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Determining the penetration resistance of a cometary surface by using data from the Philae anchoring harpoon

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On November 11 2014 ESA's Rosetta spacecraft will deliver the Lander PHILAE to the surface of comet *Churyumov-Gerasimenko*. To fix the lander safely on the surface and allow for *in situ* operation of instruments like the SD2 drill or the MUPUS experiment the spacecraft will be anchored to the surface by a harpoon-type device. In addition to the anchoring function the projectile shot into the surface contains two sensors, which will be used to obtain information on the thermo-physical properties of the cometary ice: a shock accelerometer and a temperature sensor. The former will record the deceleration history of the anchoring projectile during the penetration phase. From these data information on mechanical strength of the near surface cometary material and its variation with depth can be retrieved by using appropriate modelling approaches. The temperature sensor will measure temperature variations at the depth were the anchor finally has come to rest over the lifetime of the lander at the surface. Both sensors are part of the MUPUS experiment on *Philae*, which is devoted to the measurement of thermo-mechanical properties.

In this paper we will give a short overview on the main features of the harpoon-anchoring system in general and on the mathematical methods to be used for the evaluation of the measurement data recorded by the anchor sensors, with emphasis on the accelerometer data. An example from a test shot performed during the development phase of the Philae anchoring system is shown in the figure below.

Figure: Typical acceleration/deceleration signal recorded during a test shot of the anchor into a foam glass analogue material (upper left panel). The different phases of the shot (acceleration phase, free flight phase, deceleration phase) are clearly separated in this shot. Integration and double integration of the data (upper right and lower left panel) gives the velocity and depth profile versus time. This procedure allows finally to derive the acceleration/deceleration profile versus depth (lower right panel), which can be fed into a material model to derive finally strength data like cohesion and angle of internal friction.