Numerical Studies of Surface Erosion in a Multi-Component Comet Nucleus. N. Gortsas[1], E. Kührt[2] and U. Motschmann[3], [1]DLR, Rutherfordstr. 2, 12489 Berlin, Germany, nikolaos.gortsas@dlr.de, [2]DLR, Rutherfordstr. 2, 12489 Berlin, Germany, ekkehard.kuehrt@dlr.de, [3]TU Braunschweig, Mendelssohnstr. 3, 38106 Braunschweig, Germany, u.motschmann@tu-bs.de.

Introduction: Thermal modeling is an essential tool for investigations of cometary activity and other typical cometary phenomena. Numerous approaches have been published so far (- see for a review [1]) but the feedback of surface erosion caused by ice sublimation to the thermal state of the nucleus is commonly neglected. However, near perihelion the characteristic rate of surface erosion can be considerably higher than that of heat diffusion. Thus, depending on basic parameters, such as the thermal conduction coefficient, it is very well conceivable that surface erosion leads to a significantly less heated nucleus.

In order to address this hypothesis we developed a novel thermal conduction code that solves an initial-boundary value problem of the heat conduction equation with moving boundaries, the so called Stefan problem. A crucial constraint of our model is energy conservation at each time step.

We started our investigations with a spherical body consisting of pure water ice [2]. Rotation, orbital motion and porosity have been taken into account. Our calculations revealed a substantially less heated comet nucleus compared to calculations without surface erosion.

In a second step we extended the method to include not only dust but also a second more volatile ice species, namely CO ice. With our newly devised method we are able to successfully handle two distinct differently moving boundaries. On the one hand, we have the moving surface boundary and on the other hand we have a moving internal boundary separating regions depleted in CO ice from those containing CO ice. We address the question of whether the feedback of surface erosion to the thermal state of the nucleus could be a possible explanation for the observed strong coupling between the CO sublimation rate and the surface illumination rate in the case of comet Hale-Bopp [3].

Figure 1 shows the spatial extension of the interstitial region between the upper layer, consisting of a mixture of water ice and dust, and the lower layer, consting of a mixture of CO ice, water ice and dust. As the comet approaches perihelion water ice sublimation on the surface exceeds CO ice sublimation in the interior of the nucleus so that, at perihelion, the lower layer, and thus the mixture containing CO ice, is close to the surface. Outbound from perihelion erosion of the upper layer decreases and the CO ice rich region recedes to greater depths. The location of the material interface shows an oscillating behavior with time.

The consequences of this new approach to cometary activity, taking into account different values for the thermal conduction coefficient and porosity, are discussed.

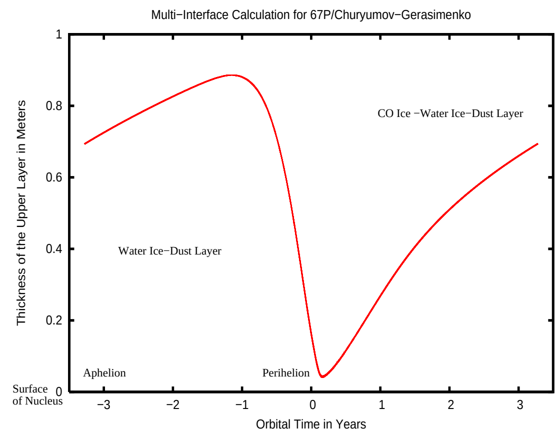

Figure 1: Thickness of the upper layer of a cometary nucleus that is depleted in highly volatile ices as a function of orbital time. The calculation has been performed for the Rosetta target comet 67P/Churyumov-Gerasimenko with a constant thermal conduction coefficient of κ = 0.001 W/(K m) for all materials.

[1] Prialnik D. et al. (2003) *Comets II (Ed. by M. Festou, H.U. Keller, and H.A. Weaver)*, 359-387.
[2] Gortsas N. et al. (2007) *Bull. Am. Astron. Soc., 39*, 498-499.
[3] Biver N. et al. (2002) *Earth Moon and Planets, 90,* 5-14.