FROM CLOUDS TO LIFE DETECTION: THE PAST, PRESENT, AND FUTURE OF LIDAR.

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LIDAR or lidar, a portmanteau of light and radar, has expanded its utility significantly since its humble beginnings in the 1960's as a cloud measurement device. LIDAR has proven its worth beyond Earth especially as an orbital elevation-mapping tool, additionally *in-situ* LIDAR instruments have also proved useful. Recent advancements in LIDAR technologies are paving the way for exciting extraterrestrial applications with the capabilities to remotely detect surface mineralogy, surface organic materials and atmospheric constituents from rovers and landers [1]. The future is now and collaboration between researchers at NASA Langley and the University of Hawai'i has yielded an all-in-one compact remote Raman/Fluorescence spectrometer/LIDAR instrument.

Raman spectroscopy can uniquely classify surface mineralogy, organic and inorganic materials, and chemical compounds. Early Raman remote detection experiments used high-powered lasers and bulky spectrographs [2-5]. Although successful, these large-scale investigations are ill-suited for interplanetary missions, particularly landed platforms. Advances in Raman spectroscopy have since improved this powerful spectral analyzer to be desirable for extraterrestrial endeavors. Fluorescence can be removed to isolate Raman backscatter, or studied separately using recently discovered time-resolved techniques. Time-resolved fluorescence is optimum for detecting polyaromatic hydrocarbons (PAHs) and biomolecules, which could be applied to the *in-situ* measurements on planetary surfaces such as Mars, Venus, Europa, etc. [5].

Venus lower-atmosphere and surface studies present particular challenges to Raman techniques, since the intense thermal noise extends well into the infrared. Ultraviolet lasers are particularly interesting in this regard, as they both increase the Raman signal and avoid the thermal noise. Raman techniques have an advantage over direct sensing techniques (e.g. GCMS) in that they can operate through a window and do not need access to the environment. Ongoing studies, based out of NASA Langley and the University of Hawai'i, are further optimizing remote LIDAR capabilities as powerful spectral detectors by using higher laser power (1-Joule/pulse), and a large telescope (1 to 2 m). This design could be used both on a lander/rover on a surface or on a balloon or orbiter, making Raman/fluorescence measurements from 5 cm -10,000m away [6,7]. [*See figure* 1]. In this poster we will present ongoing and future applications of LIDAR, and its implications for astrobiology in greater depth.

References: [1] M. N. Abedin, et al. [Abstract]. 42nd Lunar and Planetary Science Conference. Pg. 2298 (2009). [2] T. Hirschfeld, Appl. Opt. 13, 1435-1437 (1974). [3] S. M. Angel, T. J. Kulp, and T. M. Vess, Appl. Spectrosc. 46, 1085-1091 (1992). [4] P. G. Lucey, T. F. Cooney, and S. K. Sharma, Lunar Planet. Sci. XXIX, Abstract #1354. [5] M. N. Abedin, et al., Appl. Opt. 52, 3116-3126 (2013). [6] S.M. Angel, et al., Appl. Spectro., 66, 137-150 (2012). [7] S.K. Sharma, et al., 45th Lunar and Planetary Science Conference, Abstract #1678, (2014).

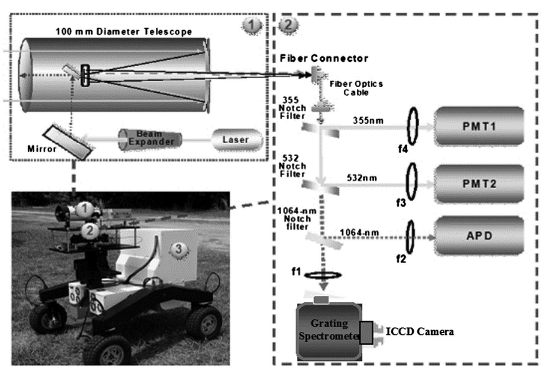

Fig. 1. Main components of the Raman and fluorescence grating spectrometer with lidar receiver system: pulsed Nd:YAG Laser, beam expander, steering mirror, mirror-2 attached with 100 mm telescope, PMT2 (lidar channel), optics. Sections 1 and 2 are mounted at the left arm of the rover, CPU control unit, power supply, ADC, pulse generator, and interface (not seen here) mounted at the back of the rover system.