Observational laboratory, Assignment 1
Due date: March 22, 2017

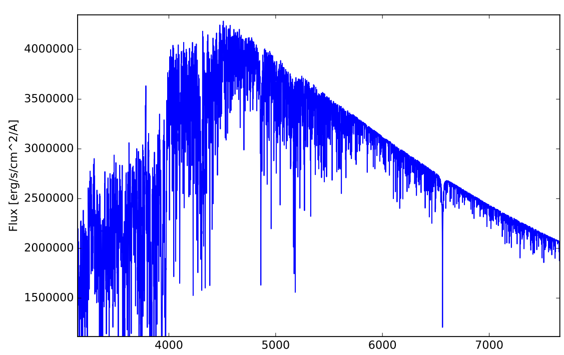
Given your education so far, you may have got the impression that stars are described well by the blackbody approximation; it is time to dispell that myth. In this exercise we will also make sure that we understand the Stefan-Boltzmann law, the Wien law, and color indices. So let's get started.

Blackbody radiation is described by the Planck curve:

$$B_\lambda(T) = \frac{2\pi hc^2}{\lambda^5} \frac{1}{\exp\left(\frac{hc}{\lambda kT}\right) - 1},$$

where T is the effective temperature, h is the Planck constant, c is the speed of light, k is the Boltzmann constant and λ is wavelength.

The *true* spectral energy distribution (SED) is obtained by using complex numerical algorithms that partition the photosphere of the star into a multitude of layers and solving the radiation transfer equations. These SED models also include tens of millions of atomic and molecular spectral lines that are superimposed on the continuum. This is an expensive numerical process that is impractical to do on the fly; for that reason, theoretical SEDs are often stored in lookup tables and interpolated to the needed atmospheric parameters (effective temperature, surface gravity, heavy metal abundance, rotational velocity). The figure below depicts a part of the solar-like spectrum computed by using the Castelli & Kurucz model atmospheres.



A synthetic spectrum of a Sun-like star. The units on the ordinate are $\mathrm{erg/cm^2/\mathring{A}/s}$. Refer to your class notes for the explanation of the units.

On the course homepage you will find this and several other spectra in digital form. The files contain two columns: wavelength in $\mathring{A}$ and flux in $\mathrm{erg/cm^2/\mathring{A}/s}$. Grab those files and do the following.

1. Figure out the unit mismatch. We are plagued by the imperial system here while all SI constants are . . . well, in SI, which means metric. So work out the conversion factors from imperial to metric and do all other problems below in metric.

2. Compare the shape of the model spectrum with the prediction of the blackbody approximation for several temperatures. Comment on any discrepancies. Do some sleuth work and *identify* those features in the spectrum. What underlying physical mechanism causes those discrepancies?

3. Compare the prediction of the Stefan-Boltzmann law with the integral of the model atmosphere. Note that the synthetic spectrum is given on the wavelength range 900–40000$\mathring{A}$. While very wide, this is not quite bolometric. Comment on the difference.

4. Compare the prediction of the Wien law with the derivative of the model atmosphere. Comment on the difference.

5. When doing photometry, one of the most useful tracers is the color index. It relates the amount of light received from the star in, say, visual (V) band, to the amount of light received in, say, blue (B) band, $B - V$. On `http://ulisse.pd.astro.it/Astro/ADPS/index.html` you will find the Asiago Database of Photometric Systems (ADPS). Download transmission curves for Johnson B and V passbands and compute the integrated photometry and color indices for the provided spectra. Comment on the results.

6. *Extra credit:* You may notice that the $B-V$ values you got are nowhere near the values quoted in the literature. Why is that? Among other spectra there is a model spectrum of Vega, the calibration standard for most photometric systems. All color indices are *by convention* set to 0 for Vega. Derive the zero-point color offset for $B - V$ and use it to correct for the obtained color indices in the previous task. You will notice that the match is much better now. Read the IAU resolution B2 adopted in 2015 (`https://arxiv.org/abs/1510.06262`) and comment on it based on what you learned.