IDL, Photometry, and Poisson Statistics

IDL and atv

Last time we had a quick tour of IDL and atv and did some initial measurements of image properties using atv. Today we’re going to do more detailed measurements of images and compare that with image noise properties. As before, the first step is to get started

1. Log in to the laptop in front of you
2. Start X11 on the machine in front of you
3. X11->Applications->Terminal
   2. From the resulting xterm,
      
        ssh -Y username@ra.phyast.pitt.edu

3. Now start up IDL by typing idl

This will give you the IDL prompt, idl>

Files for this Exercise

We will use the files you’ve previously transferred to home directory on the Astro machines in ~/images. If you did not copy over the exercise1 files during a previous exercise, do so now:

```
mkdir -p ~/images

cd ~/images  # move to your images directory
ls           # list the contents
mkdir exercise1  # create a directory for this exercise
cd exercise1  # move to that directory
```

# Now let’s get our images for this exercise

```
# (note the dot, shorthand for the current directory)

cp ~wmwv/A1263/images/exercise1/*.fits.gz ./
lsl -l  # are the files there?
lsl -l > listing  # what does this do?
less listing  # what are we looking at?
```

Press q to exit less.
Changing directories from within IDL

You can change directories from within IDL using the IDL routine ‘cd’. So from within your IDL session change to the image directory for this exercise.

\[
idl> \text{cd, ‘~/images/exercise1/’}
\]

Looking at images in IDL

Open up the main image we’ll look at today:

\[
idl> \text{atv, “M92_v.fits.gz”}
\]

if the file is still compressed. This should launch a new window with various windows, boxes, and buttons and a picture of M92.

1) Turn to the worksheet and answer the first set of questions (Part I).

The “Sky”

When astronomers refer to the “sky” in astronomical images, they are using a casual term to refer to the actual flux levels from the Earth’s atmosphere, zodiacal light from our solar system, as well as generic background lightcurve from undetected sources. For ground-based images the Earth’s atmosphere is the dominant contribution to the sky. Let’s look at the image of M92 and measure the sky levels in this image. We will do this with the help of the “i” key that generates image statistics for a region around the cursor.

Click on the title bar (the top where it says “atv: M92_v.fits.gz”) of the IDL window to make sure it’s the active window (the active window has the three circles in the top left turn colored red, orange, and green; inactive windows have them greyed out). Move your cursor to a couple of different places around the image and press i. A new window will pop up entitled “atv image statistics”. Click the “Show Region” button to show the pixels being considered to generate the numbers in the image statistics box.

2) Turn to the worksheet and answer the second set of questions (Part II).
Measuring Fluxes of Objects

Finally we get to the part that you probably thought today was going to be about. Measuring photons detected from known individual objects! atv as the ability to measure the number of counts within what’s known as an “aperture” to measure the flux coming from an astronomical source. But, underneath the object there is flux from the sky. Thus to subtract this flux, we measure the sky locally around the object of interest and subtract the average sky level off of each pixel to get our final aperture flux count. This is visually and quantitatively illustrated quite nicely by the aperture photometry window in atv.

Now move your cursor over a bright object in the image and press the “p” button. What happens?

Move your cursor over a star and click p. A window should pop up with numbers, boxes, buttons, pixels, and circles. The box in the upper right shows visually the regions in which atv is measuring flux. The radii of the green, blue, and purple circles is controlled by the values in the “Aperture radius”, “Inner sky radius” and “Outer sky radius” boxes. Change some of these values higher and lower and see what happens. Press return after changing a value for your change to be registered. After doing this a couple of times, press the “Show Radial Profile” button. How do the lines in the new display match up with the circles in the upper-right window we were just looking at? Change around the radius values again and note how the circles and lines move and change. To shift into full analysis mode (and to avoid accidentally changing the color scale and stretch with a stray click) select ImExam from the MouseMode menu. Now you can get the aperture photometry and related information on a star by just clicking on it with the cursor.

We’ll explore this in more detail in future classes. For now just play around by clicking on different stars, in between stars and near groups of stars. We’ll talk in class about what we’re seeing and what atv is doing in its aperture photometry.
A97hf, IDL atv Worksheet 1

Name:__________________________

I. Image Display:

Click the “Restretch” button and then click various places within the image display window.

1) What happens?

2) What are you controlling?

3) Think about what different settings might highlight different astronomical features? Is there a preferred way to look at astronomical images?

4) What is M92? What are we looking at in this image?
II. Poisson Statistics: Object Noise and Sky Noise:

1) Move your cursor to a relatively blank part of the image and press “i”. What do the numbers in the *atv image statistics* box refer to?

2) Do this for 5 different regions on the image. Record the Mean and StdDev values for each of these regions to one decimal place. In IDL create arrays from the Mean and StdDev columns and calculate StdDev*StdDev for the last column.

<table>
<thead>
<tr>
<th>Region #</th>
<th>Mean</th>
<th>StdDev</th>
<th>StdDev^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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3) What kind of relationship do you see between the Mean and StdDev? Plot Mean vs. StdDev in IDL.

4) Look at the pixel box in the lower half of the *atv image statistics* box. Did you get any stars in the region in step 2? What happened? Go to a star now and click *i*. What do the Mean, Median, and StdDev say now?

Move off the star a little bit and click *i* again. What happens to the numbers?

Why does the image statistics window provide both the mean and the median?
III. Object Photometry:

One of the most quantitatively useful things about "atv" is the ability to do image statistics (as we just did in part II of this worksheet) and simple aperture photometry of objects in the image. Measure the brightness of a handful of stars. Select faint stars, bright stars, and those in between. Use the table below to record the numbers from the following steps.

1) Record the reported object flux and the sky level for each object.

2) Calculate the total sky flux within the aperture using the sky level (which is per pixel) and the aperture radius.

3) Now click on “Photometry Settings...” and set the Sky Algorithm to “No Sky Subtraction”. Go back and re-photometer the stars in step 1 and record the new object counts below in the appropriate column. What relationship do you expect between the columns below? Create arrays in IDL for each column and plot various columns against each other.

3) Use the radius of the aperture, the sky level, and the object flux to calculate the flux uncertainty for each measurement, assuming Poisson statistics. Start by writing out the equation for the quantity determined in Column 1 and see if you can figure out the right expression for the uncertainty. (Use the back of this page for extra space.)

<table>
<thead>
<tr>
<th>Star #</th>
<th>Object counts w/ sky subtraction</th>
<th>Sky level</th>
<th>Total Sky</th>
<th>Object counts w/o sky subtraction</th>
<th>Measured Flux Uncertainty</th>
</tr>
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<tbody>
<tr>
<td>1</td>
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