MODEL OF ASPHERICAL DUST DYNAMICS FOR GIADA EXPERIMENT IN THE COMA OF 67P/CHURYUMOV-GERASIMENKO: I. COMPARISON WITH THE SPHERICAL APPROXIMATION.

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Introduction: The GIADA (Grain Impact Analyzer and Dust Accumulator) instrument [1], on board of the ROSETTA orbiter, is aimed to analyze physical and dynamical properties of individual particles ejected from the nucleus and will measure the number, mass, velocity and momentum of the dust particles emitted from the nucleus. In order to interpret the in-situ data collected by GIADA in the coma of comet 67P/ Churyumov-Gerasimenko, a model of dust dynamics is indispensable. The currently used 3D+t models [2,3] assume sphericity of the grains but the dynamics of aspherical grains can be very different from spherical [4]. We report the recent advances in developing of the model of aspherical dust grain dynamics in the cometary atmosphere and discuss its distinctions from the spherical grain model.

The model: We assume that dust grains are homogeneous, isothermal bodies with convex polygonal surface. The grains are moving under influence of two forces: aerodynamic and gravitational. It is assumed that presence of dust does not affect on the gas flow. The gas distribution (density, velocity, temperature) in the coma is given by an adiabatic spherical expansion of perfect gas. In the range of gas production rates of interest the mean free path of the gas molecules is much larger than the grain size, therefore for calculation of aerodynamic force acting on the grains we use free molecular expressions. Gravitational field is also assumed spherical. On the initial surface we postulate the distribution function of ejection velocity and the distribution function of initial orientation of the grains. Then we trace the trajectories of a number of grains from the surface. From this data we derive an average trajectory and dispersion around it. The goodness of spherical grain approximation is evaluated from deviation of the spherical grain trajectory from the averaged trajectory of aspherical grains expressed in terms of dispersion.

The results: In contrast to the spherical grain model aspherical grains experience not only longitudinal force (i.e. drag) but also transverse force (i.e. lift) and torque. It is convenient to represent aerodynamic force in the form of dimensionless aerodynamic coefficients (drag, lift etc.) to dynamic pressure. They have strong variation with respect to the grain's orientation alpha in the full-range of flow conditions. For example, Fig.1 shows comparison of the drag coefficient for a spherical and an ellipsoid shape grains. The difference increases for low speed regime (mol. speed ratio S<5). Results also show that for different initial orientations, the velocity along the trajectory of the identical aspherical grains changes significantly (Fig. 2).

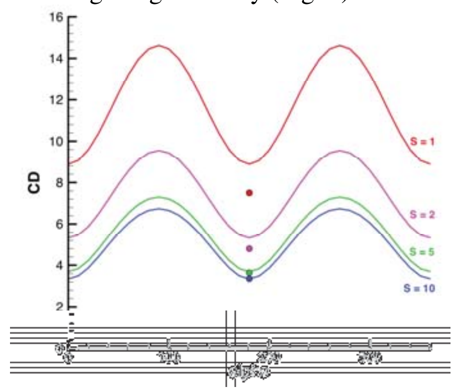

Fig. 1 Drag coefficients for an ellipsoid (dots are for sphere).

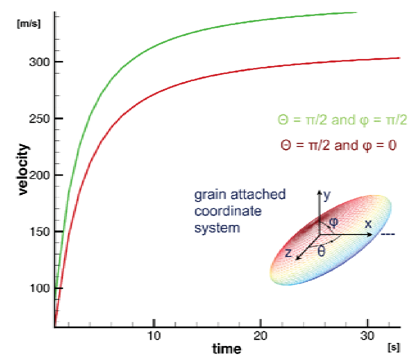

Fig. 2 Velocity of an ellipsoid along the trajectories for different initial orientation.

In our future work we plan to implement realistic distribution of gas and gravity and a variety of realistic shapes for the grains.

References:

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