EFFECT OF THE NET ENERGY RELEASED IN CRYSTALLIZATION IN COMETARY MODELS.
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Context and goals: Pure amorphous solid water is metastable at very low temperatures and pressures and crystallizes into cubic ice exothermically , transition being favored as temperature increases. Nevertheless, some experiments indicate that the net energy released during this process can be significantly affected by the presence of volatile dopants. The transition can even become endothermic if the amount of dopant is high enough [3]. Many thermophysical models for cometary nuclei assume that the initial state of cometary water ice is amorphous and that crystallization constitutes an internal source of energy [2]. Our goal is to study the role that the energetic contribution of crystallization may have in the thermal evolution of a simulated cometary nucleus.

Method: We use a classical but simplified thermophysical model to simulate a cometary nucleus [1]. Our simulated nucleus will be made of water ice (initially in amorphous state) and dust. Heat transfer and crystallization will be the dominant processes under our conditions, simulating the cometary nucleus interior. Simulations are performed for different characterizations of the nucleus material, and the influence of magnitudes such as dust-to-ice ratio, thermal inertia or bulk density in our results are explored.

Results: As expected, the effect of the net energy released in crystallization is strongly dependent on the physical characteristics of the nucleus [1].
When the net energy released in crystallization is that of pure amorphous water ice, for nuclei with a dust-to-ice of 1 and a low thermal inertia (of the order of 20 W K^{-1} m^{-2} $s^{-1/2}$), the crystallization front evolves discontinuously, with sudden, short in time, and quasi periodic increases of the crystallization rate associated to temperature increments, as can be seen in Fig. 1.

The appearance of these surges and their characteristics can be explained considering the balance between the timescale of crystallization and that of heat diffusion (which strongly depends on the dust-to-ice ratio, thermal inertia, density, ...).

For several plausible physical characteristics, these crystallization spurts and the associated increases in temperature have a similar period [1] to that of the mini-outbursts seen in comet Tempel 1 during its intensive campaign before the Deep Impact event [4].

In our simulations, we find that those crystallization rate peaks appear only when the net energy released is comparatively high. It is also found that, in general, when the net energy released is half that of pure amorphous water ice, surges in the crystallization rate do not appear.

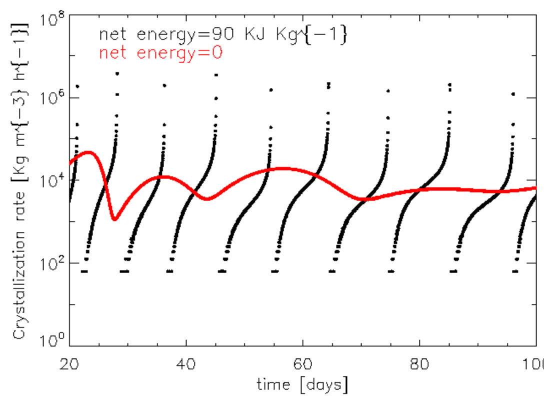

Figure 1: Instantaneous crystallization rate in a cometary nucleus with a dust-to-ice ratio of 1, a thermal inertia of 20 W K^{-1} m^{-2} $s^{-1/2}$ when the energy released in the crystallization is that of pure amorphous water ice (black) and when the transition is energetically neutral (red).

References:

[1] González, M. et al. (2008), A&A, submitted. [2] Prialnik, D. et al. (2004) in *Comets II,* eds. Festou, H. E. & Keller, H. A. [3] Kouchi, A. & Sirono, S. (2001), *Geophys. Res. Letters*, 28, 827. [4] A' Hearn, M. F et al. (2005), *Bulletin of the AAS,* 37, 1483.