

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 $n \sim 10 \text{ cm}^{-3}$. (Problem from Aaron Parsons' notes).

1. Dust is typically made of silicate grains with $\rho \sim 3 \text{ g cm}^{-3}$, $r \sim 0.1 \text{ }\mu\text{m}$ and with a mass fraction relative to the gas of 0.01. What is the number density of the dust grains?
2. Imagine a backlight with $I_\nu = 3 \times 10^{-9} \text{ erg s}^{-1} \text{ Hz}^{-1} \text{ ster}^{-1} \text{ cm}^{-2}$ at $\nu = 1 \text{ THz}$ (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 radiation. Assume each dust grain radiates as a blackbody with $T = 50 \text{ K}$ 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 calculate the emergent I_ν . Include both emission and self-absorption!
4. Now include the backlight and repeat the previous step.