Physics 346 Workshop 1

Getting to Know *IDL* and *RUPhAst*

Text Reference: *Birney, Gonzalez, & Oesper* Chapters 1, 2 and 3†

Purpose: Computers are ubiquitous in astronomy today – they control telescopes and instruments and are required to display, manipulate, and analyze images from detectors. We will be using a number of programs in this course, including *IDL* for imaging processing and analysis. This lab introduces you to *IDL* running on the Linux computer Astrolab.

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 optical images that have been obtained at Rutgers' Schommer Observatory. 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 freeware program packages are available 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, such as "how big is a feature in an image?" or "how bright is the image of a star?". 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: Each student should work independently on this virtual "lab" assignment.

0. This course uses the computer Astrolab, which lives in the machine room of the Serin Physics Lab. You will connect to this computer using the VNC program, which gives you remote access to a desktop on Astrolab. So, the first step is to follow the VNC installation instructions available on the class website. WARNING!! Astrolab is an OLD computer which can and does get very laggy if too many students are logged in at the same time – plan accordingly! Always back up important files to your computer.

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†**OPTIONAL text:** *Observational Astronomy, 2nd edition* by Birney, Gonzalez, & Oesper, Cambridge University Press, ISBN 978-0-521-85370-5

1. Use VNC to connect to your computer account on the “astrolab” computer. Create a “workshop1” subdirectory (a folder in Window-speak) and copy the files “moon.fits” and “m31.fits” from the /home/ph346/workshop1 directory into your workshop1 directory. (For example, you can use the Applications->System Tools->File Browser tool from the menu at the top of your desktop. Or you could issue the appropriate Linux commands in a terminal window, if you know them.)

2. Get a terminal window by clicking on the terminal symbol at the top of your VNC desktop (**MacOS** users can type “xgterm &” into terminal after logging into Astrolab). Start the IDL Developers Environment by typing the command *idlde* (followed by a return; “*idlde &” for **MacOS** users*). To make an icon on your **Windows** desktop for easy access, right click on the desktop, and select the “Create Launcher”; click “Browse” and navigate to /usr/local/bin/idlde; click on “OK”. Thereafter, clicking on this icon will start idl for you.

3. 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.

   If you’re using X windows rather than VNC, once you have updated your IDL path in this way, you may find it faster to simply open idl at a unix prompt on astrolib instead of IDLDE.

4. There is a lot to learn about *IDL*. In this lab we focus on the image display tool RUPhAst, which is the local Rutgers version of the PHAst tool and is a program written in IDL. A moderately-useful manual for PhAst is available on *Canvas → Files → PhAst-manual.pdf*. For mysterious reasons perhaps deeply connected to the level of entropy in the universe, before running RUPhAst issue the command “.run ruphast <return>” − TWICE – at the IDL> prompt in the IDL Console (at the bottom of IDL widget). You will see many messages about modules being compiled but should see no error messages. You can then start the RUPhAst widget by typing “ruphast <return>” at the prompt. The first time you start RUPhAst it will ask to create a directory called output – say yes.

   MacOS users: *RUPhAst can be called directly from the command line version of IDL.*

   Windows/Linux users: *The RUPhAst window tends to be larger than the VNC display, and it is easy for the title bar to end up out of reach of your cursor so that the window cannot be dragged. There is an easy solutions for this – hold your cursor anywhere over the window and use Alt + Left click while dragging*

5. Read the image moon.fits from your workshop1 subdirectory using “Read Fits File” under “File” in the top menu bar. Change the “Mouse Mode” from “ImExam” to “Color”. You can then adjust 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 PhAst 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.

   MacOS users: *adjusting the color/brightness seems to be particularly slow; try zooming out so that the entire image is in-frame, then adjust the color/brightness. It should change more smoothly and quickly.*

6. Read through the RUPhAst help (rightmost of the RUPhAst menus), in particular the keyboard commands. 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 built into IDL.

7. Find the coordinates (x,y) and brightness value of the brightest pixel in the image of the Moon. This happens to be the image-wide maximum-brightness pixel whose value is displayed on the left-hand side of the RUPhAst window. You may find the “Pixel Table” in the “ImageInfo” menu useful, in addition to the “i” key and “Color” mode we have previously experimented with. We will then measure the diameter (in pixels) of the bright crater Tycho, which is located at about the (x,y) location (1255, 1350) in the image. It will aid the eye to plot a row and a column passing through Tycho. Save these plots using the “Create PS” button on the plot window. 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 should use a more descriptive file name than the default “phast_plot”. The Open Office Writer can be used to view these .eps files by simply dragging the file onto the blank page. You will need to either copy them to your local computer (using ftp in ssh).

   Experiment with the “s” and “t” keys in the vicinity of Tycho. Save a copy of these plots as well.

8. Load the m31.fits image using “Read Fits File”. This is a field containing (some of) the galaxy M31 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 the best job. Set the minimum (black) display value to 1500 and the maximum (white) to 20000 by typing those numbers in the Min and Max boxes (remembering to hit return). Experiment with adjusting the brightness and contrast using the left mouse button. Estimate the (x,y) coordinates of the bright central nucleus of M31. What is the value of the brightest pixel in the center of the galaxy?

9. With the cursor on the star at (750, 1495), press the “p” key. Report the aperture radius, and inner and outer sky radii chosen by the program and reported in the photometry popup window. Press the “Show Radial Profile” button (if it is not already selected) to see the pixel values (yellow points) and a fitted Gaussian (solid line). Report the maximum intensity (the peak of the Gaussian, in ADU per pixel), FWHM (full width at half maximum intensity), the sky level (in ADU), and the object counts (in ADU) 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. Finally, also report the SNR (Signal-to-Noise Ratio) of this measurement.

10. Put the cursor on the star at (2245,455) 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 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?