PHY517 / AST443: Observational Techniques

Tutorial 4: Astronomy Software

Wiki pages: *Computing Resources, bash, dfits and fitsort, Astrometry.net, ds9*

1. Ssh into uhura or vulcan, with window forwarding.
2. In the directory
   `/astrolab/anja/tutorial4`
   you will find:
   - 3 "science" images of the field around the star HD189733, `science_1.fits, science_2.fits, science_3.fits` - one for each group member
   - several flat-fields, named `flats.*.FIT` - these are "auto-dark-corrected", i.e. at the time of acquisition, the camera software took and subtracted a dark frame of the same exposure time
   - several dark frames, named `darks.*.DARK.FIT`

   Copy "your" science image to your data directory (`/astrolab/Spring_21/`*username*), as well as all the darks and flats.
3. View the header of your science image. What is the exposure time? Use dfits and fitsort (see wiki page) to output the exposure times of all of the dark frames. Which dark frames need to be used for the calibration of the science data? **Homework:** Submit the answers to these questions.
4. Make a median image of the dark frames (i.e. the masterdark) that are appropriate for you science image. Subtract the masterdark from the science image.
5. How to make a master flatfield:
   (a) 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
   ```
   (b) Verify that the flat fields have similar count-levels, ideally at $\sim 30\%$ of the saturation threshold. Take the average of these frames - this is your masterflat. (Note: you can do this in python, but `ftpixcalc` – see the ftools wiki page – is a fast way of doing this on the command line).

   (c) Find the mode of the master flat-field. Normalize the flat-field by the mode.

   (d) **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.

6. Divide your science image by the masterflat.

7. 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.

8. 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 in the subsequent analysis? Open it in ds9 to see that for every pixel, the position in right ascension (α) and declination (δ) is also reported.[1]

9. Open the image with the astrometric solution in ds9 (remember to adjust the scale). Use the "Compass" region to place a North-East compass onto the image. Use the "Line" + "Text" regions, or the "Ruler" region, to add a scalebar. **Homework:** Submit a screenshot of your image with these regions overlaid.

[1] astrometry.net seems to have a bug that causes a bit shift in the count values of the output image. To fix this, add 32768 to the output image.