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PROOF-OF-CONCEPT TABLETOP TUNABLE DIODE LASER ABSORPTION SPECTROMETER INSTRUMENT (TDLAS) FOR THE DETECTION OF H2O(V) IN LUNAR REGOLITH FOR THE CANADIAN MULTIPURPOSE AUTONOMOUS PENETRATOR FOR LUNAR EXPLORATION (MAPLE) PROJECT

Abstract

The search and survey for water in-situ is a high priority for lunar exploration as it can be used for numerous applications such as the creation of fuel, breathing air, and or potable water. We present progress on the proof-of-concept tabletop Spectral Analysis (SA) Herriot Cell (HC) Tunable Diode Laser Absorption Spectrometer (TDLAS) prototype instrument under development for delivery to the lunar surface to detect in-situ water vapor. Lunar water content and other volatile compounds can be mapped with numerous penetrators deployed. The instrument combines an off-axis HC with TDLAS technology and novel SA wavelength modulation detection methods to detect and quantify H2O(v) evolved from lunar regolith samples. An off-axis HC is physically robust and increases probability of detection. The novel SA detection method is robust to system and signal noise. The wavelength region of interest is in the mid-infrared range (MIR) near 2700 nm, as H2O(v) has a well-defined absorption (electron transitions) spectrum in this region. This region is also host to strong absorption spectra for other volatile chemical compounds such as Nitric Oxide (NO), Carbon Dioxide (CO2), and Nitride (NO2). The tunable nature of the instrument allows for the detection of an assortment of compounds. The instrument specifically targets H2O(v)'s transition line located at 2701.3844 nm (3701.8056 cm-1). The design employs a distributed feedback (DFB) tunable diode laser, HC spherical mirrors, a photovoltaic photodiode, and microcontrollers. The instrument and all its sub-systems are being developed in-house to mitigate cost and provide reference for the development of a miniaturized and ruggedized flight model. To date, the instrument has been proven to work in the sense that the DFB laser can be successfully modulated through the target absorption line, and the PP detector can successfully detect the signal. Detection of H2O(v) has not yet been proven, as significant work remains on the data acquisition and signal processing systems. The instrument is still under development. The final flight model will employ a quartz microbalance to verify and confirm the TDLAS' results. The proof-of-concept design will not incorporate this component.