PHY517 / AST443: Observational Techniques

Fall 2017

Tutorial 4 + Homework 4: Astronomy Software

Imaging data

1. On mccoy, view the contents of the directory `/home/anja/PHY517_AST443_archive/TRANSITS/HD189733_2016-10-10` - this is an archival dataset of a transit of the exoplanet HD189733b. Copy one of the files beginning with `hd189733` to a directory within your own path - this is one of the science exposures. Also copy all of the files beginning with `darks` to your working directory - these are dark frames. Also copy all files beginning with `flats`, but which do not have NOAUTODARK in the filename - these are all the flat-frames that have been auto-dark-corrected.

2. View the header of your science image. What is the exposure time? What is the gain? Use dfits and fitsort (see wiki page) to output the exposure times of all of the dark frames. Which dark frames would need to be used for the calibration of the science data? **Homework:** Submit the answers to these questions.

3. Open your science image in ds9. Adjust the scale so that you can see the content of the image (check the ds9 wiki page for help on this). Note that the image does not contain World Coordinate System (WCS) information, i.e. we do not know the right ascension and declination of the objects in the image.

4. Determine the astrometric solution of your science image, i.e. its position on the sky, using astrometry.net - see the wiki page for instructions. To significantly speed up this process, look up the coordinates of HD189733 and pass them as a starting guess. Check the output of the program - which file will you want to use? Open it in ds9 to see that for every pixel, the position in right ascension (α) and declination (δ) is also reported.[1]

5. Open the Source Extractor configuration file (see its wiki page). Adjust the `GAIN` keyword, if necessary. Run Source Extractor on your science image to detect objects. Overlay your object catalog on the image in ds9 (see its wiki page). Do you detect all stars that you identify by eye? Is your catalog free of "spurious" detections? If the answer to either of these is "yes", change some of the Source Extractor parameters, in particular the analysis threshold (`ANALYSIS_THRESH`), and repeat this step.

6. **Homework:** Submit your Source Extractor configuration file, and a screenshot of your final object catalog overlaid on your image.

[1] astrometry.net seems to have a bug that causes a bit shift. To fix this, add 32768 to the output image, e.g. by using pyraf or ftools.

pyraf

1. Follow the pyraf wiki page to set up your pyraf/iraf environment on mccoy.
2. Use the `imcombine` command to make a median image of the dark frames (i.e. the masterdark) you would use to calibrate the science image (see above).
3. Subtract the masterdark from the science image.
4. **Homework:** Submit the pyraf (and bash) commands that you used to combine the images, and to subtract the masterdark. Submit a screenshot of your dark-corrected science image.

ftools

1. For each of the flat-fields, determine the mean. Hint: the quickest way to do so is to run a bash loop over all files, run `ftstat` on each file, and search for lines containing "mean":
```
for file in $(ls flats.????????.FIT); do ftstat $file | grep mean ; done
```
2. Identify a set of flat fields with similar count-levels, ideally at $\sim 30\%$ of the saturation threshold. Use `ftpixcalc` (see the ftools wiki page) to take the average of these frames - this is your masterflat.
3. **Homework:** Submit a screenshot of your masterflat (make sure the ds9 colorbar is visible, and is set to zscale), along with the commands that you used to make it.
4. Use `ftstat` to print out the image statistics for the masterdark (not -flat). Do so with, and without, 5-sigma clipping. **Homework:** Submit the outputs from the two ftstat runs.