SEDs - A Tool For Exploring Spectral Energy Distributions in the Classroom

Darryl Stanford[1], Sally Seebode[2], D. Drumheller[1], Steve B. Howell[4], D. W. Hoard[5]

Students: Katherine Hsu[2], Nathan Mooney[3], Ali Emami[3]

[1]College of San Mateo, [2]San Mateo High School, [3]Hillsdale High School, [4]NOAO, [5]Spitzer Science Center.

Introduction

The calculation of spectral type, temperature, radius and distance is often the first step in the study of stars and stellar systems. Spectral energy distributions or SEDs are of paramount importance in the determination of these quantities. We have created an innovative tool that enables high school and college physics and astronomy instructors and their students, to evaluate these parameters. This tool includes templates of main sequence stars with spectral types from O5 to M5 and associated lesson plans. Instructors can use it in a classroom setting and design lab exercises around it. Students can use it for research, determining stellar radii, distances, as well as cluster membership of stellar samples.

More complex, multi-component SEDs can be used to investigate stellar systems, with dust disks, as well as the dusty nuclei of starburst galaxies. Instructions and a link to the tool in Google Documents format is downloadable and modifiable by interested parties, at the College of San Mateo astronomy website (http://collegeofsanmateo.edu/astronomy/seds.asp). Teachers and students can add template data for other spectral types and luminosity classes, for their own projects. This study is part of the NASA/IPAC Teacher Archive Research Project (NITARP).

Background

A spectral energy distribution (SED) is a graph of the energy emitted by a star as a function of wavelength. For many stars, the SED resembles a blackbody curve and can be estimated by spectral or photometric observations that cover a broad wavelength range. Stars with different temperatures have different SEDs; Hotter stars emit more light at shorter wavelengths than cooler ones.

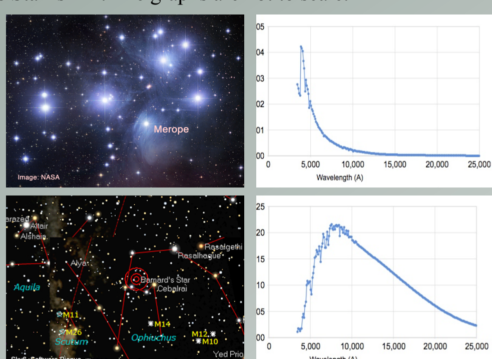
In this poster, we show examples for studying SEDs in a college or high school environment. In part 1, the relationship between stellar flux and wavelength is observed. Part 2 shows how distance can be determined by comparing a template star of known distance, to a target star. Using information learned in parts 1 and 2, this procedure can be expanded by teachers and students to include multi-component SED projects, such as drawing conclusions about star cluster membership.

SMHS student Katherine Hsu

SEDs Part 1

Introduction: This lab familiarizes students with spectral types (O5, B0, B5, A0, A5, F0, F5, G0, G5, K0, K5, M0, and M5) by comparing SEDs and temperatures. Students learn to identify a star's spectral type.

Below are two graphs representing this process. This first shows the B star Merope in the Pleiades, with its SED. The second plot shows an early M star. Barnard's Star is M4. The graphs are not to scale.



Notice the different shapes of the SEDs and the wavelength maximum. Standard temperatures and radii are also given in the program.

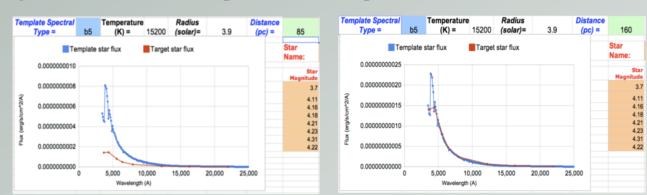
Results

Students are able to determine a target star's spectral type and distance, by iteratively adjusting spectral type and distance parameters, until the best possible fit is made between the target and template SEDs. As the table shows, students' data compares favorably with that obtained from Simbad. As an added benefit, students gain further insight about Wien's and Stefan-Boltzmann's Laws. Wien's Law explains the shift of the SED peak to shorter wavelengths as temperature increases, while Stefan-Boltzmann's Law explains the growth in height of the SED curve as temperature increases.

SEDs Part 2

Introduction: For stars of a particular spectral type, the farther away a star is the fainter it will appear to an observer. In this section students will match stellar template SEDs to an unknown star's observations. Students will learn how a star's distance affects its brightness via the inverse square law.

Below are two graphs, one represents a poor match between template and target star, while the other presents an acceptable match.



In the first SED, the template star (blue) is too close, 85 pc, and the blue line dominates the graph. The second SED has moved the template star to 160 pc and the two SEDs align nicely. This means the target star (red) is likely to be 160 pc from Earth.

Stars currently available for study in the SEDs database include Electra, Delta Cas, Gliese 876, Iota Psc, 55 Cnc, and Lambda Tau. Students and teachers can add additional stars for further investigation.

Star	Spectral Type Student Determined	Distance Student Determined	Distance From Simbad	Spectral Type From Simbad
Lambda Tau	B5	116-125	125	B3
Electra	B5	125	125	B6
Delta Cas	A5	19	31.2	A5
Alhena	A0	33	32.25	A0
HD5351	K5	31	24	K4
55 Cnc	G5	18	12.6	G8
HD187123	G5	47	34.8	G5
Gliese 876	M5	8.3	4.7	M4
Iota Psc	F5	18	13	F7

Simbad is an astronomical database: http://simbad.u-strasbg.fr/simbad/sim-fbasic
Temperatures and radii source: "Astrophysical Quantities" edited by A. Cox