Lab 4 -Image Processing

Purpose

In this lab we want to bring out the inherent detail in our raw images before combining them into a final image. These FITS (Flexible Image Transport System) files are a standard file type in astronomy and contain detailed header information including instrument, JD time, object name, coordinates, and CCD temperature.

Data reduction involves applying calibration frames (p. 9) created specifically to remove unwanted noise, and address uneven brightness levels across the field.

Also, DDP (Digital Development Process) is used to maximize the tonal range of an image. This will bring out detail in the brighter areas of images, such as the centers of globular star clusters and galaxy cores, and fainter areas of interest, like nebulae and the outer edges of galaxies.

In processing, **darks frames**, **flat fields**, and **bias frames** are combined and applied to the raw light frames, which are then combined in a final image. For this we use a program called CCDStack. http://www.ccdware.com/products/ccdstack/

Dark frame folders, containing darks of various exposure times and binning, are stored on the computer desktop. Bias frames are also in their own desktop folders. Dated flat fields are created as needed. All calibration frames will be provided for this lab.
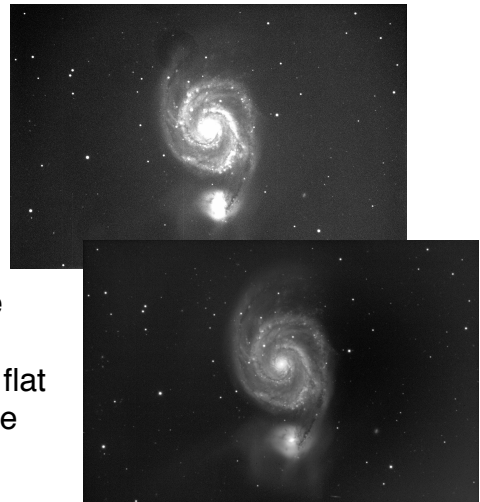
Galaxy M51 before and after processing.

Procedures

CCDStack contains many features for reducing data and creating final images. http://www.ccdware.com/Files/CCDStack%20Tutorial.pdf Here, we will explore basic procedures for processing our images of galaxies, nebulae, and star clusters.

First, locate on the desktop the specific calibration frames to be applied to your images. Exposure times and bin settings of light frames and dark frames must match (i.e. 5min1bin). Binning must also match for bias frames (i.e. bin1bias) and flats. Flat fields are created on the same date as the light frames, as they can vary due to different focus positions on each night. Flats will be located in dated desktop folders.

Note that some calibration file folders (darks and bias) may already contain master frames. Master darks and master bias frames can normally be reused, as they subtract out the same CCD noise each time.

Open CCDStack and notice the available image control windows. These will soon become familiar, and provide complete management of the process. They include:

Adjust Display: For background, gamma, and contrast control.
Image Manager: A list showing all images in the stack.
Select Image: For scrolling thru and inspecting individual images.

Calibration:
To create and apply all the calibration frames, first go to Process>Calibrate>Create master bias. Navigate to the appropriate Bias folder, and open the images. Use default combine settings, and CCDStack will create a master bias from all frames in the folder.

Use the same procedure under Process>Calibrate>Create master dark to make a master dark frame from images located in the appropriate dark frames folder.

To create a master flat using Process>Calibrate>Create master flat, say Yes to subtract the master bias just created, from each flat frame, before creating the *master* flat. Master calibration frames are now created, and ready for processing.

Go to File>Open and load all the raw light frames of your image. Go to Process>Calibrate>Calibrate and confirm the correct master frames in the Dark Subtract and Flat Field boxes. Uncheck "subtract master bias" box (we already did that) and click Apply To All. The master dark frame and master flat field are applied to all images in the stack, with a noticeable difference in contrast and density across the image.

If blooms are present:
"Blooms" occur when bright stars saturate pixels beyond their capacity. The signal then spills over to adjacent pixels, causing streaks. CCDStack's bloom removal tool finds and removes these blooms. Go to Process>Data Reject>Procedures. From the Data Reject pull down menu choose Reject Blooms> Apply to All, and wait. Bloomed pixels are found and displayed in red. From the pull down menu choose Interpolate Rejected Pixels to remove the blooms.

Blooming of bright stars in the field.   CCDStack

Align images:
All images in the stack must now be precisely aligned, before further data rejection and image combining. This is done by choosing numerous stars in the field, and star matching to each image in the stack.

From the Main Menu choose stack>register>select/remove reference stars and click 8-10 stars around the field, then Click OK. Click Align All to align the images, on the chosen stars. Click Apply> Apply to All, to apply the new alignments. All images in the stack are now aligned to sub pixel accuracy for further processing.

Normalize and Data Reject:
Normalizing helps balance signal values for each corresponding pixel in the entire aligned stack. Data reject identifies and removes unwanted artifacts in the image, such as cosmic ray hits. http://en.wikipedia.org/wiki/Cosmic_ray

Go to Stack>Normalize>Auto and click OK in the Normalize window. Go to Stack>Data Reject>Procedures. From the Data Reject menu chose "STD (Standard Deviation) Sigma Reject," http://en.wikipedia.org/wiki/Standard_deviation to identify artifacts, hit Apply to All and wait. Apply Interpolate Rejected Pixels to apply the corrections.

Combine images:
Here we combine all the aligned, calibrated images in the stack, to create the final image. Choose Stack>Combine>Sum. Sum will combine all images in the stack. Ten 5-minute exposures become one 50-minute exposure, to bring out more detail.

Open the Adjust Display window and check DDP and Autoscale. DDP stands for "Digital Development Process" and adjusts the image to bring out detail in both the darker and brighter regions of your subject. Make slight additional adjustments for contrast and brightness using Background, and Gamma sliders. Don't overdo these, as the initial default DDP settings are very effective.

Gradient removal:
This tool is sometimes useful, to flatten the image in brightness and contrast, from edge to edge. From the main menu choose Process>Flatten Background and experiment choosing background areas (left click). Generally, do all 4 corners, or as needed. Good flat fields and moonless nights create the best images, with the flattest backgrounds.

Save the image:
To save the image choose File > Save Display Bitmap, choose a format (i.e. jpeg), and save. The file is automatically saved to the original image folder. Final image adjustments for contrast and sharpness can optionally be performed in PhotoShop.