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Soil Properties Determination with Acoustic Sounding

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Exploration missions like Rosetta and ExoMars will provide in-situ experiments for the investigation of planetary surface properties. The use of mechanical vibrations may provide a new means to study the structure and elastic properties of the surface layers of terrestrial planets and minor bodies like comets. The Comet Acoustic Surface Sounding Experiment (CASSE) on the Rosetta Lander Philae has the objective to determine elastic parameters and the surface layer structure of the target comet. Combinations of planetary penetration instruments like PLUTO (on Beagle 2) or MUPUS (on Rosetta lander Philae) as strong acoustic sources with CASSE like receivers were studied in a DFG project at the DLR.

Acoustic sounding is an established method for the investigation of surface layering and soil properties on Earth. Earthquakes or mechanical bumpers act as sounders for such measurements. A shock on or in a surface will generate different wave types, body as well as surface waves. The body waves can be divided into p- (primary) and s-waves (secondary). The p-waves are longitudinal waves whereas the s-waves and the surface waves are transversal waves. In the seismology the detected signals of these waves are separated in the time series data by the long travel times. In the planned application as an instrument for planetary surfaces, the distances between sounder and receiver are very small compared to seismology scales. These small distances result in a superposition of the different waves in the registered signals.

The first task for the determination of soil properties is to distinguish these different waves and to determine their velocities. The polarisation of the waves offers a new method to distinguish the various wave types. The p-wave has a linear vibration pattern. By detecting the propagating waves with 3-dimensional accelerometers it is possible to determine the vibration characteristics. By analysing the scatter around a

linear fit to the recorded values it is possible to determine the incoming transversal s-wave as that point of time, when the scatter of the linear fit increases significantly. The increasing scatter indicates the arrival of the elliptic polarised s-wave.

With the different sound velocities of p- and s-wave it is possible to determine elastic soil properties like the Young's Modulus. In continuation to our talk in 2007 we will present first experiments applying this method to dry sand and pure ice.