Radiative Processes in Astrophysics / Problem Set #2
Due February 24, 2021

Model an interstellar cloud of gas and dust as a uniform, plane-parallel slab 100 pc thick, with a temperature of 50 K, and density dominated by molecular hydrogen with $n \sim 10$ cm^{-3}. (Problem from Aaron Parsons' notes).

1. Dust is typically made of silicate grains with $\rho \sim 3$ g cm^{-3}, $r \sim 0.1$ μ and with a mass fraction of 0.01. What is the number density of the dust grains?

2. Imagine a backlight with $I_\nu = 3 \times 10^{-9}$ erg s^{-1} Hz^{-1} ster^{-1} cm^{-2} at $\nu = 1$ THz (terahertz). Assume the dust perfectly absorbs across its cross-section. Ignoring thermal radiation by the dust, calculate the profile of I_ν through the cloud and the optical depth through the cloud.

3. Add in the thermal reemission. Assume each dust grain radiates as a blackbody with T= 50 K across its geometric cross-section. Calculate j_ν at 1 THz. Find the functional form for and sketch—for the case of *no backlight*—the profile I_ν through the cloud and the calculate the emergent I_ν. Include both emission and self-absorption!

4. Now include the backlight and repeat the previous step.