THE 67P/CHURYUMOV GERASIMENKO DUSTY COMA ANALYSED WITH ASPHERICAL DUST DYNAMICAL SIMULATIONS CONSTRAINED BY GIADA MEASUREMENTS IN FEBRUARY AND MARCH 2015. S. L. Ivanovski[1], V. Della Corte[1,2], A. Rotundi[1,2], M. Fulle[3], N. Fougere[4], A. Bieler[4], M. Rubin[5], S. Ivanovska[6] and V. Liuzzi[2]
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Introduction: The Grain Impact Analyzer and Dust Accumulator (GIADA) instrument [1] onboard ESA’s Rosetta spacecraft, performed unique measurements of the dust environment surrounding comet 67P/Churyumov-Gerasimenko (67P/CG) at both very close proximity and large cometocentric and heliocentric distances. By means of a coupled measurement of two of its subsystems, the Grain Detection System (GDS) and underneath the Impact Sensor (IS), GIADA determines the speed, momentum and mass of each detected grain. GIADA laboratory calibrations with cometary dust analogues [2] provided a refinement of the mass and geometrical cross section of GDS+IS coupled detections. The collected data allows us to address outstanding questions dealing with the cometary activity, dust dynamical properties, dust coma evolution, dominant dust cross sections, etc. In order to answer such questions advanced physical modelling of the gas and dust dynamics is necessary. The state-of-the-art gas-dust dynamical models [3, 4, 5] have assumed spherical shape for their dust particles. The non-spherical shape leads to different dust dynamics, including the effect of the velocity dispersion and rotational motion.

The dust velocities reported in [6] for grains, moving in the same gas field, with the same mass but different in shape show different terminal velocities for both identical and different postulated initial grain orientations on the surface.

Here we analyze the dust motion with numerical simulations of a dust dynamical model assuming aspherical or spherical particles and using dust particles dynamical properties measured by GIADA in the periods 19-27 February 2015 and 13-28 March 2015. These periods are characterized by low phase angles, small distances down to 50 km, and high northern latitudes above the illuminated hemisphere led to high GIADA dust detection rates providing a good image of the coma dust coma distribution [7].

In this paper, we show that for comet 67P/CG in February and March 2015 we are capable to reproduce the measured GIADA velocities by means of convex ellipsoidal shapes and sphere under the modelled local gas parameters calibrated with ROSINA [8] measurements. We obtain that the simulated particles are slow rotators with rotation frequency from 0.03 up to 2 Hz.

Methods: In order to investigate the impact of the asphericity on the interpretation of the GIADA dust data we used mass versus cross section relationship from the GIADA measurements. Figure 1 shows that with respect to the mass versus cross section dependence, almost 90% of all detected particles in the considered periods are located in the range confined by the trend of ellipsoids with aspect ratio of 5 and 0.2. Thus, we use the mass, the cross section and the assumed shape to perform numerical dust simulations with spherical and ellipsoidal shapes and to compare the obtained dust terminal velocities with the measured GIADA speeds. We take into account only the simulation cases when the derived dust grain density from the measurements and assumed shape is realistic, i. e. GDS+IS detections are due to compact particles with averaged dust bulk density of about 800 kg m^{-3}. The upper limit for the dust bulk density considered here is the same considered in [9], i.e. of Fe-sulfides 4 600 kg m^{-3}.

The translational and rotational motion of homogeneous, isothermal ellipsoidal dust particles is studied under the influence of gravity and aerodynamic force. In our simulations, the dust grains are assumed to be out of the near nucleus coma, i.e. where the gas velocity is radial and constant, therefore are either aligned or have random but constant orientation with respect to the gas drag. Therefore, we investigated the motion of convex ellipsoidal dust grains for which the axis of rotation and the gas velocity are coplanar. The motion of the aspherical grains was obtained through computing the acting forces at each time step, integrating over the surface of the grains. The description of the model can be found in [6].

We use a simplified approximation of the gas coma but we reproduce locally the characteristics of the gas flow constrained by the realistic full 3D+t simulated gas computations calibrated with the 67P/C-G ROSINA and VIRTIS gas data [10] using a Direct Simulation Monte-Carlo model with the Adaptive Mesh Particle Simulator code.

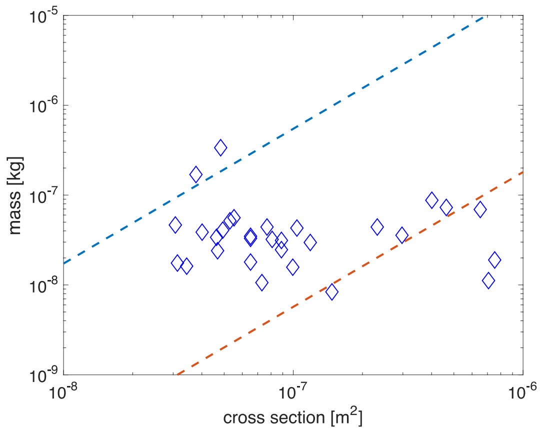

Figure 1. Mass versus cross-section of the compact particles detected by GIADA in the periods 19-27 February 2015 and 13-28 March 2015. The dashed lines are the trends of prolate and oblate ellipsoids of aspect ratio of five and with bulk densities 4600 kg m^{-3} (upper line) and 1200 kg m^{-3} (lower line), respectively.

Results: The measured GIADA particle speeds in February and March 2015 have been reproduced using aspherical dust model and gas coma solutions constrained by the ROSINA data. We complement the in-situ dust dynamical measurements by GIADA providing possible dust particle shapes constrained by the particle mass versus cross section GIADA data. The used ellipsoidal shapes of aspect ratio 0.2 and 5 in agreement with the measured mass versus cross-section trends allow to obtain dust particle velocities as those measured by GIADA in 80 % of the detections. For the ellipsoidal particles, we obtain rotational frequency that ranges from 0.03 Hz up to 0.2 Hz and the time when the rotation has started. Thus, we derive complementary information on the dust dynamical properties of the detected 67P cometary particles, information that no one of the instruments onboard Rosetta was aimed at measuring in-situ.

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