QUASI 3-D MODEL OF THERMAL EVOLUTION OF COMET NUCLEI. M.C. DeSanctis[1], J. Lasue[2], G. Magni[1], A. Coradini[3], M.T. Capria[1], D. Turrini[3] and A.C. Levasseur-Regourd[2] [1] Istituto di Astrofisica Spaziale e Fisica Cosmica, INAF, Via fosso del cavaliere, 100, Rome 00133, Italy, mariacristina.desanctis@iasf-roma.inaf.it, [2]UPMC Univ Paris 06, UMR 7620, SA/IPSL, BP 3, F-91371 Verrières, France, [3] Istituto di Fisica dello Spazio Interplanetario, INAF, Rome 00133, Italy.

Introduction: Cometary nuclei are icy bodies considered as the most primitive remnants of the solar system formation. As a consequence, their study sheds an important light on the processes occurring during the initial stages of the protosolar nebula. Numerical models of cometary evolution have been developed during the last two decades thanks to the increase in computer calculation power. Initial models used a one-dimensional representation of an ideal spherical nucleus while the last models take into account both the latitudinal and the longitudinal variations of illumination ([1], [2], [3], [4], [5]). However, the recent in situ measurements of cometary nuclei have shown typical non-spherical shape and particular topography. Here we will present a new quasi three-dimensional approach for non-spherically shaped cometary nuclei, 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

Comet shapes: The cometary nuclei observed in situ do not have spherical shapes and present various surface features. 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 latitude 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. Spheroid shapes defined by their three principal axes and spherical harmonics functions calculated over the surface of the comet can be defined and used to calculate the illumination and the thermal evolution of specific nuclei. Each global shape thus 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. Our numerical simulations make the assumption that the lateral heat transfer is negligible with respect to the radial heat transfer. 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 re-condensing 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], [5]).

Results: Calculations have been done for spherical nuclei with different obliquities, spherical nuclei with crater-like depressions and spheroid-shaped nuclei. Here we will briefly see only one case: spheroidal shape. A prolate spheroid (with semi-major axis twice the size of the two others axes, see Fig. 1) has been considered as comet shape.

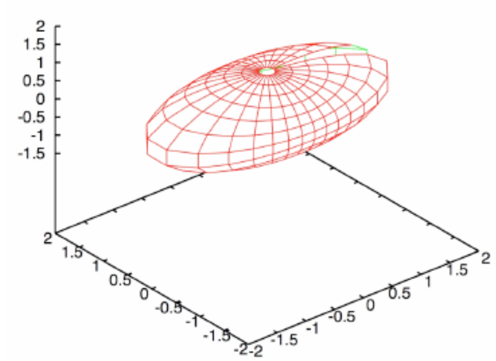

Figure 1:.Spheroidal nucleus shape.

Figure 2 shows the illumination, temperature, fluxes and erosion for the surface and the three types of ices at the perihelion of the first inner solar system orbit. Typical features significantly different from the ones of a sphere appear for the stratification of the layers. The erosion is deeper at the flattest surfaces of the nucleus where the Sun illumination is the longest, and the flux is the most important. At the equator, the evolution of erosion between the points closest and farthest from the center of the nucleus is very similar. This means that the erosion of the nucleus all along the equator goes at the same pace, keeping the initial shape of the nucleus. However, the erosion at latitudes around 50° and 70° are different depending on the location at the surface, and is stronger near the flat surfaces.

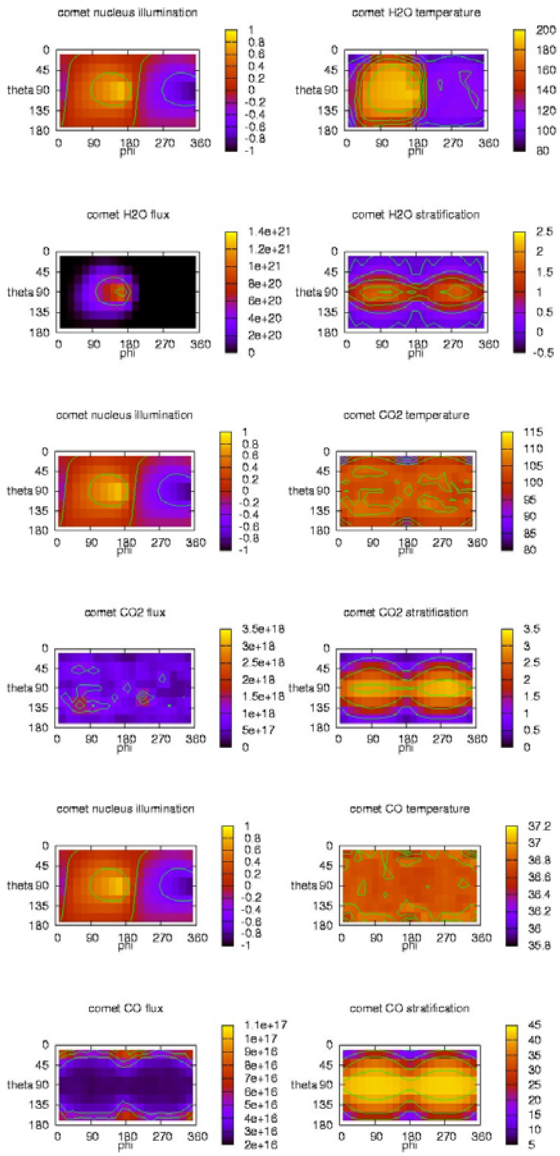

Figure 2: Two-dimensional Mercator projection of the spheroidal nucleus for the illumination (cosine of the angle between local normal and direction to the Sun; top left), the temperature, the flux and the erosion (difference between the current local radius and the initial local radius) of the cometary nucleus for the surface H_2O , CO_2 and CO layers at the perihelion of the first injection orbit.

Discussion: Our calculations have shown that local variations in the dust and gas fluxes can be induced by the nucleus shape. The presence of crater-like depressions or spheroidal deformations can induce a diurnal asymmetry of the comet activity. The spheroid shaped nucleus present a decrease by a factor of 2 in its global flux as compared to the flux of the spherical shaped nucleus. This decrease cannot be only explained by the difference in surface area of the two models of nucleus which would decrease the flux by a factor of ~1.3. This means that globally the spheroid shapes comet nuclei will not be as active as spherical nuclei.

The fluxes actually lead to the erosion of the comet nucleus and will thus modify the characteristics of the nucleus. Regarding the spheroidal nucleus shape, the maximum of erosion takes place on the flattest parts of the nucleus thus increasing the spheroidal shape through time. This means that such a nucleus will be dynamically stable for a longer time than spherical shaped nuclei since its rotation axis is already along one of its semi-minor axis.

References: [1] Capria et al. (2001), *Planet. Space Sci. 49*, 907-918. [2] Cohen et al. (2003) *New Astronomy 8*, 179-189.[3] De Sanctis et al. (2005) *Astron. Astrophys. 444,* 605-614. [4] Sarid et al. (2005) *Publ. Astronomical Society of the Pacific 117*, 796-809. [5] De Sanctis et al., (2007), *Astron. J. 133*, 1836-1846.