Phys239 - Homework 4

Lindsay Ng Lowry

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1. Question 1 - see code

2. Question 2 - *For all plots, the M82 data is plotted in green and the individual component contributions are plotted in blue.

   (a) Starlight

   - Used spectra from the 1999 data set on the STSCI website. I used data that assumed instantaneous star formation, redshift of 0.001, and time of 500 Myr.
   - All spectra from this data set peak at frequencies of about $10^{14} - 10^{15}$ Hz (visible light) which is where I would expect the contribution from starlight to be. However, this does not match the peak in the M82 data which corresponds to the only part of the spectrum not accounted for by parts (b), (c), and (d). I attempted to use simulated data using the Starburst99 program, but found the same results.

   (b) Dust

   - Obtained data on Q_{abs} from https://www.astro.princeton.edu/d̃raine/dust/dust.diel.html and used the PAHion_30 data set assuming a grain size of 3.548e-4 um.
   - Assumed a grain mass density of 4.4e-23 kg/m^3 assuming $\frac{M_{\text{dust}}}{M_{\text{gal}}} \approx 0.01$ (from https://www.astro.umd.edu/r̃ichard/ASTRO620/A620_2015_dust.pdf) and $\rho_{\text{gal}} = \frac{M_{\text{gal}}}{V_{\text{gal}}}$.
   - This spectrum matches the features of the spectrum nicely when scaled appropriately and seems to be dominant at infrared wavelengths ($\approx 10^{13} - 10^{14}$ Hz).

   (c) Synchrotron

   - A power law slope of $p = 2.4$ matches the M82 data.

- Synchrotron emission is dominant at lower frequencies, approximately in the microwave range ($\approx 10^9 - 10^{11}$ Hz).

(d) Free-free

- Used the equation for the free-free spectrum from the class notes.
- The spectrum seems to match the M82 data at higher frequencies assuming a temperature of 10,000 K, but this also seems to make the contributions at lower frequencies too large.
- Free-free emission contributes to the M82 spectrum at higher wavelengths, around the visible ($\approx 10^{14}$ Hz).

3. Question 3 - see code