PHYS 6980/8980 — Spring 2006

Homework Assignment 1

1. In the course file folders on MyUT you will find a Ritter échelle spectrum of the A0Ib supergiant star η Leo (HD 87737). Aperture 8 shows the star's Hα profile, which has been normalized to the continuum. Most of the weaker, narrow lines are due to telluric water vapor, but a few are of stellar origin.

   In the same folder, you will find a set of 6 synthetic Hα profiles computed with a standard model atmosphere code by Munari et al. (2005).[1] The file names and the image headers give the effective temperature and the $\log g$ value. All have a microturbulence parameter of 2.0 km s^{-1}. The ranges of temperature and gravity were chosen with preliminary, approximate knowledge of the results.

   The same files can also be found in `/mnt/vol01/ndm/PHYS6980`. If you are running IRAF on astro1, copy them from this path to your own iraf directory.

   This star was chosen for this exercise in part so that Hα would be narrow enough to fit within the observed spectral range. Nevertheless, the synthetic spectra show that the continuum is not quite reached within the observed range, and therefore the normalization placed the continuum too high. The normalized spectrum has been multiplied by a factor of 0.988 to compensate.

   In IRAF, overplot the synthetic profiles with the observed profile, decide which one matches it best, and estimate the effective temperature and gravity of the star. Concentrate on the fit in the wings; the synethetic spectra do not fit the line core well, for several reasons. Comment on the sensitivity of this line to effective temperature and gravity.

   Venn (1995)[2] derived a microturbulence parameter of 4.0 km s^{-1} for this star. If our synthetic profiles had been calculated with a microturbulence parameter of 4.0 km s^{-1} instead of 2.0 km s^{-1}, what differences would you expect?

2. Modern values of the basic properties of the Sun[3] (G2V, assumed error-free) and Sirius[4] (A1V, with estimated errors) are tabulated below (on back).

   (a) Calculate the luminosity, radius, and mass of Sirius in solar units; that is, calculate $L/L_\odot$, $R/R_\odot$, and $M/M_\odot$.

   (b) Using the standard rule for error propagation, calculate the errors in $L/L_\odot$, $R/R_\odot$, and $M/M_\odot$. The standard rule is, for the error in a function $f(x, y)$ resulting from independent, random errors δx and δy in the independent variables x and y:

   $$\delta f = \left[\left(\frac{\partial f}{\partial x} \delta x \right)^2 + \left(\frac{\partial f}{\partial y} \delta y \right)^2 \right]^{1/2}$$

   The take-home lesson here is that, even with highly precise values (by astrophysical standards) of $T_{\rm eff}$, $\log g$, and distance, the mass derived from them by this, the traditional method, is quite uncertain. The mass of Sirius is much better known from its binary orbit.

[1] `http://archives.pd.astro.it/2500-10500/`; Munari, U.; Sordo, R.; Castelli, F.; and Zwitter, T. 2005, A&A, **442**, 1127

[2] Venn, K. 1995, ApJ, **449**, 839

[3] *Allen's Astrophysical Quantities* (*AQ*), 4th ed., ed. A. N. Cox (2000, AIP Press and Springer) p. 382

[4] Kervella, P.; Thévenin, F.; Morel, P.; Bordé, P.; and Di Folco, E. 2003, A&A, **408**, 681, "The interferometric diameter and internal structure of Sirius A"

Fundamental Stellar Parameters

Parameter	Sirius	Sun
Parallax π (milliarcsec)	379.22 ± 1.58	$\ldots$
V (mag)	-1.47 ± 0.01	-27.3
$T_{\rm eff}$ (K)	9900 ± 200	5777
$\log g$	4.3 ± 0.1	4.44
BC (*AQ*, p. 388)	-0.25	-0.20
$M_{\rm bol}$	TBD	4.74