MODELLING THE INTERNAL STRUCTURE AND EVOLUTION OF SMALL ICY BODIES OF THE SOLAR SYSTEM

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The small, icy, Solar System bodies constitute a huge and diverse population, including comets, Kuiper belt objects and satellites, ranging from about one and up to several hundred kilometers in radius. Their composition consists of dusty (rocky) material and of ice; their structure appears to be porous. In recent years, many new objects have been discovered in the remote parts of the Solar System, and new information has been gleaned from observations and space missions.

The thermal evolution of such objects is mainly governed by radioactivity, phase transitions and irradiation. In order to follow their evolution since formation, various computer codes have been developed that solve numerically the problem of heat and mass transfer in a spherical body, in various modes and approximations, ranging from 1-D to fully 3-D, and including many volatile species or vapor and liquid transport (two-phase flow). Each problem is tackled by the best-suited method to the object considered and to the task. It is the interior that numerical simulations aim to decipher, by confronting the theoretical results with observed characteristics.

Thus, cometary research reached its climax this year, with the arrival of the *Rosetta* spacecraft to Comet 67P/Churyumov-Gerasimenko. The various instruments on board Rosetta have provided data of detail, quality and time-span never known before. The main findings concern the surprisingly complex and diverse surface structure and the evolving activity pattern of the comet. The marked inhomogeneity of both bears witness to the expected inhomogeneity of the interior, in structure and composition alike. Numerical models show that a porous nucleus, composed of dust (rock) and water ice in which other volatile species are occluded, may account for a plethora of phenomena, in line with observations, among them, diurnal cyclic activity [1], localized outbursts of gas and dust, emission of separate volatile species of different volatility, or uneven activity at localized spots [2].

The structure and evolution of larger bodies is determined by self-gravity, which may and has been neglected in the investigation of smaller objects. In order to include self-gravity in evolution codes, an equation of state, linking pressure and density, is required, suitable for porous mixtures of ice and rock. In addition, In large bodies the temperatures attained are much higher, water ice becomes liquid and new processes involving rock-ice interactions occur, such as serpentinization [3].

Models show that the mass of such a self-gravitating body uniquely determines the evolution of porosity, and thus explains the observed differences in bulk density among bodies of different size. The final structure is invariably differentiated, with an inner rocky core, and outer ice-enriched mantle. The degree of differentiation, too, is determined by the object's mass [4]. The significant result is that one basic model including phase transitions and radioactive heating is capable of rendering a wide variety of behavior patterns.

[1] Prialnik, D.; A'Hearn, M. F.; Meech, K. J. 2008. *Monthly Notices of the Royal Astronomical Society* 388: L20-L23. [2] Rosenberg, Eric D.; Prialnik, Dina 2010. *Icarus* 209: 753-765. [3] Malamud, Uri; Prialnik, Dina 2013. *Icarus* 225: 763-774. [4] Malamud, Uri; Prialnik, Dina 2016. *Icarus*