Howework # 3, due Mar 10

ASTR 511: Galactic Astronomy, Winter 2009

The data file Astr511HW3data.dat (linked to class webpage as a gzipped file) contains SDSS photometric measurements for about 900,000 stars from the so-called Stripe 82[1]. This sky area is defined by $|Dec| < 1.267°$ and $-66° < RA < 73°$. The catalog includes all sources from Stripe 82 that satisfy the following criteria:

1. Unresolved source in imaging data
2. Processing flags BRIGHT, SATUR, BLENDED, or EDGE are not set
3. At least 4 observations in ugr bands
4. Flux limit: $u < 22$
5. Color selection of F/G stars: $0.6 < (u-g) < 2.2$ and $0.2 < (g-r) < 0.6$ and $0 < 0.50(u-g) - (g-r) + 0.05 < 0.5$
6. Non-variable: $\chi^2_{pdf} < 10$ in the g band

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
- **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 (already corrected for the ISM extinction)
- **uErr gErr rErr iErr zErr:** photometric errors

For stars from this file, compute absolute magnitude and distance 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. (in prep.):

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

[1] For details see http://www.astro.washington.edu/users/ivezic/sdss/catalogs/stripe82.html

with $x = (u - g)$ and $y = (g - r)$, and the best-fit coefficients $(A\text{–}J) = (-13.13, 14.09, 28.04, -5.51, -5.90, -58.68, 9.14, -20.61, 0.0, 58.20)$. Yes, these are the same expressions as in Homework 1, and you can (and should) recycle your code.

Given the position and distance, we can now make various metallicity maps. Because this is coadded data, it extends about a factor of two further in distance than the sample analyzed in Ivezić et al. (2008). If we get something interesting, perhaps we could publish a paper together as a class!

Split the sample into four subsamples using 0.1 mag wide bins of $g-r$ color (from 0.2 to 0.6). For each subsample make the following polar plots[2] ($X = D\sin(RA)$, $Y = D\cos(RA)$; also, in all plots draw lines of constant galactocentric cylindrical radius of 10, 15 and 20 kpc, and constant distance from the galactic plane, $|Z|$, of 5, 10 and 15 kpc):

1. Plot the $\ln(N/D)$ map, where N is the number of stars in a given $X - Y$ bin (pixel), and D is the median distance to all stars in that pixel. This quantity is proportional to the local stellar number density (because the "third" coordinate is defined by the SDSS scan width of $\sim$2.5°). Is it consistent with the model from Jurić et al. (2008, ApJ, 673, 864)? Are there unexpected features, suspected data artefacts, etc?

2. Plot the median $[Fe/H]$ map. Is it consistent with the model from Ivezić et al. (2008, ApJ, 684, 287)? Are there unexpected features, suspected data artefacts, etc?

3. Plot the map for $[Fe/H]$ root-mean-square (rms) scatter per pixel. Is the rms scatter constant? If not, think of an explanation for the observed variation.

4. Plot the skewness map for $[Fe/H]$ (the skewness for small samples is defined in eq. 2 from Sesar et al. 2007, AJ, 134, 2236). Is your map consistent with a Gaussian distribution of $[Fe/H]$?

5. Think of a method/metric/statistic for finding deviations from Gaussianity and make a map! Did you find any deviations? Streams, bad data, other junk?

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[2] X and Y have nothing to do with Galactic X and Y coordinates seen in some figures from the lectures; X and Y here are simply convenient projection coordinates for stripe 82 geometry.