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Towards a high-accuracy geological model of the 67P comet

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Abstract

It was recently shown that the layered structure of each of the two lobes of comet 67P/Churyumov-Gerasimenko (67P) can be modelled as a set of concentric ellipsoidal shells. The ellipsoidal model is able to correctly predict the major layering-related features on the comet surface; however, the ellipsoidal model is a first order approximation of a more complex internal structure. A better description of this latter requires an improved model. In this contribution preliminary results in building a refined three-dimensional model of the comet are presented with focus on the Small Lobe. The model is realized using a 3D geo-modeling technique that embeds linear and planar features (layer joints and terraces) as well as other geometric characteristics (e.g. vectorial fields) as constraints, influencing the reconstruction of the comet layered structure. Results allow accounting for features that are not predicted by the ellipsoidal model, therefore such refined 3D model is a step towards a model of the comet nucleus that may clues useful in unraveling the complex history that shaped it to its present configuration.

1. Introduction

After the recognition of sets of ordered terraces and mesas on the surface of the comet 67P/Churyumov-Gerasimenko [1], evidences were provided that the two lobes of the comet are characterized by large-scale internal layering [1]. The recognition of the layered structure opened to efforts aimed at modelling in three dimensions the structure of the cometary nucleus. Recently, a 3D model made up of two independent sets of concentric ellipsoidal shells was proposed [2]. These shells (Fig.1A and 2A), characterized by a fixed aspect ratio, are obtained from non-linear optimization of the orientations of the terraces on the lobes. The ellipsoidal model is able to predict orientation of cliffs and terraces in several regions of the comet (e.g. Wosret and Hathor of the Big Lobe). However, in other regions, and in particular on the Small Lobe, discrepancies between the model-predicted layers and the visible layering and terraces are locally visible (Fig.1A) and suggest that a refinement of the 3D model would be needed to account for a structure that in specific areas appears to be more complex than expected.

Preliminary results of a refined modelling by using SKUA-Gocad geomodeling software [3] are here presented and provide a further step towards the realization of a 3D stratigraphic model of the 67P comet.

2. 3D modelling in SKUA-Gocad

The 3D model of the Small Lobe of the 67P has realized using SKUA-Gocad geomodeling suite and in particular the StructuralLab plugin. The procedure applies an implicit modeling approach in which layers are modeled as iso-surfaces within a 3D scalar field interpolated within a tetrahedral mesh [4]. A key-point of this modeling procedure is that a large number of constraints can be used to influence the shape of the iso-surfaces. This makes the modeling more flexible and able to reproduce complex and irregular geometries. In the here presented preliminary model, the center of the ellipsoidal shells [2] was kept as center of the layered envelopes, and the vectorial field made of the normals to the identified terraces was used as orientation constraint. In addition, linear features, recognized on the comet surface and interpreted as bedding joints of the

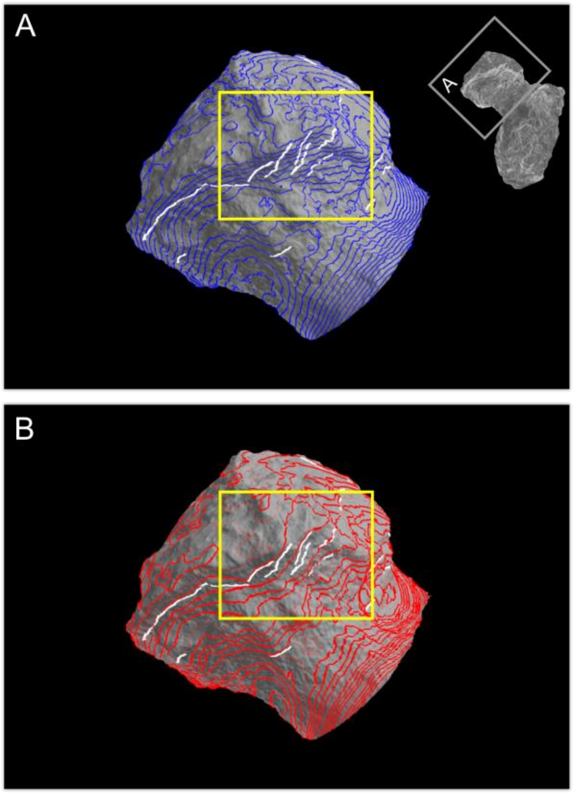

Figure 1 View of the Small Lobe of comet 67P with highlighted some observed layering traces (white) and A) the traces of layering from the ellipsoidal model (blue) and B) the traces of layering calculated from the SKUA model (red). Note (within the yellow rectangle) that discrepancies in A) are resolved in B).

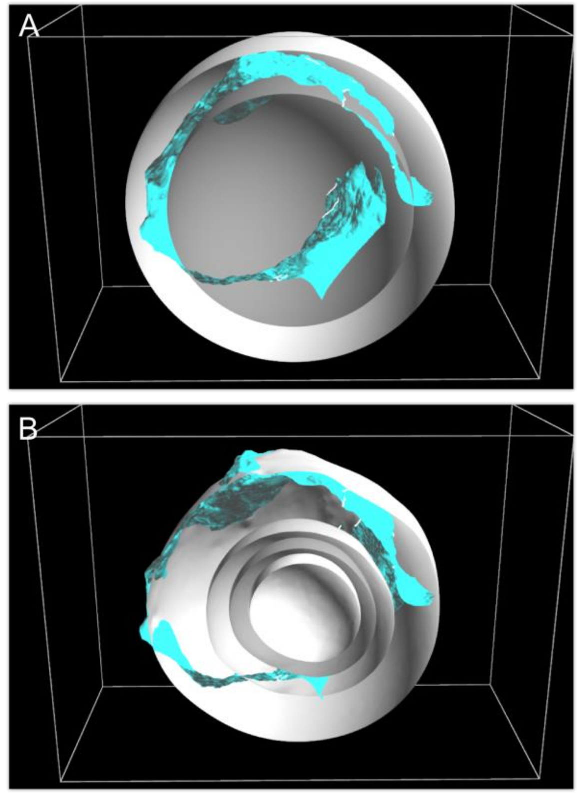

Figure 2 A) cross-section of the Small Lobe (surface painted in light blue) showing concentric shells of the ellipsoidal model. B) same cross-section showing envelopes of the model realized in this work.

layered structure, were traced and fixed as linear constraints so that in the new model each line lays on an iso-surface [4].

3. Results and Conclusions

In the new model the overall shape of the concentric shells results more irregular than that of the ellipsoidal model (Fig.2A and 2B). Since the linear features are used as constraints, a better correspondence between the modeled shells and the visible layers is obtained (Fig.1B. These preliminary results show that a modeling approach embedding a larger number of constraints (e.g. stratigraphic joints) may provide significant support for a more comprehensive 3D representation of the cometary body. The refined model may allow for resolving the actual geometry and highlighting thickness variations of the. This could help shedding light on its origin. For instance, the geometry of the layering may provide clues on the dynamics of the collision between the two lobes whereas thickness variations within layers on the mechanisms of cometary accretion.

4. References

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