Astr 8000 – Problem Set #3
Due Thursday, April 11, 2019

1. Compare the expected UBV colors for black bodies and Kurucz model fluxes in this question.

   a. Compute the predicted UBV color indices, $B-V$ and $U-B$, for a black body using (Gray, Chapter 1):

$$B - V = -2.5 \log \left(\frac{\int F_\lambda W_B(\lambda) d\lambda}{\int F_\lambda W_V(\lambda) d\lambda} \right) + 0.710$$

$$U - B = -2.5 \log \left(\frac{\int F_\lambda W_U(\lambda) d\lambda}{\int F_\lambda W_B(\lambda) d\lambda} \right) - 1.093$$

   Copy from the class Web site the file `ubv.dat` that gives a table of the UBV response functions $W(\lambda)$. For each filter the columns list the wavelength, percentage transmission (use these), and transmission normalized to unity at maximum (ignore). You may wish to use the function `planck.pro` in the IDL Astronomy Library to calculate the Planck curve in the wavelength ranges of these filters. Plot your results in the $U-B$ versus $B-V$ diagram for a grid of temperatures from 4000° to 50000°. Note: these diagrams are traditionally plotted with bluer colors to the left in $B-V$ and to the top in $U-B$. Add tick marks to indicate the positions for temperatures of 5000°, 10000°, and 20000°.

   b. Get the predicted colors from the Kurucz model atmospheres from the file `kurucz.colors` posted on the class Web site. Select models for $\log g = 4.5$ (main sequence values). Plot the Kurucz colors on the same graph as produced in part (a), and again indicate the positions for temperatures of 5000°, 10000°, and 20000°. How and why do the Kurucz and Planck curve colors differ?

   c. Interstellar reddening tranforms both color indices along a line with slope 0.72. Make a plot of the Kurucz $U-B$ versus $B-V$ values for no reddening (solid line) and $E(B-V) = 0.5$ (dotted line). Draw on your plot the region where reddening lines cannot be extrapolated back to a single temperature point (i.e., where the reddening line may intersect the main sequence curve in more than one place). In what temperature ranges are there never any ambiguities about the dereddened color of the star? [40]

2. Create an atlas of classification dispersion spectra from the spectral catalogue of Jacoby et al. (1984, ApJS, 56, 257). You can read these and make plots (using the IDL program rjacoby.pro, which is available at the class Web site). Please select one star each from the O - M main sequence stars, plus one G-supergiant and one M-supergiant. Mark on each of these plots two of the prominent features described in the notes from Nancy Houk that I handed out in class. [30]

3. Construct a graph of the positions of the echelle orders on the focal plane for the CCD Echelle Spectrograph on the KPNO 4-m telescope. Use the information at
`http://www.noao.edu/kpno/manuals/echman/node16.html`
on the 79-63° echelle, long focus camera, and 226-1 cross disperser. Determine what echelle orders cover the range between 3500 and 8000 Å. Then determine the nominal limits of the free spectral range for each order (wavelengths corresponding to $m \pm 0.5$). Use the dispersion in each echelle order to determine the x-offset position for these wavelengths, and then use the dispersion for the cross disperser to find the y-offset positions. Show your results in a (x, y) graph which illustrates the line segments for each echelle order. Label the starting and ending wavelengths for each order. [30]