# AST 381: Planetary Astrophysics

## Homework #3, Due ???

**Reminder: Show your work!** Each part is worth equal weight, and the assignment is worth 100 points in all. **Solutions should be typeset with LaTeX. Hand-written solutions will not be accepted. All code should be posted on github, in such a way that I can access it, and the link should be given in the TeX.**

The goal of this assignment is to build a toy model of a debris ring. We'll be taking several expedient shortcuts along the way, but they shouldn't make too much of a difference for our purposes.

**Part 1:** Write a computer code that takes stellar properties (temperature and radius) as input, and computes the flux density in Jansky (energy per unit time per unit area per unit frequency) at a user-specified orbital radius. That is, it should produce the properly flux-calibrated spectrum that would be seen by a spectrograph with 100% throughput and no slit losses. It's fine to approximate the star as a blackbody. Test it for Fomalhaut, at orbital radii of 10 AU and 130 AU, and plot the resulting spectra.

**Part 2:** Write a computer code that takes the output of Part 1, and calculates the total power absorbed by a dust grain of "astrosilicate" if it has a size of 0.1 microns, 1 micron, or 10 microns, or by a perfect absorber with a radius of 1 millimeter. You can find dust grain models (which specify $Q_{abs}$ as a function of wavelength) here:

`http://www.astro.princeton.edu/~draine/dust/dust.diel.html`

You want the "Smoothed UV Astronomical Silicate" models, and to use the middle link (suvSil_21). Test it on each dust grain type at 10 AU and 130 AU away from Fomalhaut.

**Part 3:** Write a computer code that takes the output of Part 2, and computes the equilibrium temperature and emission spectrum for a dust grain of each size/type. Be sure to appropriately account for the $Q$ term in the emission spectrum as well. Again, test it on each dust grain type and at 10 AU and 130 AU away from Fomalhaut, calculating the temperature and luminosity and making a plot of the spectrum in each case.

**Part 4:** Go dig up an infrared+millimeter SED of Fomalhaut's two (warm+cold) debris belts out of the literature, and compare it to the SEDs computed in Part 3. For each dust grain size/type, how many dust grains are needed to roughly match the observed SED of each component? What is the corresponding dust mass, if you assume the Fomalhaut debris ring is made out of grains of that size and that dust grains have a density somewhere around 2 g/cc? Which dust grain size produces the best fit to the SED shape?

**Part 5:** In class we talked about radiation pressure and Poynting-Robertson drag in terms of ideal blackbodies. However, for previous problems you've already calculated the actual energy absorption and emission of real particles, which should allow you to calculate better versions of each force. For each particle size, calculate the real radiation pressure and Poynting-Robertson drag at each radius. Estimate a characteristic timescale for dust grains of each size to be removed from the system, assuming they start at 10 AU or 130 AU.