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Comet 67P/Churyumov–Gerasimenko: the GIADA dust environment model of the Rosetta Mission target

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ABSTRACT

Context. The ESA Rosetta spacecraft will reach the short–period comet 67P/Churyumov–Gerasimenko in 2014. Orbiting strategy, orbiter safety conditions, landing scenarios and expected results from dust collectors depend on models of the 67P dust environment. Many papers already tackled this matter, analysing a limited set of observations, and therefore often reaching conflicting conclusions.
Aims. We consider a set of observations representative of all ground–based and IR (thermal infrared) Spitzer data collected over the last three perihelion passages, to determine the 67P dust environment after the end of the gas drag on dust (at about 20 nucleus radii) consistent with available 67P gas and dust coma photometry, images of the dust coma, tail and trail, at optical and IR wavelengths.
Methods. In order to obtain the best fit to 67P data, we consider three independent tail and trail simulation codes (developed by three independent groups), which parametrise cometary dust by the quantity β, the ratio between solar radiation pressure and gravity forces. GIADA, the dust monitor instrument of the Rosetta orbiter, will provide an experimental determination of the β–dust mass relation.
Results. A 67P environment model based on a perihelion–symmetric dust velocity and on a perihelion–asymmetric dust size distribution, is consistent with all available data. During most Rosetta operations, the dust cross–section is dominated by mm to cm–sized grains, while the ejected dust mass is dominated by grains larger than a few mm, with a dust–to–gas ratio of 3 around perihelion.
Conclusions. 67P onsets its activity at Sun–distances $r_h \geq 3.4$ AU; the dust geometric albedo is 0.04 ± 0.02; at 3.0 AU, 10 g grains escape the nucleus gravity field (10 kg grains at perihelion) with a dust mass–loss rate of 10 – 40 kg s^{-1} (500 kg s^{-1} at perihelion); 67P's activity depends on seasons, with the northern heminucleus (rich in large grains and CN depleted) active before perihelion.

Key words. Comets: individual: 67P/Churyumov–Gerasimenko – Space Vehicles: instruments

1. Introduction

Comets are considered to be formed by the most primordial material in the Solar System, and spend most of their life in the coldest regions of the planetary system. Therefore, cometary nuclei are likely composed of relatively unprocessed material, and may even preserve pre–solar grains. A deeper knowledge of their nature will constrain the evolutionary processes such as radial mixing in the solar nebula from the hottest internal regions to the colder outer part beyond Neptune (Brownlee et al. 2006). In particular, the Jupiter Family Comets (i.e., Short Period Comets with aphelion at Jupiter's orbit; see Marsden (2009) for the current definition of comet families) likely originate from the trans–Neptunian reservoir known as the Kuiper Belt (Fernández 1980; Duncan et al. 1988), and are fragments of larger Kuiper Belt Objects (Farinella & Davis 1996; Duncan et al. 2004). They should be studied in the framework of a global evolutionary process of the Solar System (see e.g. Morbidelli 2005).

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