Term Project # 1

Galactic Astronomy (Astr 511); Winter Quarter 2015
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The data file Astr511HW1data.dat (linked to class webpage as a gzipped file) contains SDSS measurements for about 600,000 stars with $b > 80°$ (i.e. within $10°$ from the north galactic pole) and $14 < r < 21$. The data are listed as one line per star, with each line containing the following quantities:

- **ra dec:** right ascension and declination (J2000.0) in decimal degrees
- **run:** SDSS observing night identifier
- **Ar:** the value of the r band ISM extinction used to correct photometry (adopted from the SFD maps; for bands other than r standard SDSS coefficients are used)
- **u g r i z:** SDSS photometry (corrected for the ISM extinction)
- **uErr gErr rErr iErr zErr:** photometric errors
- **pmL pmB:** proper motion vector components in the longitudinal and latitudinal directions (mas/yr); set to 999.99 when no measurement is available
- **pmErr:** mean proper motion error (mas/yr); set to 999.99 when no measurement is available

For stars from this file, compute absolute magnitude using a photometric parallax relation, $M_r(g-i, [Fe/H])$, given by eqs. A2, A3 and A7 from Ivezić et al. 2008 (ApJ, 684, 287). For computing metallicity, $[Fe/H]$, instead of their eq. 4, use an updated expression from Bond et al. 2010 (ApJ, 716, 1):

$$[Fe/H] = A + Bx + Cy + Dxy + Ex^2 + Fy^2 + Gx^2y + Hxy^2 + Ix^3 + Jy^3, \qquad (1)$$

with $x = (u-g)$ and $y = (g-r)$, and the best-fit coefficients $(A–J) = (-13.13, 14.09, 28.04, -5.51, -5.90, -58.68, 9.14, -20.61, 0.0, 58.20)$. This expression if valid only for $g - r < 0.6$; for redder stars use $[Fe/H] = -0.6$.

Since $b > 80°$, for these stars the distance from the galactic plane, Z, and the distance from us, D, are approximately the same. Using $Z = D$, where D is computed from $r - M_r = 5 * \log(D/(10\text{pc}))$, do the following:

1. For stars with $0.2 < g - r < 0.4$, plot $\ln(\rho)$ vs. Z, where ρ is the stellar number density in a given bin (e.g. look at Figs. 5 and 15 in Jurić et al. 2008, ApJ, 673, 864 for similar examples). You can approximate $\rho(Z) = N(Z)/V(Z)$, where $N(Z)$ is the number of stars in a given bin, and $V(Z)$ is the bin volume (note that the solid angle is $\Delta\Omega \sim 314$ deg°). What is the Z range where you believe the results, and why?

2. Add $\ln(\rho)$ vs. Z for stars with $0.4 < g - r < 0.6$, $0.6 < g - r < 0.8$, and $0.8 < g - r < 1.0$ (you can rescale all curves to the same value at some fiducial Z, or leave them as they are). Discuss the differences compared to the $0.2 < g - r < 0.4$ subsample. Why do we expect larger systematic errors for $0.8 < g - r < 1.0$ than for the adjacent bin with $0.4 < g - r < 0.6$?

3. For subsample with $0.2 < g - r < 0.4$, separate stars into low-metallicity sample, $[Fe/H] < -1.0$, and high-metallicity sample, $[Fe/H] > -1.0$. Compare their $\ln(\rho)$ vs. Z curves. What do you conclude?

4. For these low-metallicity and high-metallicity samples, plot and compare their differential r band magnitude distributions (i.e. the number of sources per unit magnitude, in small, say 0.1 mag wide, r bins). What do you conclude? How would you numerically describe these curves (i.e. what kind of functional form for the fitting functions would you choose)?

5. What should be the faint r band limit for a survey to be able to map the $\ln(\rho)$ vs. Z profile out to 100 kpc using main-sequence stars? Assume the same color distribution as for the SDSS sample. For a solid angle of 1 deg^2, how many stars with $0.2 < g - r < 0.4$ would you expect with distances between 90 kpc and 100 kpc? Assume whatever additional information you need to solve this problem (not all required information is provided here).