Integrated Remote Raman/Fluorescence Spectroscopy and Lidar Instrument for Planetary Surface and Atmospheric Sensing

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Objective

Develop a remote Raman / Fluorescence spectrscopy and Lidar instrument capable of investigation and identification of minerals, organics, and biogenic materials as well as conducting atmospheric studies of Mars, Europa, Titan, and other planets from rovers and landers.

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Approach

- The remote Raman spectroscopy and lidar instrument will be based on inelastic (Raman) and elastic (Mie-Rayleigh) light scattering
- This instrument will monitor atmospheric aerosol and cloud distributions by operating the instrument in the lidar mode at 532 nm
- This integrated remote instrument will be operated from a robotic platform and will perform Raman spectroscopy out to >100 m on the surface features and long-range (to >10-km) atmospheric profiling capability

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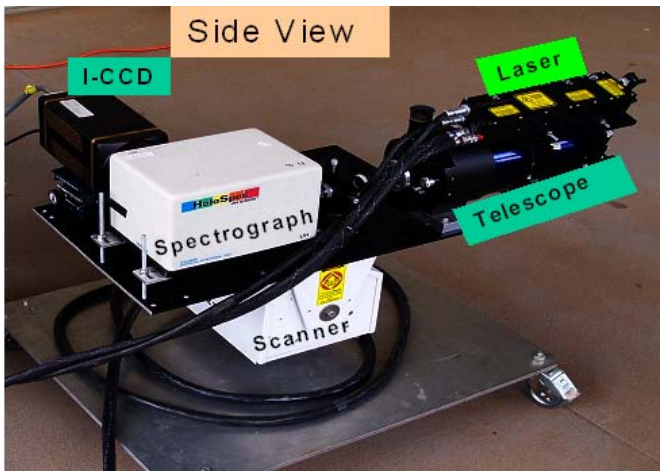
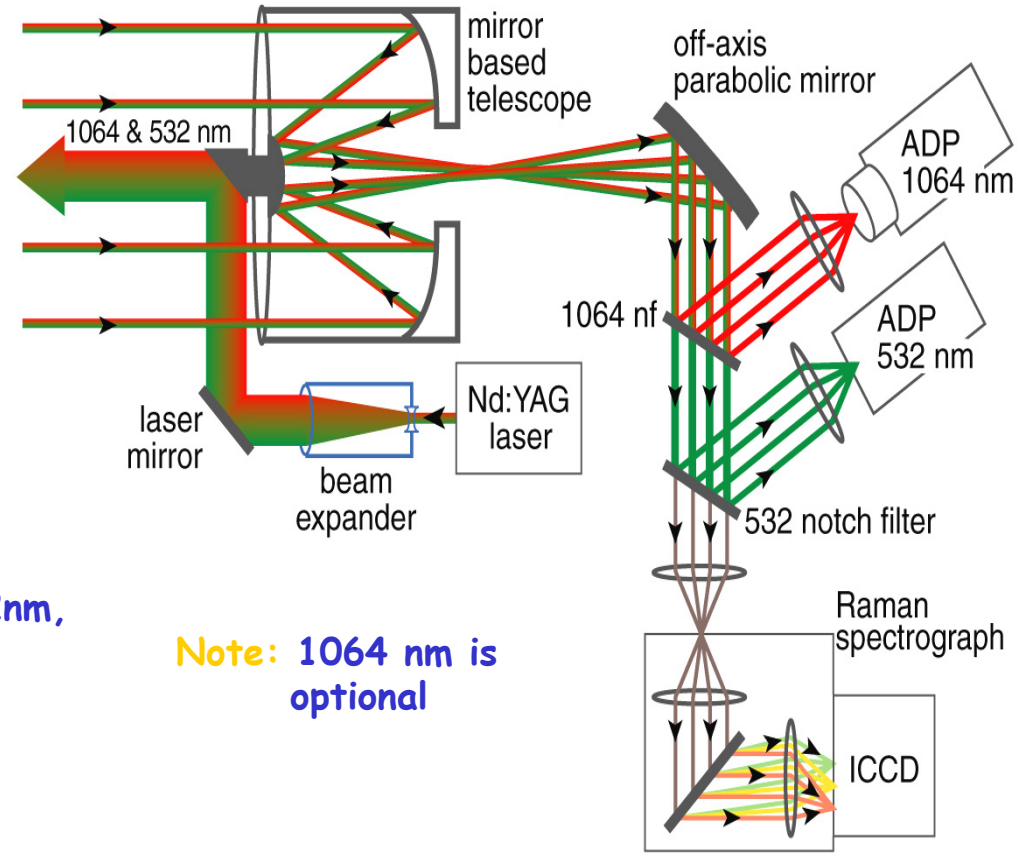
Remote Raman & Elastic Lidar Instrument

Remote Raman System in Coaxial Geometry



Optical Design of Remote Raman & Lidar Instrument



Laser: Pulsed Nd:YAG doubled to 532nm, 20 Hz, 35 mJ/pulse

Telescope: Meade ETX-125
125 mm Maksutov Cassegrain

Note: 1064 nm is optional

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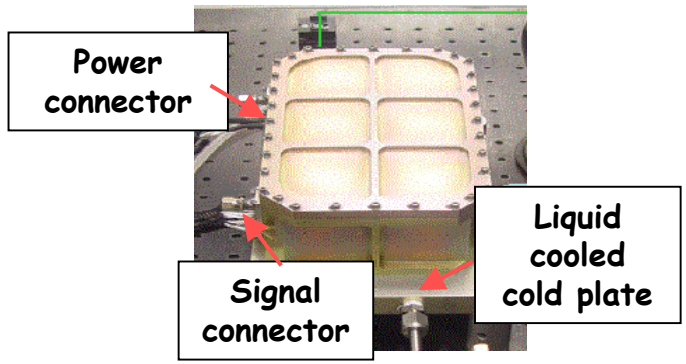
Compact Remote Raman & Lidar Instrument Key Components

Transmitter

Nd:YAG laser from Fibertek (3-wavelengths: 355-,532-, and 1064-nm, total laser energy: 45mJ with repetition rate 20 Hz)

Assembled laser



Dimensions: 20.3 cm x 12.3 cm x 6.3 cm
Volume: 1596 cm^3; Mass: 2.09 kg

Rceiver System Components

- Telescope (4" Diameter)
- ICCD camera
- Photomultiplier Tube (PMT) & Avalanche Photodiode (APD)
- Optical components (focusing lenses, beam expander, super notch filters, dichroic beam splitter, prisms)
- Compact spectrometer

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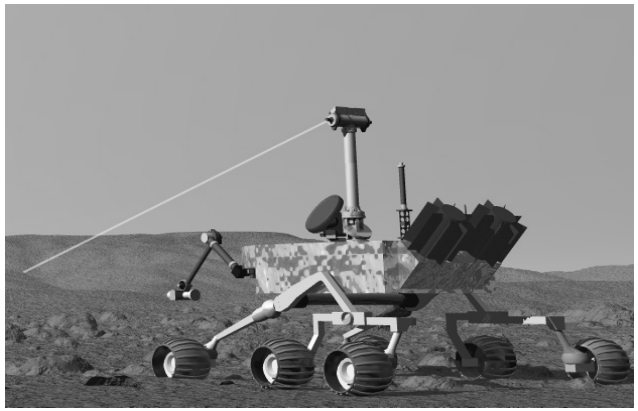
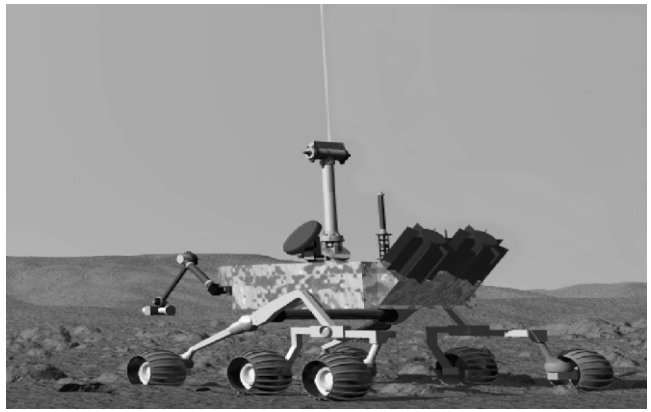
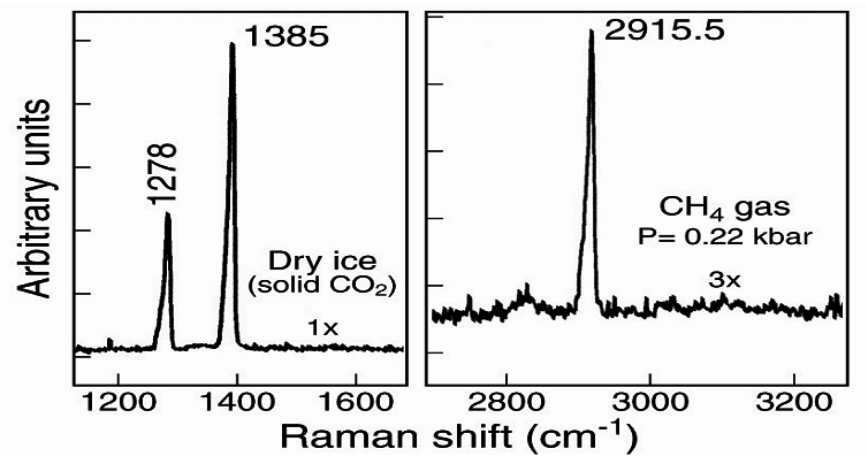
Remote Raman & Lidar Instrument in the Raman Mode

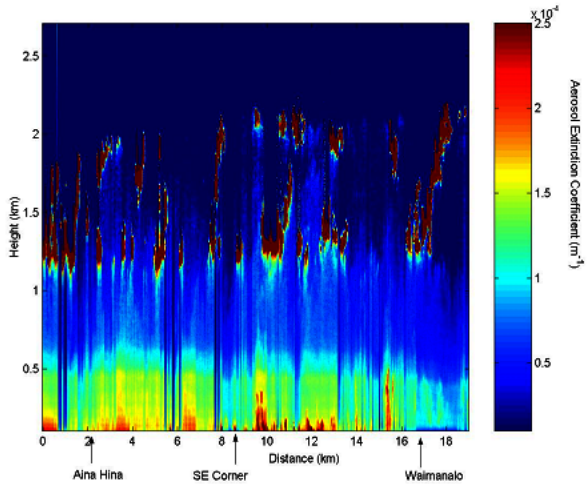


Remote Raman & Lidar Instrument in the Atmospheric Lidar Mode (>10 km range)





Remote Raman spectra of solid CO_2 and compressed CH_4 gas at 10 m with Telescope diameter 125 mm



Aerosols, dust, clouds to 10 km as well as solid and gaseous CO_2 & CH_4 gas plumes can be detected to >100 m

Aerosol scattering coefficient derived from lidar data around SE Oahu. Clouds are shown in dark values. Laser 532 nm, 12 mJ/pulse, 20 Hz.

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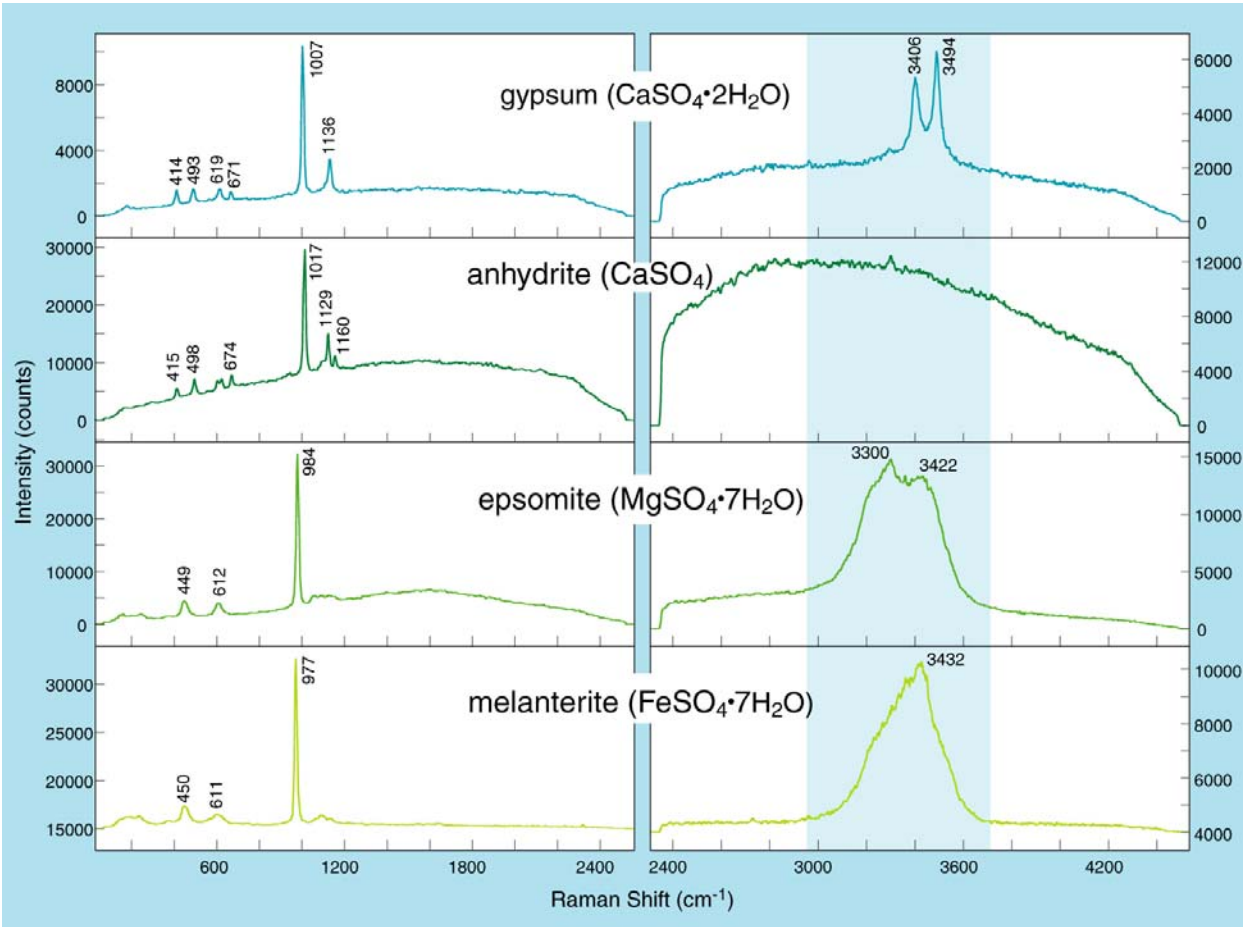
Remote Raman Spectra of hydrated sulfates of Ca, Mg, and Fe at 10 m

(125 mm diameter telescope)



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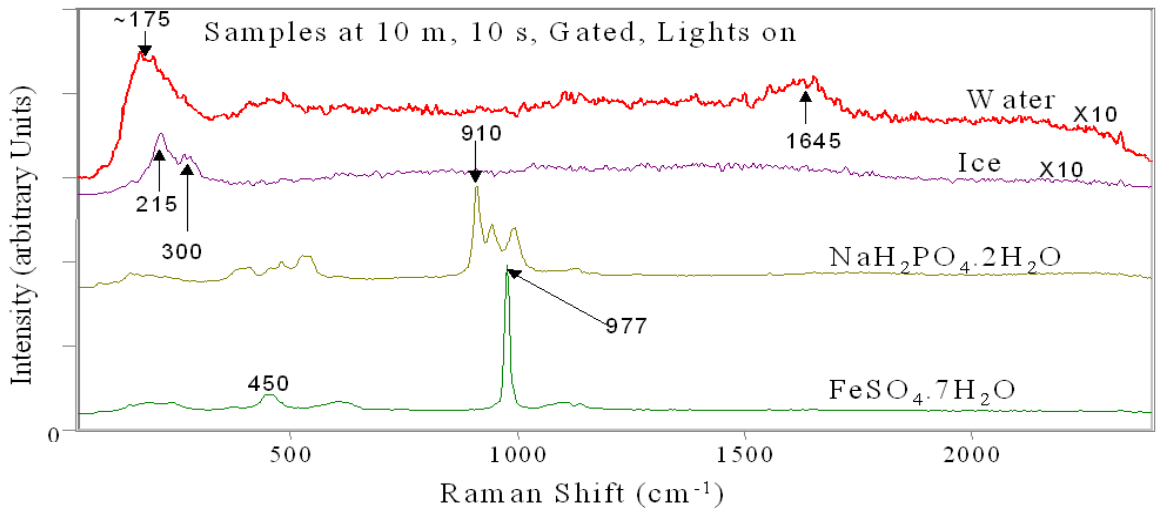
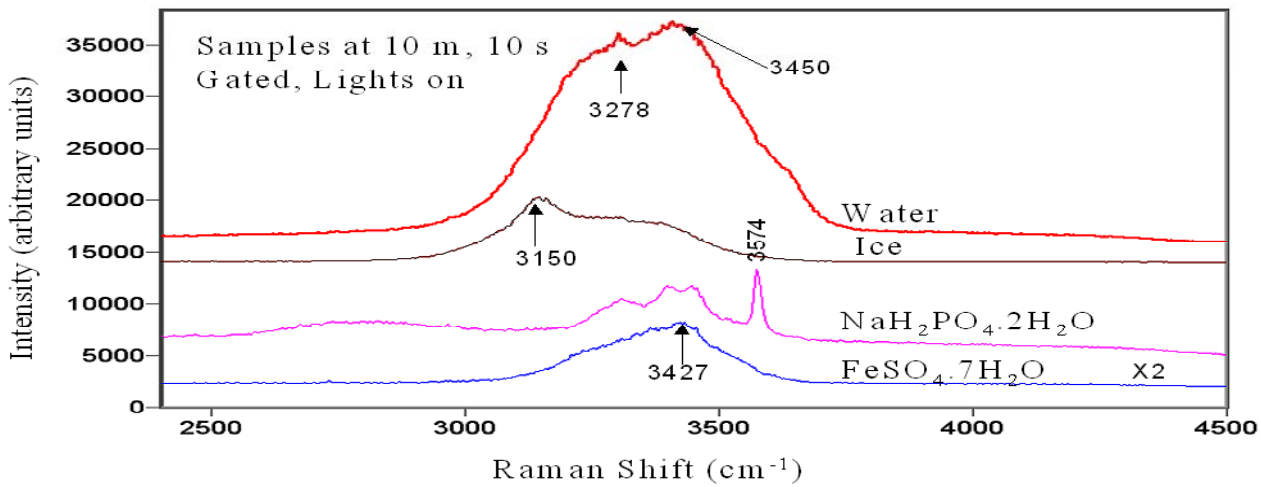
Remote Raman Spectra of water, H_2O-ice and hydrous minerals at 10 m

(125 mm diameter telescope)





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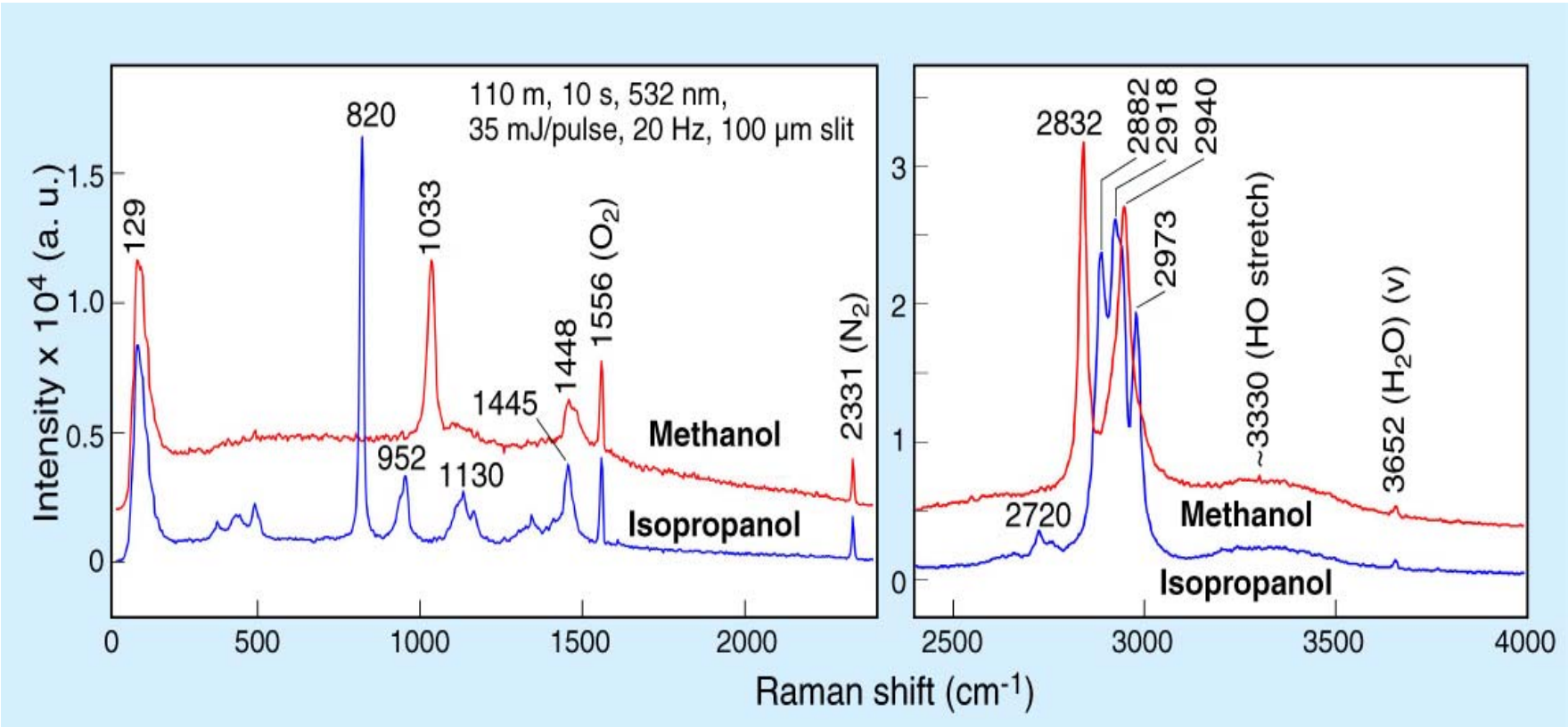
Remote Raman Spectra of Methanol and Isopropanol at 110 m

(204 mm diameter telescope)



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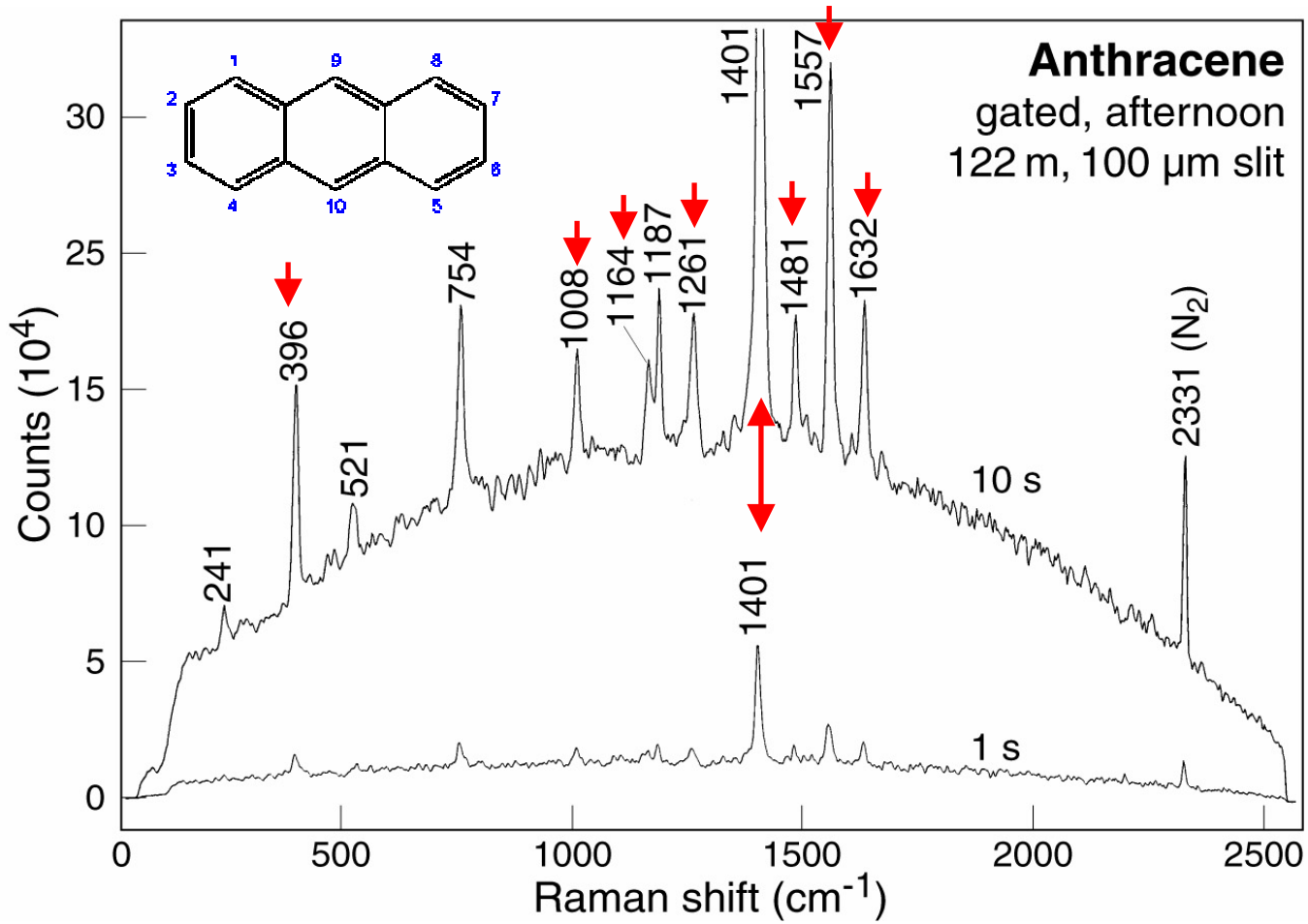
Remote Raman Spectra of Anthracene ($C_{14}H_{10}$) at 122 m

(125 mm diameter telescope)



The strong 1401 cm^{-1} is the ring-breathing (A_g) mode; 396, 1008, 1164, 1261, 1481, 1557 and 1631 cm^{-1} are other A_g modes of anthracene.

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Applications/Missions:

- Characterization of geologic processes on the surface and in the subsurface regions, and to determine the biologic potential for habitability assessment of planets in the Raman mode.
- Characterizing the distribution of dust, aerosols and clouds; and also measure nitrogen and methane, in the elastic backscatter lidar mode.
- Minerals, ices and organic compounds on the surface of Mars, Titan, Europa, and other icy satellites of outer planets and for characterizing the distribution of dust and aerosols as appropriate.
- Mars, Moon, Europa, Titan, and other Outer Planet Flagship Missions

Note: In Europa, water ice, non-ice hydrated constituents, hydrated magnesium and sodium sulfate minerals [McCord et al. 1998b]. CO_2 is located preferentially on the less icy parts of Europa [McCord et al. 1998a], and Sulfuric acid hydrate ($H_2SO_4.nH_2O$) and various sulfate salts [McCord et al. 1999, 2002]

In Titan, atmospheric composition, i.e., nitrogen, methane, and other hydrocarbons, nitriles [2007 Titan Explorer Mission Concept Study]

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