Physics 344 Lab 3
An Introduction to IDL and ATV

Due: Thursday, September 29
Text Reference: On-Line IDL Manuals

Purpose: Computers are now the tool of choice for manipulating and analyzing data in astronomy, as is the case for all fields of science. Interactive Data Language (IDL) is a commercial program designed for working with images, and is widely used in astronomy, especially in space sciences. It will be our primary tool for both display and quantitative analysis of the images that we will obtain in this course. The goal of this lab is to start becoming familiar with IDL.

As its name implies, IDL is interactive – you can type commands into it one at a time and see the results. It is also a programming language – you can define new commands by writing programs using the basic commands of the language. Some of the "basic" commands are quite complex and most commands are equally able to operate on scalars or one, two, or three-dimensional numeric arrays. This makes it possible to perform complex operations simply. For example, the command **c = a + b** could add image **a** to image **b** and put the result into a new image **c**, carrying out the operations c(1,1) = a(1,1)+b(1,1), c(1,2)=a(1,2)+b(1,2), …, c(n,m)=a(n,m)+b(n,m), where **a** and **b** are two dimensional arrays of numbers, each of size n x m. If **a** and **b** were simple numbers, or one or three-dimensional arrays, the same command would add them appropriately and create an output object **c** of the correct type and size.

IDL is used by astronomers around the world and a number of program packages are available on the Web to perform common astronomical tasks. We have included some of the most popular and useful of these packages in our IDL libraries. These tasks often involve extracting quantitative information from images: how big is a feature in an image? how bright is the image of a star? etc. This is rather different from the kinds of image manipulation performed by packages such as Photoshop, which are primarily concerned with manipulating the visual appearance of an image (contrast, color balance, etc.)

Procedure:

1. Use VNC to connect to your computer account on the "astrolab" computer (see the VNC handout for details). Start the IDL Developers Environment with the command *idlde* typed into a command window. You will need to push the "IDL Workbench" button the first time you start idlde. To make an icon on your desktop for easy access, right click on the desktop, and select the "Event Launcher"; click "Browse" and navigate to /usr/local/bin/idlde; click on "OK". Thereafter, clicking on this icon will start idl for you.

2. Set your path in IDL: in IDLDE, click on *window/preferences*, then select *IDL* and *Paths*; click on *Insert*, and then in the Places window navigate to *File System* and double click. Then navigate to */usr/local/src/idl* (make sure *idl* is highlighted) and click *OK*. This path will be added to the path window. Check the box preceding this item to include the subdirectories. Then click *Apply* and *OK*. You only need to do this once, and then the IDL astronomy libraries will be automatically added to your path every time you run IDL.

3. Use the Help/Contents menu to open the extensive IDL on-line help documentation. Read the introductory material in the "Using IDL/Introducing IDL" chapter to learn how to get started with IDL. Note that there is a wealth of information available – you don't need to read it all (or even a small part of it) to get started!

4. Work through the "IDL Quick Tutorial Number One" (there is a link to this tutorial on the class webpage). This was created for command-line driven Unix IDL systems, so some of the things in it are unnecessary for our system. In particular, use the help menus rather than the help scheme discussed in section 2.2 of the tutorial, and ignore section 2.3 and section 4. Experiment with the IDL commands as you read them in the tutorial.

5. ATV is an image display tool written in IDL, and RUATV is a locally-modified version. We will use it for examining images and performing simple analysis with them. Create a two-dimensional array of Gaussian random numbers with zero mean and a standard deviation of one by typing the following into the IDL> command line box at the bottom of the workbench:

   ```
   a = randomu(seed,400,400,normal=1)
   ```

   Display this array using RUATV by typing:

   ```
   ruatv, a
   ```

   Change the display contrast and brightness by holding down the left mouse button and dragging: left-right changes the brightness, and up-down changes the contrast. Try zooming the image with the buttons on the RUATV tool, and panning the zoomed image by dragging the green outline in the small window. Note that clicking the right mouse button centers the display on the location of the cursor.

6. Read through the RUATV help (rightmost of the RUATV menus). See what typing the r, c, and i keys (with the cursor somewhere on the image) does. Use the "i" key to inspect the statistics for the pixel values in an 11 x 11 box centered on the cursor location. You can change the size of the box by typing a number in the "Box Size for Stats" box *and then pressing the enter key*. The number isn't recognized until you press enter – this is a generic feature of the graphical user interface build into IDL.

7. Get the image statistics for an 11 x 11 pixel box centered at X=200, Y=200. In your report, list the minimum and maximum pixel values in this region, the mean, the median, and the standard deviation of the pixel values about the mean. (Make sure that you understand the meaning of all these statistics.) Why is the mean not exactly zero, and the standard deviation not exactly one? Repeat the exercise with a 151 x

151 pixel box centered about X=200, Y=200 and report the values. Comment on the differences for the large sample.

8. Copy the files "moon.fit" and "sn2011fe.fit" from the /home/ph344/lab3 directory into your area. (For example, you can use the Applications->System Tools->File Browser tool from the menu at the top of your window.) Load the image moon.fit into RUATV using the "File/Read Fits" menu option. Find the coordinates (x,y) and brightness value of the brightest pixel in the image. Determine the diameter (in pixels) of the Moon in the vertical direction. Is this the best estimate of the diameter of the Moon? Can you do better? Experiment with the "s" and "t" keys. Plot a row and a column passing through the center of the image.

   Save these plots as encapsulated postscript files by first pressing the "h" key while the cursor is in the RUATV window – notice that the message "Hardcopy plots on" is displayed in the IDL GUI. Then put the cursor on the desired row/column in the RUATV window and pressing the "r" or "c" keys. In this mode, a window will pop up allowing you to customize the printing parameters. Select the "Encapsulated (EPS)", and deselect the "Color Output" settings, and use the "Choose…" button to navigate to your local directory, then change the extent from ".ps" to ".eps" and save the file. You may want to use a more descriptive file name than the default "atv". The Open Office Writer can insert these .eps files directly into your lab report. To print these plots, you will need to either copy them to your local computer (using ftp in ssh) and then use your printer, or print them on the 4astro printer located in room 401. Include the plots with your lab writeup. Make sure to press the "h" key again to exit the hardcopy mode.

9. Load the "sn2011fe.fit" image using Read Fits. This is a field containing the galaxy M101 and the supernova SN 2011fe taken with our telescope. What was the exposure time of this image and what date and time was it taken? What filter was used? (Hint: use the "ImageInfo/ImageHeader" menu item.) Use the "Full Range" and "Auto Scale" buttons to experiment with changing the display map. (Full Range maps the brightest pixel to white and the faintest to black; Auto Scale maps a smaller range of "most common" pixel values to the grey scales from black to white.) For this image, even autoscale does not do a great job. Set the minimum (black) display value to 625 and the maximum (white) to 725 by typing those numbers in the Min and Max boxes (remembering to hit return). You will then be able to see M101, which is centered at about coordinates (695,950), if you use the mouse to stretch the contrast. It also helps to ZoomOut once. The supernova is at (390,877). What is the value of the brightest pixel in the supernova?

10. With the cursor on the supernova, press the "p" key. In the photometry popup window, set the aperture radius to 7, the inner sky radius to 14, and leave the outer sky radius at 20 (remember to press "enter" after each change). Note how the colored circles change in the display. Press the "Show Radial Profile" button to see the pixel values (yellow points) and a fitted Gaussian (solid line). Report the FWHM (full width at half maximum intensity), the sky level, and the object counts for this star. Note that the "object counts" value is the sum of the pixel values within the aperture radius minus the contribution from the "sky" background, estimated from the values of the pixels between the inner and outer sky radii.

11. Put the cursor on the star at (848,245) and press the "p" key. Again record the FWHM, sky level, and object counts. This star has a V magnitude of 12.751 ± 0.031. Use the object counts for this star and the supernova to calculate the magnitude of the supernova when this image was taken. Be sure to also calculate the uncertainty for your magnitude. How does your value compare to the light curve that you can find for the date of the observation by following the "M101 Supernova Shines On" link at the Sky & Telescope magazine website (http://www.skyandtelescope.com).

12. Put the cursor on the star at (1979,373) and press the "p" key. Note how the radial profile of this star has a flat top near a value of 64,000. This star is "saturated" – it is so bright that the pixel signal values were larger than the analog electronics of the CCD detector system could handle, and all information about the bright portions of the star has been lost. What is the reported FWHM of this star? Explain why this is different from the FWHM of the supernova and the star of the previous question. How would you change the way the image was taken to obtain useful information about the brightness of this star?