ASEN 6519. Lidar Remote Sensing

HW Project #1 - Estimation of Lidar Return Signals

This is the beginning of a series of lidar simulation projects through our class. HW Project #1 is to estimate the return signals for both 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.

This project contains the following tasks –

(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 to use 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.

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: $\sim 10 \times 10^{-16}$ 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}