Lab 1 - Fitting a Stellar Spectral Energy Distribution (SED)

Due Sept 14, 2025

Goal: Use the photometry of several stars to determine their temperatures and sizes.

1 Lab

1.1 Get Photometry of Stars

Get optical and infrared (WISE) photometry for the five stars below:

- ʻAua (Betelgeuse)
- Ka ʻōnohi aliʻi (Procyon): analyze the companion, Procyon B, using photometry from Table 3 here.
- Hiku lima (Alioth)
- Hōkū kau ʻōpae (Rigel)
- Ka maile hope (Alpha cen A)

Use the databases from SIMBAD (`http://simbad.u-strasbg.fr/simbad/sim-fid`) and from AllWISE (when available; `http://vizier.u-strasbg.fr`). Optional: use `astroquery` to get the data.

1.2 Calculate Flux Density

Convert the magnitudes to physical units (e.g., erg s^{-1} cm^{-2} Å).

Note that this requires a zeropoint! Most of the photometry is given in Vega magnitudes (with the exception of the *ugriz* filters, which are given in AB), so first convert them to AB magnitudes. You can use the tables found at these links `https://www.astronomy.ohio-state.edu/martini.10/usefuldata.html` and `https://wise2.ipac.caltech.edu/docs/release/allsky/expsup/sec4_4h.html`. You can then convert your AB magnitudes to flux densities. You'll also need to know the effective wavelength of each filter.

Plot the flux density vs. wavelength on a log-log scale for each star.

1.3 Fit the Temperature

Write a program to fit the observed SED with a Planck black-body function (make sure to use the λ version). You can do a grid search, or something more sophisticated.

Compare your derived temperatures to the expected values for each star's spectral type in SIMBAD, if it's available (use, e.g., `https://sites.uni.edu/morgans/astro/course/Notes/section2/spectraltemps.html`).

1.4 Calculate the Radius

Integrate under the SED to get the total flux.

Get the distance (look up the parallax in SIMBAD), and calculate the true luminosity in erg s^{-1}.

Use the Stefan-Boltzmann Law to calculate the radius of the star.

2 Write-Up

Include the following sections. Submit report as a PDF via email or google classroom; Google docs links will not be accepted. Include a single .py file (*not Jupyter or Colab format*) with your code. LaTeX is encouraged but not required.

2.1 Hua

Introduce the relevant theory and the purpose of the lab. Why is it interesting to learn about stellar properties?

2.2 Haʻalele

Describe the data, referring to the databases you used. Discuss how you obtained it. Include your plots of flux density for each star.

2.3 Huakaʻi

Describe your analysis procedure, including methodology for determining temperature and stellar radii.

2.4 Hūʻina

Discuss your results and compare with what your classmates found. Report your temperatures and compare to the expected values and the sunʻs temperature. Report your radii and compare to the sun's radius. Compare to the scientific literature: are these stars typical? What different evolutionary stages do they represent?

2.5 Hāʻina

Reflect on your findings. For example, how close did you get to the expected answer? How well are the SEDs fit by the Planck function, and can you think of any reasons for discrepancies? Make sure you report assumptions that are made in this lab, and discuss what you could do in future work to improve your results.