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COMET SURFACE ENGINEERING PROPERTIES AND ACTIVITY ESTIMATION FOR SPACE MISSIONS: THE CASE OF 67P/CHURYUMOV-GERASIMENKO

Abstract

Introduction ESA's Rosetta mission is on its way to comet 67P/Churyumov-Gerasimenko where it will deploy a long-lived lander, Philae, to the comet surface. The Discovery mission proposal CHopper foresees several sorties to the surface of comet 46/P Wirtanen, the original target of the Rosetta mission. Comet sample return missions, ultimately returning a cryogenic sample of a comet's subsurface material, are in preparation. Common to all those missions is that the mechanical properties of the surface of a comet are an important design driver for landing, anchoring and sampling. Another concern is the outgassing flow perturbing the spacecraft/lander motion. Observational data on total gas production of comets is scarce except near perihelion.

Aim In this paper, we continue previous work (Biele, 2009 and SkorovBlum, 2011) on the estimation of surface strength and try to narrow the bounds on this on respective parameters. We also outline the rationale for our estimation on the min/max outgassing rates for 67P from 4.5 AU to perihelion.

Method In particular, we review the definitions of relevant mechanical parameters and their dependencies on scale and velocity and review laboratory and in-situ measurements on comet material analogs, comet-derived meteroids and actual comets. We also discuss a new hierarchical model for comet surface matter which is consistent with the putative formation of comets and the observed activity characteristics (SkorovBlum, 2011). Emphasis is laid on the estimation of not only tensile, but also shear strength and, in particular, compressive strength. Applications for landing and anchoring spacecraft as well as implications for surface penetration, e.g. , for anchoring, sampling or inserting measurement probes is analyzed. Surface activity (gas release through the crust) is discussed in the framework of a new thermophysical model.

Results For comet 67P/Churyumov-Gerasimenko in particular we summarize our findings in an updated comet surface engineering model to be applied for the Rosetta mission and a table for bounds on the gas production rates as a function of heliocentric distance (pre-perihelion).