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A buried snow line in the Solar System

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Abstract

Main Belt comets (MBCs) are recently discovered objects that are orbiting in the Main Belt and are showing cometary activity. The activity of MBCs implies the possibility for a body orbiting the inner Solar System to retain ice. This ice is very probably buried, or was buried before the event that activated the body. Using a thermal evolution model we explore the conditions at which, in the interior of bodies orbiting the Main Belt, ice is stable against sublimation on ages comparable with the Main Belt formation. In this way, a "buried snow line" can be defined.

1. Introduction

Main Belt comets (MBC) are recently discovered objects that are orbiting in the Main Belt and are showing cometary activity [3], [4]. These objects are peculiar because their cometary activity is coupled with a Tisserand invariant Tj>3, implying an asteroid-like orbit stable since very long time. Four of them are known until now: 133P/Elst-Pizarro, P/2005 U1 Read, 176P/LINEAR, and P/2008 R1 (Garradd). Many more, currently inactive or faintly active, are probably existing. Dynamical transition from outer Solar System is nowadays infrequent, and the orbits of MBCs are stable: this implies that MBCs have been formed in the Main Belt, or be there since a lot of time.

2. A buried snow line

A widely accepted explanation for the triggering of observed activity is an impact in a recent past, that has been able to expose fresh material buried under the surface. This explanation implies two facts:

1) MBCs are comet-like bodies, that is they are composed by a mixture of ice and refractory particles.
2) A number of bodies should exist, orbiting the inner Solar System, that have been able to keep ice in their interior for a very long time span.

In order to study at which depth, and in which conditions, ice can be stable against sublimation for millions of years, thermal evolution models developed for more classical comets can be applied [1, [2]. We apply the model to study bodies orbiting on circular orbits from 2 to 3.27 AU. In this way we can define a "buried snow line"[5], that is the depth, at each heliocentric distance, at which ice must be buried in order to survive for billions of years.

This depth depends obviously on the physical properties of the mantle, in particular its thermal conductivity: it is well known that under a devolatilized, low-conductivity mantle ice-rich layers can survive for a very long time.

It is found that a depth of few tens of meters is able to keep water ice stable for a very long time span.

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