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The Simultaneous Spectral Temporal Adaptive Raman Spectrometer (SSTARS) for Planetary Mineralogy

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The Simultaneous Spectral Temporal Adaptive Raman Spectrometer (SSTARS) is a planetary instrument under development at the Jet Propulsion Laboratory, capable of time-resolved in situ Raman and fluorescence spectroscopy.

Combined Raman and fluorescence analysis of rock and soil samples provides information about the conditions under which minerals have formed. Since the extent of fluorescence on planetary bodies is unknown, it would be prudent to send a Raman instrument that can operate under all fluorescent conditions. Strong fluorescence has recently been observed in Mars meteorites, and therefore could be present at a new landing site which may differ significantly from locations that have been thus far explored. In the presence of new and unknown planetary regions, mineralogical studies can address questions such as: What classes of minerals are present which may yield clues to surrounding environmental changes? Are there secondary minerals associated with water activity? If fluorescence is found and can be studied with the same instrument a more complete picture can be painted of the environments under which the present minerals have formed.

When combined, Raman and fluorescence techniques provide complementary and definitive information on planetary mineralogy. However, instruments currently on the drawing board for in situ missions lack time resolution capability and therefore have two limitations: 1) the Raman signals can often be lost in the fluorescence background and 2) overlapping signals from different fluorescence centers in the same mineral can make fluorescence spectra difficult if not impossible to interpret. SSTARS makes use of the unique time scales associated with Raman scattering and fluorescence. Raman scattering is virtually instantaneous (< 1 psec) while fluorescence lifetimes vary from picosecond to millisecond time scales depending on the material, which may contain many fluorescence centers. Time resolved spectroscopy is therefore a highly effective way of both obtaining Raman spectra under all fluorescence conditions and of deconvolving fluorescence spectra from each other. The result is a method that can provide unambiguous mineral identification as well as identification of ions within these minerals. The SSTARS laboratory instrument will provide a path to a future flight instrument capable of: imaging a rock or soil sample in situ (e.g. on a Mars rover), identifying an interesting region of the image, and measuring a picosecond-scale time-resolved Raman and fluorescence spectrum in a single scan, all using a compact, low-power, low-mass and high resolution system.

We will discuss the system design, including results of system modeling which predicts that Raman spectra will be attainable under very high fluorescence backgrounds. Emphasis will be placed on selection of key components such as a streak camera with picosecond scale time resolution, and a pulsed miniature microchip laser. We will show Raman spectra obtained using the selected front end optics and pulsed miniature microchip laser, and we will discuss the performance of system components.