IRAF Spectroscopy Analysis Lab Report

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AIM

In this report spectroscopy on image data of J0840+3633 using observation taken using the IUCAA Giravali Observatory(IGO). We aim to learn the basic reduction steps, techniques to identify spectral features and calibration steps involved in the data analysis.

Software used: IRAF and DS9.

INTRODUCTION

IUCAA Giravali Observatory has a 2-meter optical telescope with a workhorse imaging spectrometer IFOSC (IUCAA Faint Object Spectrograph and Camera).

This instrument has the capability for imaging in various bands (U, B, V, R, I etc with band-pass filters) and also performs spectroscopy (with grisms and echelle grisms etc) in these bands. It has a CCD with 2048X2048 pixels with 13.5μ size each. It can also do polarimetric and spectro-polarimetric measurements in these optical bands. This instrument is placed at the Cassegrain focus and renders a field-of-view (FOV) of about 11 square arc-min in the sky.

ANALYSIS

Any spectroscopy analysis is based on the dispersion of light to get useful information of absorption and emission lines in their spectra. In order to deduce that the object file is usually accompanied by the standard star, calibration, bias and flat-fielding (since CCD is used).

Based on my understanding the raw files are as follows:-

FILE NAME	TYPE
bias.3948.0.f its Bias bias.3949.0.f	Bias
bias.3949.1.f its Bias bias.3949.2.f	Bias
Hiltner600_s150_gr7.5811.0.f	Standard Star
Hiltner600_s150_gr7.5812.0.f	Standard Star
Hiltner600_s150_gr7.5812.1.f	Standard Star
j0840 + 3633_s150_gr7.5685.0.f	Object file
j0840 + 3633_s150_gr7.5688.0.f	Object file
j0840 + 3633_s150_gr7.5844.0.f	Object file
hene_s150_gr7.5769.0.f	Calibration (He- Ne)
hene_s150_gr7.5769.1.f	Calibration (He- Ne)
hene_s150_gr7.5769.2.f	Calibration (He- Ne)
hal_s150_gr7.5770.0.f	Flat (Halogen lamp)

hal_s150_gr7.5770.0.f	Flat (Halogen lamp)
hal_s150_gr7.5770.0.f	Flat (Halogen lamp)

Bias Subtraction

- **"zerocombine"** forms a master bias from the three bias images provided.
- Using readnoise = 4 and gain = 1.5 provided in the image header, a median combine was employed for combining. This method helps in outlier rejection and gives a usable master bias.
- The master bias was subtracted from all other remaining 9 files using the task **imarith**, which helps do pixel-level operations on fits files directly.

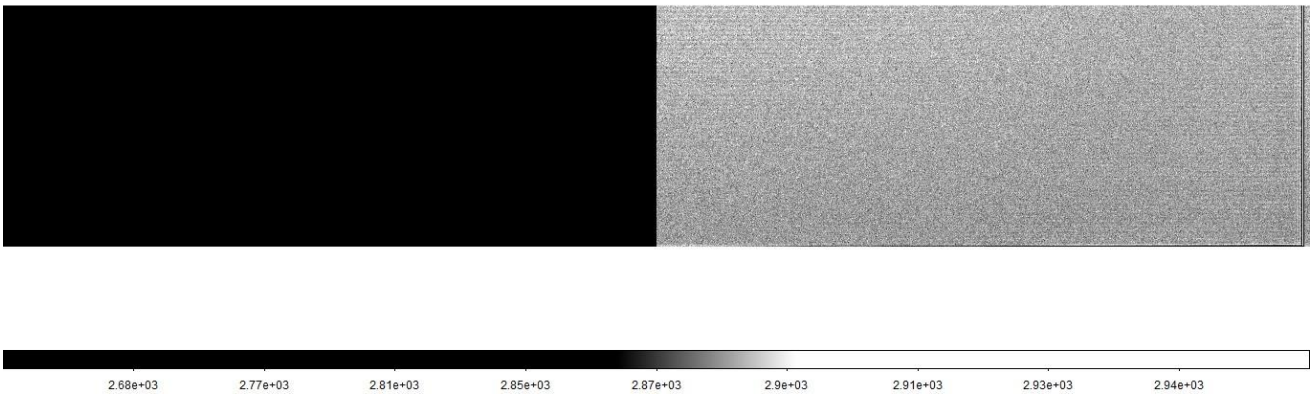


Fig 1: Combined bias file using the 3 bias images.

Flat-Fielding

- **"flatcombine"** was used to combine the 3-flat files taken using Halogen lamps here.
- The combined flat field file has some overscan region on both ends and observable pixel value variations. So threshold is applied to remove that region before any further analysis.

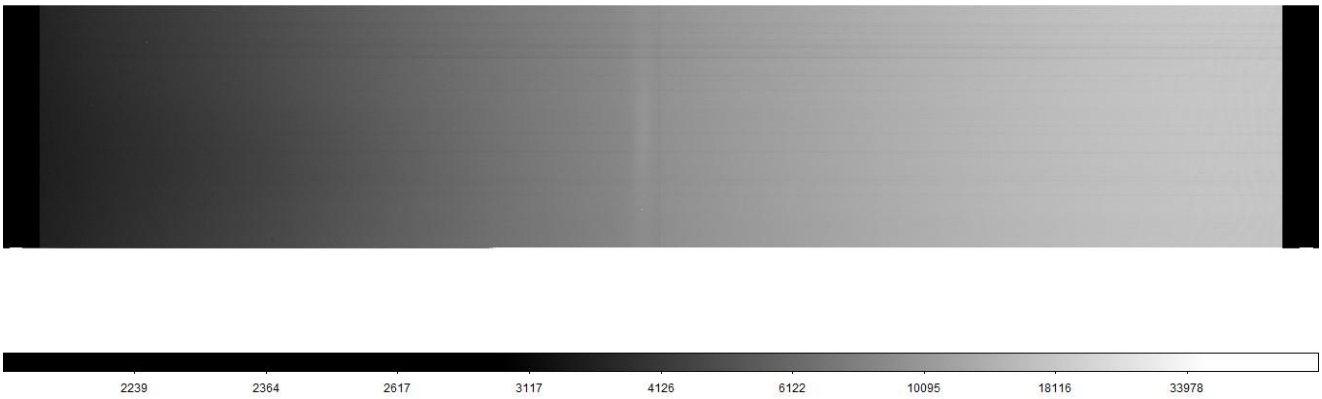


Fig 2: Combined Flat using the given flat images (in log scale).

• Due to large variation, normalization of flat files obtained from 3 sets is important. We use **"response"** task under **twodspec** to perform the same.

• The functional fit to the response along the dispersion axis is shown in Figure 3 with a horizontal bar showing the region assumed for fitting.

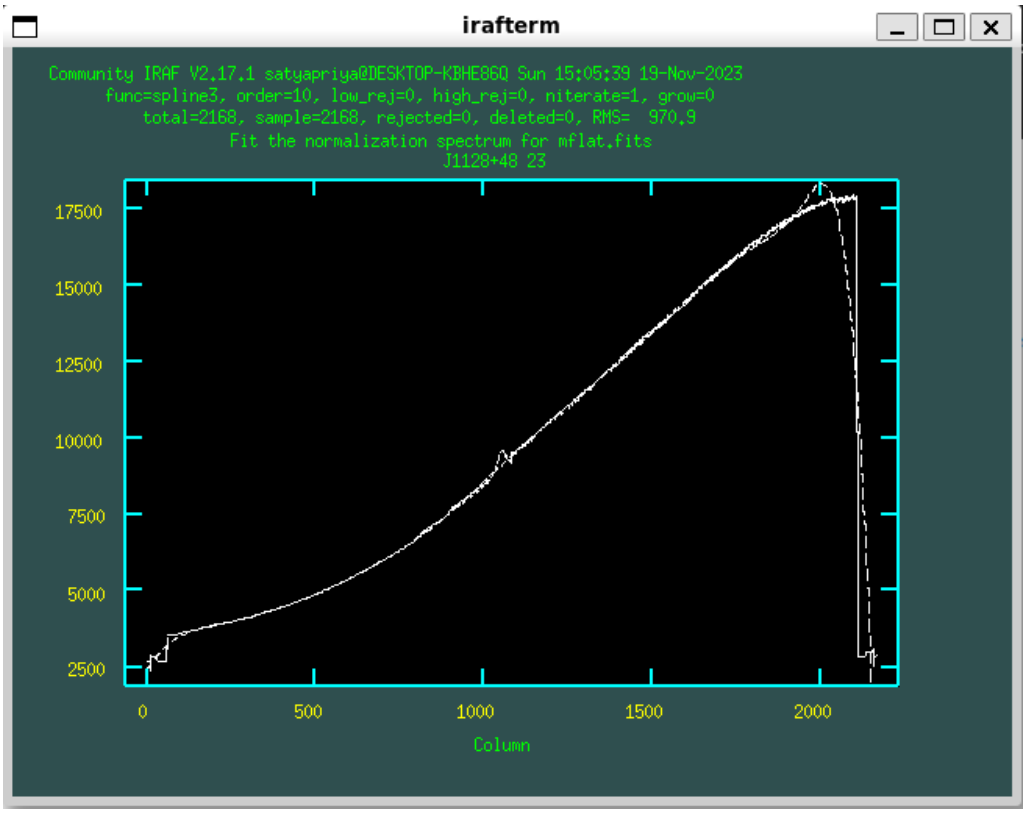


Figure 3: Interactive plot showing response fit using spline order 10.

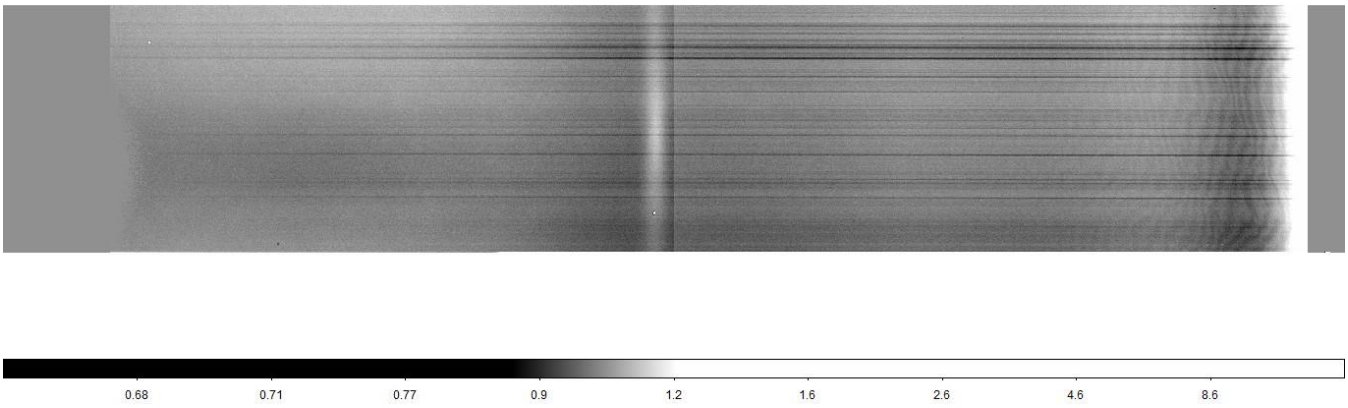


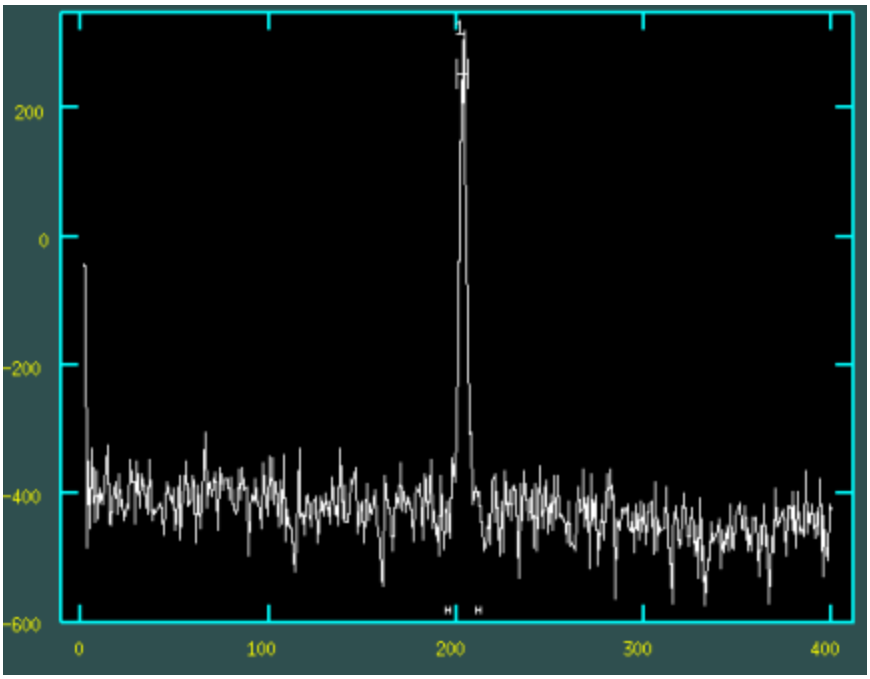
Fig 4: Normalized master flat field image (log scale)

- This normalized flat file was divided from all the files except bias to obtain the final file set.
- The obtained files were also treated for cosmic rays removed using **"crmedian"** from **crutil** which uses a median filter box to flag any pixels contaminated by cosmic rays. I also attempted to remove using **"cosmicrays"** but it was only able to partially remove it.
- Now, the photometric corrections on the observation, important due to CCD usage, are complete and further analysis can be done.

Spectrum Extraction

The **"apall"** is the task of IRAF written specifically for aperture extraction from the CCD image. As the CCD takes an image of the dispersed light from the slit, the source is confined to some pixels while there is the existence of background spectra as well. It automatically finds and centers the spectrum from the given image provided. However, the dispersion axis should be set to horizontal before analysis. The routine also calculates the background and traces the spectrum.

The aperture extraction was not working when given a list. So, individual aperture extraction is done by selecting the background, deleting erroneous points, fitting data and saving the spectrum. Saved as **"<number><j/H>.fits".**



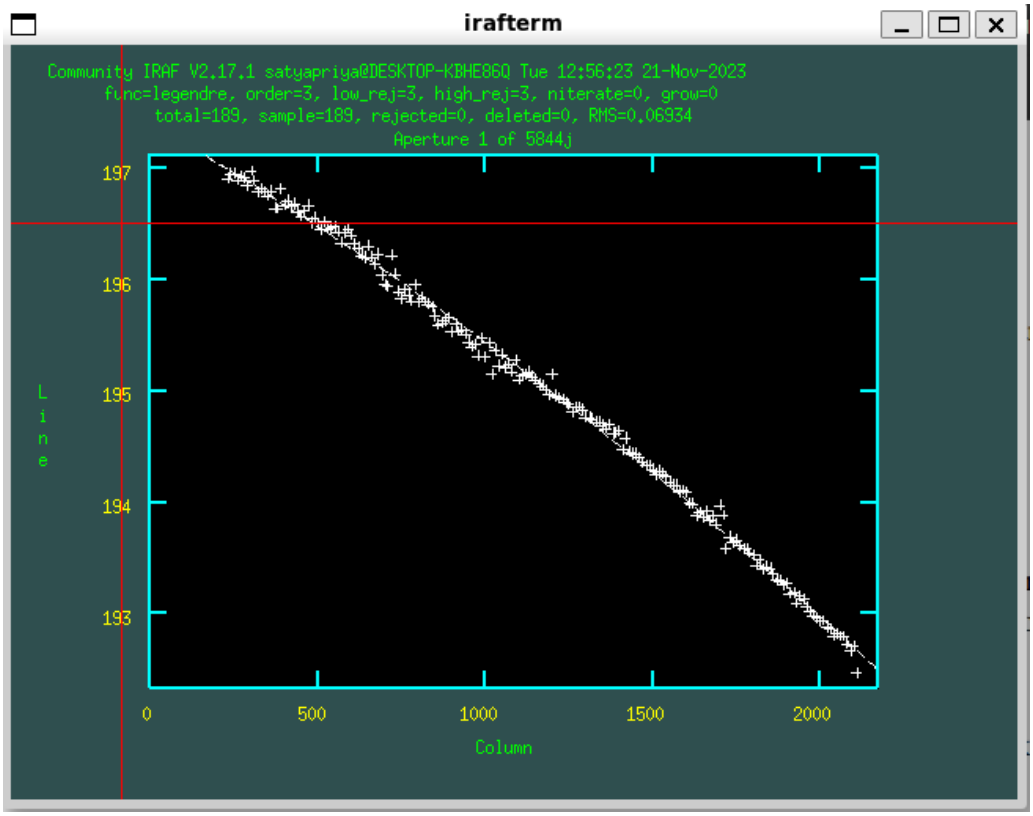


Fig 5: Fitting the data and extracting the spectrum.

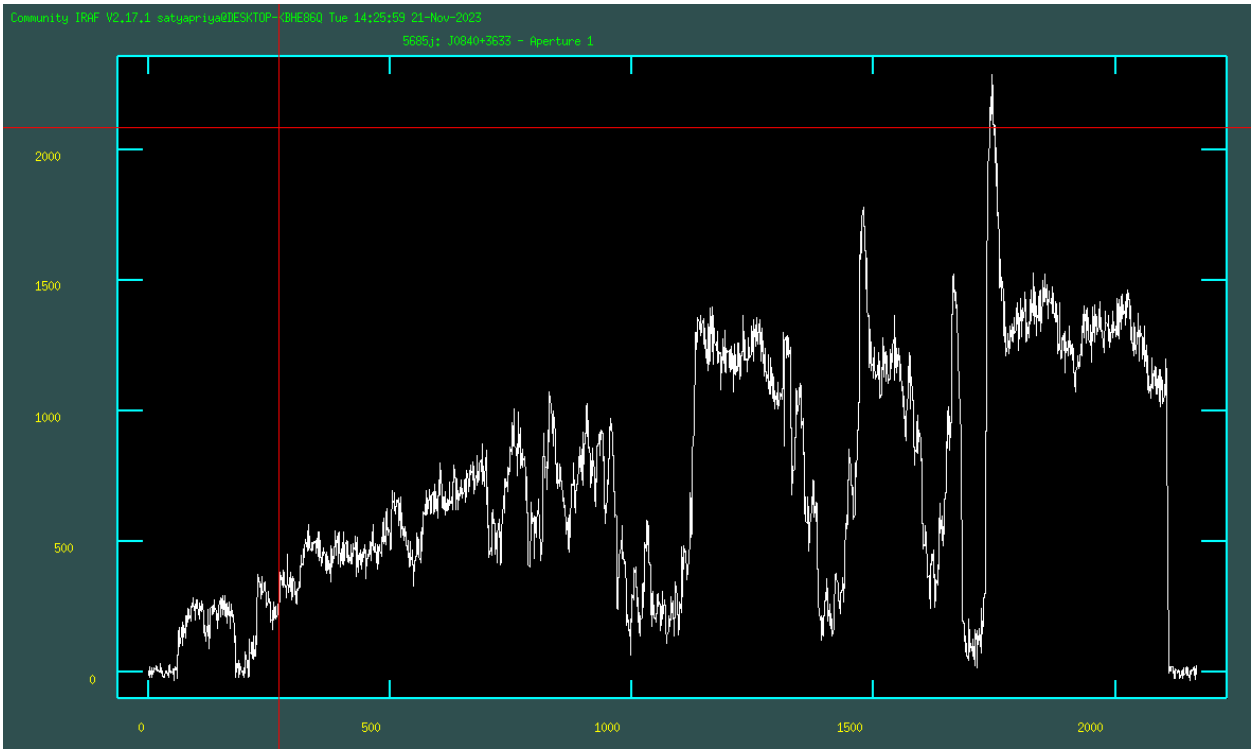


Fig 6.1: Spectrum of object file 5685j.fits

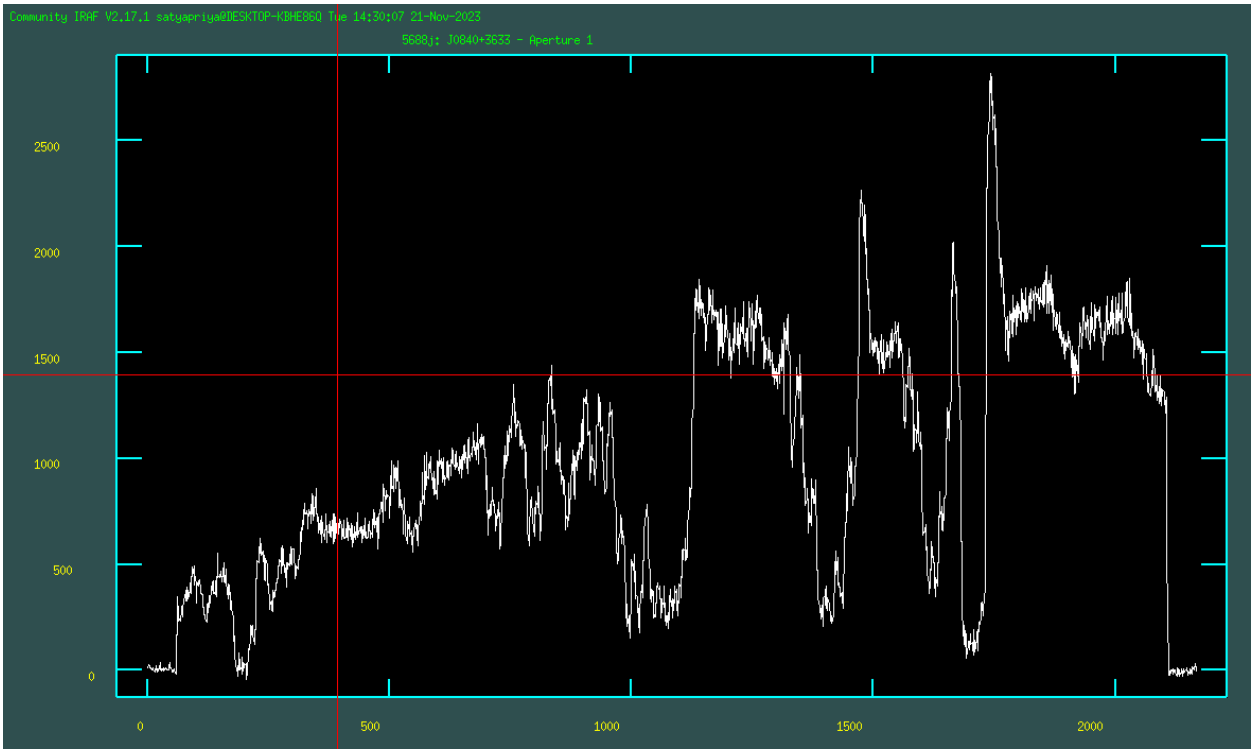


Fig 6.2: Spectrum of object file 5688j.fits

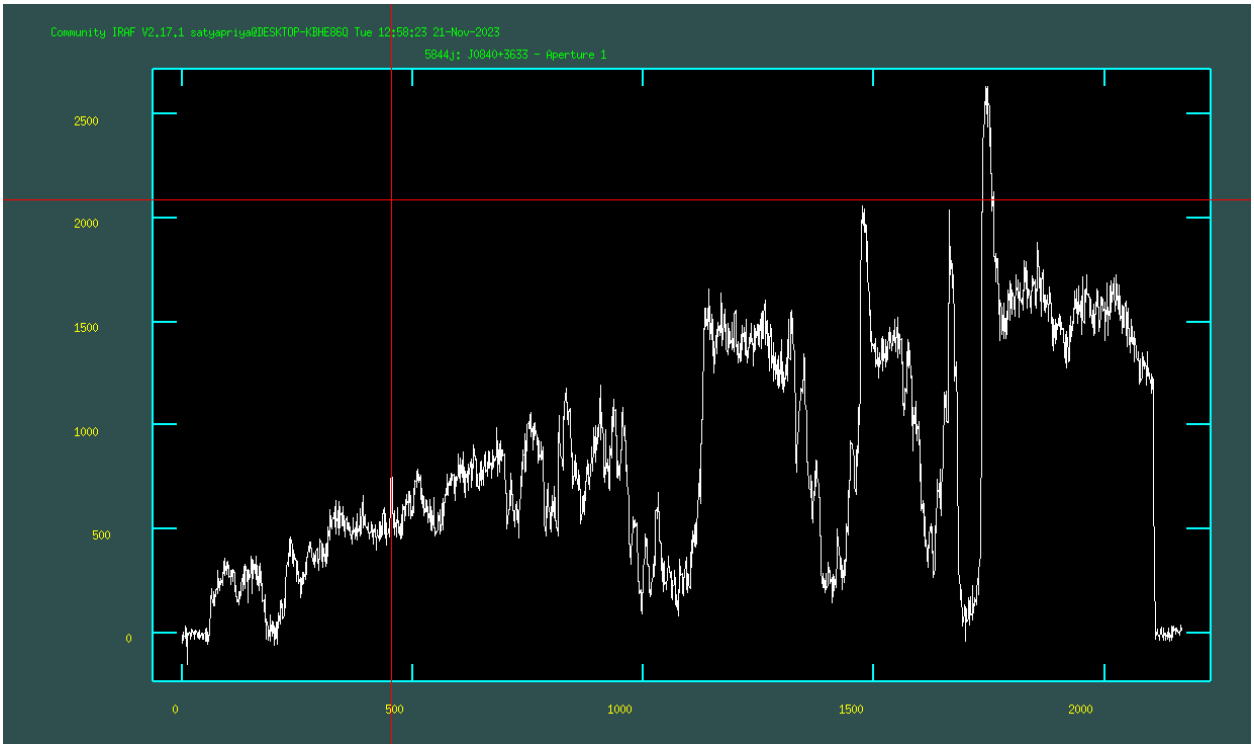


Fig 6.3: Spectrum of object file 5844j.fits

Wavelength Calibration

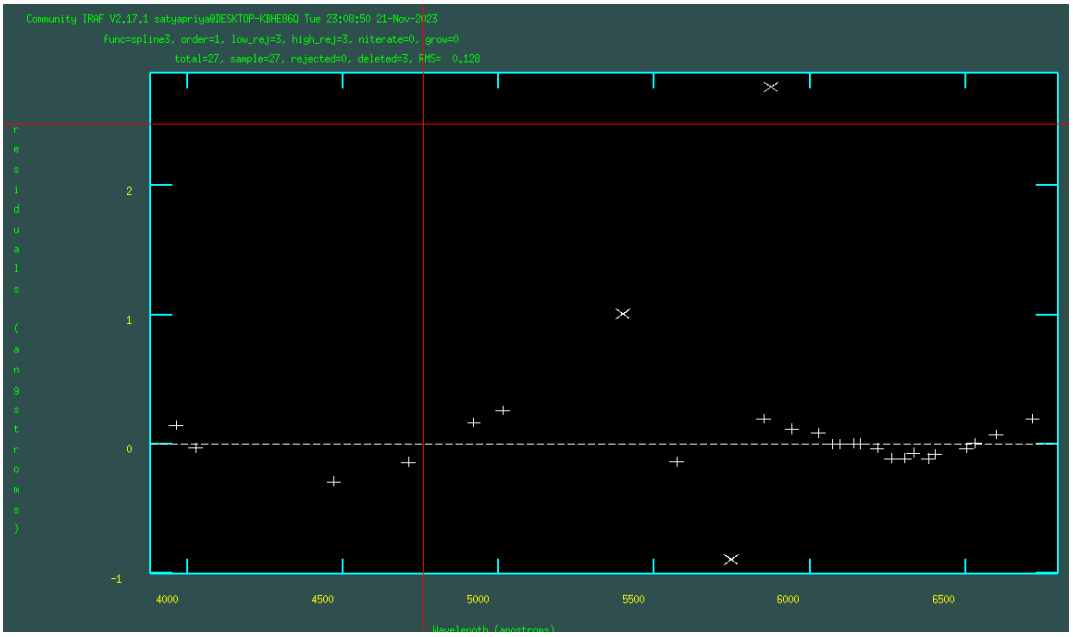


Fig 7: Removing erroneous points to fit the wavelength scale. Rms=0.128

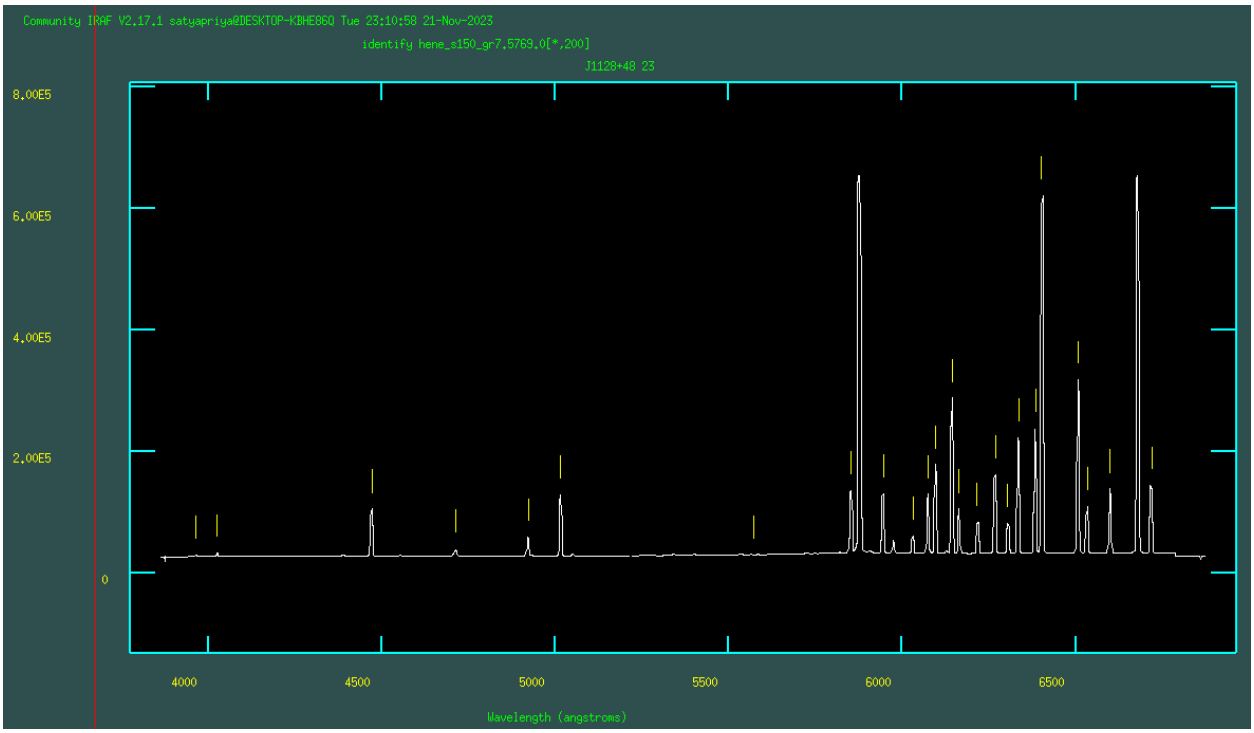


Fig 8: Automatic fitting of peak wavelength (cleaned version)

- The **"identify"** task is used to mark the spectral features of the calibration file in terms of wavelength. It is done by utilizing the known emission lines provided in the dataset to visually compare and mark.
- Figure 8 shows the marked peaks in the standard lamp file. This referenced calibration image maps pixel to wavelength in all other spectrum files using the task **"refspec"** and **"dispcorr".**

Results

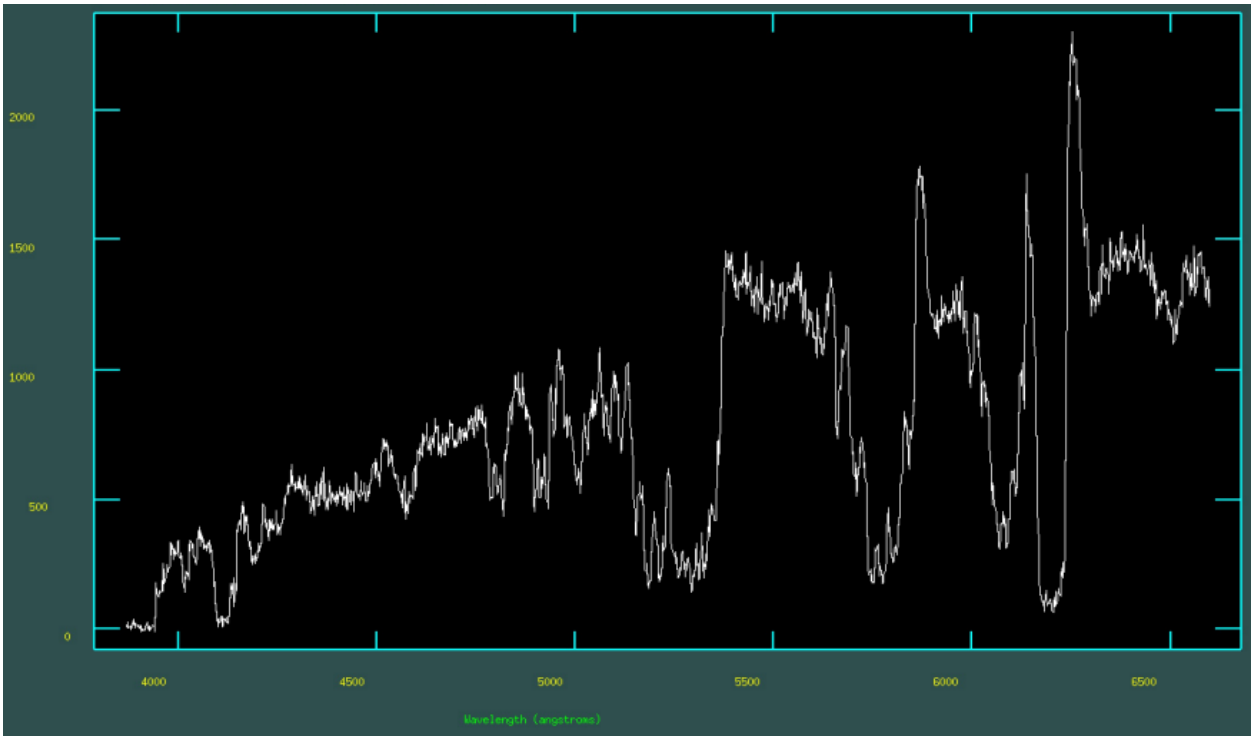


Fig 9: Combined wavelength calibrated object spectrum

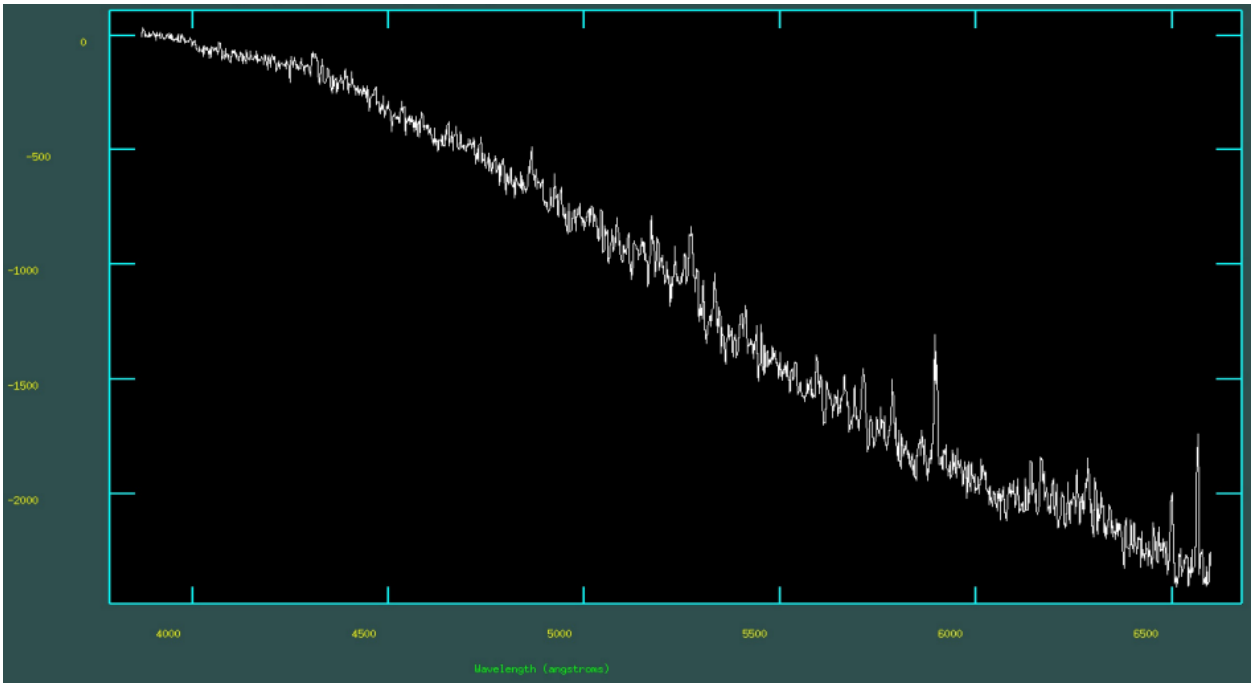


Fig 10: Combined wavelength calibrated standard star spectrum.

Science cases of project

The object of our study is J0804+3633 which we can see in Fig 9. Based on the absorption features observed in the spectrum, an observation of broad spectral absorption features is made. The distinctive feature of the spectra is the presence of forest of lines, due to the collection of absorption lines closely spaced together, which may be indicative of certain elements in the star. Roughly around 4000-5200, 5400-5700, 6200-6700 angstroms we can see the forest of lines. Due to the presence of the latter part which I have mentioned it can be later stage star G, K, M. Here, absorption features can be a combination of both ISM and the star so it is difficult to distinguish but we can roughly claim that as stated above.

Comparing it with NIST Atomic Spectra database, the feature between 5000 Å and 5500 Å corresponds to an absorption feature for Fe-II, at 2300 Å. Thus, we see that the wavelength we see here is longer than the actual case, hinting towards the possibility of redshift.

References

- IRAF documentation guide (https://iraf.readthedocs.io/en/latest/)
- NIST Atomic Spectra Database