool Bar Reference

These are provided as convenient way to access functions also found in pull-down menus. Functions common to the pull-down menus are detailed in their respective pull-down menu descriptions. Functions unique to the toolbars are described in detail here.

Tool bars may be repositioned or hidden according to your individual needs by simply dragging them to new positions along any of the edges of the StellaImage work area. Alternatively they can be placed within the work area where they "float" above the images in the work area.



File Tool Bar

From left to right,

[Open]
[Save]
[Save As]
[Revert]

[Import TWAIN]
[Print]

[Undo]

Levels Tool Bar

From left to right,

[Levels]

[Apply Levels]

[Copy Levels]
[Auto Levels Setup]

This tool bar also includes a slider for convenient adjustment of the levels of the active image. Adjust the black point using the black triangular handle, and the white point using the lighter triangular handle. Note that this adjustment affects only the viewed levels and not the underlying data until a composite or filtering function is applied, so **[Undo]** does not affect this adjustment.

Curves Tool Bar

From left to right,

[Curves]
[Brightness/Contrast]

[Digital Development]

[False Color]
[Color Balance]
[Lab Color]

[Invert]

Image Tool Bar

From left to right,

[Dark Frame/Flat field]

[Calculate]

[Image Size]
[Canvas Size]

[Flip Horizontal]
[Flip Vertical]

[90 degrees CW]
[90 degrees CCW]
[180 degrees]
[Arbitrary]

[Color Mode]
[Grayscale Mode]

[Duplicate]

[Image Info]

Filter Tool Bar

From left to right,

[Mean Blur]
[Blur Non-edge Areas]
[Median Blur]
[Gaussian Blur]
[Background Smoothing]

[Sharpen]
[Enhance Edges]
[Unsharp Mask]
[Sharpen Stars]

Composite Tool Bar

From left to right,

[Composite]

[Combine RGB]
[Combine CMY]

[Combine LRGB]

Edit Tool Bar

These functions appear only on this tool bar and do not correspond to any pull-down menu function. From left to right,

[Select]
[Zoom]

[Ref. Point]
[PSF]

[Text]
[Line]
[Ellipse]
[Rectangle]
[Pen]

[Pixel Data]
[Measure]
[2D Graph]
[3D Graph]

[Foreground Color]
[Background color]

[Select]

The selection mouse pointer (arrow) allows an area to be designated by clicking and dragging to define a rectangular area. Alternatively, the entire image may be selected by pressing **[Ctrl-A]** or the selection may be canceled with **[Ctrl-D]**.

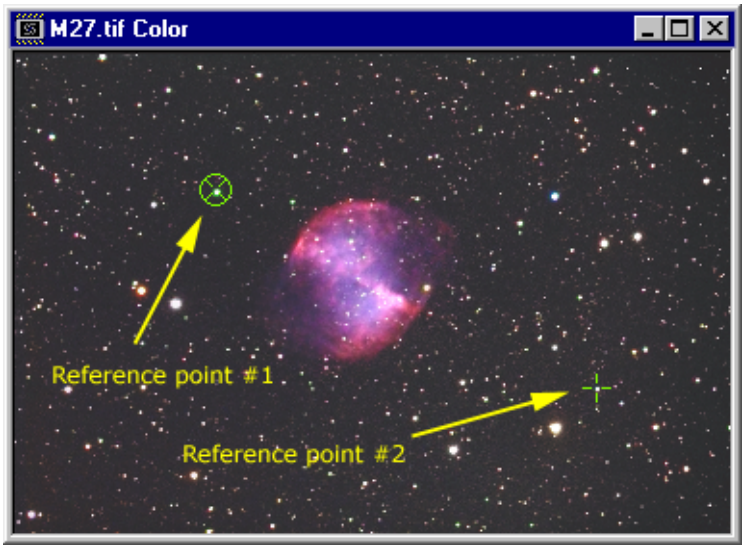
By pressing the right mouse button while the selection pointer is on an image, any command from the menu can be selected. This is most convenient when the image is displayed in full-screen mode and the tool bars are not visible.

[Zoom]

Enlarges the active image, centered at the click point. Clicking while holding the **[Shift]** key reduces the size of image. Right-clicking on the active window brings up a menu of preset magnifications which may be selected.

[Ref. Point]

Assigns the reference point(s) for functions **[Composite]**, **[Mosaic]**, **[Combine RGB]**, **[Combine CMY]**, **[Combine LRGB/WCMY]** or **[Batch Process - Composite]**. The pixel with the peak value at the center of the crosshairs is used as the reference point. Select the first reference point by clicking and dragging to create a box which encompasses the target star. A green "X" within a circle will be placed at the peak value point which is selected as the reference point.



By assigning the first reference point on several images, the images are combined so that corresponding reference points match up.

Pressing the **[Shift]** key while repeating the selection sequence (click and drag the target box) allows a second reference point to be assigned on an image. When two reference points are assigned the images to be combined are rotated as well as translated for matching. The second reference point is not required if the two images are not rotated with respect to each other.

Right-clicking on the image brings up pop-up options:

[Clear]
[Set Color]
[Cursor]

which allows clearing the selected reference point as well as convenient access to other functions when the tools are not visible on the work area.

[PSF]

Selects star(s) for measurement of the PSF radius. After selecting multiple stars, PSF median and mean values are calculated and appear on **[PSF Measurement]** of **[Deconvolution Filters]**. PSF radius is the value indicating the image quality degradation which is used with **[Wiener]**, **[Maximum Entropy]** and **[Lucy-Richardson]** functions.

Stars (independent and non-saturated ones) are selecting by clicking with the arrow point on the target star. A square will appear indicating the star selection. Select as many stars as possible to assure that an accurate PSF value is calculated. Saturated stars are excluded for the calculation.

To clear selections, press the right mouse button. A single selection can be canceled with **[Clear Single]**, or all selections can be canceled with **[Clear All]**.

[Text]

Text may be overlaid at the location of a mouse click using the foreground color previously selected. by left-clicking on the image, you can type the text, and set the font and size. by right-clicking on the image, a menu appears including the **[Foreground Color]** function so that the text color can be set. Other functions are available through the **[Cursor]** selection.

[Line]
[Ellipse]
[Rectangle]

With the appropriate function selected, a mouse drag creates a line, ellipse, or rectangle using the color set in **[Foreground color]**. The Line tool creates a line 1-pixel wide, dragged from the start point to end point. For **[Ellipse]** and **[Rectangle]**, right-clicking opens a menu which allows setting color fill-in on or off using the foreground color.

[Pen]

This allows for fine retouch work to be applied to the active image (e.g. removal of noise not handled satisfactorily by the noise filters).

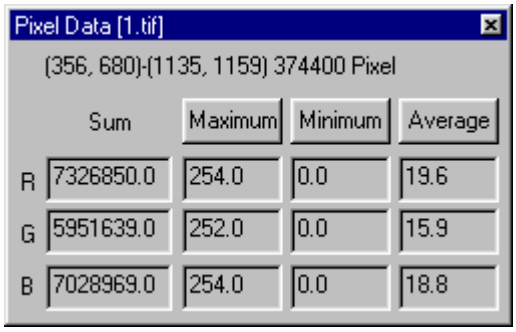
Right-clicking on the image allows the selection of several pen tools:

[Foreground]
[Background]
[Mean]
[Median]
[Setup]

Specifying **[Foreground]** or **[Background]** causes the pen tool to apply that color to the image. **[Mean]** or **[Median]** applies a color calculated from the surrounding pixels. **[Setup]** also allows for fine-tuning the **[Mean]** or **[Median]** color selection process.

[Pixel Data]

This shows the pixel statistics for a single point (by left-clicking) or a rectangular area (by left-dragging). Up to 10 additional areas may be displayed by holding the **[Shift]** key while using the mouse. If the image is a color image, R, G, and B values are shown separately.



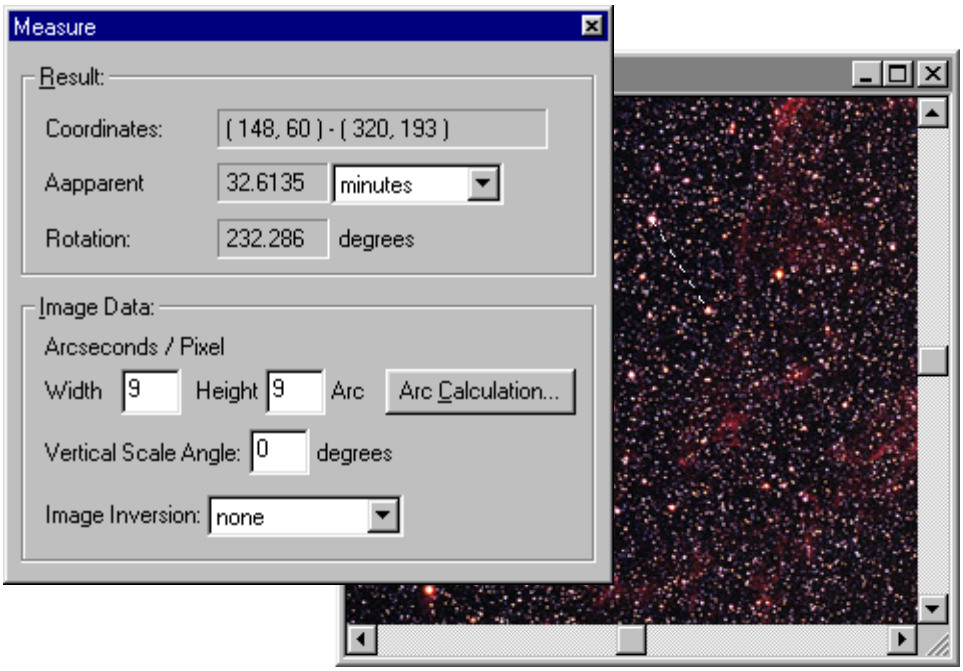
By right-clicking the **[Set Histogram Mark 1 to 5]** function can be used to designate reference points which will be indicated in subsequent levels processing histograms. By using the right-click menu, the median values may optionally be displayed in addition to the arithmetic averages. The min/max/average/median sampling kernel for clicking on a single point can also be set using **[1x1]**, **[3x3]**, or **[5x5]** sampling.

Hints:

1. After a pixel is chosen as a histogram mark, open **[Adjust] [Levels]**. A red reference mark will appear on the histogram. As an example, choose background and highlight values by first selecting histogram marks 1 and 2 somewhere in the background and highlight areas of the image. These reference marks will then show up on the histogram when adjusting levels, making it easy to set the shadow and highlight level controls.

2. Left-clicking or left-dragging repeatedly while pressing Shift-key will cause a maximum of 10 pixel statistics data windows to appear.

[Measure]



This measures the dragged line's apparent distance and rotation angle (useful for double-star measurements, for example). Once the line has been specified the **[Measure]** dialog appears, allowing image scaling parameters such arcseconds per pixel to be specified, which adjust the displayed results. Note that in the case of wide field images, the results have a little error since the celestial sphere is spherical, but the image is flat.

Dialog details:

[Arcseconds / Pixel]
Specifies the image scale vertically and horizontally in arc seconds.

[Arc Calculation]
Automatically calculates arc second per pixel based on lens focal length and model number of CCD camera or pixel size:

[Focal length]
Specifies the imaging lens focal length.

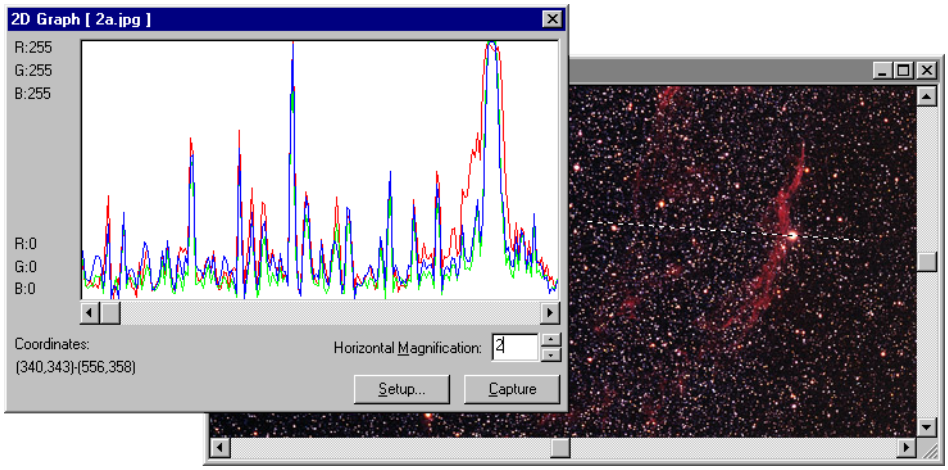
[Pixel Size]
Specifies the pixel size for the CCD chip. Choose a camera's model number from [Select from list] or input the number in microns if your camera is not listed.

[Vertical Scale Angle]
Specifies how much the image's vertical direction is rotated with respect to the direction of the celestial north pole.

[Image Inversion]
Sets image's left/right inversion or up/down inversion.

[2D Graph]

Creates an intensity profile graph along a line specified by dragging the mouse. This is useful when examining the intensity range, noise or saturation across an image.



[Horizontal Magnification]

Use the horizontal magnification controls or directly type in a value to change the x-axis scaling.

[Setup]

More options are available via the **[Setup]** dialog:

[Vertical Scale]

This allows the vertical axis scale to be selected from:

[Auto]

Automatically scales so that the entire range of pixel values can be displayed.

[Adjust Within Levels]

Sets the lower and upper limits to match the shadow and highlight levels selections.

[Fixed]

Sets the limits as specified manually. The "Luminosity/R" parameters are used for a monochrome image, or the R channel of a color image. G and B channels of a color image are set separately.

[Display Luminosity]

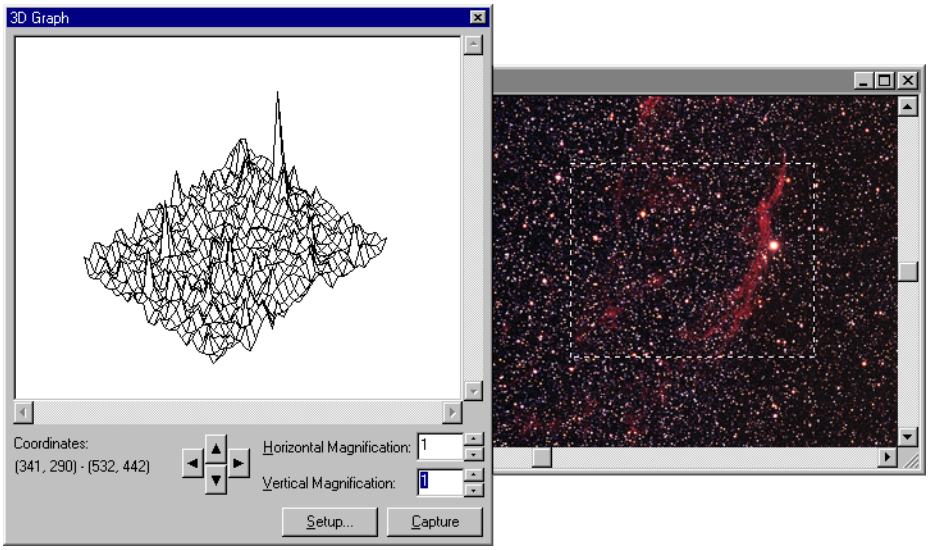
When it is on, the graph of a color image indicates only the luminosity value rather than the separate R, G, and B channels.

[Capture]

This function captures the intensity profile graph to another new window. It is useful for printing or saving for inclusion in other documents.

[3D Graph]

The pixel intensity values within the dragged rectangular area are displayed in a 3D graph. It is useful for studying an object's luminosity distribution or analyzing an image's saturation and noise.



[Up/Down] buttons
These buttons change the 3D graph viewing angle (tips the z-axis towards or away from the observer).

[Left/Right] buttons
It rotates 3D graph viewpoint around the z-axis of the graph.

[Horizontal Magnification]
Adjusts the xy-axis scaling of the graph.

[Vertical Magnification]
Adjusts the z-axis scaling of the graph.

[Setup]
Allows more options to be accessed in a separate dialog window:

[Vertical Scale]
Sets the vertical (z-axis scaling) according to one of the options:

[Auto]
Automatically scales so that the entire range of the data may be displayed.

[Adjust Within Levels]
Sets the lower and upper limits to match the shadow and highlight levels selections.

[Fixed]
Sets the limits as specified manually.

[Pixel Value]

Each mesh area on the graph consists of multiple pixels. This option allows specification of how the mesh value is calculated from the pixels encompassed by it:

[Average]

Uses average value of pixels.

[Maximum]

Uses maximum value from pixels.

[Minimum]

Uses minimum value from pixels.

[Capture]

Copies the graph to an image window where it can be annotated, printed, and saved to a file just as any image file may be manipulated.

[Foreground Color]

Foreground color assigns the color used for **[Text]**, **[Line]**, **[Rectangle]**, **[Ellipse]** etc.

[Background color]

Background color assigns the color to be used for **[Canvas Size]**, **[Rotate]**, **[Mosaic]**, or **[Surface Projection]** when additional background pixels need to be generated during the operation. This also affects the default color used when a new window is opened.

Pull-down Menu Reference

File

New

The "New" function creates a new image file for active processing. The default format is FITS, but a dialog window pops up so that the width and height of the new image may be adjusted, and the mode (color or monochrome) may be set as desired.

Open

The "Open" function creates a new window and reads a specified file into the window. A dialog will pop up which allows browsing through files and directories. The file types supported include:

Format	Extension/type	Open	Save	Remarks
BMP	.bmp	Y	Y	
DIB	.dib	Y	Y	
Bitran	.ccd, .drk, .flt, .fdk	Y	N	
FITS	.fit, .fts, .fits			Color & B/W formats are supported, default is color
	8-bit Unsigned Int	Y	Y	
	16-bit Signed Integer	Y	Y	
	16-bit Unsigned Integer	Y	N	
	32-bit Signed Integer	Y	Y	
	32-bit Unsigned Int	Y	N	
	32-bit Real	Y	Y	
	64-bit Real	Y	Y	
JPEG	.jpg, .jpeg	Y	Y	
Mutoh	.mtf, .bin	Y	Y	
TIFF	.tif, .tiff			
	8-bit color	Y	Y	
	16-bit color	Y	Y	
	8-bit B/W	Y	Y	
	16-bit B/W	Y	Y	
SBIG	.st4, .st5, .st6, .st7, .st8, .st9, .stx, .237, .255, .r, .g, .b	Y	Y	Save overwrites existing file

Hint: To open multiple files, click on the files to be opened while holding the CTRL key down. Or, click on the files at the ends of a range of files to be opened while holding the SHIFT key down.

WARNING: In FITS, MUTOH, and SBIG formats, files without level information will be automatically leveled.

Close

The "Close" function closes the active image window. If the image has been modified, a dialog

window pops up and allows changes to be saved if desired.

WARNING: Unless the image is saved in FITS format, there is a possibility for loss of precision due to the limitations of the file format selected. Images which will be processed further should be saved in FITS floating point (real) format.

Save

The "Save" function allows an image in a window to be saved to disk without closing the window down. A pop-up dialog may appear with data format options, depending on the file type of the original image.

WARNING: Unless the image is saved in FITS format, there is a possibility for loss of precision due to the limitations of the file format selected. Images which will be processed further should be saved in FITS floating point (real) format.

Save As...

The "Save As.." function allows an image in a window to be saved to disk as a different file than originally opened.

A pop-up dialog allows the file name and type to be specified. Supported file types include:

BMP (.bmp)
DIB (.dib)
Bitran (.ccd, .drk, .flt, .fdk)
FITS (.fit, .fts, .fits)
JPEG (.jpg, .jpeg)
Mutoh (.mtf, .bin)
TIFF (.tif, .tiff)
SBIG (.st4, .st5, .st6, .st7, .st8, .st9, .stx, .237, .255, .r, .g, .b)

After the name and type have been specified, a dialog specific to the file type chosen will pop up so that additional parameters may be specified:

BMP/DIB:
Color: 8-bit (256 colors) or 24-bit color

FITS:
Data: Integer or Real
Bits: 8, 16, 32, or 64 bits

JPEG:
Quality: 1-10 (a lower number means higher compression and lower quality).
Progressive: On or off for progressive JPEG

TIFF:
Bits: 8 or 16
Byte Order: IBM PC or Macintosh
Compression: None, LZW, or Packbits

WARNING: Unless the image is saved in FITS format, there is a possibility for loss of precision due to the limitations of the file format selected. Images which will be processed further should be saved

in FITS floating point (real) format.

Revert

"Revert" discards the data in the active image window and re-reads the last saved data from the file. A pop-up dialog appears, allowing the user to confirm the action before it actually is performed. This function is useful when an operation has been performed on an image, but the result is not satisfactory. Before the image is saved, the "Revert" function can restore the image to the state prior to the current image processing session.

Import

TWAIN source...

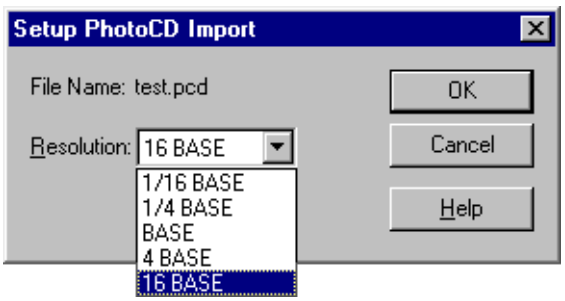
This function allows the source for TWAIN imports to be specified.

Import TWAIN...

This function starts the TWAIN driver for the scanner device specified using the **[TWAIN source…]** function.

PhotoCD...

This opens a browser dialog from which a PhotoCD (.PCD) file may be specified. The file is opened and presented in a new window.

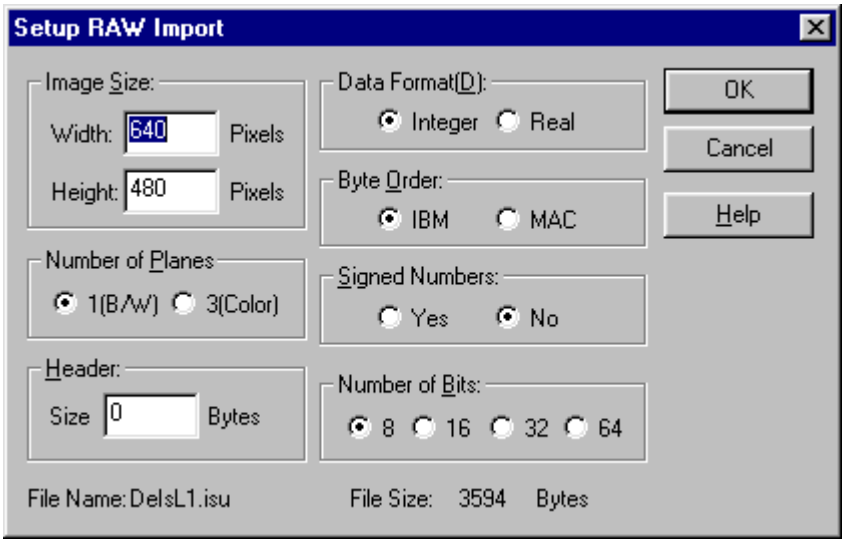


Unsigned FITS...

This opens a browser dialog from which an unsigned FITS (.fts, .fit, or .fits) file may be specified. The file is opened and presented in a new window.

Raw...

This opens a browser dialog window from which a raw (.raw) file may be specified. After specifying the file, a dialog opens, allowing specification of the image format:

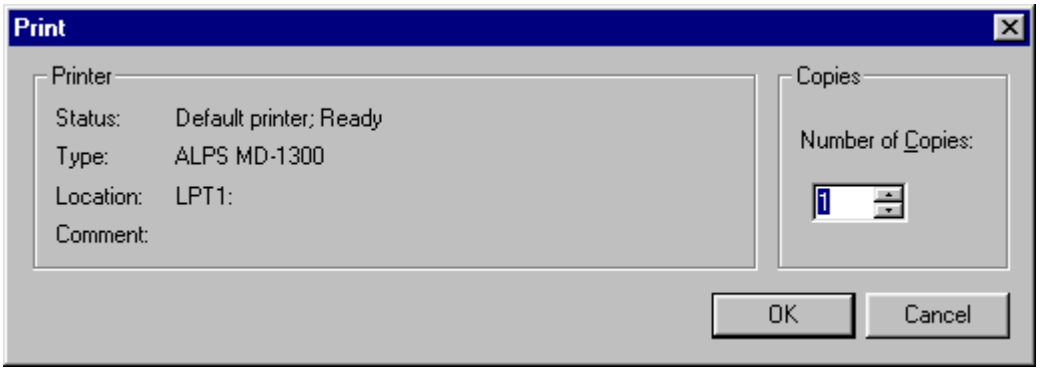


WARNING: If the image specifications are not properly set, the image file will not be interpreted correctly and the image will be distorted.

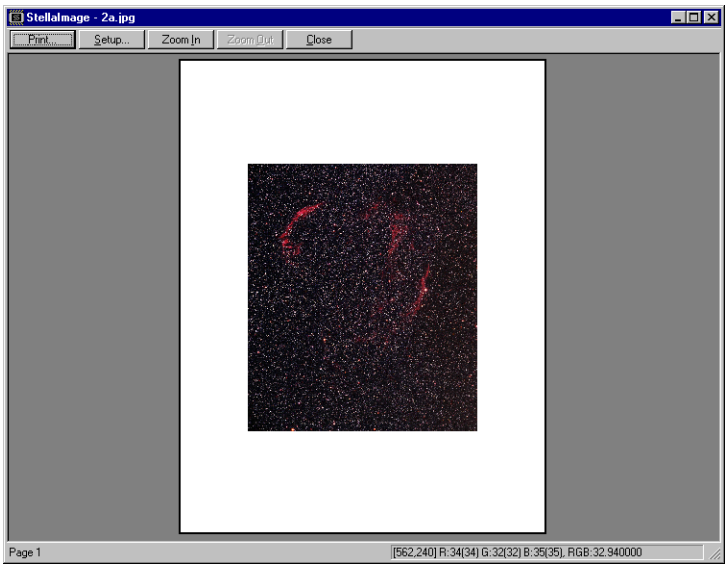
Image size: sets width and height in pixels
Number of planes: B/W or color
Header: specifies the number of bytes
Format: Integer or Real (floating point)
Byte Order: IBM PC or Macintosh
Signed Numbers: specifies signed or unsigned format
Bits: sets number of bits in each pixel

Print...

"Print..." brings up a dialog box indicating what printer is selected and its status. The number of copies may be set here before starting the printing by clicking on the "OK" button.



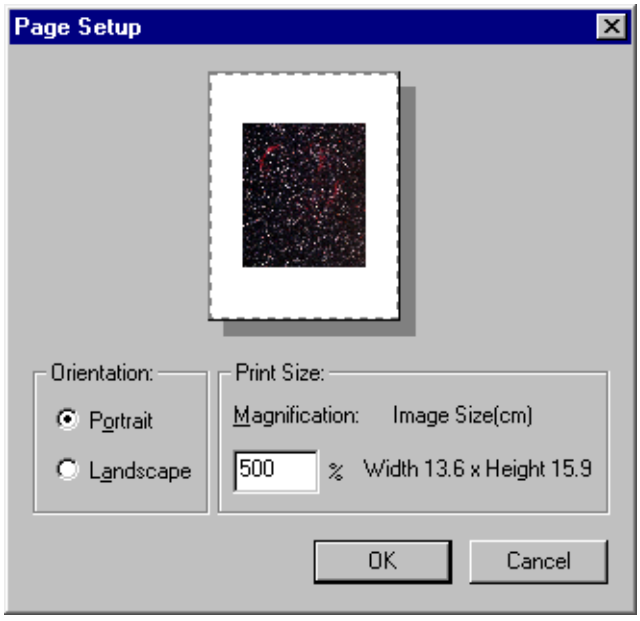
Preview



This brings up a preview window so that the active image can be seen scaled to the printer's paper. Printing and paper settings are set in the "Print Setup" and "Page Setup" functions.

The preview window allows zooming in and out as well as proceeding to printing or going back to the page setup function.

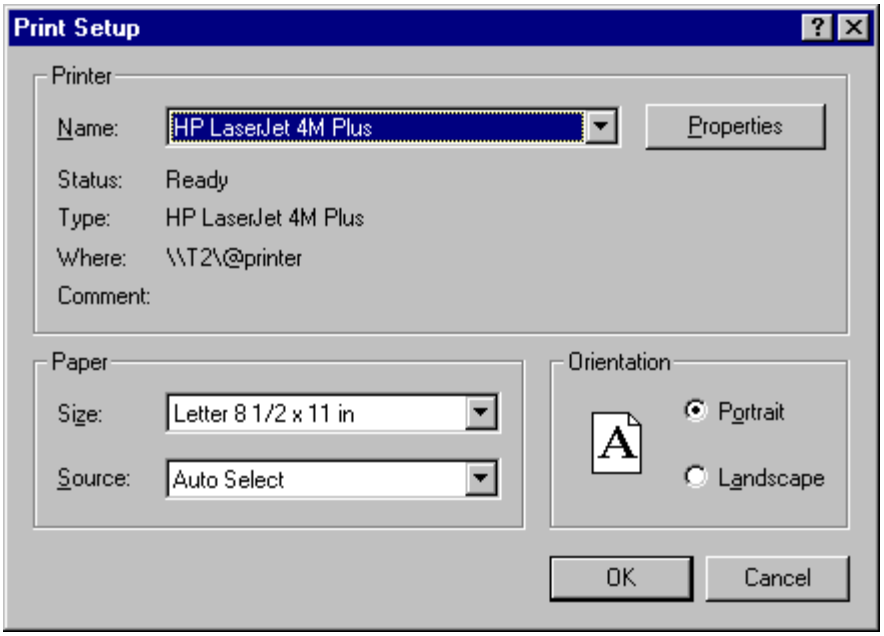
Page Setup...



This function pops up a dialog window showing the active image against the page in a preview, based on the settings currently selected. The page orientation may be changed as well as the enlargement of the image on the page.

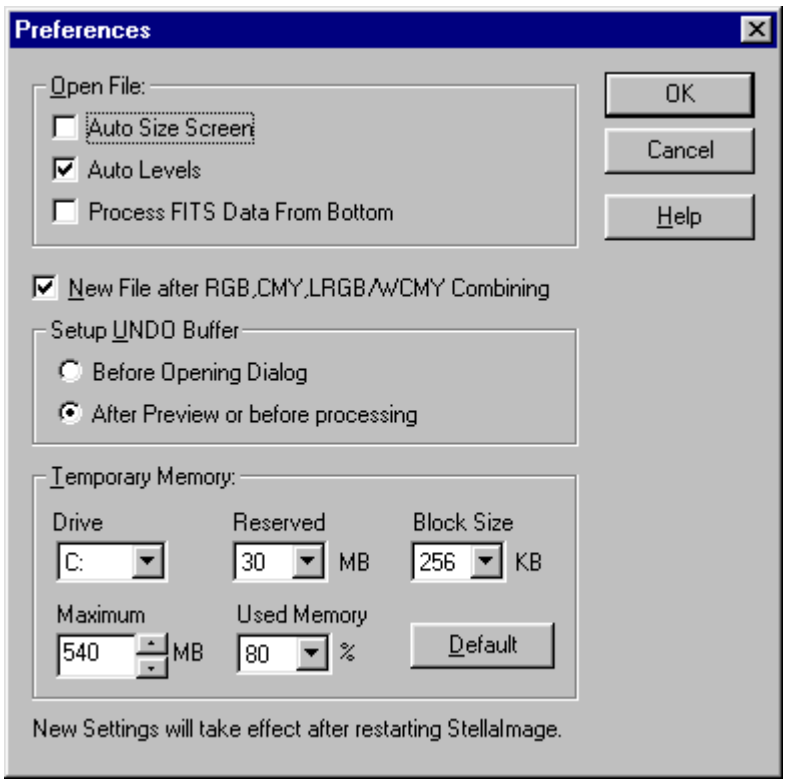
Print Setup...

This allows the printer to be selected, orientation, paper size, tray, etc. to be set. Click on "Properties" to set advanced features specific to the printer selected.



Preferences...

Several default behaviors of StellaImage may be controlled through the "Preferences..." function. All settings take effect the next time StellaImage is restarted. A pop up window will appear which allows the following behaviors to be set:



Open File:

Auto Size Screen:

Yes/no - allows StellaImage to automatically adjust the window size depending on your system desktop size.

Auto Levels:

Yes/no - allows StellaImage to automatically adjust levels when opening an image if required.

Process FITS Data From Bottom:

Yes/no - sets the direction which StellaImage interprets FITS data. If FITS images are being opened flipped vertically, change this setting. Alternatively the image flip function may be used to fix specific images.

New File after RGB, CMY, LRGB, WCMY Combining:

yes/no - selects whether or not a new image window is created each time a tri-color or quad-color image is created by combining component images. Selecting "no" will place the result in the active window.

Setup UNDO Buffer:

This sets the point at which the UNDO buffer is created:

Before Opening Dialog:

Selecting this causes the pop-up dialog to be slower but previewing is faster.

After Preview or before processing:

Selecting this makes the pop-up dialog faster but previewing slower

Temporary Memory:

Drive:

Selects the letter of the drive to be used for temporary files during processing.

Reserved:

Sets the space reserved for Windows and other applications.

Block Size:

Sets the block size for allocating temporary memory.

Maximum:

Sets the maximum amount to be used by StellaImage.

Used Memory:

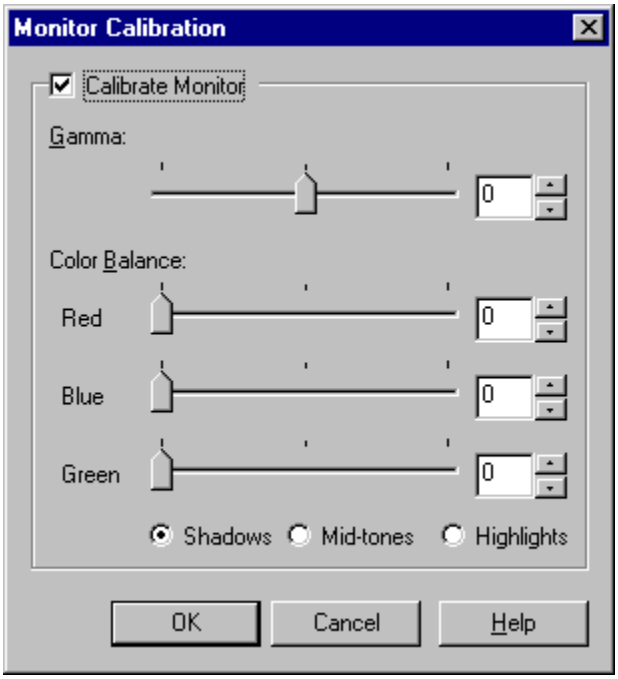
Sets the maximum percentage of available space (excluding reserved space) that StellaImage may use.

Hints:

1. Decreasing the reserved memory and increasing the percentage of memory which StellaImage may use speeds StellaImage up at the expense of other applications.

2. Setting the block size larger decreases the time required when StellaImage must swap data to disk, but when many small image files are processed at the same time, using a larger block size may waste memory capacity.

Monitor Calibration...



The monitor calibration function is provided to allow tuning of the matching between prints and images displayed on the monitor. If your system hardware and software provides this function, all calibration should be done outside StellaImage. StellaImage's calibration can be used to fine tune the matching. To enable or disable StellaImage's color correction, use the checkbox ("Calibrate Monitor") at the top left corner of the calibration dialog box.

To adjust the luminosity gamma, use the "Gamma" slider control which controls the midtone point (positive values lighten midtones). The file CHART.BMP, provided on the StellaImage CD-ROM can be used by setting the checkered pattern at upper right (18% gray) to appear plain gray.

The individual color balance should be set in reference to a color print made on your printer. The "Color Balance" sliders can be adjusted separately for shadows (dark areas), mid-tones, and highlights (bright areas). Note that when adjusting color balance, the lighting used to view the reference print affects the calibration. For best results, when performing calibration, view the reference print under lighting which matches the lighting you will normally use to view your prints.

(Files)

In this section of the "File" pull-down menu, the most recently accessed image files will be listed for quick reloading. This list is preserved across StellaImage editing sessions, making it easy to return to files which require further processing.

Exit

This function ends the StellaImage program. If any images in windows have been modified and not saved, StellaImage will ask whether or not the images should be saved before shutting down.

Edit

Undo

"Undo" reverses the last action applied to an image. Once the undo function is used, it changes to "Re-do" to allow reversing the undo.

Copy

"Copy" copies a selection to the Windows clipboard. If no selection area has been designated, the function is disabled.

Paste

"Paste" transfers a previously copied selection from the Windows clipboard into a new window. If nothing is on the clipboard, this function is disabled.

Select All

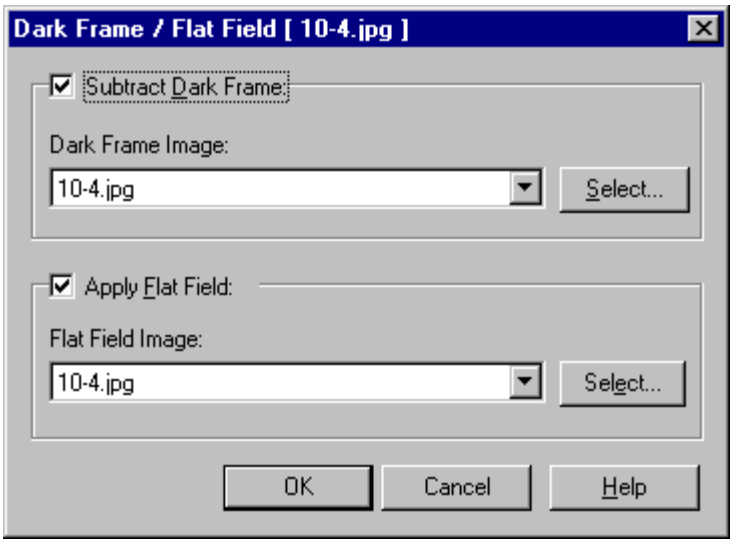
This selects the entire area in an image for copying or other functions involving a selected area.

Cancel Selection

This function un-selects an area, removing the dotted selection box.

Image

Dark Frame/Flat Field...



This subtracts a dark frame and/or divides by a flat field to produce a corrected image, normally for CCD images. This processing should always be done before any other processing except for level corrections.

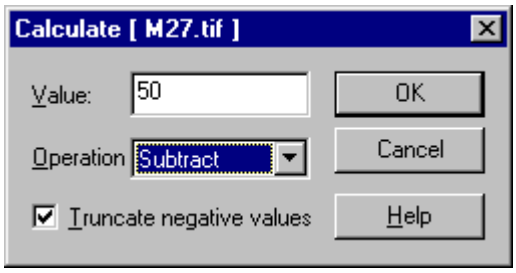
The flat field image should first itself be corrected by subtraction of the dark frame. So the first step is to select the flat field image and use this function to subtract the flat field image (check the "Subtract Dark Frame" check box and uncheck the "Apply Flat Field" check box).

Once the flat field image has been corrected, then the main image can be processed with this function, automatically applying both the dark frame and flat field corrections.

To speed up repetitive processing of images, note that the last 5 correction files used of each type are remembered by StellaImage even when the program is shut down. To use new correction files for processing, press the appropriate "Select..." button. This will open another pop up window for browsing directories and selecting a new correction file.

NOTE: If a pixel value is negative after dark frame subtraction, StellaImage sets the value to zero. Other software (such as CCDOPS from SBIG) add an offset to the entire image to eliminate negative values. Thus the results may be different even though the same raw files were used in the processing.

Calculate...

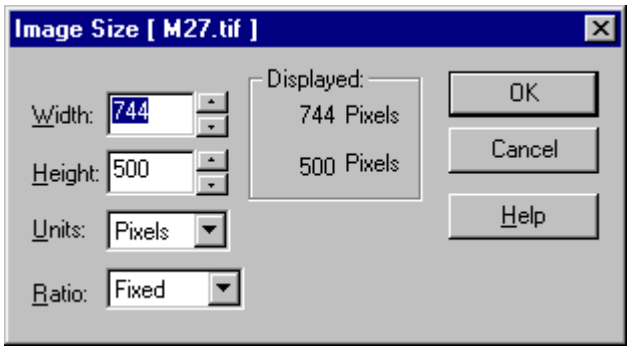


Adds, subtracts, multiplies, or divides an image by a specified constant value. In the case of subtraction, if a pixel value goes below zero, the "Truncate negative values" option may be checked. In this case the negative values will be set to zero.

Note that in some cases, the resulting pixel values will cause the image to apparently disappear. In this case, the image levels should be adjusted.

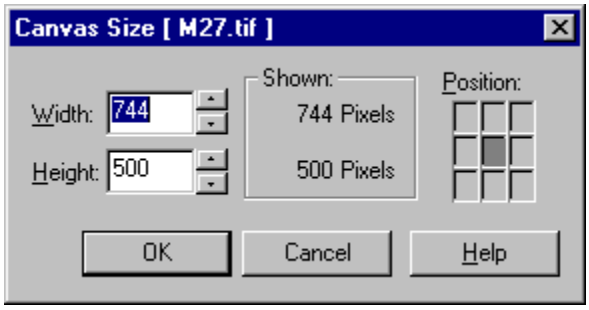
Image Size...

This allows the active image size (height and width) to be adjusted. This can be done in pixel units or by percentage. The aspect ratio can be chosen to be fixed (preserve the original aspect ratio), variable, or forced to match the SBIG ST-6.



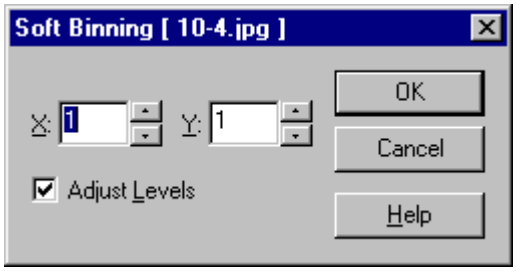
Canvas Size...

This function allows the image canvas (background under the image) to be enlarged or trimmed. This does not affect the scale of the image itself. If a smaller height or width is selected, image pixels will be removed, reducing the total size (not scale) of the image. If a larger height or width is specified, a border with the current background color will be added.



The position of the image relative to the added or deleted canvas is specified by clicking in one of the nine cells in the "Position" selection area. For example if the new canvas size is larger than the current image size in both height and width, and the upper left position cell is clicked, pixels of the current background color will be added to the bottom and right side of the image.

Soft Binning...



This allows software simulation of "binning", the addition of adjacent pixels to create a lower resolution image with increased value in each pixel. Normally this is done at the CCD detector to increase the signal level, but one application would be to create a color image from a high resolution L and binned G and B images. In this case the R image would be extracted by binning the L down to the same resolution as the G and B images and subtracting them to create a synthetic R image. The 4 components may then be combined to produce an LRGB composite color image.

When using the soft binning function, an automatic level adjustment option may be enabled. Otherwise manual adjustment of levels may be necessary after the operation.

Flip Horizontal

This is a left/right mirror reflection transformation.

Flip Vertical

This is a up/down mirror reflection transformation.

Rotate

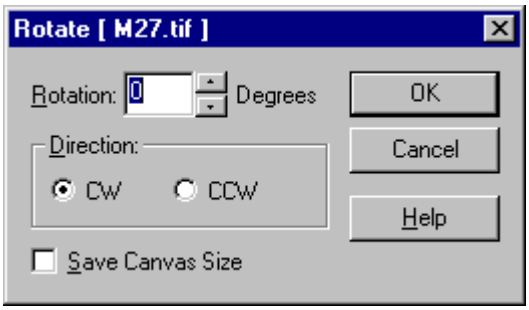
This function opens a secondary pull-down menu for four different rotation possibilities:

90 degrees CW
Rotate the image 90 degrees clockwise (CW).

90 degrees CCW
Rotate the image 90 degrees counterclockwise (CCW).

180 degrees
Rotate the image 180 degrees.

Arbitrary...
This allows the direction and arbitrary rotation angle to be specified in degrees. If the rotation results in blank canvas being exposed, it will be filled in with the current background color.

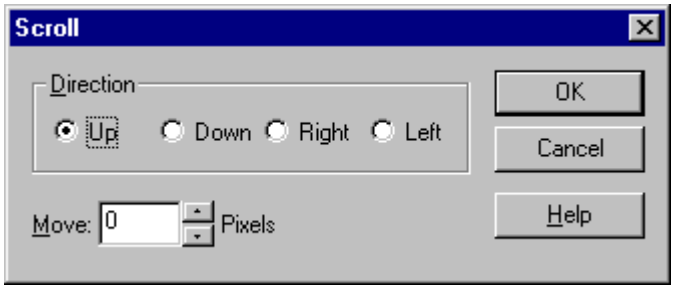


An additional option check box option is "Save Canvas Size." If this is not checked, the canvas will be resized as required so that none of the original image is lost. If this option is selected (checked), the original canvas size will be retained, and corners of the image may be cut off.

Note that rotation of the image degrades the image slightly, so repeatedly applying rotation transformations is not recommended. If rotations must be used to line images up for compositing, the rotations should be the last transformation applied before the compositing.

Scroll...

This function will shift an image by the specified number of pixels in the direction selected (left, right, up, down). Pixels scrolled off an edge are scrolled onto the opposite edge, preserving the original image dimensions.



Color Mode

Convert a monochrome (grayscale) image into an RGB color image. When the active image is already a color image, this function is not available on the pull-down menu.

Grayscale Mode

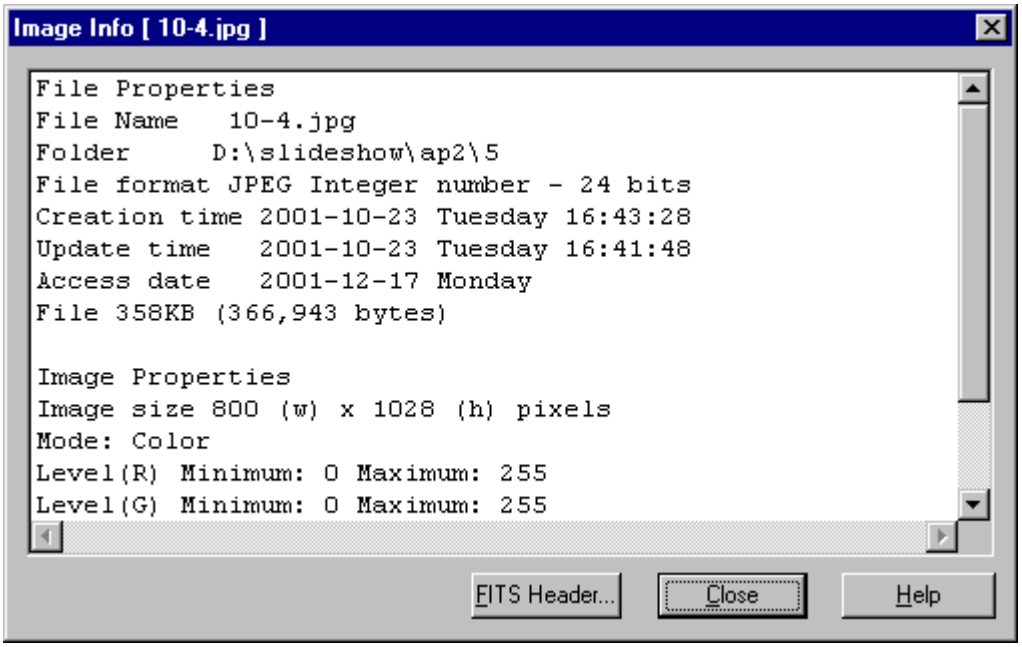
Convert a color image to a monochrome (grayscale) image. When the active image is already a monochrome image, this function is not available on the pull-down menu.

Duplicate...

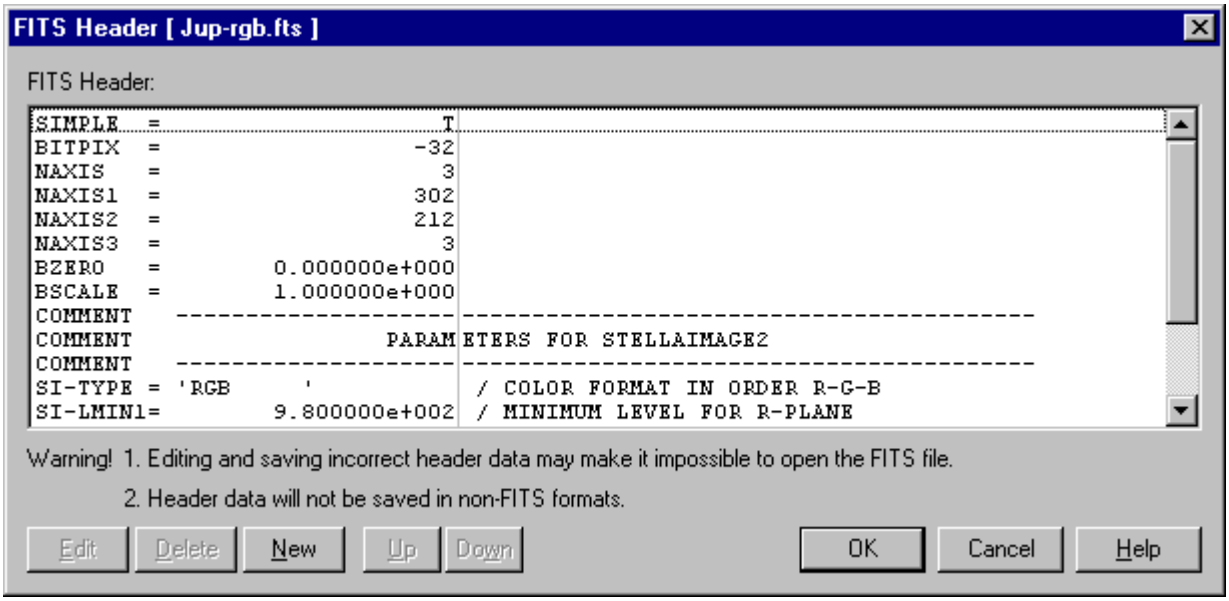
This function duplicates the active image in a new window. You will be prompted for a file name to be used for the new window.

Image Info...

This function opens a window displaying information about the active image. Depending on the format of the active image, additional header information may be available via the header button.



In the case of a FITS file, the header may be edited manually. However, incorrectly adding or modifying header information may make it impossible to later load the file, so caution is advised. FITS header information will be lost if the file is subsequently saved in a non-FITS format.



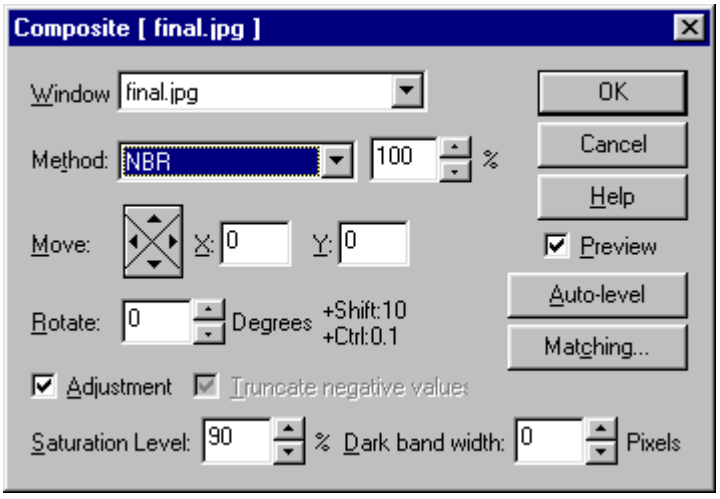
Combine/Split

Composite...

The "Composite" function allows a variety of operations to be performed on the active image in combination with a second designated image. After some operations, highlights may appear saturated, but no data has been actually lost due to the fact that StellaImage utilizes floating point format internally. After compositing, levels may be adjusted to achieve the proper appearance of the image.

The reference point tool can be used to preset reference points on the images to be composited so that registration of the images is done automatically. For planetary images, set the reference areas to surround the entire planet image. If a reference point or area cannot be set in the case of a highly magnified image of the moon or the solar corona, images can be registered using the automatic image matching function as long as the images are not rotated with respect to each other.

For compositing functions, a dialog window pops up with the following options:



Window:

Allows you to designate the second image window for a compositing function.

Method:

Specifies the compositing function to be applied:

Sum and Average

Adds the images and divides by 2 for a resulting average value. When using this function to combine a large number of images, use a power of two so that the weight of each image is equal. For example, combine 4 images by first combining raw #1 and raw #2 to create the average #1, and then combine raw #3 and raw #4 to create average #2. Then combine average #1 and average #2 for the final result.

Add

Adds two images. Since StellaImage uses a floating point representation internally, there is no practical limit to the number of images which may be added, though level adjustments may need to be made to the result.

Stack and Average

Adds two images together using a specified weighting percentage (parameter box to the right of the method). This percentage refers to the relative weight of the image specified by the "Window" parameter. 0% means the original image is unchanged, 100% means the window image replaces the original, and 50% is the same as "Sum and Average". This is useful when combining a number of images which is not a power of two.

Subtract

Subtracts the window image from the original image. If the result goes negative you can retain this negative value or force it to zero with the "Truncate to zero" checkbox option at the bottom right of the dialog window.

Multiply

Multiplies the two images together.

Divide

Divides the original image by the window image.

Absolute Difference

Computes the absolute difference between images. This function is useful for seeing differences such as an object which has moved between two images.

Bright

Takes the brighter value of the two images.

Dark

Takes the darker value of the two images.

NBR (Non-Blooming Rotational) composite

Combines two CCD images, ideally, one rotated by ~90 º, to remove the blooming caused by saturation of the CCD sensor by bright objects.

For maximum effectiveness, reference points should first be placed on the two images to be composited so they can be registered properly, or the images can be manually registered using the manual controls in the dialog window (described below).

The brightness of the two images used should be equal. If they are not already equal in brightness, use the adjustment to the right of the "Method" parameter box. This allows adjustment of the weighting (in %) of the first image to compensate for the brightness difference.

Next the saturation level (% of maximum image luminosity) must be specified. This is used to determine what portion of the image is considered to be part of the blooming trail during the compositing process. A final optional parameter to enter is the width of the dark band (0, 1, or 2 pixels) which often is adjacent to the blooming trail.

Note that if blooming trails from the two source images overlap, some residual saturated pixels will be left. These must be touched up manually to complete the NBR composite processing.

This algorithm was jointly developed by Dr. Mototsugu Motoki, Dr. Kunihiko Okano, and Mr. Masaaki Uto.

Move:

Allows the window image to be moved in x and y for alignment of the images. Pixel offsets may be directly typed in, or the cursor buttons may be clicked for single pixel stepping. To step in 10 pixel increments, hold the SHIFT key down while clicking on the cursor buttons. To step in 0.1 pixel increments, hold the CTRL key down while clicking on the cursor buttons.

Rotate:

Allows the window image to be rotated. The rotation angle in degrees may be typed in directly or the up/down buttons may be used to step in 1 degree increments. Hold the SHIFT key or CTRL key while clicking on the up/down buttons for stepping in 10 degree or 0.1 degree increments, respectively.

If reference points have been set, the first point specified will be used as the center of rotation.

Adjustment:

This option allows StellaImage to automatically adjust the level of the output based on the levels of the images being used to create the composite.

Auto-level:

Automatically adjust the current preview levels. This is useful when the result of an operation caused the levels to be affected enough to lose details in the preview image window.

Matching...

This brings up another dialog window for the automatic image registration function. You may specify a maximum offset which constrains the matching function and speeds up processing, but the matching location must be within the constraint parameters or it will be unsuccessful.

Another option is to enable or disable sub-pixel movement. Enabling sub-pixel movement makes finer alignment possible, but requires more processing time.

Hint: Automatic registration is useful for combining diffuse images such as close-ups of the moon or solar corona, but it has a limitation that it doesn't support image rotation. If the image has a border, this can interfere with the registration. In this case the image should be cropped or manually registered.

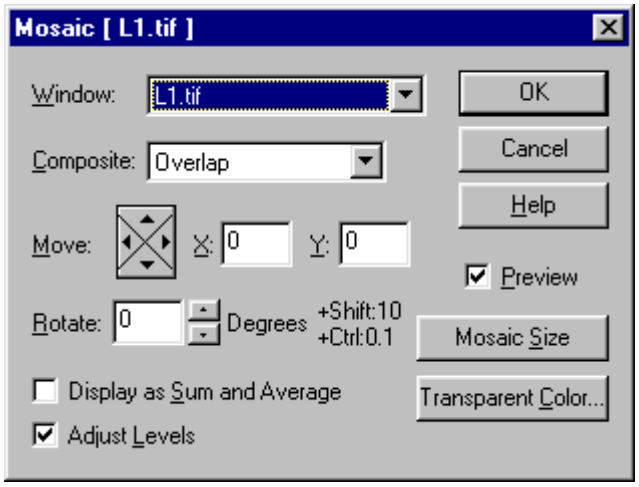
Saturation Level

This specifies the saturation threshold in % of the maximum value in an image to be composited with the NBR process (see description above). All pixels above this value are considered to be pixels affected by blooming.

Dark Band Width

Specifies the width of the dark area which sometimes appears on the side of the blooming trail. Acceptable values are 0, 1, or 2. Refer to the NBR description above for complete details of use.

Mosaic...



The Mosaic function stitches two images together to create a single larger image. When this function is invoked, a dialog window will appear with the following options:

Window:
Allows you to designate the second image window.

Composite:
Allows the method of joining to be specified:

Overlap:
Places the image specified in "Window" on top of the first image, completely obscuring the first image.

Transparent Color:
Sets the designated color to be transparent so the lower image shows through in these areas. Use the "Transparent Color" button to set the color to be used.

Light:
Selects the brighter of the two images in areas of overlap.

Dark:
Selects the darker of the two images in areas of overlap.

Move:
Allows the window image to be moved in x and y for alignment of the images. Pixel offsets may be directly typed in, or the cursor buttons may be clicked for single pixel stepping. To step in 10 pixel increments, hold the SHIFT key down while clicking on the cursor buttons. To step in 0.1 pixel increments, hold the CTRL key down while clicking on the cursor buttons.

Rotate:
Allows the window image to be rotated. The rotation angle in degrees may be typed in directly or the up/down buttons may be used to step in 1 degree increments. Hold the SHIFT key or CTRL key while clicking on the up/down buttons for stepping in 10 degree or 0.1 degree increments, respectively.

Display as Sum and Average:
Display the preview as an average so that components of images can be seen.

Adjust Levels:
Displays the combined results after auto-leveling. This is most useful if the two images are at different levels.

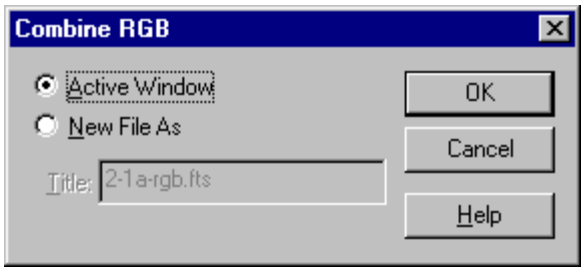
Mosaic Size:
Displays the actual composite image size in a preview.

Transparent Color...:

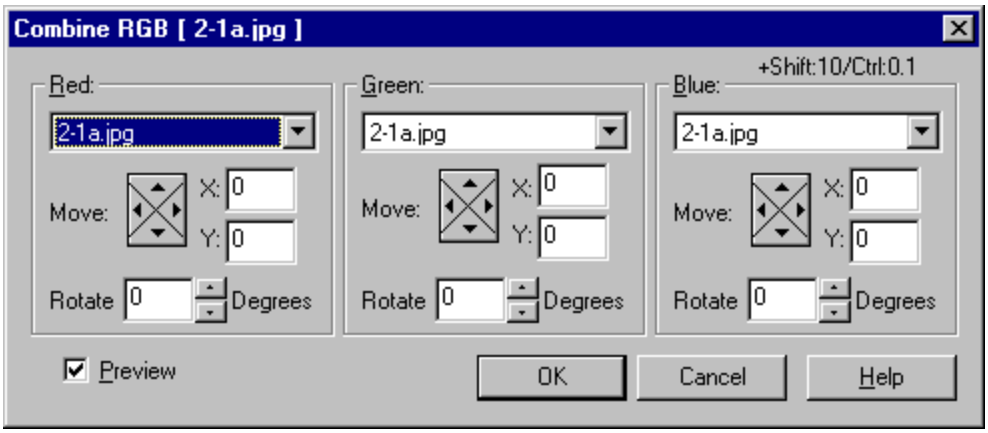
This pops up a dialog window through which the transparent color can be selected either by directly entering the values of the 3 color components, or by clicking on a part of the image in the window view. If a reference point has been selected previously it is used to designate the transparent color.

Combine RGB...

This combines 3 separate monochrome images into a single color image. The first dialog window which opens (right) allows the output to be directed to the active image window, or into a new file.



Next a dialog window opens so that the 3 monochrome component files may be specified. The position of each component may be adjusted manually using the x-y move or rotation controls:



Move:

Allows the window image to be moved in x and y for alignment of the images. Pixel offsets may be directly typed in, or the cursor buttons may be clicked for single pixel stepping. To step in 10 pixel increments, hold the SHIFT key down while clicking on the cursor buttons. To step in 0.1 pixel increments, hold the CTRL key down while clicking on the cursor buttons.

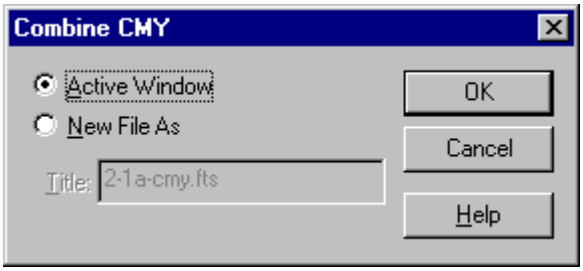
Rotate:

Allows the window image to be rotated. The rotation angle in degrees may be typed in directly or the up/down buttons may be used to step in 1 degree increments. Hold the SHIFT key or CTRL key while clicking on the up/down buttons for stepping in 10 degree or 0.1 degree increments, respectively.

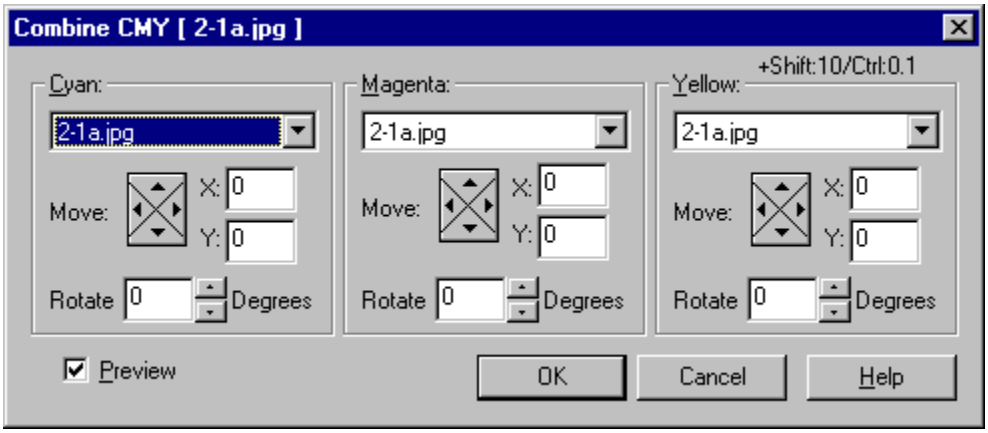
For automatic matching, reference points should be specified in each of the components prior to using the "Combine RGB" function.

Combine CMY...

This combines 3 separate monochrome images into a single color image. The first dialog window which opens allows the output to be directed to the active image window, or into a new file.



Next a dialog window opens so that the 3 monochrome component files may be specified. The position of each component may be adjusted manually using the x-y move or rotation controls:



Move:

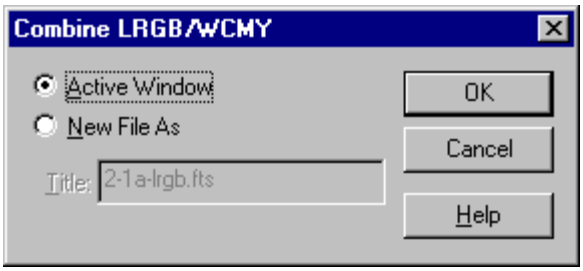
Allows the window image to be moved in x and y for alignment of the images. Pixel offsets may be directly typed in, or the cursor buttons may be clicked for single pixel stepping. To step in 10 pixel increments, hold the SHIFT key down while clicking on the cursor buttons. To step in 0.1 pixel increments, hold the CTRL key down while clicking on the cursor buttons.

Rotate:

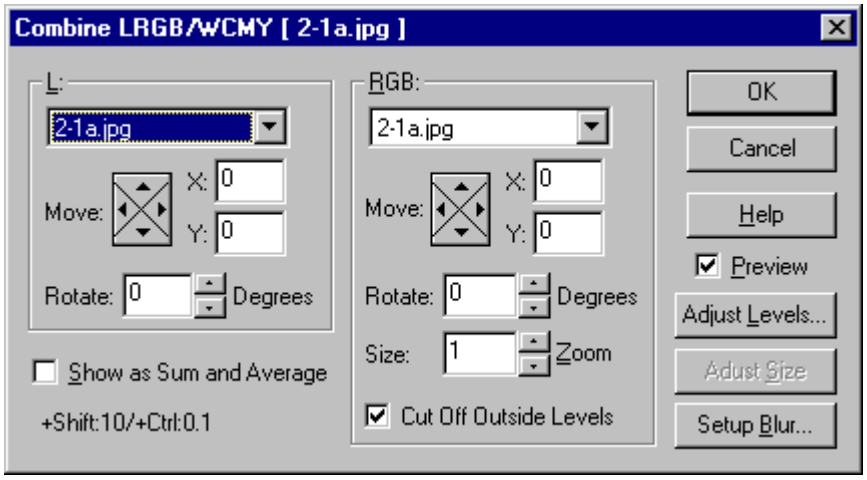
Allows the window image to be rotated. The rotation angle in degrees may be typed in directly or the up/down buttons may be used to step in 1 degree increments. Hold the SHIFT key or CTRL key while clicking on the up/down buttons for stepping in 10 degree or 0.1 degree increments, respectively.

For automatic matching, reference points should be specified in each of the components prior to using the "Combine CMY" function.

Combine LRGB/WCMY...



This combines a monochrome luminosity image (L or W) file and an RGB or CMY color file into a single color image. The dialog window which opens allows the output to be directed to the active image window, or into a new file.



Once the output destination has been specified, a second dialog window will open from which the position of the two files may be adjusted manually using the x-y move or rotation controls:

Move:

Allows the window image to be moved in x and y for alignment of the images. Pixel offsets may be directly typed in, or the cursor buttons may be clicked for single pixel stepping. To step in 10 pixel increments, hold the SHIFT key down while clicking on the cursor buttons. To step in 0.1 pixel increments, hold the CTRL key down while clicking on the cursor buttons.

Rotate:

Allows the window image to be rotated. The rotation angle in degrees may be typed in directly or the up/down buttons may be used to step in 1 degree increments. Hold the SHIFT key or CTRL key while clicking on the up/down buttons for stepping in 10 degree or 0.1 degree increments, respectively.

In addition to the translation and rotation, the color image's scale may be adjusted using the zoom control and **[Adjust Size]**.

For automatic matching, reference points should be specified in each of the components prior to using the "Combine LRGB/WCMY" function.

Since the component images need not be taken with the same optics, StellaImage will use the active image as the reference for the output image's scale. When combining LRGB images, generally the color images are undersampled compared to the L image, so the L image must be the active image.

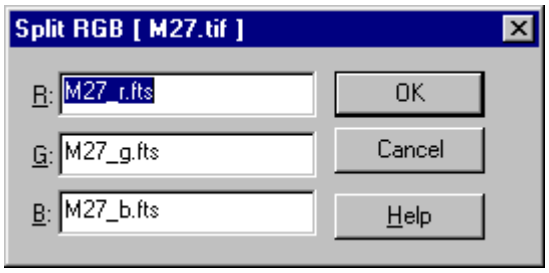
The color image may also be blurred (and truncated outside the range specified with the Levels command) using a Gaussian blur prior to combining. Use the "Setup Blur" function to set the Gaussian blur radius in units of pixels. The output color image will be truncated outside the levels range when the composite is produced.

Adjustment of levels is via the "Adjust Levels" dialog window which pops up with thumbnails of the L (grayscale) image and the RGB image. Using the images, adjust the L image levels and curves so that the color level of the LRGB composite is close to the original RGB.

Hint: One application of the "Combine LRGB/WCMY" is to take a color image, convert a copy to grayscale for image enhancements such as filtering. As a final step, the grayscale image can be recombined with the color copy. This saves processing time by working only on the grayscale luminance version, yet preserves the color balance of the original image. It is also possible to reduce the size of the color version of the image during processing so that processing time is saved.

Split RGB

A color image may be separated into R,G, and B component monochrome files with this function. A dialog window pops up to allow the output files to be specified.

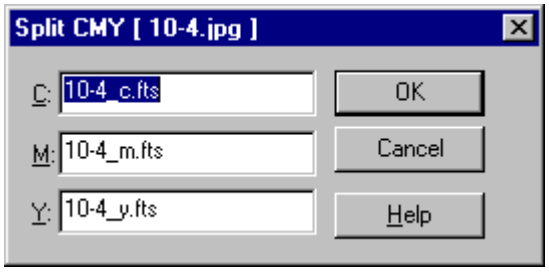


Split CMY

This function splits a color image into C, M, and Y component monochrome files. The conversion is computed as follows:

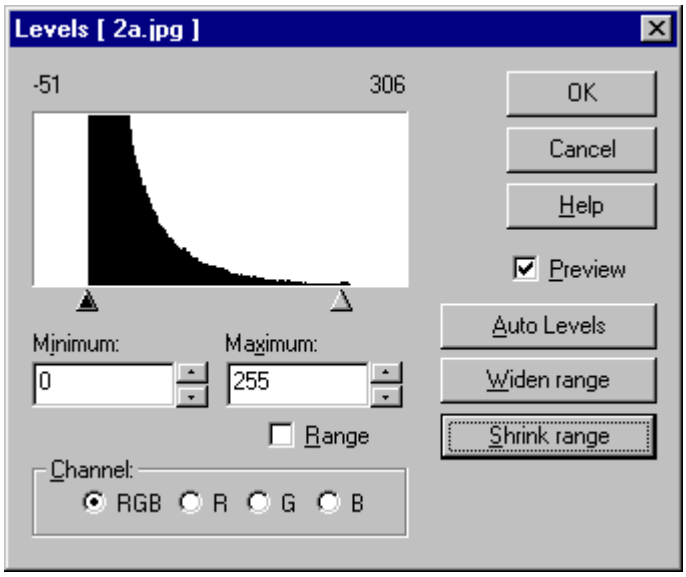
C= (B+G)/2
M= (B+R)/2
Y= (G+R)/2

A dialog window pops up (as shown at right) to allow the output files to be specified.



Adjust

Levels...



This function allows an image's tonal range to be set. Adjustments are made only to the displayed image without affecting the original data, allowing any number of adjustments to be made without degrading the image data.

The range endpoints may be set by dragging the light and dark triangle-shaped sliders below the displayed histogram, or by typing a values into the "Minimum" and "Range" parameter entry boxes. These may also be incrementally adjusted by clicking on the up or down arrows on the parameter entry boxes.

Alternatively the range controls may be set to show the minimum and maximum instead of the minimum and range. Set the "Range" checkbox for the appropriate mode.

If the range settings need to be set to a value outside the displayed histogram, click on the "Shrink Range" button. To use the sliders to set a narrow range accurately, set the sliders to their approximate desired positions, then click on "Widen Range" to zoom in on the range for more accurate adjustment. Alternatively, type the values directly into the parameter entry boxes.

For color images, Adjustments may be made to the overall image by clicking on the "RGB" button. Later fine adjustments may be made to individual color channels.

To use automatically determined range values, use the "Auto Levels" button. This function does an automatic adjustment of the image range based on the settings entered in **[Adjust][Auto Levels Setup...]** function.

Hint: The Tool Bar's **[Pixel Data][Set Histogram Mark X]** can be used to select several areas of the image which will then be indicated in the histogram display for Levels adjustments. One application of this is to set a mark in the background area and one on a bright object (e.g. star) in the image so that the actual limits of the original image are indicated on the Levels histogram.

Thresholds

This function truncates the image data at the limits specified using **the [Adjust][Levels]** function. This modifies the actual image pixel values used for this processing session. However, the original file pixel values may still be retrieved using the **[File][Revert]** function until the original file is overwritten with a **[File][Save]** function.

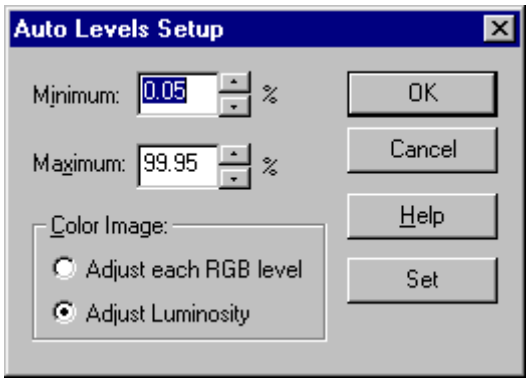
Apply Levels

This is a short-cut equivalent to using the **[Adjust][Levels...][Auto Level]** sequence. It applies the automatic leveling thresholds specified in the **[Adjust][Auto Levels Setup...]** dialog.

Copy Levels

This function copies the level settings from the active image into the Auto Levels parameter set where it may be used later for Auto Leveling other files. This function saves time on similar images by allowing level adjustments made on the first file to be rapidly applied to the other images.

Auto Levels Setup...



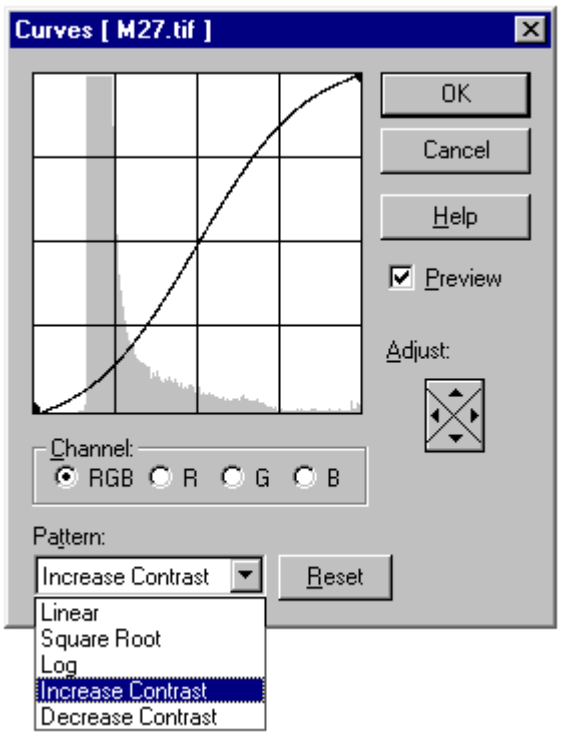
This dialog allows criteria for automatic level settings to be entered for subsequent use via the **[Adjust][Auto Level]** and **[Apply Levels]** functions. The "Minimum" and "Maximum" parameter boxes set the positions of the minimum (shadow) value and maximum (highlight) value by way of specifying the percentage of the total image pixels below each level threshold. For example, if the Minimum is set to 2% and the Maximum is set to 99%, the shadow cutoff will be set to the point where 2% of an image's pixels fall below the shadow cutoff, and 99% of the image's pixels fall below the highlight cutoff. When applied to an image, pixels below the shadow cutoff will be set to black, and pixels above the highlight cutoff will be set to white.

Percentage values outside the range [0..100] may also be specified to broaden the range beyond the actual dynamic range of the image.

For color images, you may select the option of having the level settings applied to the luminosity of the image or to have the settings applied to each individual R, G, and B channel.

The **[Set]** button saves the entered parameters for subsequent Auto Level operations. Alternatively, use the **[OK]** button to save the parameters and exit the dialog.

Curves...



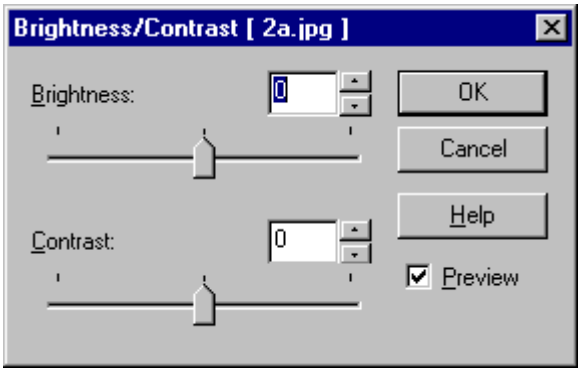
This function opens a dialog which allows very flexible adjustment of the tone or gamma curve to be applied to the active image. The curve is shown as a black line set against a gray histogram plot for the image data. For color images the curve may be applied to the color channels together (select RGB button) or to each color channel selectively (select R, G, or B button).

The general shape of the curve defaults to a linear function, but several common curves may be selected using the "Pattern" selector which provides the following choices:

Linear
Square Root
Log
Increase Contrast
Decrease Contrast

Once the basic curve shape has been selected, it may also be modified using the left/right/up/down "Adjust" buttons or by clicking along the curve to add an adjustment handle which may be dragged to produce the desired curve shape. Multiple handles may be added to give virtually unlimited flexibility in adjusting the image curve function. Note that the extreme ends of the curves already have handles which may be dragged for adjustment. To remove an individual handle, right click on the handle.

Brightness/Contrast...



The Brightness/Contrast function opens a simple dialog which provides sliders for adjusting the brightness and contrast between -100 and 100. The initial setting of zero in each control is the neutral position (original image setting). For fine adjustment, numerical values may be typed directly into the respective parameter entry boxes, or the up/down arrow buttons may be used for fine control of the settings.

Digital Development...

Digital Development Processing (DDP) applies a special algorithm to linear electronically captured images (such as from CCD cameras) to give them a more "natural" photographic look. This is done by converting the linear data to the nonlinear 'S'-shaped response curve which mimics the look of traditional film that undergoes chemical developing. Essentially, for a monochrome image, this compresses the dynamic range in the shadow and highlight ends and applies some unsharp masking to the highlight region. The basic underlying equation for DDP is:

$$Y = k * X / (\{X\}+a) + b$$

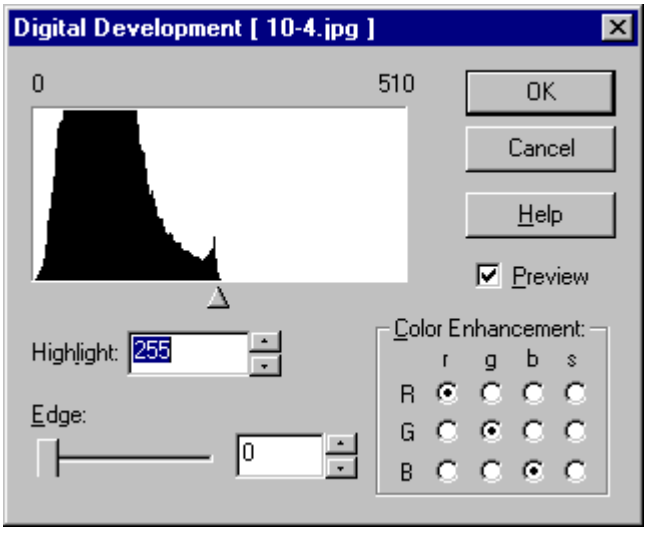
where,

Y	is the output image
X	is the input image
{X}	is a blurred version of the input image
a	is a parameter which sets the knee of the nonlinear curve (highlight end)
b	is the parameter which sets the level of the "toe" of the curve (shadow end), preventing the output from going to zero (pure black)
k	is a scaling parameter used to control the maximum value of the output image

To control the DDP processing, you are required to set the parameters a, b, and the degree of edge enhancement. The output scaling parameter k is automatically controlled by StellaImage.

To begin processing an image, first, using the **[Adjust][Levels]** function, set the minimum and maximum levels, taking care that the image has maximum detail in the shadow and midrange regions. Do not be concerned if the highlight areas become saturated. It will be automatically adjusted in the DDP processing.

Next start the DDP function. The DDP dialog will open with the histogram of the image displayed, starting at the minimum value. The minimum value is used to derive the 'b' parameter, while the maximum value is used to derive the 'a' parameter. If the preview of the image does not look good at this point, the highlight parameter may be adjusted by dragging the triangle under the histogram or by directly typing a value into the Highlight parameter box. Fine adjustments may also be made by clicking on the up/down arrow buttons next to the "Highlight" parameter box.

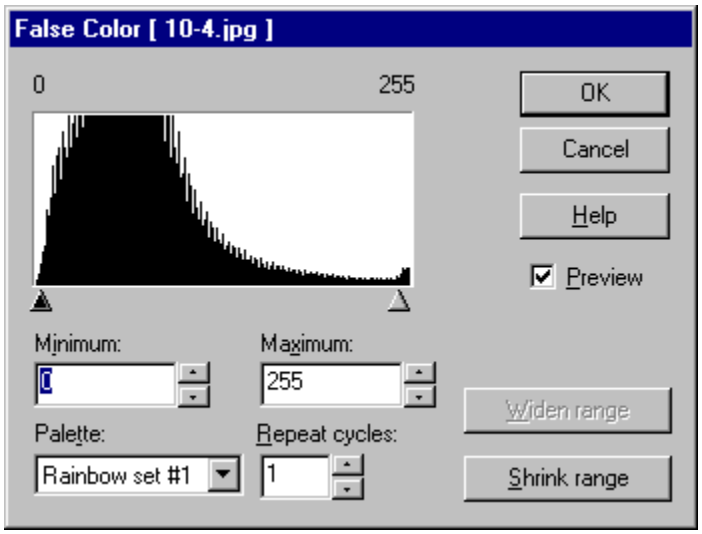


In addition to adjusting the Highlight parameter, the "Edge" parameter should be adjusted to control the degree of edge enhancement applied in the highlight regions. This control may range from zero (no edge enhancement) to 2 (maximum edge enhancement). Inspect the image carefully to insure that the edge enhancement is not overdone. Stars with black rings around them may be visible when excessive edge enhancement has been used.

When processing color images with DDP, a typical effect is that color saturation in the highlight areas is reduced, giving an impression of washed out colors. This effect can be reduced by using the Color Enhancement controls which are enabled when a color image is the active image.

By default, DDP is applied to each color component independently, though with the same a, b, and edge enhancement parameters. To control the color emphasis, when the DDP is applied to each channel, the blur mask {X} may be computed from a different channel. For example, the 'R' channel processing may be best using a blurred version of the 'B' channel. In this case, press the 'b' button in the 'R' row. Each color channel may be controlled separately in this manner. The 's' button specifies the use of the blurred average of all channels. Experimentation is recommended to get a good 'feel' for these controls and to decide what is the 'best' color for a particular image.

False Color...



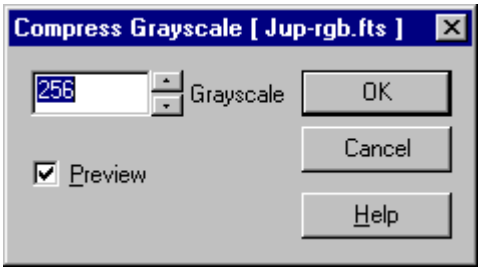
This function maps the intensity of an image to a set of colors, thus enhancing the visibility of subtle intensity level differences. Using the triangular sliders under the histogram displayed in the dialog, the input intensity range for the mapping function may be specified. Use the Minimum parameter entry box and/or up/down arrows for fine control of the lower value, and the Maximum parameter entry box and/or up/down arrows for the upper value. To set the controls beyond the edge of the displayed histogram use the Shrink Range button, or to zoom in for finer control, use the Widen Range button.

The selection of colors is made using the Palette selection box which gives the following choices:

- Rainbow Set #1 (violet to red)
- Rainbow Set #2 (same as Rainbow Set #1, including black on the shadow end and white on the highlight end)
- Blue-White (blue to white, with black used for out-of-range data
- Blackbody (blackbody colors - black/red/yellow/white

To apply false colors to images with very subtle tone changes, use the Repeat Cycles control to increase the number of times the colors are used within the specified range. This will create a repeating striped pattern across an area where the intensity is gradually changing.

Compress Grayscale...

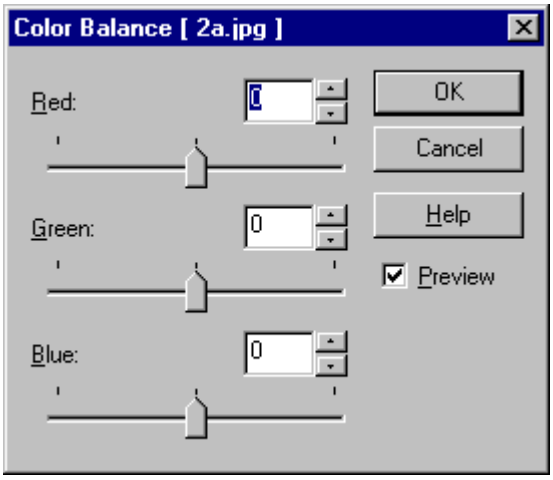


This function will compress the number of intensity levels in an image as specified in the Grayscale parameter entry box (up/down arrows may also be used).

Hint: This function may be used to create contour maps with the following procedure:

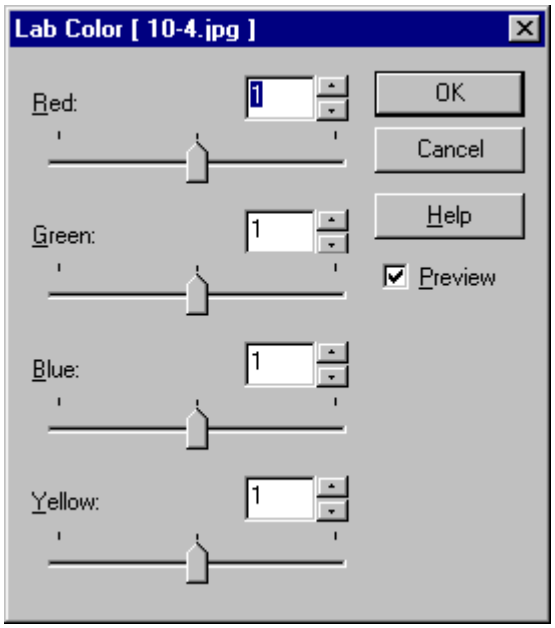
1. Apply a mean blur function -- **[Filter][Mean Blur]**, Enhance:2, Area:Large.
2. Compress grayscale -- **[Adjust][Compress Grayscale...]**, Grayscale:12 or 16, for example.
3. Define edges -- **[Filter][Enhance Edges]**
4. Adjust levels for clarity -- **[Adjust][Levels]**

Color Balance...



This allows individually controlling the brightness for each of the color channels. The range for each parameter is [-100..100]. A setting of zero leaves the color channel unchanged.

Lab Color...



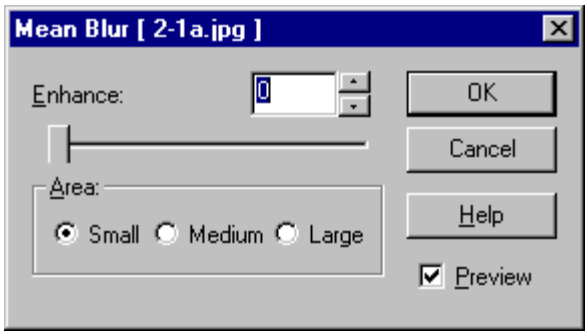
This function allows adjustment of an image's colors in the Lab color space. Adjustments may be done within the range [0..2] for each color using the slider or parameter value entry box or up/down arrows on the side of the value entry box. A value of '1' means the original image is not altered. Adjustment of colors using the Lab controls is often easier because white objects (e.g. stars) are not affected.

Invert

This function inverts the active image (each color channel is handled independently for a color image). The Minimum/Maximum range values set in the **[Adjust][Levels]** function defines the image inversion range.

Filter

Mean Blur...



The mean blur function low pass filters an image. A pop-up dialog allows fine control of the filter parameters:

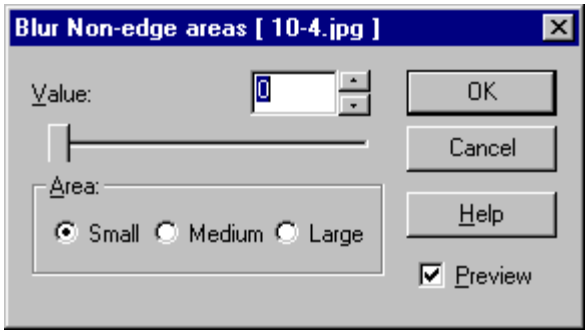
Enhance:

Controls the strength of the filtering function. A zero value means no blurring, and using the slider allows setting the strength up to a value of 2. Directly typing a value in allows you to select higher values.

Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Blur Non-Edge Areas...



This blurring function applies the same function as the mean blur but this acts only on non-edge areas (i.e. not on areas where pixel values are rapidly changing). A common use of this function is to reduce noise in the background areas of an image. The filter parameters are controlled with a pop-up dialog:

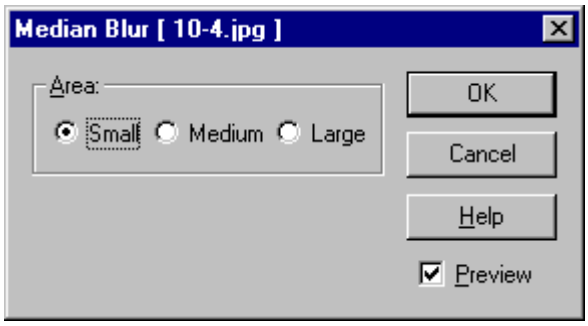
Enhance:

Controls the strength of the filtering function. A zero value means no blurring, and using the slider allows setting the strength up to a value of 2. Directly typing a value in allows you to select higher values.

Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Median Blur...

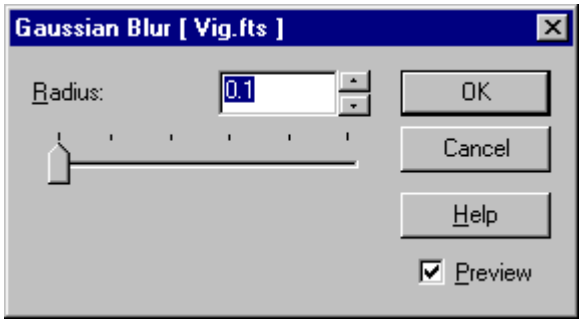


The median blur computes the value of a pixel by taking the median of nearby pixel values. A pop-up dialog window allows control of the filter:

Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Gaussian Blur...

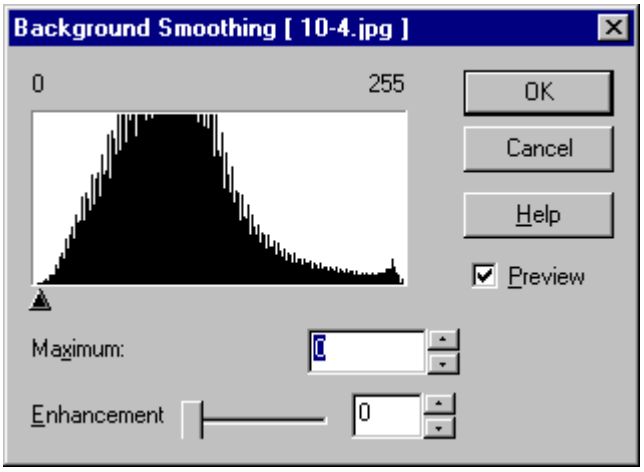


The Gaussian blur applies a Gaussian profile kernel to the active image window. A pop-up dialog window allows control of the filter:

Radius:

Use the slider or edit the value directly to control the radius of the filter kernel (in pixels).

Background Smoothing...



This applies a low pass filter to sections of an image which are below a specified threshold. Parameters are specified via a pop-up dialog:

Maximum:

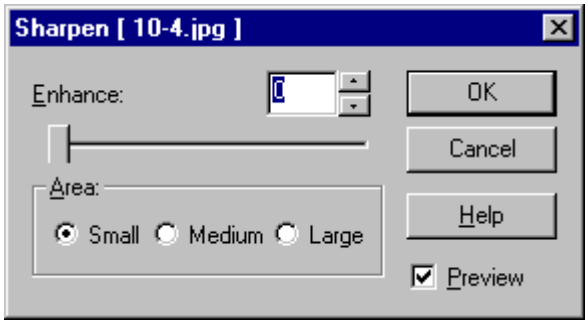
Allows the threshold for the filter to be set by either using the slider under the histogram shown or by directly typing the value into the parameter box.

Enhancement:

Sets the blurring strength via the slider or by direct entry. A zero value here means no effect. Use a higher value to increase the blurring filter strength.

Hint: The Pixel Data Tool can be use to mark the value of the background level so that when the background smoothing parameter is being set, the background level will be visible in the displayed histogram.

Sharpen...



The Sharpen function applies a high-pass filtering function to the active image. A pop-up dialog allows fine control of the filter parameters:

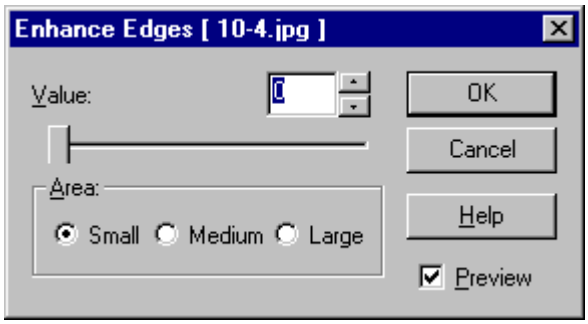
Enhance:

Controls the strength of the filtering function. A zero value means no sharpening, and using the slider allows setting the strength up to a value of 2. Directly typing a value in allows you to select higher values.

Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Enhance Edges...



The "Enhance Edges" function applies a high-pass filtering function to the active image, but is limited to regions where the pixel values change rapidly (i.e. edges). A pop-up dialog allows fine control of the filter parameters:

Value:

Controls the strength of the filtering function. A zero value means no sharpening, and using the slider allows setting the strength up to a value of 2. Directly typing a value in allows you to select higher values.

Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Unsharp Mask...

This high pass filter enhances fine details in an image. A pop-up dialog allows fine control of the filter parameters:

Enhance:

Controls the strength of the filtering function. A zero value means no sharpening, and using the slider allows setting the strength up to a value of 2. Directly typing a value in allows you to select higher values.

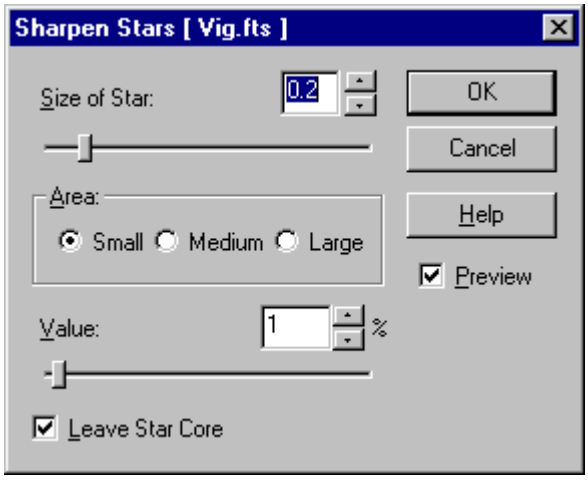
Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Value:

Allows the selection of a threshold value above which unsharp masking will be applied. By adjusting this value, sharpening an object is possible without sharpening the background noise. A number larger than 100 may be entered by directly typing the value. The maximum value possible with the slider control is 100.

Sharpen Stars...



This is a nonlinear sharpening function which is applied only to bright point sources (stars). This filter, which makes star images smaller and sharper, was co-developed by Dr. Kunihiko Okano and AstroArts, Inc. A pop-up dialog allows fine control of the filter parameters:

Size of Star:

Controls the enhancement applied. A smaller value increases the enhancement (decreases the sizes of stars).

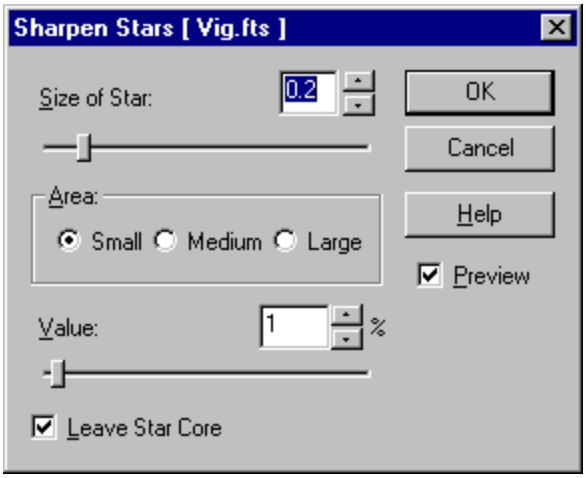
Area:

Allows selection of the kernel size. "Small" corresponds to 5 pixels, "Medium" corresponds to 9 pixels, and "Large" corresponds to a 21 pixel kernel.

Value:

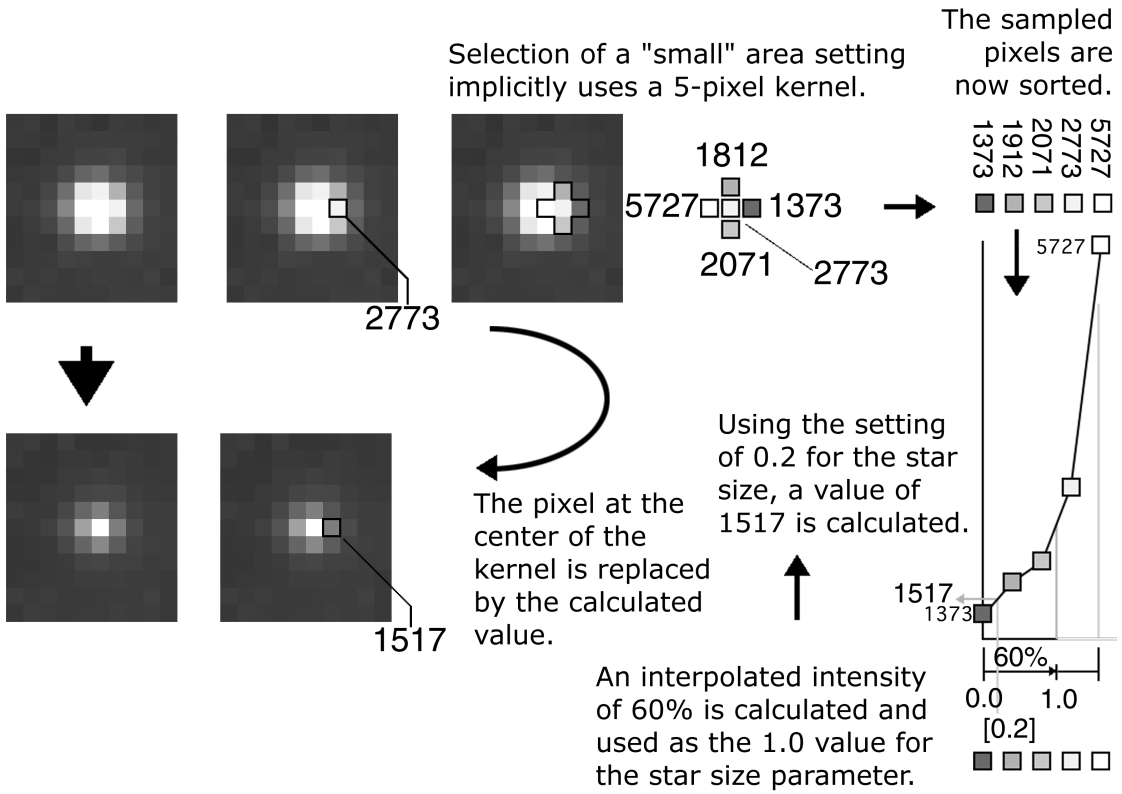
Controls the strength of the sharpening effect. Adjustment of this control allows stars to be sharpened without affecting diffuse objects such as nebulae.

A closeup view of the effect of the star sharpening algorithm is illustrated below using a small "Area" parameter (5-pixel kernel) and "Size of Star" parameter of 0.2.

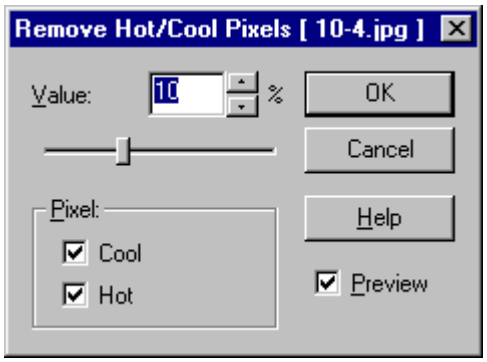


For each application of the kernel, the intensity values of the sampled pixels are sorted and the 60% intensity value calculated by interpolation. This value is used as the 1.0 reference position for the star size parameter. In this case, a user selection of a star size parameter of 0.2 results in an output value of 1517 for the pixel centered on the kernel position.

For best results, this filter should be used on oversampled images.



Remove Hot/Cool Pixels



This function removes hot or cool pixels which typically are found in CCD images. Each pixel is compared with the median value of the surrounding 5x5 array of pixels. If the comparison pixel differs significantly from the median, it is replaced by the median value. Control of this function is via a pop-up menu:

Value:

Controls the threshold at which pixels are considered hot or cool compared to the surrounding pixels. Careful setting of this value will allow noise to be removed without affecting real image features.

Cool:

Checking this box enables removal of cool pixels.

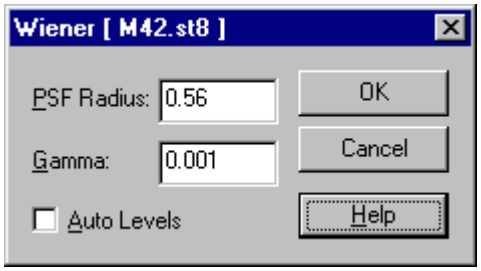
Hot:

Checking this box enables removal of hot pixels.

Deconvolution Filters

Wiener...

This function applies the Wiener restoration filter. Using a minimum square method, degrading effects of atmospheric turbulence can be partially reversed. The following parameters are available via a pop-up menu:



PSF Radius:

Specify the target radius for the point spread function (PSF). Prior to using this function, select multiple stars using the **[PSF]** tool button and the **[Deconvolution Filters][PSF Measurement]** to use StellaImage to determine the radius.

Gamma:

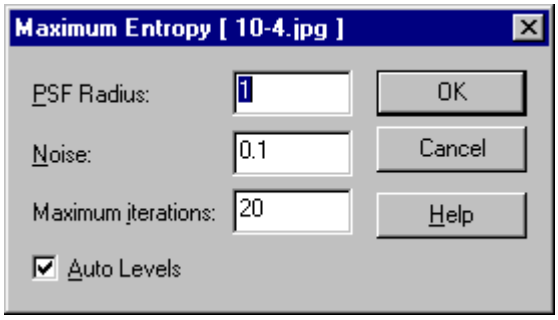
Controls a parameter associated with the signal-to-noise ratio of the image. Typically appropriate values are between 0.001 and 0.01. Larger values cause loss of image details (high frequency content), while 0 enhances noise as well as image details.

Auto Levels:

Checking this option allows StellaImage to automatically adjust the levels after processing. Without this enabled, the image levels may be altered significantly as a result of processing.

Hint: After processing if manual level adjustments are made, the processing cannot be reversed with the UNDO function, so the Auto Levels function should be used in this case.

Maximum Entropy...



The maximum entropy deconvolution function attempts to reconstruct images blurred by atmospheric seeing. This procedure is best used on linear data such as images from CCD cameras. The following parameters are available via a pop-up menu:

PSF Radius:

Specify the target radius for the point spread function (PSF). Prior to using this function, select multiple stars using the **[PSF]** tool button and the **[Deconvolution Filters][PSF Measurement]** to use StellaImage to determine the radius.

Noise:

Use this to designate the noise spreading function. The default value is 0.1, and a value between 0 and 20 is recommended. Larger values reduce high frequency noise, but sharpness is sacrificed and the effectiveness of the deconvolution is reduced.

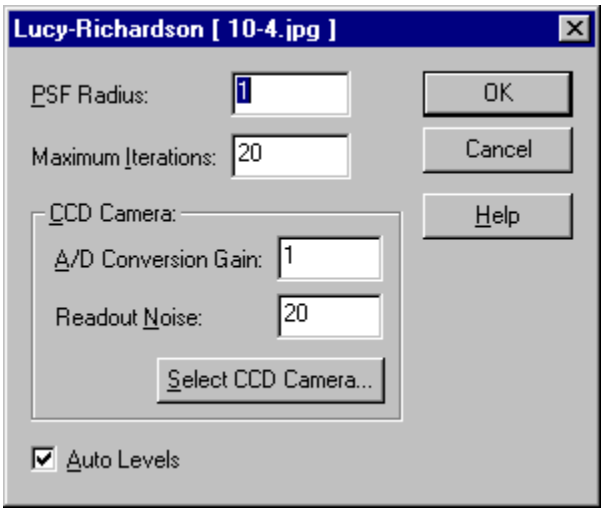
Maximum Iterations:

Allows a limit to the number of iterations to be specified if the function does not converge properly. This number must be determined empirically. Using too many iterations increases noise.

Auto Levels:

Checking this option allows StellaImage to automatically adjust the levels after processing. Without this enabled, the image levels may be altered significantly as a result of processing.

Lucy-Richardson...



The Lucy-Richardson function attempts to reconstruct images blurred by atmospheric seeing. This procedure is best used on linear data such as images from CCD cameras. The following parameters are available via a pop-up menu:

PSF Radius:

Specify the target radius for the point spread function (PSF). Prior to using this function, select multiple stars using the **[PSF]** tool button and the **[Deconvolution Filters][PSF Measurement]** to use StellaImage to determine the radius.

Maximum Iterations:

Allows a limit to the number of iterations to be specified if the function does not converge properly. This number must be determined empirically. Using too many iterations increases noise.

CCD Camera:

A/D Conversion Gain:

Specify the ADU value based on each camera manufacturer's specifications, or use the following values:

Camera	A/D Conversion Gain
Mutoh CV-04	1.30
Mutoh CV-04 (2x2)	5.19
Mutoh CV-04 (3x3)	5.19
Mutoh CV-04L)	0.69
Mutoh CV-04L (2x2)	2.75
Mutoh CV-04L (3x3)	5.19
Mutoh CV-16	1.30
Mutoh CV-16 (2x2)	5.19
Mutoh CV-16 (3x3)	5.19
Mutoh CV-16L	0.69
Mutoh CV-16L (2x2)	2.75
Mutoh CV-16L (3x3)	5.19
Bitran BT-01	0.95
Bitran BT-10	0.69
Bitran BT-11	0.69
Bitran BT-12	1.30
Bitran BT-20/20B	5.34
Bitran BT-21/21B	5.34
SBIG ST-4	15.0
SBIG ST-237	4.0
SBIG ST-5C	2.0
SBIG ST-6B	6.7
SBIG ST-7	2.3
SBIG ST-8	2.3

Readout Noise:

Designate the readout noise based on each camera manufacturer's specification.

Select CCD Camera...:

Allows selection from the list of supported cameras:

Mutoh CV-04
Mutoh CV-04 (2x2)
Mutoh CV-04 (3x3)
Mutoh CV-04L
Mutoh CV-04L (2x2)
Mutoh CV-04L (3x3)
Mutoh CV-16
Mutoh CV-16 (2x2)
Mutoh CV-16 (3x3)
Mutoh CV-16L
Mutoh CV-16L (2x2)
Mutoh CV-16L (3x3)
Bitran BT-01
Bitran BT-10/10L
Bitran BT-10/10L (2x2)
Bitran BT-10C
Bitran BT-11/11L
Bitran BT-11/11L (2x2)
Bitran BT-11/11L (3x3)
Bitran BT-11C
Bitran BT-12
Bitran BT-12 (2x2)
Bitran BT-12 (3x3)
Bitran BT-20/20B
Bitran BT-21/21B
Bitran BJ-30L
Bitran BJ-30L (2x2)
Bitran BJ-30C (High Res)
Bitran BJ-30C (Normal)
Bitran BJ-30C (Gray)
Bitran BJ-31L
Bitran BJ-31L (2x2)
Bitran BJ-31C (High Res)
Bitran BJ-31C (Normal)
Bitran BJ-31C (Gray)
Bitran BJ-32L
Bitran BJ-32L (2x2)
Bitran BJ-32C (High Res)
Bitran BJ-32C (Normal)
Bitran BJ-32C (Gray)
SBIG ST-4
SBIG ST-237
SBIG ST-237 (2X2)
SBIG ST-237 (3X3)
SBIG ST-5/5C
SBIG ST-5/5C (2X2)
SBIG ST-6/6A/6B
SBIG ST-7
SBIG ST-7 (2X2)
SBIG ST-7 (3X3)
SBIG ST-8
SBIG ST-8 (2X2)
SBIG ST-8 (3X3)
Meade Pictor 208
Meade Pictor 208 (2x2)
Meade Pictor 216
Meade Pictor 216 (2x2)
Meade Pictor 416
Meade Pictor 416 (2x2)
Meade Pictor 1616
Meade Pictor 1616 (2x2)

Auto Levels:

Checking this option allows StellaImage to automatically adjust the levels after processing. Without this enabled, the image levels may be altered significantly as a result of processing.

Note: If the Lucy-Richardson processing is performed on a multiple image composite, adjust the ADU and readout noise as follows:

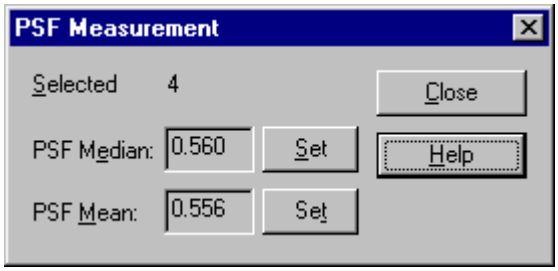
Adding N images:

ADU= same as for single image
Readout noise = sqrt(N) x (single image readout noise)

Add and average N images:

ADU= N x (single image ADU value)
Readout noise = (single image readout noise) x sqrt(N)

PSF Measurement...



This function calculates the mean and median values of the point spread function (PSF) radius of stars designated using the PSF tool. If the mean and median values are far apart, select other stars and recalculate the PSF measurements.

Once the values are acceptable, click a **[Set]** buttons to store one as a starting point for the Wiener, Maximum Entropy, and the Lucy-Richardson functions.

Note that StellaImage uses stars to determine the PSF since they are point sources degraded by atmospheric processes which approximate a gaussian distribution.

Batch Process

Combine...

The Batch Combine (composite) function allows several images in open StellaImage windows to be stacked in one operation. By default all open windows will be combined, but the Remove or Add buttons can be used individually on any image window which has its name highlighted by selection with the mouse.

Registration of the images before stacking can be turned on or off. If used, the registration can be done using reference points previously specified on each image, by automatically matching the calculated image centroids, or automatic object matching (correlation). The maximum offset for the search area for the object matching may be specified in pixels. Sub-pixel offsets may be enabled for more precision, but more calculation time is required. Note that registration prior to stacking consists only of x-y translations.

The composite method used may be selected via one of three choices:

- Add
- Sum and average
- Median

The output may also be specified to be directed to a new window or the currently active window.

Dark Frame / Flat Field 1...

This function allows multiple images to be processed by dark frame subtraction and flat fielding. Each file to be processed must be selected along with its own dark frame image and flat field image, and with an output file specified.

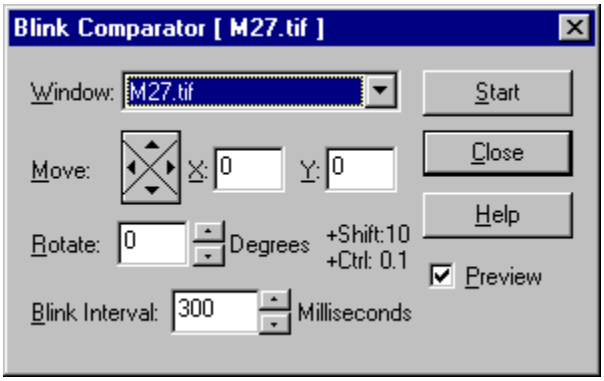
Dark Frame / Flat Field 2...

This function allows multiple images to be processed by dark frame subtraction and flat fielding. The same dark frame image and flat field images are applied to each of the input files specified.

Tools

Blink Comparator...

The blink comparator allows two images to be alternately viewed so that objects which change position or appearance can be easily found.

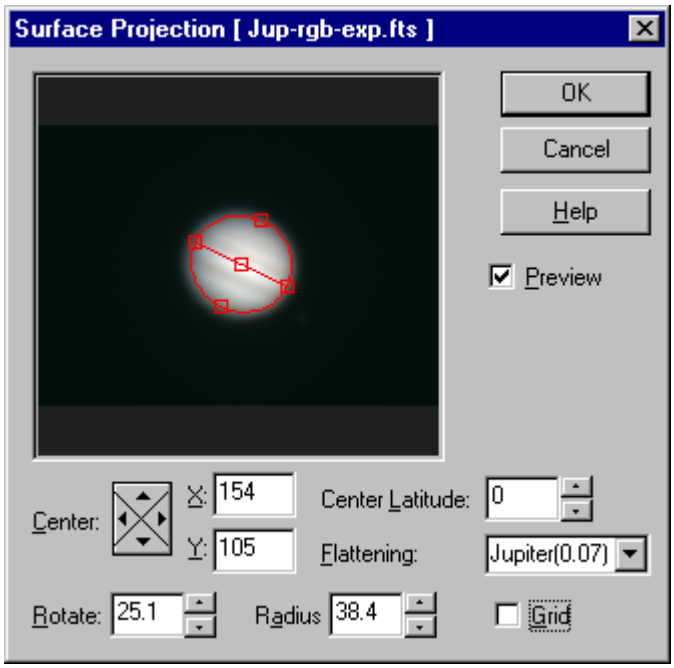


The active image window is used as one of the images. A pop-up dialog allows selection of a second window (the second image must have already been loaded into StellaImage). The second image may be translated in x or y and rotated using the controls in the dialog. The blink interval can also be specified in increments as fine as 1 ms.

Surface Projection...

The surface projection function is used to map an image of a spheroidal object (planets, the sun, or the moon) onto a flat surface. When the surface projection function is initially selected, a dialog appears so that the output window/file name may be specified along with the desired size.

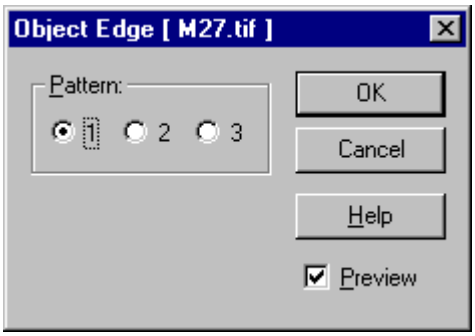
After the output parameters have been specified, a second dialog appears which allows you to define the limits of the edge of the object to be mapped. A red circular overlay with handles at the center, top, bottom, right, and left sides appears. Use the center handle to position the overlay over the center of the object, and the right or left handles to rotate the overlay to the same orientation as the object in the image. Using either the top or bottom handle allows you to set the radius of the object. Alternatively, these parameters may be set by typing the values directly into the parameter entry boxes.



If the object is flattened by rapid rotation, the flattening may be specified as a parameter. Jupiter's flattening value (0.07) may be directly selected as an option for convenience.

A grid may also be turned on for the output window.

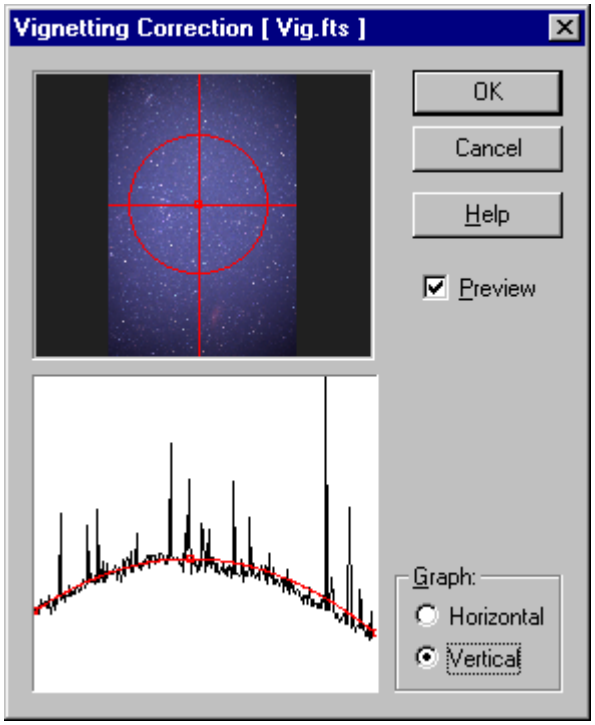
Object Edge...



Enhances the outline of an object. This is particularly useful for an application such as creating an intensity contour map of an object such as a comet. To create a contour map, the image should be reduced to just a few grayscale levels. Blurring may also be necessary to avoid generating contours around noise spikes.

Three outline patterns are available for selection. Select the one that best shows the desired contour lines.

Vignetting Correction...



This function compensates for an uneven background response typically caused by lens vignetting. A radially symmetrical correction is assumed, but the center point of the correction and degree of correction with radial distance may be controlled by the use of the handles shown on the two thumbnail shots.

In the upper thumbnail, the centerpoint handle allows the centerpoint of the vignetting to be specified if it is not at the center of the frame of the active image.

The centerpoint handle of the lower thumbnail allows the vignetting background level to be specified. The horizontal or vertical profile line for the intensity profile is shown as a reference. Selection of the horizontal or vertical profile is via the two buttons provided in the pop-up window. Generally, the profile should be chosen to lie in the direction of the long axis of the frame.

The right or left handles on the lower thumbnail allows control of the rate of vignetting to be compensated. Use the intensity profile plot as a guide as to the degree of vignetting correction to apply. With the preview checkbox enabled, the results may be seen in real time before committing the correction to be applied to the image.

Window

Cascade

This function arranges the StellaImage windows in an orderly, overlapping cascade so that the name of each window is visible.

Tile

This function arranges StellaImage windows from the top to the bottom of the work area.

Arrange Icons

Arrange the minimized StellaImage windows at the bottom of the work area.

Tool Bar

This function opens a sub-menu which allows you to turn on or turn off the display of the following tool bar groups:

File
Edit
Image
Combine
Curves
Filter
Levels

A check box appears next to the group which has been selected for display.

Tip: Tool bars maybe moved by dragging them around with the mouse. If the StellaImage workspace is reduced in size, then some toolbars may disappear from view. To retrieve them, restart StellaImage while holding the SHIFT key. This restores default settings which puts the toolbars at their original positions.

Status

This controls whether or not status information is displayed at the bottom of the StellaImage application window.

Coordinates, image levels, and current adjusted level of the image point under the mouse are displayed in the form:

[160,84] 3603 (131)

where the first pair of numbers is the [x,y] location of the mouse, 3603 is the pixel value, and the adjusted 8-bit level is 131. Color images have additional information for each of the RGB color planes.

Full Screen

This function expands the current image to occupy the entire screen. Pressing **[Ctrl-F]** will restore the screen to its previous state.

Zoom 33%

Reduce the current image to 1/3 size (3 pixels per screen pixel in each axis).

Zoom 50%

Reduce the current image to 1/2 size (2 pixels per screen pixel in each axis).

Zoom 100%

Set the current image to display 1:1 (1 screen pixel for each image pixel)

Zoom 200%

Set the current image to display 2:1 (2 screen pixels in each direction for each image pixel)

Zoom 300%

Set the current image to display 3:1 (3 screen pixels in each direction for each image pixel)

Help

Search

Open the help window so that help topics may be browsed or information may be found by keyword.

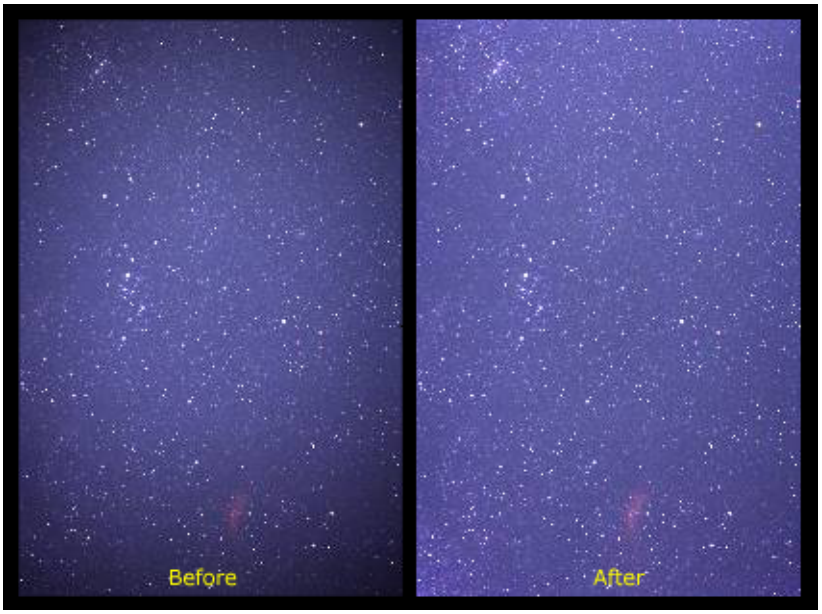
About...

This opens a window which displays StellaImage program version and copyright information.

Appendix A. Image Processing Examples

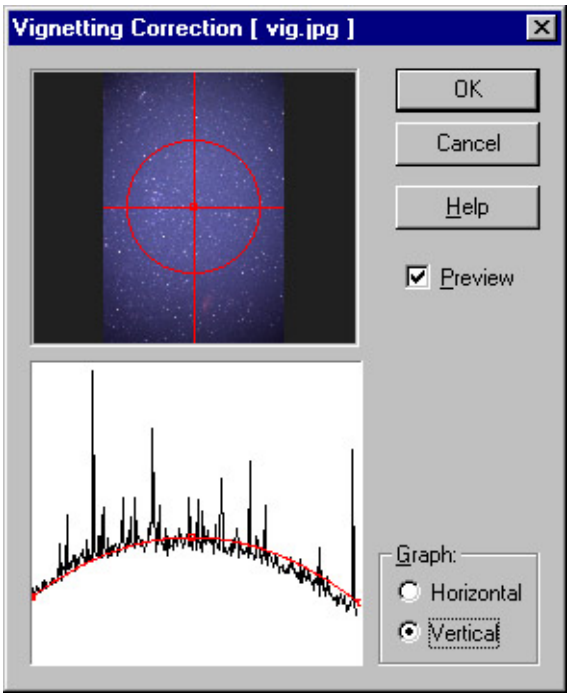
All image files used in the examples presented in this section are provided along with StellaImage 3 for familiarization purposes.

A.1 Vignetting Correction Example



Above, left is the raw, vignetted image. At above, right is the result after vignetting removal using StellaImage 3. The dialog window settings used are shown at right

Sample file name: **`vig.fts`**



A.2 Unsharp Mask Filtering Example

Processing parameters used:

- Enhance: 2
- Area: Large
- Value : 0

Notes: The unsharp mask filter enhances fine details but the Enhance parameter may have to be adjusted downwards on noisier images. Selection of a small or medium value will enhance smaller details in the image.

File: **`moon-g1.tif`**

A.3 Wiener Filtering Example

Processing parameters used:

- PSF Radius: 4.7
- Gamma: 0.01
- Auto Levels: On

Notes: There is no single set of parameters which can be applied to all images. However, as a starting point one can set the gamma to 0.01 and vary the PSF value. If a star is visible in the image, the star can be used as the PSF reference.

File: **`jup-rgb.fts`**

A.4 Star Sharpening Filter Example

Processing parameters used:

- Size of star: 0.7
- Area: small
- Value: 20%
- Leave star core: On

Notes: Star sizes are adjusted by changing the Size of star parameter and the Area parameter. Choosing a larger Area value has more effect on making the star smaller. How far one can adjust these parameters is subjective and depends on the effect on non-stellar parts of the image.

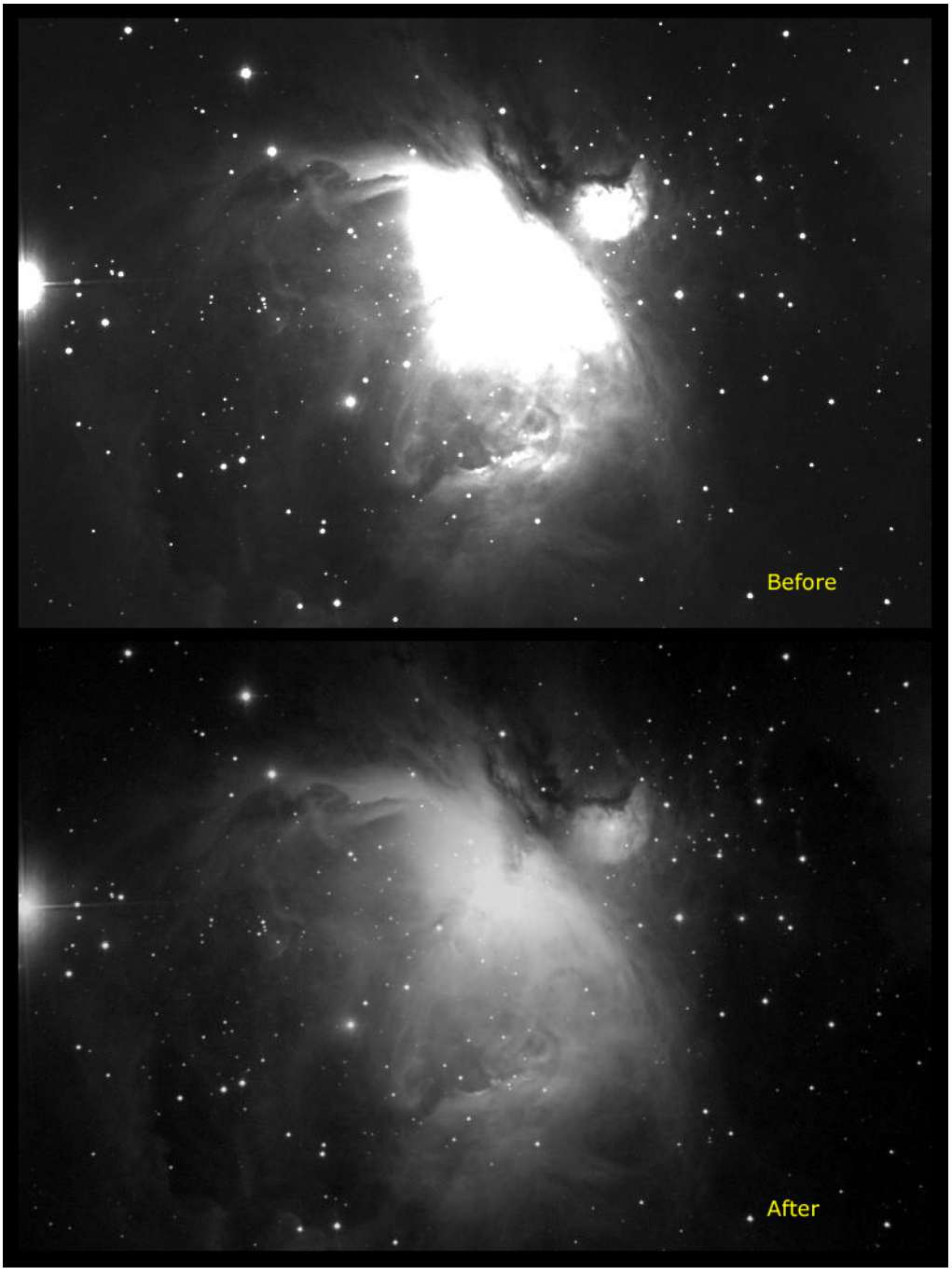
File: **`m27.tif`**

A.5 Digital Development Processing (DDP) Example

Processing procedure:

First adjust levels to bring out the thin nebulosity as much as possible (background is brought to a gray level):

- Minimum: 286
- Maximum: 1942



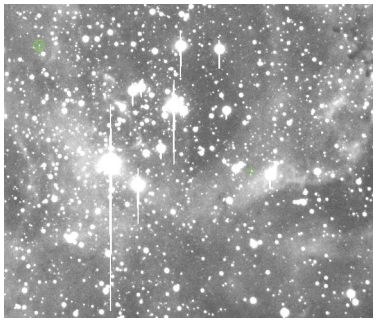
Next apply the DDP function:

- Highlight: 1177
- Edge: 0.01

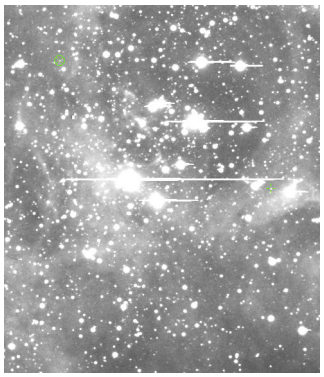
Notes: DDP is used to convert wide dynamic range linear CCD images to nonlinear "photographic" images. Note that M42 becomes "softer" and more "photographic" in image quality in the final step. Adjust the levels in the final image to suit your preferences.

If too large a value for the Edge parameter is used, black rings will appear around each star (especially visible in the nebulosity). If this happens, adjust the Edge parameter interactively until the black rings are not visible. For globular clusters, the Edge parameter can be set larger.

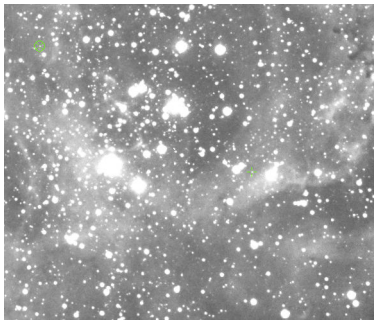
A.6 Non-Blooming Rotational (NBR) Compositing Example



CCD Image #1



CCD Image #2
(rotated CCD camera)



NBR composite result

Parameters used:

- Saturation: 95%
- Dark band width: 1 pixel

Image processing example provided by Dr. Mototsugu Motoki.

Notices

##
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