Determining Redshift via Astronomical Spectroscopy
Joshua Glatt

Introduction

- Astronomical spectroscopy is the spectroscopy method used to analyze the electromagnetic spectra of various celestial objects.
- Spectroscopic observations are vital to astrophysicists, as they provide a multitude of information about celestial objects (chemical composition, distance, relative velocity, etc.)

Theory

- Elements emit and absorb photons at wavelengths specific to them. Absorption lines are found in the spectra of celestial objects and can be used to determine their chemical composition by comparing them with emission spectra of various elements.
- Celestial objects in motion are also subject to an increase/decrease in their spectral wavelength known as ‘redshift’ due to the doppler effect.
- Using the below formula, spectra of these objects can be compared to those measured from discharge tubes and a value for the object’s redshift, denoted by the letter z, can be obtained.

\[ 1 + z = \frac{\lambda_{\text{observed}}}{\lambda_{\text{emitted}}} = \frac{1 + \frac{v}{c}}{\sqrt{1 - \frac{v^2}{c^2}}} \]

- Also important is to adjust the spectrometer’s integration time as needed. The CCD will need longer integration times for dimmer objects and vice versa.
- Averaging multiple spectra for an object allows for a lower signal-to-noise ratio which results in more well-defined spectrum.

Experimental Setup

- The telescope was first manually aligned by using the onboard computer. After alignment, the celestial object of interest was positioned into view.
- The spectrometer’s collimating lens was then inserted into the scope’s eyepiece and a spectrum for the object was acquired and saved.
- It is important to ensure the object is perfectly centered in view before attaching the spectrometer. If the object is off-center, no light will enter the collimating lens.

- The spectrum of Sirius, taken with previously used USB4000 spectrometer (left).

Future Study/Conclusions

Possible explanations for signal detection failure:
- Entrance slit of 5µm causing severe reduction in the intensity of the source signal, requiring much higher integration times than previously needed.
- Telescope’s tracking/guidance does not have the necessary precision, resulting in the object becoming uncentered (more pronounced with longer integration times).
- Focusing of the telescope is affecting the light transmission through the collimating lens.
- For future work, use the USU Observatory’s 0.5m telescope for its increased tracking precision and wide aperture.
- Advanced tracking mounts for the Celestron telescope are also available and may fix tracking issues.

Results

- New spectrometer with higher resolution has caused complications when trying to obtain spectra for various celestial objects.
- In the lab, the emission spectrum for Hydrogen was easily observed, yet no signal was able to be detected when viewing objects through the telescope (see figure)

- Ocean Optics HR4000 spectrometer with fiber optic cable, collimating lens, and telescope eyepiece adapter