ASTRONOMY LAB: Last Session

Session Plan

1. Learn about Photometry Concepts
2. Do photometry on a 2mass image and compare results with catalog

Introduction:

Photometry involves the measurement of flux from sources of interest in specific bands. In the optical and IR, the conventional way to express the flux is by magnitudes. Photometric methods are by no means trivial. The two major factors involved are (1) the atmospheric extinction and (2) the background.

(1) Atmospheric Extinction: The extinction coefficient it estimated by taking a set of observations in the passband of interest. The observations involve obtaining the flux of a sample standard star as a function of the zenith angle (and hence the airmass). This yields the coefficient which is then used to correct the observed magnitudes of the targets. The result will give the flux above the atmosphere.

(2) The other major complication in doing photometry is that the object of interest is superimposed on flux from the sky. This background light comes from a variety of sources - unresolved stars and galaxies, sunlight scattered into the beam (particularly from the moon!), stray light bouncing around in the telescope, and light from manmade sources. A simple model for the sky is to assume it's uniform, at least in the immediate vicinity of the object of interest. The sky brightness is then given in magnitudes per square arc second. The sky brightness depends on the wavelength under consideration, as well as the phase of the moon. Hence, subtracting the sky is crucial in estimating the flux from the target. This becomes a source of error if the target of interest is in a crowded field.

A common technique for determining the sky level is to specify an annulus around the star, and compute the mode or median of the intensity in the annulus. This value is then subtracted from the pixels that contain the object of interest.

For any given telescope, filter and detector system, the apparent brightness of an object, expressed in apparent magnitudes, is given by $\mathrm{m} = 2.5\log_{10}(\mathrm{f}) + \mathrm{m}_0$ where the constant m_0 (the "zeropoint") is determined by measuring the flux for "standard" stars that serve as calibrators. This zeropoint in magnitude is the single scaling factor for an astronomical imaging system. You can measure the flux in A/D converter units ("ADUs") per second, plug those values into the formula above, and sweep all the calibration factors into the system's zeropoint. If done this way, the zeropoint represents the magnitude of an object that would produce a detected signal accumulation of 1 ADU per second.

There are two tecniques involved in the extraction process depending on the nature of the target.

(1) Aperture Photometry: This is the simplest technique. It is usually used in case of sparse fields where the stars are well separated. This amounts to just placing an aperture around the star and adding up the pixel values within this. Selecting a proper aperture depends on the expected outcome of the photometry. If the measurements are aimed at obtaining relative fluxes of sources in the field then an aperture of a fixed size can be used and the fluxes compared. However, if one is interested in obtaining the absolute flux of the source, then the choice of the aperture becomes crucial. In this case, the approach is to obtain the 'curve of growth' to get the total flux.
(2) PSF Photometry: Aperture photometry is not good for crowded fields. The contribution of the other nearby stars in the aperture set introduces serious errors in magnitude (flux) estimation. In such cases, the PSF of the image is determined from isolated, bright stars. Then a model PSF is constructed and fitted to the image and the flux is determined.
In this session we will learn about Aperture Photometry and perform the same on a 2MASS image.

Aperture Photometry using 'imexamine':

1. Download the 2MASS J-band image of the field around the standard star AS 13 (FS 13) whose coordinates are 05 57 7.5 +00 01 11. You can fix your image size to 240 arcsecs to ensure that there are reasonable number of sources in the field.

   Q. Is it a crowded field?

2. Start IRAF and display this image on the 'image-viewing' tool.

3. Check the header of the image. The parameter of interest is the zeropoint magnitude.

   Q. What is the value of zeropoint magnitude for this image?

4. Use the task 'imexamine' to perform aperture photometry. Read the help and find out how to do it. You will require to set some parameters (like zeropoint magnitudes, etc.) in the parameter file. Check with 'epar imexamine' or 'epar rimexamine'. You can set the following at the default values. Before that read and find out from the help file what are these parameters.

   - Centering box width = 5
   - Inner radius of sky annulus = 15
   - Width of sky annulus = 10

   The rule of the thumb is that the aperture size (radius) should be 4 - 5 times the FWHM to ensure that all the flux is taken into account. Use 'imexamine' to determine the FWHM and set the value of the 'aperture' in the parameter file. Use a good number of stars to get an average value of the FWHM.

5. Select 15 stars in the field and get the magnitudes using the tasks within 'imexamine'

6. Select one 'good and bright' star. Get the 'curve of growth' by using a set of apertures. Start from an aperture size of one pixel. Make a table listing the aperture size and the corresponding magnitudes. Plot the COG.

Aperture Photometry using 'qphot':

1. Take the same image and display.
2. Use the task 'qphot' (noao.digiphot.apphot.qphot). Read the help and proceed.
3. You can use the 'interactive mode' as well as the 'passive mode'. For interactive mode go to the star on the display and press 'i'. For the passive mode you need to make a coordinate file. Name it as 'AS13-J.coo'. This file should contain the x and y coordinates from the image. You can use the 'imexamine' task to generate this file. Display the image. Start 'imexamine'. Go to each of your selected stars and press 'a' (Oops! I have already told you what to do.....anyways...) and generate the coordinate file. The output file will have the extension .mag.1.
4. You can extract relevant information from the output file by using the task 'txdump'. See the parameters and the help of this task and use it. Extract the image name, xcenter, ycenter,flux, mag, merr.
5. Using the above task one can generate a plot that shows the magnitude error (the y axis) versus the magnitude of the objects you measured.

   txdump <filename>.mag.1 mag,merr yes — graph point+

   Q. What does this plot imply?
6. By setting a number of apertures get the COG and plot it (same as you have done for the 'imexamine' photometry'.

Results:

- Make a table with the following columns for the 15 selected stars.

  Star No.,Image Coordinates, RA and DEC, Mag (from imexamine), Mag (from qphot), Mag (from 2MASS catalog)
- Generate a plot which will has the 'qphot' mags on the x- axis and the 2MASS values on the y- axis.
- Try to find out about the photometric accuracies of the 2MASS catalogued values from documentation available on the net. Are they consistent with your results?

Note: The 'imexamine' and 'qphot' are the quicklook photometry tools. More sophisticated ones are available in IRAF like Daophot, etc. The interested students can have a look at those tasks.