Ay 122a Fall 2012 – HOMEWORK #1

Due Friday October 26, 5pm Mislav's mailbox in 249 Cahill

1. Simple Extinction Consider the atmosphere of the Earth as a plane-parallel absorbing medium (ignore any emission and also line absorption). A particular star, seen overhead on a given night, has an apparent magnitude $m_V = 3$ mag. After several hours the same star is at a zenith angle θ=60° and has an apparent magnitude m_V=3.1086. Assuming that the atmosphere is uniform and static, calculate:

- The vertical optical depth τ_o at zenith.
- The true apparent visual magnitude of the star (i.e., above the atmosphere).
- If it is an A0 star (Like Vega, so roughly colorless on the Vega magnitude system) star, what apparent magnitudes would be recorded with your instrument at 3600Å, 4400Å, 7000Å, and 10,000Å assuming the Palomar extinction coefficients derived by Hayes & Latham 1975, Ap.J. 197, p597?

2. Which Way Is Up? You are observing a star cluster with position RA= $18^{\rm h}$, Dec= $-30°$ as it transits through the local meridian, midnight local time. (a) What is the local siderial time? (b) What day of the year is it? (c) What is the approximate universal time (assume that you are in California)? (d) Can you do this from Palomar anyway (Palomar's latitude is $+33°21'\ 21''$ (e) What is the RA of the Sun at that moment? (f) What are the Galactic coordinates of this source?

3. Thinking Big... Suppose you are put in charge of designing a 30m optical/IR telescope, and that the baseline configuration is a Ritchey-Chretien design with with a primary focal ratio of f/1.0. Suppose that the final ratio at the R-C focus is f/15 (this would probably be a Nasmyth focus for this telescope). What will the plate scale be at the f/15 focus (in arc-seconds per millimeter)? The natural size of the field for this design is about 20 arc minutes in diameter with good images (astigmatism is the main optical aberration for R-C designs). What is the *physical* size of the focal plane? Comment on what this means for instruments placed at f/15 that desire to use a substantial fraction of the field. Approximately how large would the secondary mirror have to be to provide the above prescription?

4. Coma As You Are The Palomar 200-inch (5m) Hale telescope has a focal ratio at prime focus of f/3.5. The conic surface of the P200's primary mirror is a paraboloid (the best one could do 70-80 years ago), which produces good images on-axis but the image quality degrades rapidly with field angle, due primarily to coma. In general, for a parabolic mirror with focal ratio f and and diameter D, the physical size of the coma at a physical distance h off–axis in the focal plane is given by $C \approx 3h/16f^2$. In typical seeing conditions, what then is the *angular* size of the useable field of the Palomar 200-inch prime focus before coma begins to cause significant degradation of the images? Please state any assumptions that you make in answering.

5. Sensitivity Training Suppose that you are observing faint stars, and you are well into the background-limited regime– i.e., source counts << background counts in the aperture used for measurement). Quantify how the limiting sensitivity depends on the FWHM of the seeing profile (you may define limiting sensitivity in any reasonable way, as long as you justify and decribe it). How does the limiting sensitivity (for point sources) scale with integration time? Suppose instead that you are detector-limited (i.e., detector read noise dominates over all other sources)–what are the scaling relations with FWHM and integration time? Please state any assumptions you make.