

CCD Images: A Tutorial

Materials Needed—

- Computer with ds9 installed
- Destry’s image library

Objectives—

- Practice using *SAOimage ds9* to examine images.
- Explore the properties of images of a “star” taken with a CCD.
- Introduce the concept of flats.

Introduction— In this activity you’ll be examining CCD images that illustrate the concepts you learned with the cups and bean. The camera used to take the images is a Nikon D70, which has a moderately good CCD that is different from the science-quality CCDs you’ll be using with your telescopes: the Nikon, like most digital cameras, uses a color CCD.

Color CCDs have three types of pixels: red, green, and blue. They are sensitive to different wavelengths of light and are nested together and treated as one color-sensitive pixel. When observing astronomical objects, we don’t want to ignore any of the light, so astronomical CCDs use pixels that are all sensitive to all wavelengths. The images you will be examining were all originally in color, but we have converted them to grayscale for the sake of our analogy.

Procedure— *SAOimage ds9* is an image viewer specially designed for astronomical images. To open the first image select *Open* in the *File* menu. Open the image called “light6.fit.” You should see the candle which will be our fake star.

In the middle of the window there are a bunch of buttons. The top row changes which buttons are displayed in the bottom row. Click on *zoom* and zoom out until you can see the whole image. The two windows in the top left of the program show a close up on where your mouse is on the right and the whole image on the left.



FIG. 1.— Destry’s Star, visible only from the planet Brooklyn.

In the top left of the window you’ll see some numbers. The number next to *Value* is the value of the pixel your mouse is over. Below that are values for the X and Y coordinate of that pixel.

1. How were the pixel values and X and Y coordinates represented in the previous activity in which you used cups and beans?

Click on the *Edit* button in the top row and then *Pan* in the bottom row. Move your view so that it is centered on the flame of the candle. Zoom in as far as possible to inspect the individual pixels.

3. How is the pixel value and the brightness of the pixel related? (Don’t over-think this.)

Zoom out some. You can change the contrast of the image to show detail at different levels. Click on the *Scale* button in the top row. The different buttons on the second row change how the pixels are shown on the screen. You can see the scale along the bottom of the window. Play around with different scalings.

4. Can you make it so that you can see the whole candle?
5. Can you change the scale so that you can see the wick?
6. Is it possible to see both the wick and the whole candle?

Now click on *Frame* in the top row of buttons and then *New* in the bottom row, followed by *Tile*. The window below should now be split in half. You can select one or the other using the *Previous* and *Next* buttons. Select the window on the left and then Open the file called “light7.fit.” Zoom out so you can see most of the image. Then select the window on the right and open the file called “light3.fit” and zoom out.

You should have two images of a candle side-by-side. Move your mouse over the images and watch the zoomed-in window in the upper right and the pixel values in the upper left.

7. What is different between the two images?
8. What would cause this?
9. The differences are due to changing just one setting of the camera. What is it?
10. Which image do you think contains more information?

With the image on right selected, open the file called “light1.fit.” Notice the difference between this image and the previous two. Under the *Frame* button click *Single* and then zoom so that you have a good view of the candle. Move your mouse over the area where the flame should be and watch the pixel values.

11. What do you notice about the region around the flame?
12. Can you change the contrast so that you can see the wick?
13. In terms of the cups and beans analogy, what’s going on here?

Lastly, switch back so that you see just one image and open the file called “flat.fit.” This is an extremely out-of-focus image of a wall, which is basically flat white. Zoom, scale, and examine the whole image.

14. What do you notice about the shape of the image?
15. What should it ideally look like for an out-of-focus image of a white wall?
16. What does this tell us about the rest of our images?