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Surface characteristics and activity of a dynamically new comet

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Abstract

A dynamically new comet is a comet coming directly from the Oort cloud and entering for the first time in the inner Solar System. In this work we discuss how its surface could be different from that of a comet belonging to better known dynamical classes such as Jupiter family and Halley-type comets. We also study its activity along the inbound branch of a typical orbit, looking for possible differences with respect to the other classes of comets.

1. Introduction

The results from the space missions to comets in the last years gave us the possibility to study the geomorphology of cometary surfaces. A surprising variety of structures has been identified on the surfaces of 67/P Churyumov-Gerasimenko, 9P/Tempel 1, and 103P/Hartley 2, originating a debate on which features are the result of typical cometary activity and which ones can be considered as "primitive", that means existing since the formation time. An obvious answer would be that activity has probably erased all the traces of primitive structures, but this is not necessarily true, as demonstrated by the layering seen on 67P (and probably also on Tempel 1), of probable primitive, or at least very old, origin.
All the nuclei explored until now belong to Jupiter-family or Halley-type comets, bodies orbiting in the inner Solar System from a more or less long time. Their surface can by no means be defined as being primitive, and surely most, if not all, of the features and characteristics we see are due to the activity. A dynamically new comet (hereafter DNC) is instead a comet coming directly from the Oort cloud [1,2] and entering for the first time in the inner Solar System: this means that, after its formation in the colder part of the disk, the nucleus has been almost immediately transferred in cold storage in the Oort cloud. This would imply minimum, if any, collisional evolution, and no sublimation-driven activity, with the exception of a possible sporadic surface heating due to passing very luminous stars. DNCs are a class of cometary nuclei never explored before.
In this work we discuss the morphological and compositional features that could characterize their surface, in comparison with those of other nuclei belonging to the better known comet families. We also study their activity along the inbound branch of a typical orbit, looking for differences in the emission patterns of gas and dust fluxes with respect to other types of comets.
This is of interest in order to better understand the formation processes and early history of comets.

2. The method

A thermophysical model, developed to simulate icy bodies in the Solar System [3], is being used to simulate the behaviour and activity of a DNC entering the inner Solar System, that is on its inbound orbit arc. The code solves the coupled equations of heat transfer and gas diffusion, accounting for the solar radiation reaching the surface, heat conduction in the interior, heat advection by gases, sublimation of ices, amorphous-crystalline ice transition and gas and dust fluxes from the nucleus. The dust grains are released by the sublimation of the ices and undergo the drag exerted by the escaping gas. The nucleus model is composed by dust, described as a distribution of grains with different sizes, and ices (water, CO_2, CO). We are assuming that the ices more volatile than water are very close to the surface, or still on the surface. The model is being used to study the beginning of the activity and its effects on the surface and the layers immediately below, and the gases emission patterns along the orbit arc.

3. Conclusions and future works

It is highly probable that the surface of a DNC will show different morphological and compositional characteristics with respect to that of a Jupiter-family or Halley-type comet. We are also planning to review the literature on the observed DNCs to collect information on their activity.

References

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