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# Revealing the properties of Chuyurmov-Gerasimenko's shallow sub-surface through CONSERT's measurements at grazing angles

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## Abstract

The aim of the Comet Nucleus Sounding Experiment by Radiowave Transmission (CONSERT) is the characterization of the inner structure and electrical properties of the Chuyurmov-Gerasimenko's nucleus. The instrument will sound the comet's nucleus between the lander Philae at the comet's surface and the Rosetta main spacecraft. A coarse three-dimensional model of the complex dielectric permittivity inside the nucleus will be reconstructed from the whole set of data obtained during the first science phase [3]. The work presented here show how a limited set of data acquired at grazing angles during a single low altitude fly-by can be used to characterize the shallow sub-surface of the nucleus. The study is based on simulated data obtained by two different electromagnetic models: the accurate pseudo spectral time-domain method and a much faster ray-based approximation taking into account material and path-loss.

## 1. Introduction

Our aim is to get estimates of the shallow subsurface dielectric and physical properties of the comet's nucleus, which will tell us about its recent history. To do that, we plan to use a limited set of data that will be collected by CONSERT at grazing angle during fly-bys of the main spacecraft.

The electromagnetic models used with simple nucleus geoelectrical models to generate the simulated data are briefly presented, compared and used for our preliminary inversion study.

## 2. Nucleus simplified model

In order to investigate and understand the influence of the permittivity gradient near the surface, the study is carried out with a simple nucleus model. Cometary dielectric models derived from the layered-pile model by Belton et al. [1] are considered. The permittivity at the surface is taken equal to 2 in agreement with the analysis of the observations performed in 1982 with the radar system of the Arecibo Observatory [4]. The permittivity variations implemented in the sub-surface are approximations of the models described by Heggy et al. [2] and described by a permittivity change $\Delta\varepsilon$ that occurs over a thickness $\Delta h$ just below the surface.

## 3. Electromagnetic models

As explained previously, we use simulated data for our study. These sets of data are obtained independently by two different electromagnetic methods: an accurate but time consuming pseudo-spectral-time domain method and a fast but approximate differential ray tracing method.

Results obtained by both methods are compared for various nucleus configurations. Figure 1 shows an example of the results obtained by the two methods (Ray-tracing: RT and Pseudo-Spectral-Time Domain: PSTD) for the same nucleus configuration. While small discrepancies are noticeable on the propagation delays and amplitudes computed, some features like the existence and extension of an occultation zone (where no signal is detected) and of a zone where multipath propagation occurs are similar for both methods.

By comparison with the accurate PSTD method, the validity domain for the approximate ray-tracing method has been estimated for nucleus models that are characterized by a permittivity gradient.

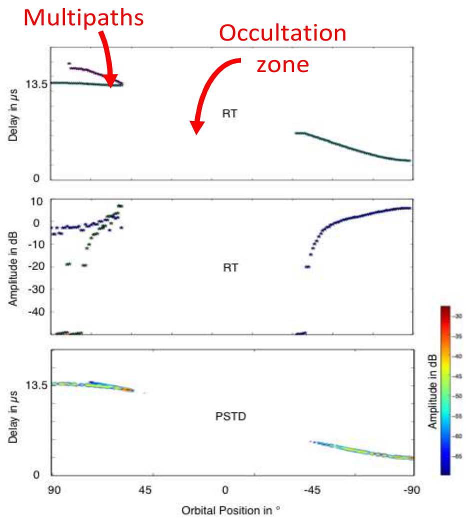


Figure 1 : Comparison of PSTD and RT to validate the ray-tracing approach.

## 4. Preliminary results

Ray tracing simulations are fast enough to study the impact of the subsurface parameters values. Preliminary results (fig. 2) indicate that it is possible to estimate the width of the transition zone (shallow layering) and the core permittivity from measurements of the occultation and multipath zones.

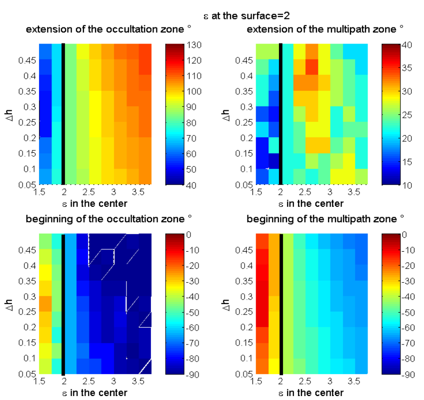


Figure 4: Influence of the transition zone's thickness (Δ**h)** and of the core permittivity on the occultation and multipath zones.

## 5. Summary and Conclusions

The preliminary results obtained on our simulated data show that the limited data volume obtained during a single fly-by at low elevation allow the retrieval of the permittivity gradient below the surface of the comet nucleus. When the experimental CONSERT data are available, comparison with a comprehensive sets of simulated data will provide very rapidly a first estimate of the permittivity behavior below the surface. This information will help constrain the nucleus model and understand the comet history.

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