Experimenting with Exposure Time

Think Before You Experiment:

We can think of telescopes as light funnels, gathering light over a large area and focusing or directing it into a smaller area. In the same way funnels are not much good without a container, the telescope needs something to catch the light it gathers. Usually, we think of a person standing at the end of a telescope. In this case their eye is acting as the light detector, sensing the light coming down the funnel. Your eye sends continuous signals to your brain about the light it is receiving. Your brain interprets the information it receives. The result is you see the light.

More and more often, astronomers are replacing the human eye light detector with a CCD camera. The CCD has the advantage over our eyes of being able to collect light over different periods of time. So, the CCD not only acts as a light detector but also a light bucket. Just as a bucket can collect and store different amounts of water, a CCD camera can collect and store different amounts of light before sending it off to a computer to be analyzed. Astronomers vary the amount of light collected and stored by the CCD by changing the amount of time light is allowed to enter the camera (the funnel is allowed to fill the bucket). **EXPOSURE TIME** refers to how long the camera is allowed to receive light.

Problem – How do variations in exposure time affect the image we get from a telescope?

The Experiment –

Designing an experiment to find out the answer to this problem depends upon taking a series of images of the **same** object in the sky on the **same** night with the **same** telescope and CCD camera while changing only the exposure time. There are several image sets of different types of object. Each image in the set has a different exposure time. All of these images were taken with the full aperture of the 24 inch telescope at University of Chicago's Yerkes Observatory.

Prediction/hypothesis – It is time for you to make a prediction and write out a hypothesis that addresses the problem. Use as much detail as you can. If you think the image will change in some way, describe how much. There are several image sets. Think about possible differences between objects.

Image Sets – We recommend that you study as many sets as you have time. Image sets are on the school computers (in room 322) or you can download them from our class web page.

Using your IMAGEJ OR MICROOBSERVATORYIMAGE software, open each of the images in the set you want to work with first.
The names of the folder give you a hint about the class of objects or are a part of the object's nickname.
Compare the images to determine the effect of exposure time. The effect may be different for different types of objects.

There are many image sets for this activity. You may work with as many as you have time. As you work with each new image or set of images, record your conclusions about exposure time and note the evidence for your ideas.

Analyze the Images and Record Data –

Record your observations and measurements. Hints: Pay attention to the Min/Max values. Use the measure tool to measure starlight. Check out the values for the Sky (brightness of the background). Are there any comparisons you can make between the different objects at the same exposure? Consider using a

spreadsheet and graphing tools to organize and present your results.

Conclusions – *Look carefully at your results.*

Answer the problem question.

Analyze your hypothesis and determine if it is validated or not. Comment on whether or not your data support your hypothesis. Be specific. (Do not change your hypothesis to match results. It is better to follow the scientific process and be open to results opposite of what you had expected than to change your data to match your hypothesis or change your hypothesis to match your data.)

Remember to record any unexpected results.

Explain how you might use this information to help choose the best exposure time for a particular object.

Whether the source is a human mistake, differences in analyzing data, something mechanical or seeing conditions, anything that makes you question your results is called error. Compare your results with others in the class. Examine your experiment for any possible sources of error. Comment on each source and the amount of error you think it may have introduced into your results.