



SHERLOC: An investigation for Mars 2020

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SHERLOC is a Deep UV (DUV) native fluorescence and resonance Raman spectrometer that was selected as part of the Mars 2020 payload. It is a robotic arm mounted instrument that utilizes a DUV laser to generate characteristic Raman and fluorescence photons from a targeted spot. The DUV laser is co-boresighted to a context imager and integrated into an autofocusing/scanning optical system that allows us to correlate spectral signatures to surface textures, morphology and visible features. Additionally, it has recently been augmented with an imaging system that is a built-to-print version of the MArs Hand Lens Imager (MAHLI) instrument on the Mars Science Laboratory (MSL).

Through the use of an internal scanning mirror, autofocusing lens, and a depth of focus of $\pm 500 \mu\text{m}$, the $100 \mu\text{m}$ laser spot can be systematically scanned over a $7 \times 7 \text{ mm}$ area with a fine-scale spatial resolution on natural or abraded surfaces and boreholes to a depth of at least 13 mm, without further arm movement. Through the use of the context imager, SHERLOC's data products can be combined with observations made by other instruments on the Mars 2020 payload. By bringing to bear multiple scientific instruments on a single sample, our ability to assess the habitability of ancient environments and search for potential biosignatures preserved within the geologic record will be greatly enhanced, making possible the selection of high-priority samples for caching.

The SHERLOC investigation combines two spectral phenomena, fluorescence and pre-resonance/resonance DUV Raman scattering. These spectral features are resolvable when a high-radiance, narrow line-width, laser source illuminates a sample. In fluorescence, the incident photons are absorbed and re-emitted at a longer wavelength. The difference between the excitation and emission wavelength is the difference between the excitation frequency and the lowest electronic state frequency that increases with increasing aromatic structure (i.e. number of aromatic rings). Typical fluorescence cross-sections are 10^4 greater than traditional Raman, enabling the detection of sub-picograms levels of aromatic organic compounds.

SHERLOC's narrow-linewidth (3 GHz) DUV laser (248.6 nm) enables fluorescence-free Raman scattering for additional classification of aromatics and aliphatic organics and minerals. Raman scattering is inelastic scattering where the loss of energy from the excitation energy (40225 cm^{-1}) and defines the vibrational energy of a bond with which it interacted. This enables classification of bonds such as C-H, CN, C=O, C=C, NH_x , NO_x , SO_x , PO_x , ClO_x , and OH. It should be noted that Raman shifts (cm^{-1}) (i.e. peak position as energy loss from the excitation energy) are invariant to excitation wavelength. Thus peak positions in Raman databases (at 229, 248, 488, 532 and 785 nm) can be compared (c.f. <http://rruff.info/>).

Fluorescence emission of organics extends from $\sim 270 \text{ nm}$ into visible wavelengths. On the other hand, mineral fluorescence emission stemming from crystalline defects and impurities is weak in the deep UV, and typically begins longward of 360 nm continuing into the NIR. Mineral fluorescence is very unlikely to be seen in samples found on Mars. The DUV fluorescence technique employed by SHERLOC is well-suited to the detection of organics on mineral surfaces.