MINIATURE AND COST-EFFECTIVE REMOTE RAMAN, FLUORESCENCE, AND LIDAR MULTI-SPECTRAL INSTRUMENT FOR CHARACTERIZATION OF PLANETARY SURFACES AND ATMOSPHERE FROM ROBOTIC PLATFORM.

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With support from Center investment funds, the team at NASA Langley Research Center (LaRC) developed a bench-top system that demonstrated the feasibility of a Raman-Fluorescence spectrograph and compact Lidar system. Leveraging this work, a joint LaRC and University of Hawaii team submitted, and was subsequently awarded in 2008, the proposal, "Combined Raman, Fluorescence, and Lidar Multi-Sensor (RFLMS) Instrument Development Program" under the NASA Mars Instrument Development Project (MIDP). The complete remote Raman, Fluorescence, and Lidar prototype instrument has been successfully integrated onto a rover system and demonstrated at NASA LaRC. The objective of this proposed study is to develop an innovative remote Raman-Fluorescence spectroscopy and Lidar multi-sensor instrument capable of investigation and identification of minerals, organics, and biogenic materials, as well as atmospheric studies of Mars, Moon, asteroids/comets, Europa, Titan, Venus, and other planetary bodies from rovers, landers, and aerial surveillance vehicles. Surface and atmospheric characterizations have been performed with the prototype instrument from a robotic platform to successfully identify water, ice, dry-ice, hydrous minerals, and other materials at a 15-meter distance (Fig. 1). It has also been used to conduct atmospheric aerosol and cloud distribution and profiling (Fig. 2). Results from these characterizations were presented at the 42nd and 43rd Lunar and Planetary Science Conferences, Woodlands, TX (2011, 2012) [1-2] and The Geological Society of America (GSA), Minneapolis, Minnesota (2011) [3]. Prior to the development of this prototype instrument, mineralogical and surface organic information were obtained by using only the Raman-Fluorescence mode, and the results were presented at other technical conferences [4-5]. Lidar measurements taken from the Phoenix Mars Lander [6-7] demonstrated the usefulness of lidar systems in planetary missions.

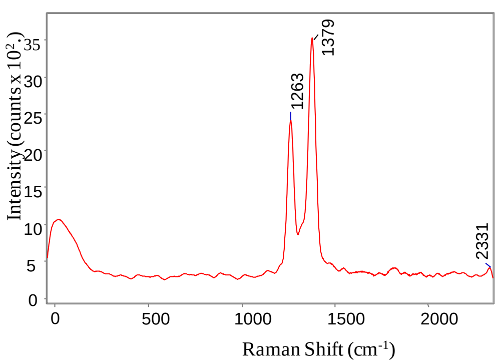
From the Concepts and Approaches for Mars Exploration, the program addresses NASA's planetary Science Mission Directorate, Human Exploration and Operations Mission Directorate, and the Office of Chief Technologist for the next several decades of exploring Mars. The goal is to seek ideas, concepts and capabilities to address critical challenge areas, focusing on a near-term and mid- to longer-term timeframes. Therefore, the NASA Langley team, in collaboration with the University of Hawaii, will build a multi-spectral instrument (8-10 kg, 12"x12"x10", low power, low cost) demonstrated on a robotic platform to provide high-fidelity scientific investigations, scientific input, and science operations constraints in the context of planetary field campaigns with the 2018 launch opportunity. It will do this by conducting scientific investigations analogous to investigations anticipated for missions to Mars. The major capabilities of this remote sensing, multi-spectral instrument are:

- Detect minerals and trace-level organic matter in rock and dust constituents of surface and subsurface material and samples using multi-spectral approaches.
- Perform site characterization for ionizing radiation and material toxicity (for example, Chromium VI) for purposes of human health risk reduction to support crewed missions to Mars.
- Conduct remote operation and data collection from an instrument mounted on a rover during the robotic exploration of sites to support future landing systems.
- Measure dust aerosol and cloud distributions; measure near-field atmospheric carbon dioxide; and identify surface CO_2-ice, surface water ice, and surface or subsurface methane hydrate to contribute to our understanding of atmosphere and surface interactions in preparation for future robotic missions to Mars and other planets.

The multi-spectral instrument will be capable of performing Raman and Fluorescence spectroscopy out to a 100-meter radial distance from the rover system [8-9] and provide multi-wavelength aerosol/cloud profiling over long ranges (>20 km).

This instrument is suitable to multiple remote sensing applications, specifically those designed for upward/horizontal-looking and target surface backscatter signal detection from a lander or rover system (Fig. 3). The instrument is already integrated and demonstrated on a mobile rover that is capable of performing teleoperated and limited autonomous surface operations. The rover provides a definitive method of advancing the TRL of the instrument by enabling it to be demonstrated in a host of environments, as well as requiring that the unit be easily integrated using conventional interfaces (e.g., power, data, mechanical). The demonstration of a fully-integrated remote Raman, Fluorescence, and Lidar Multi-spectral prototype instrument on a robotic platform is an important step in developing a qualified and calibrated instrument for the Mars Sample Return (MSR)/Mars Astrobiology Explorer-Cacher (MAX-C), Asteroids/Comets, and other NASA SMD missions. In addition, this integrated instrument is suitable for multi-platform applications on planetary surfaces and atmospheres such as those of Mars, Moon, Near Earth Objects (NEO), and the moons of Mars as a precursor to future human exploration activities within NASA Human Exploration and Operations Mission Directorate (HEOMD) missions.

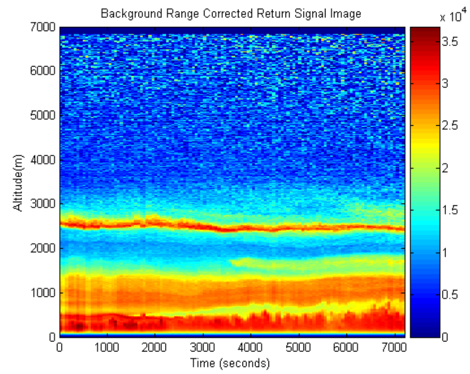
a



b

Fig. 1. Laser beam pointed to the surface target sample at a 15 meter distance in (a); Raman spectra of dry-ice (soild-CO2) in (b).

a



b

Fig. 2. Laser beam pointed to the atmosphere in (a); Atmospheric range corrected image of data collected with 1 minute (1200 shot) average in (b).

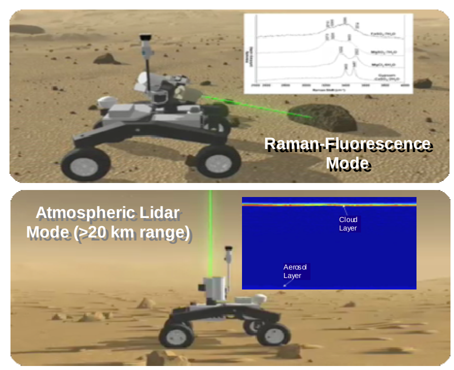


Fig. 3. Remote Raman, Fluorescence & Lidar Sensor (RFLS) Instrument on LaRC's Planetary Science Instrument Rover

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