Homework Assignment 2

Due: Sep.17

Problem 1 (10 Points)

Instruction: to compute Planck function go to

http://irina.eas.gatech.edu/irina/PlanckFunction.aspx

Derive the asymptotic limit of the Blank function for large wavelengths and estimate its accuracy at several different temperatures.

Problem 2 (20 Points)

The mass absorption coefficient is often used in calculations of IR radiation. This requires a knowledge of the amount of an absorber in [mass] $[length]^{-2}$.

A) Ozone amount is measured in Dobson units. On September 5 over Atlanta, the ozone amount was 277 Dobson units. What was the ozone amount in g/cm^2? What is the optical depth if the ozone absorption coefficient is 0.1 cm^2/g.

B) Water vapor amount is measured in precipitable cm or inches, which is the height of the column of water resulting from condensing all of the water vapor out. At 12 GMT on September 5, the Atlanta radiosonde recorded 0.56 inches. Convert this to absorber amount in g/cm^2 and estimate a monochromatic transmission function at a certain wavelength in the microwave at which the absorption coefficient of water vapor is about 10 cm^2/g.

C) Carbon dioxide concentration is measured in parts per million by volume (ppmv). There are small seasonal and geographical variations and an increasing trend, but the current value is about 370 ppmv (as measured at the NOAA Mauna Loa Observatory, Hawaii). Convert this concentration to an absorber amount in g/cm^2 above the Mauna Loa (3400 m altitude, 680 mb pressure). Under this condition, at what spectral band would you expect to see the largest absorption of CO2?

Problem 3 (30 Points)

The HITRAN database contains information on all gaseous species that are of importance to radiative transfer in the atmosphere. Between 691 cm^{-1} and 693 cm^{-1}, CO2 has two lines with the following parameters from HITRAN:

Line center, ν_0 (cm^{-1})	Line strength, S (cm/molecule)	Air-broadened half-width, α_0 (cm^{-1})	Temperature coefficient , n
691.972498	9.167E-20	0.0684	0.78
692.129032	4.010E-21	0.0686	0.78

a) Calculate and plot the absorption coefficient $k_{a,\nu}$ for these CO2 lines. Consider the Lorenz line shape. What is the relative contribution of each line to the monochromatic absorption coefficient at 692.0 cm^{-1}?

b) Consider a 1 km thick atmospheric layer at standard pressure and temperature. Calculate and plot the CO2 monochromatic optical depth and CO2 transmission function for this layer between 691.0 cm^{-1} and 693.0 cm^{-1}.

c) Perform the above calculations but for a 1 km thick later with P = 0.5 bar. Assume that the CO2 amount remains the same. Explain the differences in transmission functions calculated for (b) and (c) cases.

Problem 4 (30 Points)

The outer atmosphere of Saturn consists of atomic hydrogen H with a very small admixture of atomic deuterium D at very low pressure, and at the temperature of 1000 K. D and H have absorbing lines at 121.533 nm and 121.566 nm, respectively, with the same line intensity.

a) What are the Doppler line widths of H and D lines?
b) At what ratio will there be equal absorption by both gases at the center of the deuterium line?