ASEN 6519. Lidar Remote Sensing

HW Report #2

Please address in your report the following questions concerning physical interactions involved in lidar remote sensing: (mainly based on Lectures 5 and 6)

1. **Light transmission through the atmosphere**: The Rayleigh scattering by air molecules contributes to the light attenuation when light propagates through the atmosphere. Let us calculate the light transmission through the atmosphere from ground (0 km) to 150 km for a 589-nm laser beam if only Rayleigh scattering induced extinction is considered. Empirical formula of total Rayleigh scattering cross section (Equation (5.10) or Equations (5.15) and (5.16) given in Lecture 5) and atmospheric density provided by an empirical model (MSISE-00) should be used in the calculation.

   In your solution, please provide the equations you used to derive and calculate the light transmission, and then show the result as a figure of transmission versus altitude. The transmission at 0 km is set to unity 1. The altitude step can be 0.5 km or 0.1 km, but no larger than 1 km. (You may try such calculation for various wavelengths, such as 532, 770, 372, and 355 nm.)

   Note: The MSIS atmospheric density can be calculated using a MatLab built-in MSISE-00 model "atmosnrlmsise00.m" for the following conditions: year = 2012; month = 5; day = 23; time = 12; latitude = -77.83 deg; longitude = 166.67 deg; and default solar flux and geomagnetic index. Code is available from the instructor. You can also take the MSIS data from the following file (obtained at different geographic conditions):

http://superlidar.colorado.edu/Classes/Lidar2011/HWFinalProjects/MSISE00zTPND52N102182.dat

2. **Doppler shift and Doppler broadening**: in the atmospheric region free of aerosol and fluorescence, we send a lidar beam (532 nm) to detect the pure Rayleigh scattering from air molecules. (1) If the laser is assumed to be single frequency (no linewidth), then how much is the full-width-at-half-maximum (FWHM) of the scattered Rayleigh signal spectrum at 280 K? (2) If the laser has a Gaussian lineshape with rms width of 100 MHz, how much is the FWHM of the scattered Rayleigh signal at 280 K? How about if the laser's FWHM is 1 GHz?

3. **Boltzmann distribution**: for Fe-56 isotope, the energy difference between the two lowest levels (J = 4 and 3) in the ground state is 415.932 cm^{-1}. Please compute the population ratio P1/P2, where P1 and P2 are respectively the populations on the levels of J = 4 and J = 3, for three temperatures T = 150, 250, and 300 K.

4. **Raman scattering**: if a 532-nm transmitted photon is shifted to 607 nm by the vibrational-rotational (VR) Raman scattering of atmospheric molecule N_2, then what wavelength should you detect for N_2 VR Raman scattering if the transmitted photon is changed to 355 nm or 372 nm? Please show your calculation procedure and explain your basis.

Report #2 is due on September 21, 2012 in class.