ASEN 6519. Lidar Remote Sensing

HW Report #3. Resonance Fluorescence and Envelope Estimation

1. **Extinction caused by constituent absorption** in MLT region: Given the conditions below, please calculate the transmission T_c (due to Na absorption) versus altitude in MLT region, and then give the overall extinction for the round trip of the photons going through the Na layers (i.e., the integrated extinction).

   1) Assume the Na layers in MLT region has a Gaussian distribution with a peak at 91.5 km, rms width of 4.6 km and the column abundance of 4×10^9 cm^{-2}.

   2) Assume vertical wind V_R = 0 m/s, and the MLT temperature is given by MSIS-00 data that can be downloaded at the following website:

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

   3) Laser frequency is tuned to the Na D2a peak, and the laser has a Gaussian line-shape with a rms width of 60 MHz.

   4) Repeat the calculations for K case: using the same laser lineshape and linewidth parameters, atmospheric winds and temperatures, but change the K layers to a Gaussian with a peak at 91.0 km, rms width of 4.7 km, and column abundance of 6×10^7 cm^{-2}. The laser central frequency is tuned to the K D1a peak whose frequency is -180 MHz away from the line center.

   Related atomic parameters can be found in the textbook "Laser Remote Sensing".

2. Envelope estimate of the return signals for a K Doppler lidar and a Na Doppler lidar using the knowledge we gained through the lidar class. The knowledge includes our understanding of (1) the lidar equation and the lidar remote sensing procedure; (2) different physical processes involved in lidar; and (3) the process of lidar simulation, etc.

(1) Start to write a MatLab code for lidar simulations. Gather all necessary fundamental constants, atomic and molecular parameters, lidar parameters, and atmospheric parameters. You may want to set up the platforms so that you can add things later on. Also, you may consider using global variables for universal constants.

(2) Simulate the non-range-resolved return signals (photon counts per pulse) of potassium resonance fluorescence from the entire K layers in the mesosphere and lower thermosphere (75-115 km) using the Arecibo K Doppler lidar parameters and atmosphere conditions. Estimate the return signals (photon counts per pulse) of Rayleigh scattering from a 150-m bin at 30 km using the Arecibo K Doppler lidar parameters and atmosphere conditions.

(3) Repeat (2) for a Na Doppler lidar.

(4) From your simulation results, why are the Na lidar counts higher than the K lidar counts? What are the key factors here? How would you improve the K lidar photon counts?

Related parameters are listed at the end of the assignment for both K and Na lidars.

You are required to show (1) your equations used for simulation, (2) your MatLab code, and (3) your simulation results.

HW Report #3 is due on October 1st, 2012 in class.

Related Arecibo K Doppler lidar parameters are

- Laser pulse energy: 100 mJ
- Laser repetition rate: 30.55 Hz
- Laser wavelength: 770.1088 nm (in vacuum)
- Transmitter mirror reflectivity: 99.8% for each mirror and total of 3 mirrors
- Telescope primary mirror diameter: 80 cm
- Primary mirror reflectivity: 91%
- Fiber throughput: 75%
- Transmission of receiver optics: 74%
- Interference filter peak transmission: 80%
- PMT quantum efficiency: 15%
- Geometric factor for above 20 km: 1
- Lidar station base altitude: 0.1 km

Related atmosphere parameters are

- Lower atmosphere transmission at 770 nm: 80%
- Atmosphere number density at 30 km: 3.83×10^{23} m^{-3}
- Atmosphere pressure at 30 km: 11.97 mbar
- Atmosphere temperature at 30 km: 226.5 K
- Mean potassium column abundance is 6×10^{7} cm^{-2}
- K layer: Gaussian, peak at 91 km, rms width of 4.7 km

Related atomic parameters are

- K effective cross section: ~10×10^{-16} m^2
- Molecular weight of ^{39}K: 38.9637069
- Molecular weight of ^{41}K: 40.96182597
- Molecular weight of standard K: 39.0983

Related CSU Na Doppler lidar parameters are

Laser pulse energy: 20 mJ
Laser repetition rate: 50 Hz
Laser wavelength: 589.1582 nm (in vacuum)
Transmitter mirror reflectivity: 99% for each mirror and total of 3 mirrors
Telescope primary mirror diameter: 75 cm
Telescope primary mirror reflectivity: 90%
Telescope secondary mirror reflectivity: 90%
Fiber throughput: 75%
Transmission of receiver optics: 90%
Interference filter peak transmission: 85%
PMT quantum efficiency: 40%
Geometric factor for above 20 km: 1
Lidar station base altitude: 1.6 km

Related atmosphere parameters are

Lower atmosphere transmission at 589 nm: 70%
Atmosphere number density at 30 km: 3.83×10^{23} m^{-3}
Atmosphere pressure at 30 km: 11.97 mbar
Atmosphere temperature at 30 km: 226.5 K
Mean sodium column abundance is 4×10^9 cm^{-2}
Na layer: Gaussian, peak at 91.5 km, rms width of 4.6 km

Related atomic parameters are

Na effective cross section: $\sim 10 \times 10^{-16}$ m^2