A404 (Stellar Astrophysics) **Homework Assignment 4**
March 16, 2018 (due March 30, 2018)

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1. Use the "cleaned" HST ACS photometry data from the website `http://astrowww.phys.uvic.ca/~dpa/A506_StellarPops.html` for the globular clusters M3 (NGC 5272) and M13 (NGC 6205) to plot their CMDs using your favorite plotting software. Note the difference between morphologies of their HBs. This is a manifestation of the second parameter problem, when two globular clusters with a same [Fe/H] have different HBs. Its possible solutions are differences in the age or in the initial helium mass fraction.

2. Use the theoretical ZAHB from the same website to estimate the apparent distance moduli $(m-M)_V$ for the clusters. Try different values of $(m-M)_V$ to transform the apparent `F606W` magnitudes of the observed CMDs to the absolute magnitudes until the ZAHB fits the bottom of the observed HB.

3. Use the Victoria-Regina software to prepare and select isochrones that are best fitting the MSs, MSTOs and subgiant branches of M3 and M13 (neglect a small disalignment of the RGBs). Assume that $[\mathrm{Fe/H}] = -1.55$, $[\alpha/\mathrm{Fe}] = +0.4$ and $Y = 0.25$ for both clusters. To generate isochrones for the (`F606W`,`F606W-F814W`) plane, you will need to prepare BC tables `bc_std.data`, `bc_p04.data`, `bc_p00.data` and `bc_pm04.data` for all of the four choices of the $[\alpha/\mathrm{Fe}]$ variations available in `selectbc.data` for the corresponding photometric bands and $E(B-V) = 0.0$. This can be done with the MARCS BC software (see the reference on the website). When fitting the isochrone, use your estimated $(m-M)_V$ value, while varying the colour excess $E(B-V)$.

4. Use the found apparent distance moduli $(m-M)_V$ and reddenings $E(B-V)$ to first calculate the true distance moduli and then the distances to M3 and M13. Compare your values of $(m-M)_V$, $E(B-V)$ and distances for M3 and M13 with those from the catalogue `http://physwww.physics.mcmaster.ca/%7Eharris/mwgc.dat` (they don't necessarily have to be precisely the same). (Note that $A_{\mathrm{F606W}} = 2.876E(B-V)$ from Table A1 of Casagrande and VandenBerg.).

5. Mark the major evolutionary phases along the plotted isochrones and CMDs.

6. The MS lifetime of a star with the initial mass M and chemical composition close to that of M3 stars can be approximated as

$$\log_{10} t_{\mathrm{MS}}(\mathrm{yr}) \approx 0.8192 \log_{10}^2 M - 3.168 \log_{10} M + 9.705.$$

For the Salpeter IMF, $dn = C\, M^{-2.35} dM$, estimate the fraction of M3 stars that have already completed its MS evolutionary phase.