IRAF LAB 3 REPORT

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THEORY

The measurement of flux from the stars in various sources of interest in the specific wavelength band is called photometry. There are mainly two effects that hinder the analysis they are mainly atmospheric effects which we can calibrate by plotting observed magnitude as function of zenith angle via which we can calculate the atmospheric extinction coefficient. That is to be used to find the actual flux from the source. And the second issue is background radiation which can be due to various reason such as man-made sources, airglow lines, zodiacal light, nearby sources in the sky etc.

For any telescope, filter and detector systems, the apparent brightness of an object is expressed in apparent magnitudes given by $m = -2.5\log_{10}(f)+m_0$ where the constant m_0, known as zero-point magnitude is determined by measuring the flux of standard stars which as used for calibration.

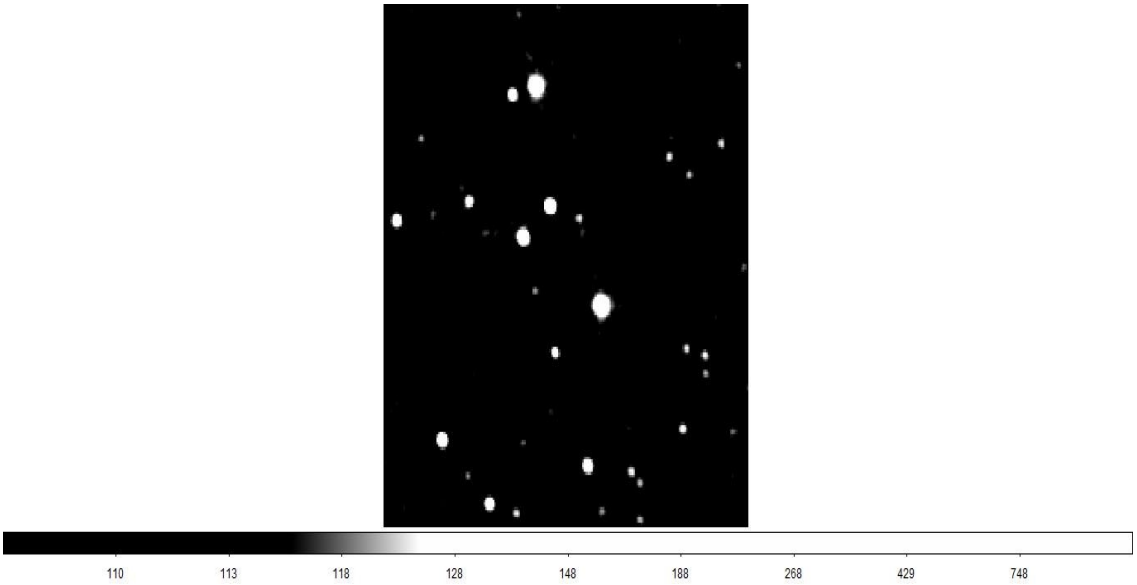
Hence before using the data for scientific use one need to correct for such effects. That is done via aperture and PSF photometry. They are as follows:

1. **Aperture Photometry:** In this method take a circular aperture of diameter larger than the FWHM corresponding to the point spread function(PSF) of the instrument. The sum of all pixel values of pixels lying inside this aperture centered around a star gives us the sum of the source signal corresponding to the star and the background signal over all pixels lying in the aperture. We take an annulus of inner diameter greater aperture diameter and some outer diameter and use it to sample the background. The median of the pixel values of pixels inside the aperture is taken as the background per signal in the vicinity of the star. This background per pixel is multiplied by the number of pixels in the aperture and subtracted from the sum of pixel values for pixels in the aperture to obtain the source signal for the star in ADU. This is generally done for sparse fields.
2. **PSF Photometry:** In PSF photometry, annulus just larger than the PSF is taken. Then fitting of a model to the PSF image is done. Here no separate analysis of background is needed. It is generally done for crowded field.

Procedure

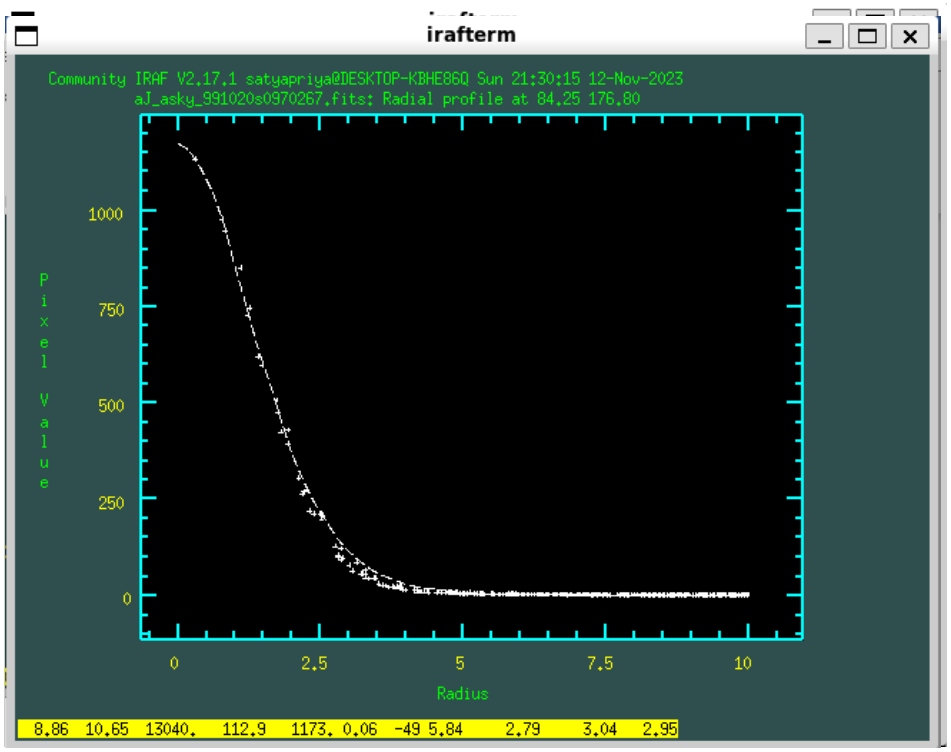
1. Downloaded the 2MASS J-band image of the field around the standard star AS 13 (FS 13) whose coordinates are 05 57 7.5 +00 01 11. The image size is 240 arcsecs to ensure that there are reasonable number of sources in the field. From visual inspection we can conclude that the field is not crowded.

2. Start IRAF and display this image on the DS9.



3. Check the header of the image. The parameter of interest is the zero-point magnitude. The value of zero-point magnitude for this image is 20.9376

4. As we can see as an example from the radial profile below. The average value of FWHM of PSF is around 4 pixels. Thus, the aperture radius was taken to be 12 pixels(3 times FWHM of PSF). This value was applied to the 'imexamine' task using the 'epar rimexam' command.



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

Ans: Taking object radius 12 and background buffer 3 caused another star in the vicinity get selected. Hence to remove this, object radius 8 and background buffer 7 is selected after trying various combinations.

X position	Y position	Magnitude
84.27	176.78	10.65
71.36	173.33	13.87
77.29	116.5	12.17
92.11	128.62	12.54
120.08	89.12	10.49
94.63	70.34	14.96
112.86	24.97	13.38
32.84	35.32	13.06
58.82	9.86	13.82
167.24	71.93	16.05
176.98	65.81	15.01
185.72	154.16	15.62
157.45	148.7	15.25
47.51	130.62	14.35
164.72	39.87	14.99
137.95	21.72	14.79
108.57	122.68	15.25
168.63	140.91	15.32

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

Table: **Curve of Growth for star FS13**

Radius	Magnitude
2.0	11.04
4.0	10.54
6.0	10.5
7.0	10.49
8.0	10.49
9.0	10.49
10.0	10.48

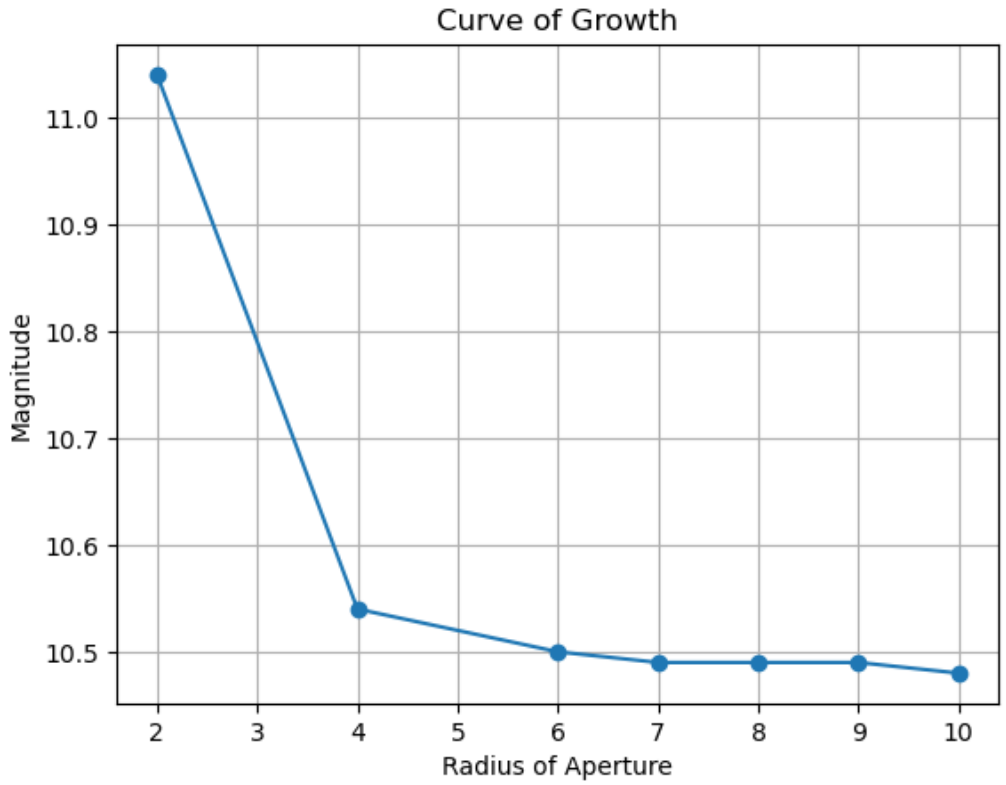


Fig: Plot for Curve of Growth for FS13 found using 'imexamine'. The plot was made in Python.

Aperture Photometry using ‘qphot’:

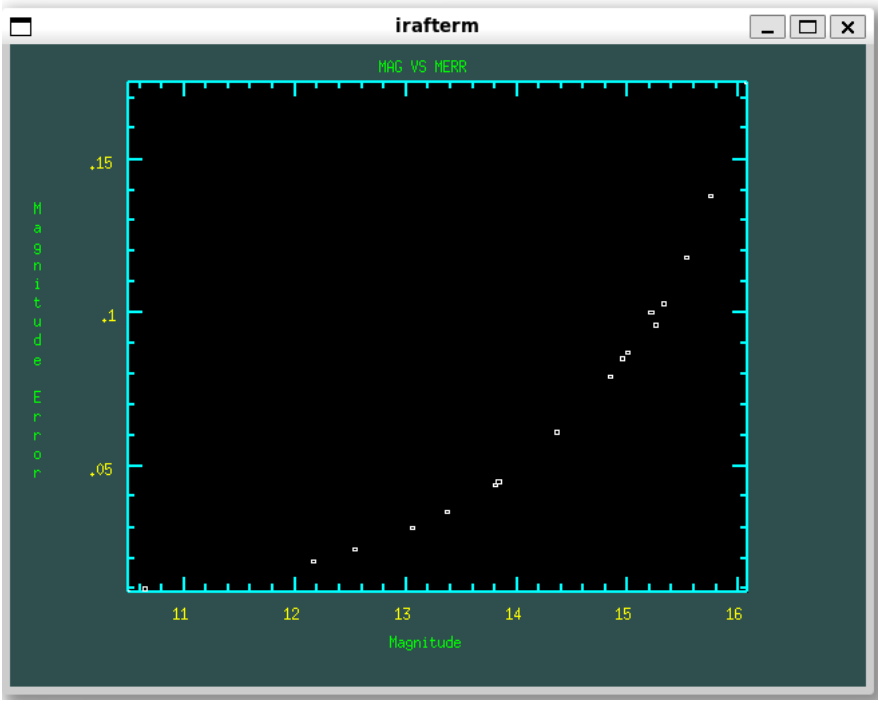
- The image was opened in DS9 again and IRAF was opened for analysis.
- The parameters for ‘qphot’ were edited using ‘epar qphot’ to change the parameters corresponding to the aperture radius, inner radius and width of annulus, centering box width and zero-point magnitude. Their values were set to 8,15,10,5 and 20.9376 respectively. The parameter for interactive mode was set to ‘no’ to open ‘qphot’ in a passive mode.
- The x,y coordinates of the chosen 15 stars were taken from the photometry table compiled at the end of the previous section and saved in a region file as ds9_qphot_method.reg . The ‘coords’ parameter in ‘qphot’ was set to ‘15stars.reg’ so that coordinates are read from here.
- The ‘qphot’ task was run and the output got stored in a file called ‘abc.fits.mag.5’. The image name, xcenter, ycenter ,flux, mag, merr values were saved into a new file by entering the command “txdump abc.fits.mag.5 XCENTER,YCENTER,FLUX,MAG,MERR yes > qphot_15_analysis.txt’’

XCENTER	YCENTER	Magnitude	Magnitude Error
84.353	176.701	10.646	0.010
71.446	173.458	13.837	0.045
77.390	116.496	12.168	0.019
92.124	128.553	12.534	0.023
120.073	89.174	10.490	0.009
94.758	70.304	14.960	0.085
112.916	25.002	13.371	0.035
32.872	35.402	13.059	0.030
58.755	9.891	13.812	0.044
166.606	71.778	16.083	0.175
176.902	69.394	15.533	0.118
186.011	153.663	15.748	0.138
157.245	148.455	15.262	0.096
47.509	130.551	14.360	0.061
164.611	39.752	15.004	0.087
136.571	22.574	14.846	0.079
108.248	123.783	15.210	0.100
168.345	141.340	15.326	0.103

Figure 7: Table with results for photometry using qphot

Using the command, 'txdump abc.fits.mag.5 MAG,MERR | graph po+' a plot that shows the magnitude error versus the magnitude of the 15 stars was found. The 'xlabel', 'ylabel' and 'title' parameters were edited using the 'epar graph' command to change the x and y labels and title of the plot. The plot is shown below.

Fig: Plot of Magnitude vs Error in Magnitude for chosen 15 stars



We can see that with increasing magnitude, the error is also increasing. Which is indeed correct. Because increasing magnitude means we are dealing with fainter object which have lower SNR thus they have bigger errorbars.

Result

Table: Table of Photometric Results. X,Y are the image co-ordinates of the stars. MAG refer to magnitudes. Data from the 2MASS catalog or found using 'imexamine' or 'qphot'.

XCENTER	YCENTER	RA	DEC	Mag(imexamine)	Mag(qphot)	Mag Error	Mag(2MASS)
84.353	176.701	89.29146	0.044231	10.65	10.646	0.01	10.644
71.446	173.458	89.295045	0.04325	13.87	13.837	0.045	13.896
77.39	116.496	89.312642	0.04325	12.17	12.168	0.019	13.842
92.124	128.553	89.293387	0.027486	12.54	12.534	0.023	12.539
120.073	89.174	89.281508	0.019864	10.49	10.49	0.009	10.499
94.758	70.304	89.288556	0.014637	14.96	14.96	0.085	14.799
112.916	25.002	89.283511	0.002038	13.38	13.371	0.035	13.383
32.872	35.402	89.305719	0.004895	13.06	13.059	0.03	13.067
58.755	9.891	89.298521	-0.00212	13.82	13.812	0.044	13.83
176.902	69.394	89.265764	0.014349	15.01	15.533	0.118	15.45
47.509	130.551	89.301618	0.031418	14.35	14.36	0.061	14.473
164.611	39.752	89.269161	0.006177	14.99	15.004	0.087	15.267
108.248	123.783	89.284862	0.029481	15.25	15.21	0.1	15.652
168.345	141.34	89.26815	0.034418	15.32	15.326	0.103	15.965

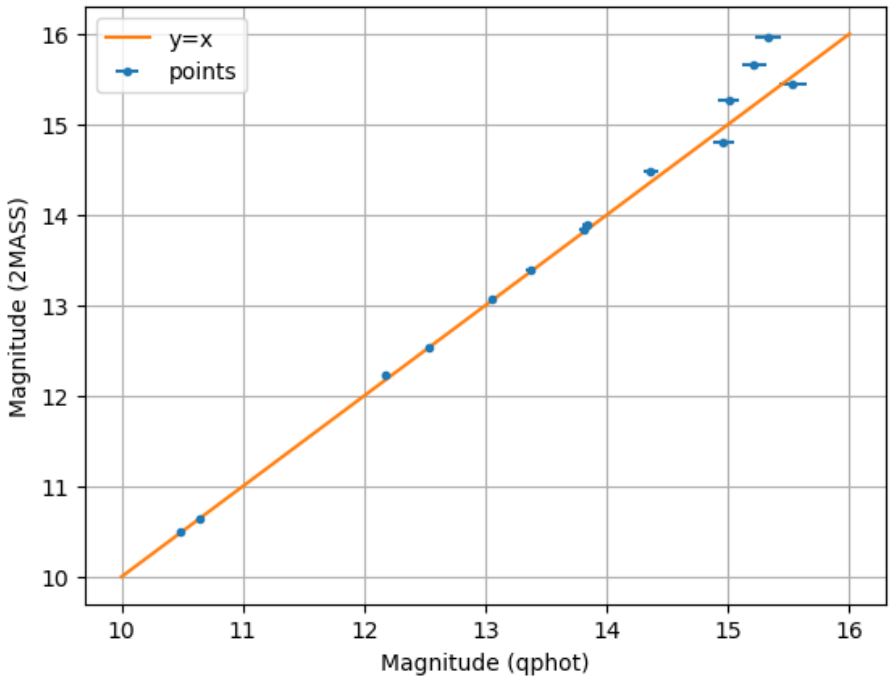


Fig: Plot of 'qphot' mag values vs mag values from 2MASS with errorbars. The function y=x has been added to help with comparison.