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What is it?

- LIDAR acronym for Light Detection and Ranging.
- Uses laser as light source.
- Remote sensing, to measure, observe, and monitor without making actual physical contact.
- Major techniques: Range finding, Differential Absorption (DIAL), and Doppler.
Motivation

– The Clean Air Act Amendments.
– Capable of obtaining small particle in the air, such as aerosols.
– Obtain higher spatial resolution, thus better resolution in underwater imaging.
– Crosswind detection, turbulence sensor.
Backscattering Method

- Simplest Lidar techniques.
- Detects elastic scattering of laser pulses by aerosols or small particles suspended in the air.
- A laser pulse is transmitted to the atmosphere and scattered.
- Profiles of the aerosols can be visualized by collecting the backscattered light with high speed detectors.
Backscattering method

Doppler Infrared Lidar Sensor

- Use 2-μm Tm:YAG
- Detect the shift in frequency of the backscattered pulses due to the motion of aircraft.
- Highly variable velocities along the laser beam indicate the presence of clear-air turbulence.
Backscattering Method

- Nd:YAG that can be frequency doubled and tripled, and Q-switched
  - 160-mJ to 500-mJ per pulse.
  - 10-Hz Rep Rate.
  - Photomultiplier tubes and RCA avalanche photodiode.

Altitude-time plot taken by Shuttle Discovery with LITE in a 1994 mission.
Differential Absorption

- Molecules vibrate, spins, and rotates differently.
- Distinct emission of light in different materials.

Resonant losses
Differential Absorption

2.0-m Telescope

– Sugimoto’s high altitude ozone Lidar.

Low-Altitude System

2.0-m Telescope

Chopper

PMT

XeCl

XeF

D₂

308

339

351-nm

Mini Computer

Transient recorder

Photon Counter

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Differential Absorption

- 500-mJ Tracking Beam
- 50-Hz
- 2 CO₂ Laser

Retroreflected beam
50-cm Retroreflected Mirror
Atomosphere

Signal beam
Reference beam

Tracking System
Data System
Bathymetry

– Triangulate the target by illuminating it with a laser, then capture the reflection with a CCD Camera.

\[ D = \frac{S}{\tan \phi - \tan \omega} \]
Bathymetry

- Airborne or underwater.
- Utilized frequency doubled pulse Nd:YAG (532nm).
- Blue-green laser minimizes water absorption.
Bathymetry

– Each pulse generates a pixel.
– Operating at repetition rate of several kilohertz.
Bathymetry

Above taken by US Army Corps of Engineers

Lake Tahoe of Nevada
Other Applications

- Airborne mapping of beach erosion.
  › Fly over beach at 135-mph with GPS.
  › High rep rate needed.

- Protects against biological warfare agents
  › Consist of a infrared transmitter, receiving telescope, and a detector with an information processor integrated into the frame.

- Air cool laser with high energy-per-pulse mounted on helicopters.
Other Applications

- Wind profiling Lidar for Air Drops
  › Mounted on C-130 transport.
  › Provide 3-D maps of wind from altitude to ground.
  › Eye-safe Tm:YAG, 2-μm, 12-mJ/pulse at 100Hz.
  › Weight 600-lbs and occupies 45-ft².
Summary

– Capable of real-time data analysis, wide-area surveillance and multi-material measurement analysis.

– Good tool for understanding the environmental changes.

– Room for improvement.

– Potential for image recognition.
Reference