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Cometary activity described by chain dust modeling applied to the VIRTIS and GIADA data in the coma of 67P/Churyumov-Gerasimenko

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Abstract

The unprecedented close-to-a-comet observations of dust particles in the circumnuclear coma of comet 67P/Churyumov-Gerasimenko opened room for new data fusion studies in cometary science. Here we use observations performed by two of the instruments onboard Rosetta, Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) and Grain Impact Analyser and Dust Accumulator (GIADA). On one hand, VIRTIS, coupling high spectral and spatial resolution in the VIS (0.25-1.07 micron) and IR (0.95-5.1 micron) ranges, provides information on the composition and temperature (derived from the 4.5-5.1 μm portion of the spectrum) of the surface. On the other hand, GIADA measures the speed, momentum and optical cross section of individual particles detected in situ, deriving their mass and geometrical cross-section. We study the dust dynamical properties in dependence on the surface illumination conditions and on the hidden under-near-surface activity, using two models calibrated by the observational data of the two instruments. The first model, a 2D nucleus thermal model(TMP) computes the dust fluxes for given dust grain size bins assuming a dust particle size distribution on the surface. The second model, an aspherical dust dynamical model computes the trajectories and dynamical properties (grain velocity, rotational frequencies and dust velocity dispersion) of ejected dust from different locations of the nucleus surface. Based on chain modeling, i.e. using the output of the thermal nucleus model as input for the dynamical model we obtain complementary information on the dynamics of dust particles having masses and sizes for which there is no observational dynamical data or are beyond of the instruments detectable sensitivity. The TMP model provided surface temperatures and gas production rates as input to the aspherical dust model that in turn provided rotational frequencies and dust speed distribution. Our models were applied to observational data acquired before 67P/C-G perihelion. We obtained grain speeds ranging from $\sim$ 1 m/s to $\sim$ 150 m/s for grain masses of 10^{-6} kg and 10^{-16} kg, respectively. The number of rotations per seconds for ellipsoidal isothermal grains varies from 1 per hundred seconds up to 10 per second.

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