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Accretion and thermal evolution of TransNeptunian Objects: A new model

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1 Introduction

Modeling the evolution of large- and mid-size TransNeptunian Objects (TNOs) is a challenging task. Indeed, models developed so far (Hussmann et al. 2006 [1], Prialnik and Merk 2008 [2], Desch et al. 2009 [3], Desch and Neveu 2017 [4], Shchuko et al. 2014 [5], Bierson et al. 2018 [6]) have highlighted the strong dependence of modeling outputs on the thermo-physical and structural parameters involved. Most of them are poorly constrained for the vast majority of currently known TNOs. Therefore for a given object, current models can predict evolutionnary tracks going from maintaining a fully pristine interior, to significant processing involving differentiation, the formation of a subsurface ocean or cryovolcanism.

2 Observational motivation

The detection of crystalline water ice at the surface of several TNOs (e.g. Brown and Calvin 2000 [7], Jewitt and Luu 2004 [8], Barkume et al. 2008 [9], Guilbert et al. 2009 [10]), and the presence of ammonia or ammonia hydrates at the surface of a few of them (e.g. Brown and Calvin 2000 [7], Delsanti et al. 2010 [11]) have been first interpreted as signs of past cryovolcanism. They have thus prompted studies of the past thermal processing of TNOs. We are now aware that alternate explanations (like molecular diffusion through the icy matrix) may exist for understanding the presence of these compounds at the surface of these objects (Holler et al. 2017 [12], Cruikshank et al. 2015 [13]). However, the recent observations performed by the New Horizons probe of both Pluto and Charon (Stern et al. 2015 [14]) do show important hints that differentiation, subsurface oceans and possibly cryovolcanism, did play an active role in the evolution of these objects (Stern et al. 2015 [14], Trilling [15] 2016). Hence, key questions remain:

- are those processes ubiquitous amongst TNOs, and what is their role in shaping objects as we see them today?
- is knowing the bulk and surface properties of TNOs enough to understand their thermo-physical evolution?

3 New model for TNOs formation and thermal evolution

In this work, we present preliminary results from a new model developed to address those key questions.

- The code solves the heat equation in a 1D sphere,
- It uses a finite volume method with a boundary constant temperature at surface,
- It includes decay of short- and long-lived radionuclides,
- It begins with the accretion thanks to an adaptative grid,
- It includes the possibility of phase change from ice to liquid and the assiociated differenciation.

The results presented are applied to a range of mid-sized TNOs for which the evolution is widely unclear.

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