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Mini-Raman Spectrometer System for Planetary in-situ Exploration

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In planetary exploration unresolved issues that need to be addressed in order to understand the evolution of our solar system are: (1) What actually is the composition of the different areas of the surface of the explored solar system body (and what is the interrelation to each other)? (2) How have these materials been altered, mixed, and transformed into the surface seen today? The first question can be answered by a landing mission with in-situ measurements that provides the mineralogy and elemental abundance of at least some of the various surface areas.
Raman spectroscopy is a method for structural and chemical analysis by spectral investigation of radiation inelastically scattered by a pointed sample. It is not applied in planetary exploration up to now. Remote Raman instruments are planned for future missions like RLS for ExoMars 2018 and SuperCam on Mars 2020. Raman spectroscopy has many advantages. For example no sample preparation is needed for Raman measurements. Furthermore, a big variety of samples can be investigated. Apart from the pure identification of mineralogical, inorganic, organic, or biological compounds, Raman spectroscopy also provides information on the chemical environment of the investigated sample. Structures and symmetries of the molecules can be deduced from Raman spectra by comparing the fingerprint like spectra with a database. Moreover, the time required for a Raman measurement is in the range of minutes and the measured spectrum is directly interpretable. Microscopic as well as distant measurements up to several meters are possible. Several configurations of Raman spectrometers are conceivable. It can be designed as a compact and light weight instrument that can be mounted on a rover or robotic arm together with complementary instrumentation like LIBS (Laser induced breakdown spectrometer, see this conference), pointing camera and/or IR spectrometer. A Raman instrument for measurements on extraterrestrial bodies of our solar system (like asteroids, comets, moons of Earth or Jupiter) may consist of a sensor head and a Raman instrument module. The sensor head consists of the laser for Raman excitation and a dedicated optical system that collects the scattered radiation. It can be mounted e.g. on a robotic arm and is directly connected to the Raman instrument module which comprises the spectrometer and the detector as well as the electronic support subsystems for instrument control, power conversion and distribution, and data processing. The Raman instrument module can be placed separately e.g. inside the lander or rover and can be connected to the sensor head with optical fibers.