MODELS OF ROSETTA TARGET COMET 67P/CHURYUMOV-GERASIMENKO.

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Introduction: Comet nuclei are considered as the most pristine bodies of the solar system and consequently their study sheds an important light on the processes occurring during the initial stages of the solar system formation. Rosetta's main objective is to rendezvous with comet 67P/Churyumov-Gerasimenko. It will study the nucleus of the comet and its environment, from the onset of the activity near the aphelion to the perihelion, thus giving insights both on its origin and on its evolution.

The recent in situ measurements of cometary nuclei have shown typical non-spherical shape and particular topography. Here we will present the results of a new quasi three-dimensional approach for non-spherically shaped cometary nuclei [1], which has been developed to interpret the current activity of comets in terms of initial characteristics, and to predict shape and internal stratification evolution of the nucleus. We applied this model to comet 67P/Churyumov-Gerasimenko.

Model parameters: Compositions and internal structure of comet nuclei are poorly known, and cannot be easily determined from ground observations. Parameters used in these simulations are derived from the observations of 67P/Churyumov-Gerasimenko when available, or otherwise chosen among those that are considered typical for comets [2]. The shape of the comet can be described in our model through a two-dimensional discreet grid defined with the angles θ and φ corresponding to the colatitude and longitude of the points considered on the comet. The illumination at one point of the grid is calculated as the illumination over the surface circumscribed by the four faces of the quadrilatere defined by the four points on the grid. Each global shape (spherical, ellipsoidal, spherical harmonics) defined can be altered by the presence of a crater-like depression. For each shape or altered shape, the shadow of each point on the surface of the nucleus is calculated by determining whether the direction to the Sun from the point considered crosses another part of the nucleus or not.

Thermal evolutions: The thermal evolutions are calculated locally, using as input the solar illumination and the different parameters of the cometary material beneath the surface. The numerical code computes the heat diffusion in the porous cometary material, leading to the water ice phase transition and the sublimation of the volatile ices. The initially homogeneous nucleus differentiates, exhibiting a layered structure, in which the boundary between different layers is a sublimation front. The model takes into account the amorphous-crystalline transition with the release of gases trapped in the amorphous ice, if any. The gases diffuse inside the pore system, either recondensing in the colder layers or else escaping into space. The gas flux is computed according to the kinetic theory. When the ices begin to sublimate, refractory particles are liberated subject to the drag exerted by the escaping gas, so that some are either blown off or accumulate on the surface to form a crust. Surface erosion due to ice sublimation, particles ejection, crust formation and compaction is computed at each step. For further details, see previous articles ([1], [3], [4]).

Results: Calculations have been done for differently shaped nuclei. Each shape can have different obliquities and be altered with crater-like depressions. Here we will briefly see only one case: spherical shape with obliquity of -50°.

We followed the comet from the Kuiper belt to the present orbit. During the first two orbits in the solar system (before the 1959 close encounter) the large perihelion distance allows the formation of the dust mantle that is on the northern hemisphere. Figure 1 shows the dust mantle that covers the comet before the last Jupiter encounter.

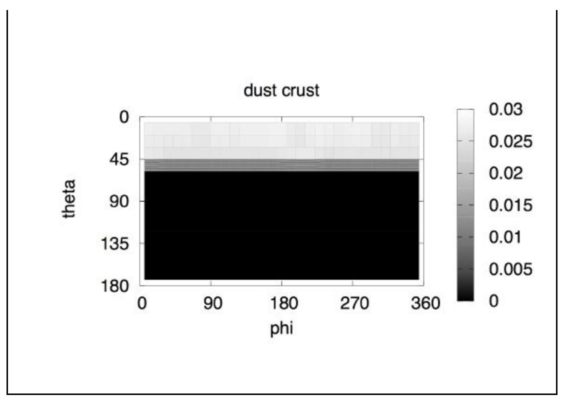

Figure 1: Two-dimensional Mercator projection of the dust mantle distribution before the 1959 close encounter. A thin dust mantle covers most of the northern hemisphere.

The last close encounter with Jupiter had the effect of reactivation of the comet, with the loss of part of the dust mantle. After the 1959 close encounter, with the perihelion distance reduction, a large part of the crust is removed and the nucleus is reactivated with the ablation of the external layers.

Figure 2 shows the illumination, temperature, fluxes and stratification patterns for the layers of ices at the perihelion of the present solar system orbit. The orientation of the nucleus is such that it shows its south pole to the Sun at perihelion on its orbit. The southern hemisphere is the one that shows the largest erosion for the water ice, due to the fact that most of the water flux come from the regions that are illuminated at the perihelion.

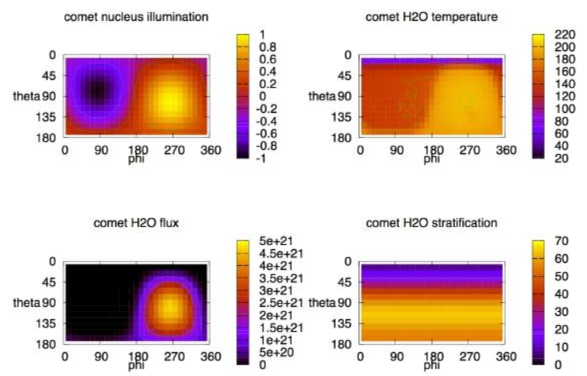

Figure 2: Fig.2. Two-dimensional Mercator projection of illumination (cosine of the angle between local normal and direction to the Sun; top left), temperature, fluxes and erosion (difference between the current local radius and the initial local radius) for the water at the perihelion of the present 67P/Churyumov-Gerasimenko orbit.

The CO2 ice shows a stratification pattern similar to that of water ice, while the CO stratification is completely different. The erosion of the CO ice, with respect to the initial homogenous distribution, is larger in the equatorial regions and symmetrically distributed in the two hemispheres. The CO ice distribution is mainly due to the past evolution in the multistage capture processes from the Kuiper belt to the inner solar system, where the obliquity effects are negligible. Due to low sublimation temperature of this ice, the CO is confined in the interior of the nucleus, while water and CO2 ices are more external and follow the illumination condition.

Discussion: Our calculations have shown that local variations in the dust and gas fluxes can be induced by the illumination conditions on the nucleus shape. The fluxes actually lead to the erosion of the comet nucleus and will thus modify the characteristics of the nucleus. The most volatile ices, like CO, are less influenced by the nucleus shape and obliquity, while water flux is strongly dependent from the illumination condition. The water comes from illuminated regions of the comet and follows the day/night illumination variations and the seasonal illumination variations. The CO2 flux, coming from layers near the surface follows the general illumination conditions but is not so strictly related to the sun incidence angle. Seasonal effects can be seen the activity behavior and distribution patterns.

References: [1] Lasue et al. (2008), *Planet. Space Sci.*. [2]. Huebner et al. (2007), Heat and gas diffusion in comet nuclei. *ISSI Book, ESA, Noordwijk, The Netherlands*. [3] De Sanctis et al. (2005) *Astron. Astrophys. 444,* 605-614. [4] De Sanctis et al., (2007), *Astron. J. 133*, 1836-1846.