EXTINCTION MEASUREMENT LAB

SATYAPRIYA DAS (SC20B159)

AIM

- To observe the change in apparent magnitude (before extinction correction) magnitude of a star as a function of its zenith angle.
- To find the extinction coefficients for the red and green filters.

Theory

Atmospheric extinction is the reduction in brightness of starlight as its light passes through the eart's atmosphere. The amount of dimming depends on three factors: transparency of the air, elevation above sea level and altitude above the horizon. Its effects needs to be corrected if we want to study the intrinsic properties of the star. The value of $\int \rho \, ds$ that a beam of light from a star is an zenith has to cover to reach the observer is referred to an one airmass. Then for a star at some zenith angle z, the approximate relation $X = \int \rho \, ds = 1 \text{ Airmass} \times \sec(z)$ is used. This value of X refers to the airmass for the star at zenith angle z.

Procedure

- Pole star alignment was done by setting the telescope stand in the north-direction.
- Two-star alignment was done.
- The Grab feature in CCDOps was used for capturing the images. Since there was an issue of size mismatch and the presence of ring like features while doing flat-fielding, the division of other images with flats is not done.
- Image data analysis for the Alfard star (Alpha Hydrae) is carried out in this analysis.
- Five images each in r and g filter of integration time = 0.3 seconds is taken.
- The dark frame is taken by keeping the shutter close and then taking grab of 0.3 sec and in bias it is set to 0 sec but it automatically set to 0.12 sec (lowest time).
- The subsequent analysis is done in IRAF.
- Using task rename, all files were changed from *.fit to *.fits extension.
- Cosmic ray removal is done using the task "noao-imred-crutil-cosmicrays".
- Master bias and master dark is created using the task "imcombine". By giving 'bias_*.fits' and 'dark_*.fits' as input and 'master_bias.fits' and 'master_dark.fits' as output respectively.
- Master bias is subtracted from all frames including the master dark.
- Then the master dark is subtracted from the filter frames of Alfred star.
- List is made using "!ls *.fits>list1" and manually removed those that are not required. Similar process is followed wherever we must do operation on bulk of images.

- To view the image, DS9 is opened using "!ls ds9 &" in IRAF.
- To mark the coordinate in the images, I pressed 'c' in DS9 after opening one image after another and it will keep the XY position which is then saved as text file and used for further analysis.
- I used 200,200 as my reference point and shifted all the images by making a shift file where shift_X = 200-X and shift_Y = 200 – Y.
- After keeping the names of only the Alfred star in list1, I used imshift with input as @list1 and shift file as shift.txt
- Then for each filter and time stamp, file of name list named <color>_<time_stamp> I made.
- Each of those are then passed through task 'imcombine' (eg:- input = @g_744, output = avg_g_744.fits).
- Then 'noao-digiphot-apphot-qphot' is used to do aperture photometry.
- For g_7:44 pm file, curve of growth is plotted and from that as we can see in figure 1, aperture = 8 pixels is selected for the photometry.

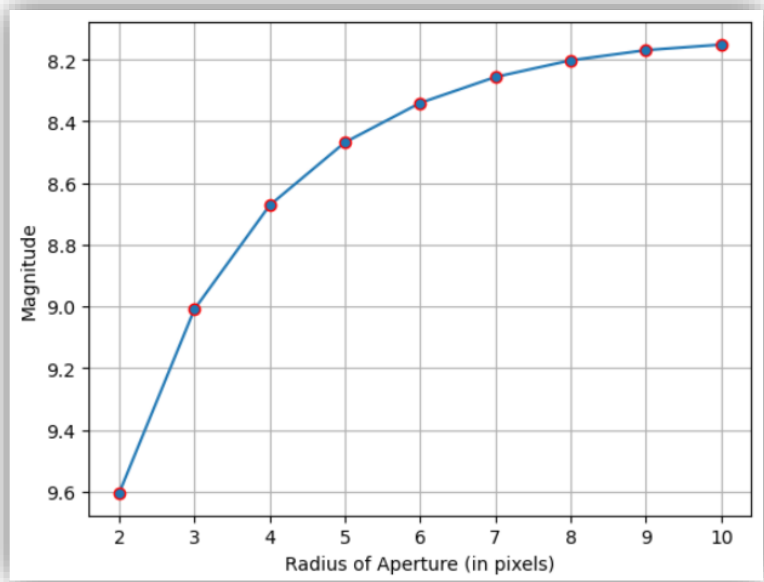

Fig 1: Curve of Growth for g_7:44 pm file

To find the zenith angle, the value of altitude of Alphard at the time of each observation was noted from https://eco.mtk.nao.ac.jp/cgi-bin/koyomi/cande/horizontal_rhip_en.cgi after selecting the star (by entering Bayer no.), entering the time zone, date, time of observation, and entering coordinates of the site of observation. And zenith angle = 90 – altitude is applied.

Table 1 shows the time of observation, magnitude and error in both green and red filter using aperture photometry of average each in each time stamp and the zenith angle from the website.

Table 1: The compiled data for observations of Alphard

Time (pm)	MAG (Green)	MAG error (Green)	MAG (Red)	MAG error (Red)	zenith angle
7:44	7.393	0.002	6.298	0.001	78.0126
7:54	7.282	0.002	7.282	0.002	75.5935
8:04	6.706	0.002	6.023	0.001	73.1754
8:16	6.335	0.001	5.69	0.001	70.2772
8:41	5.882	0.001	5.518	0.001	64.2597
8:53	5.805	0.001	5.495	0.001	61.3847
9:03	5.91	0.001	5.604	0.001	58.9972
9:14	5.851	0.001	5.415	0.001	56.3811
9:23	5.807	0.001	5.503	0.001	54.2497
9:33	5.763	0.001	5.506	0.001	51.8926
9:43	5.869	0.001	5.436	0.001	49.5487
9:54	6.023	0.001	5.731	0.001	46.9882
10:04	5.972	0.001	5.479	0.001	44.6793
10:14	6.159	0.002	5.625	0.001	42.3915
10:26	5.96	0.001	5.455	0.001	39.679
10:50	5.858	0.001	5.141	0.001	34.3945
11:01	5.888	0.001	5.195	0.001	32.0554
11:11	6.033	0.001			29.9887

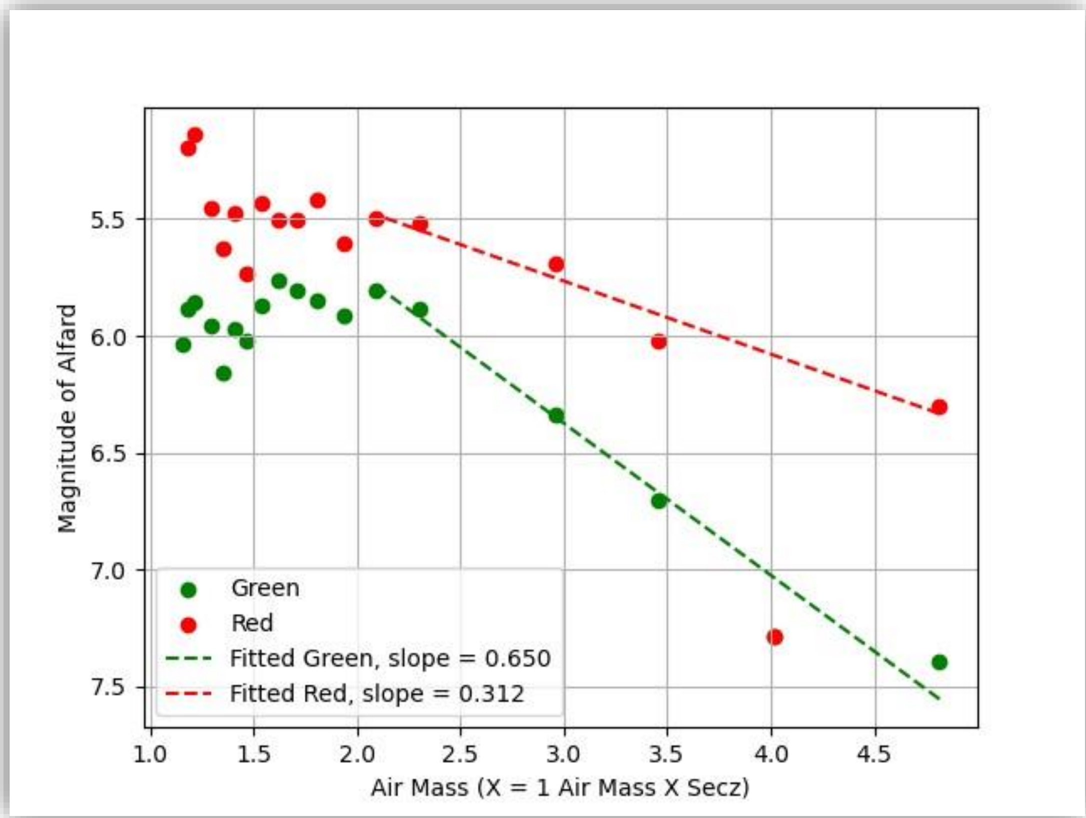

Fig 2: Plot of airmass vs observed magnitude of Alphard in the green and red band. The effects of saturation has made many data points unusable for further analysis. We are ignoring the red data point at 4 airmass because it is an outlier.

We can very clearly see that the magnitude decreases (flux increases) steadily for the first few observations in both bands but then starts fluctuating. To understand this unexpected behavior, the radial profiles of various frames were checked along with visually inspecting the images and it was found that the central region of the profile was getting saturated for most observations after the first few. This made those observations unsuitable for further analysis.

The above plots also show the same, the observations taken when the star was at higher altitude have been rendered unusable by the effects of saturation.

The figure shows the radial profile for one of the saturated frames and an image of the frame. From the raw images itself, it wasn't possible to see any bleeding which made it difficult to realize that saturation had taken place.

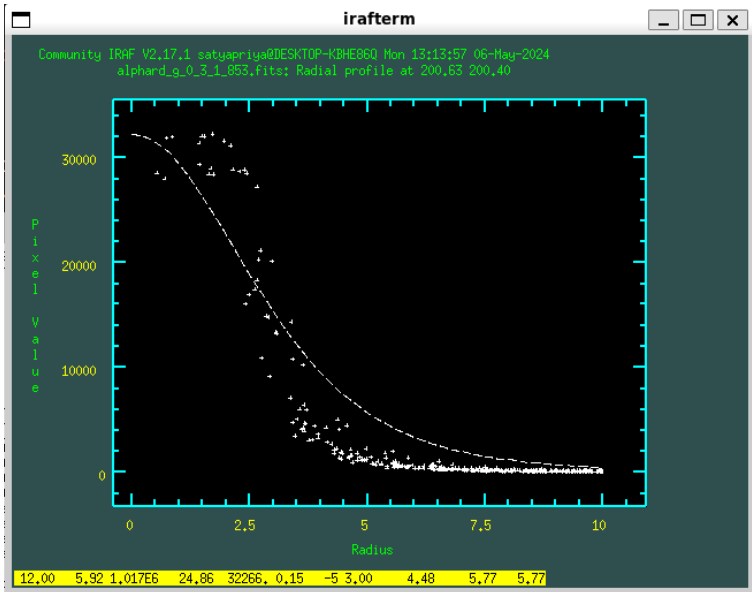

Fig 3: Radial profile of Alphard_g_8:53 pm

In the image a region of very bright points not at all like what is expected from a PSF can be seen. On inspecting all the frames carefully, it was found that for the green band only observations before 8:41PM were free of saturation for certain while for the red band only observations before 8:16PM were free of saturation for certain. This leaves us with only 4 and 3 data points for the two bands respectively.

The values for the atmospheric extinction coefficients in the two bands found by taking the least square fit slopes using curve_fit from scipy for the useful points as shown in Fig are as follows:

- K_{red} = 0.312 mag/Airmass
- K_{green} = 0.650 mag/Airmass

Conclusion

- The atmospheric extinction coefficients in the two bands were found to be K_{red} = 0.312 mag/Airmass and K_{green} = 0.650 mag/Airmass.
- Since very few data points were left after removing those affected by saturation, the values might be inaccurate.
- But still we can see that as estimate of atmospheric extinction coefficients in the green band is larger than that found in the red band. This agrees with what we expect due to the atmospheric scattering being more for light of lower wavelengths.