Homework 1 - Astro 335 Cosmology
February 1, 2002; Due in class Friday, February 8.

1. (This problem gives you a chance to enhance your skills in working with astronomical magnitudes. Unfortunately, its based on real life experiences of your professor.)

A. Theoretical stellar structure models show that a star with $60 \, M_\odot$ produces radiates about 530,000 $L_\odot$ when it first begins hydrogen burning on the main sequence. Using Table 1.3 from S & G (on the class hand-out), estimate the spectral class and absolute visual magnitude of this star.

As a member of a team that is studying stellar populations in galaxies with the Hubble Space Telescope Advanced Camera for Surveys, ACS (pronounced “aces”), you know that you can photometer stars to $V=28$ (Vega system). You assume that your target has an extinction of $E(B-V)=0.3$ mag. What is the maximum distance where you could successfully make a photometric measurement of a $60 \, M_\odot$ star on the zero age main sequence?

B. Due to your success with your HST project you are asked to work with a team proposing new instruments for the Next Generation Space Telescope; NGST. You are asked to check if typical Cepheid variable stars with $M_H \approx -5$ (Vega system) can be observed in galaxies near the Coma cluster of galaxies ($D=100$ Mpc) with your proposed infrared camera on the NGST. Model calculations show that this camera should measure stars with $H_{AB} = 31$ with sufficient precision to allow distances to be determined from Cepheid variables. Explain your answer.

2. A main sequence fitting distance to the Magellanic clouds. Figure 1 below shows the observed CMD for the Hyades based on Hipparcos parallaxes for an assumed distance of 45 pc. Figure 2 is a similar color-magnitude diagram for a star cluster in the Large Magellanic Cloud (LMC) based on observations made with the Wide Field Planetary Camera 2 (WFPC2) on the HST. Assuming a total extinction from the Galactic foreground and within the LMC of $E(B-V)=0.1$ mag, estimate the true distance and distance modulus of the LMC and email your result to me by Thursday evening, Feb 7. We will then look at and discuss the distribution of distances in class on Feb 8. (So please make your own measurements.) Explain the process that you adopted and what you would estimate for your errors.

3. Figure 3 shows the I-band P-L relationship for LMC Cepheid stars. Caution: the log(P) scale is offset for each bandpass.) In Figure 4 we present results from WFPC2 observations of the spiral galaxy M100 which is in the outskirts of the Virgo cluster of galaxies. Using your distance estimate to the LMC from problem 2, find a distance and its estimated error for M100. Then assuming that the spiral galaxy M100 is at the same distance as the Virgo cluster and a “corrected” (we will discuss these corrections in Unit 3 of our course) Virgo redshift of 1300 km/s, derive your estimate of the Hubble constant, $H_0$ and its error.
Fig. 13. Colour-absolute magnitude diagram for 92 high-fidelity members (Sect. 9.3). This sample excludes all mem-

Fig. 1.— Hyades main sequence based on Hipparcos measurements (Bruijne, Hoogerwerf, & de Zeeuw 2001, A&A 367, 111).
Fig. 2.— Color magnitude diagram for a star cluster in the LMC (Brocato, Di Carlo & Menna 2001, A&A, 374, 523).
Fig. 3.— Cepheid period-luminosity diagrams for the LMC (from Madore & Freedman 1991, PASP, 103, 933).

Fig. 4—Magellanic Cloud Cepheid period-luminosity relations at seven wavelengths, from the blue to the near-infrared, constructed from a self-consistent data set (Freedman & Madore 1992). LMC Cepheids are shown as filled circles; SMC data, shifted to the LMC modulus, are shown as open circles. Note the decreased width and the increased slope of the relations as longer and longer wavelengths are considered.
Fig. 4.— Period-luminosity relationship observed in the spiral galaxy M100 with WFPC2 in the Vega-system I-band (Ferrarese et al. 1996, ApJ, 464, 568).

Fig. 4.— Period-luminosity relationship for the sample of Cepheids listed in Table 5. For reasons discussed in the text, only the Cepheids with periods between 8 and 70 days are plotted. The solid line represents the best unweighted fit to the Cepheids with periods between 20 and 70 days, using phase weighted mean magnitudes, and corresponds to an apparent distance modulus of $31.18 \pm 0.05$ mag. The dashed lines, drawn at $\pm 0.36$ mag, reflect the finite width of the Cepheids instability strip, and thus the expected intrinsic $2 \sigma$ scatter around the best-fitting PL relation. The three points plotted as open circles mark outliers falling more than $4 \sigma$ away from the mean, in either the $V$ or the $I$ PL plots.