Planetary surface exploration using Raman spectroscopy for minerals and organics

Authors

Blacksberg, J*, Jet Propulsion Laboratory, Pasadena, CA, USA
Alerstam, E, Jet Propulsion Laboratory, Pasadena, CA, USA
Maruyama, Y, Jet Propulsion Laboratory, Pasadena, CA, USA
Charbon, E, Delft University of Technology, Delft, Netherlands
Rossman, GR, California Institute of Technology, Pasadena, CA, USA
Shkolyar, S, Arizona State University, Tempe, AZ, USA
Farmer, JD, Arizona State University, Tempe, AZ, USA

Abstract

Raman spectroscopy has been identified as one of the primary techniques for planetary surface mineralogy. It is widely used as a laboratory technique since it can identify nearly all crystalline mineral phases. Using a small spot size on the surface (on the order of a micron), mineral phases can be mapped onto microscopic images preserving information about surface morphology. As a result, this technique has been steadily gaining support for in situ exploration of a variety of target bodies, for example Mars, the Moon, Venus, asteroids, and comets. In addition to in situ exploration, Raman spectroscopy has been identified as a feasible means for pre-selection of samples on Mars for subsequent return to Earth. This is in part due to the fact that Raman can detect many organics in addition to minerals. As a result, the most relevant rock samples containing organics (potentially fossil biosignatures) may potentially be selected for return to Earth. We present a next-generation instrument that builds on the widely used 532 nm Raman technique to provide a means for performing Raman spectroscopy without the background noise that is often generated by fluorescence of minerals and organics. We use time-resolved laser spectroscopy to eliminate this fluorescence interference that can often make it difficult or impossible to obtain Raman spectra. We will discuss significant advances leading to the feasibility of a compact time-resolved spectrometer, including the development of a new solid-state detector capable of sub-ns temporal resolution. We will address the challenges of analyzing surface materials, often organics, that exhibit short-lifetime fluorescence. We will present result on planetary analog samples to demonstrate the instrument performance including fluorescence rejection.

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