Assignment 2: IRAF Fundamentals

Due: Nov. 1

Value: 5% (AST326), 10% (AST325); assignment to be written in LaTeX

This assignment is designed to give you some practice in the fundamentals of IRAF. To this end, you will explore two major components of the IRAF data manipulation system; the manipulation of image headers (via tasks involved with the computation and transformation of celestial coordinates and times) and the manipulation of image pixels (via tasks involved in the pre-processing of CCD images).

The data for both sections of this assignment can be found on the following webpage (www.astro.utoronto.ca/∼blee/ast325/assignments/ass2/images/). There are two sets of relevant files. Copy the files *bias.fits, dark1.fits, dark2.fits, flat.fits, stars.fits* to your own directory prior to starting Section 2. For Section 1, you will need to copy only a single file (one of *testXXXX.fits*, where *XXXX* is the first 4 letters of your first name).

1 Image Headers

Any 'image' you are likely to encounter in an astronomical setting will be composed of two major sections: (1) an image 'header' which typically contains such observational details as the instrument setup, the time of observation, the integration (i.e. exposure) time etc., and (2) the actual image 'pixels', which are detector count values (usually expressed in raw form as ADU — Analog to Digital Units). This first section deals with header data only.

Before going further, take note of a few of the simplest IRAF commands, which give information about, or manipulate the parameters controlling other tasks. These are **eparam**, **lparam**, **unlearn** and **help**, where the execution syntax is the command followed by the name of the other IRAF task. The **help** task is by far the most useful — expect to use it a lot, since we don't have time to cover every single aspect of every single task in class!

The only image you'll use for this section is the *testXXXX.fits* image — be sure you have copied this image over, as instructed above, before proceeding further.

To get some practice in using these tasks, answer or do the following:

a) How many pixels (i.e., image size in x,y) are there in this image?
[**imheader**]

b) What are the RA, DEC and Epoch of the observation?
[**imheader** or **imgets** or **hselect**]

c) Transform the coordinates specified in the header, from the header epoch to equinox 1950, then enter the precessed coordinate values into the header as items named RA1950 and DEC1950.
[**hedit** or **hfix**, **noao.astutil.precess**].

d) Compute the galactic coordinates (l,b) for this image, using your *precessed* RA, DEC and epoch from c) above. Enter the values as new header items named LGAL and BGAL.
[**hedit**, **noao.astutil.galactic**]

e) Compute the UT at the start of the observation, the UT at the middle of the observation, and the mean sidereal time for the middle of the observation, then enter these into the image header as UT, UTMID, and MST.
[**hedit**, **noao.astutil.asttimes**]

f) Compute the airmass at the middle of the observation and enter it into the image header as AIRMASS. If you use **noao.astutil.asthedit** or **astcalc**, use the unprecessed coordinates for the computation.
[**hedit** or **hfix**, **noao.astutil.asttimes**, **noao.astutil.setairmass** or **noao.astutil.asthedit**]

g) Attach a printout of the image header to your assignment, reflecting the required changes and additions specified in c)-f).

A fast, alternative, all-in-one option for doing sections c) to f) is to script the calculations using the **noao.astutil.asthedit** task with the **astcalc** features (if you wish to try this, start by looking at the **asthedit** help page examples, and adapt them to the particular keywords in your own header), but note the above mentioned tasks are often useful on their own.

2 Images

(a) The five image files (*bias.fits, dark1.fits, dark2.fits, flat.fits, stars.fits*) are simulations of raw data, as it might appear directly from a CCD camera. The file names should be self-explanatory. In this section of the assignment you will be asked to create a fully pre-processed final **stars** image. To do this, you will need to use several different IRAF tasks, such as **imstat**, **imheader** and **imarith**. To get some practice in using these tasks, answer or do the following:

i) What is the mean pixel value in the raw bias image? [**imstatistics**]

ii) What is the mode of the pixel values in the raw dark1 image? [**imstatistics**]

iii) What is the maximum pixel value in each image? [**imstatistics**]

iv) What is the integration time for the stars image? [**imheader**]

v) What are the integration times for the two dark images? [**hselect**]

vi) Divide the longer duration dark image by the shorter duration image. What is the median value of the resulting image? [**imarith**, **imstatistics**]

(b) Using the online exercise on flatfielding / CCD pre-processing as a guide, create a fully pre-processed stars image. Note that the images you have been given do not have an overscan region, so you should skip over the overscan correction and trimming step. Note also that the calibration frames (such as the flat field) will need to be pre-processed to some extent before application to the stars image. Finally, be sure to re-normalize the flat field (i.e. divide it by its own mean value, so that the mean value of the flat field is 1.00) after pre-processing it, and before applying it to the stars image; this insures that the mean flux in the stars image is unchanged by flat-fielding. Once you have produced a final stars image, answer or do the following:

i) What is the mean and standard deviation of the pixel values in the final stars image?

ii) What is the standard deviation of the pixel values in the final flat field image (after re-normalization)?

iii) Did you do anything to the bias image before applying it to other images? Why or why not?

iv) If the stars image had been a $10\times$ longer integration, could you have used the same bias image to de-bias it? Why or why not?

v) Which dark image did you use to dark correct the stars image? Did you use the other dark image at all?

vi) If the stars image had been a $10\times$ longer integration, could you have used the same dark image to dark-correct it? Why or why not?

vii) *Assume* that the dark current scales linearly with time. Suppose that you had a very long integration image (10,000 seconds, say) and that you wanted to correct it for dark current. In terms of the quality of the final image, is there any difference between subtracting a properly pre-processed 10,000 second dark frame, and subtracting $100\times$ a properly pre-processed 100 second dark frame?

viii) Does the removal of the bias signal from an image *completely* remove the effect of that additional signal? Why or why not? If no, can one ever completely remove the effects of such a signal? (Hint: think in terms of noise)

ix) Attach a printout of the final processed image to your assignment. Also attach a plot of the 58^{th} line of the image. [**imexamine**]