Fall 2016 Astro 250: Stellar Populations

Instructor: Dan Weisz (dan.weisz@berkeley.edu)

Problem Set 5 – Unresolved Nearby Galaxies

Assigned: 11/7/16
Due: 11/21/16

Please complete the problems using your github repository.

This problem set will make use of data from GALEX UV survey of nearby galaxies presented in http://adsabs.harvard.edu/abs/2011ApJS..192....6L. You can download a summarized data set here: https://github.com/dweisz/ay250_fall2016/blob/master/problem_sets/ps5.data.

The columns in the data file are:

1. Galaxy Name
2. RA
3. DEC
4. Distance (Mpc)
5. Apparent B-band (AB mag)
6. Morphological Type Number (see https://en.wikipedia.org/wiki/Galaxy_morphological_classification)
7. Milky Way Foreground E(B-V)
8. Apparent FUV (AB mag)
9. Apparent FUV error (AB mag)
10. Apparent NUV (AB mag)
11. Apparent NUV error (AB mag)

Values of 99.999 mean there is no data. There are no formal uncertainties attached to the B-band magnitudes. It would be fair to assign them random Gaussian uncertainties of order 0.1 mag.

Using the above data, this problem set explores the relationship between galaxy SFR, stellar mass, and metallicity.

Problem 1. UV Star Formation Rates

(a) Derive a relationship between a galaxy's intrinsic far-UV luminosity and SFR using `python-fsps`, i.e., $\dot{M}_\star$ ($M_\odot$ yr^{-1}) = $\log(L_{FUV}) - \log(C_{FUV})$ (Equation 12 in Kennicutt & Evans 2012). Assuming a constant SFH over the history of the Universe, a fully populated Kroupa IMF, and a single (solar) metallicity, find the value of C_{UV}.

Some potentially useful quantities:

- An AB magnitude reflects a specific flux: F_ν
- $L_\odot$ = 3.846e33 erg/s
- 1 pc = 3.085677581467192e18 cm
- AB magnitude zero point: $m_{ab,0} = -2.5\log_{10}(3631 \times 10^{-23})$
- h = 6.6260755e-27 erg s
- c = 2.99792458e18 Å/s

Hint: Be careful with unit conversions. It may be helpful to write the flow of this problem out on paper before coding it up.

(b) How does your value of C_{FUV} compare to the value listed in Table 1 of Kennicutt & Evans (2012)? Why might there be differences?

Problem 2. Stellar Mass

It is possible, although not ideal, to use B-band luminosity as a proxy for a galaxy's stellar mass. Adopting the same assumptions as in Problem 1 (a) (e.g., constant SFH, IMF), use `python-fsps` to determine a relationship between absolute B-band magnitude and total stellar mass. Make a plot that shows this theoretical relationship of M_B vs. $M_\star$ (or $\log(M_\star)$). Why is B-band not a great proxy for a galaxy's stellar mass?

Problem 3. Metallicity

Determine values of M_B for all galaxies in your sample. Using the luminosity-metallicity relationship from Berg et al. (2012), convert M_B to a metallicity (i.e., 12 + log(O/H)) for each galaxy. Plot the distribution of metallicities for galaxies in the sample.

Problem 4. Trends in SFR, Mass, and Metallicity

(a) Make a plot showing SFR_{FUV} vs. $M_\star$ (or $\log(SFR_{FUV})$ vs. $\log(M_\star)$) for galaxies in the sample.

(b) Use `emcee` to fit a simple functional form (e.g., line, quadratic) to the linear-linear or log-log data from part (a). Make the usual diagnostic plots (e.g., triangle plot) and overplot draws from your posterior on the real data.

(c) Repeat parts (a) an (b) only for metallicity instead of stellar mass.

Problem 5. Caveats

Briefly comment on limitations of the above analysis. Pay particular attention to what assumptions you made in your analysis might be problematic and suggest how they might be remedied. Along the same lines, what data would improve determination of the SFR-mass or SFR-metallicity relationships for this sample and why?