EPSC Abstracts
Vol. 10, EPSC2015-857-1, 2015
European Planetary Science Congress 2015

CONSERT Radar Investigations of the Shallow Subsurface of Comet 67P, in the Vicinity of the Philae Lander

V. Ciarletti (1), J. Lasue (2), F. Olagnier (2), A.C. Levasseur-Regourd (3), D. Plettemeier (4), Y. Brouet (5), A. Hérique (6) and W. Kofman (6)

(1) UVSQ (UPSay); CNRS/INSU; LATMOS-IPSL, Guyancourt, France (2) Université de Toulouse; UPS-OMP; CNRS; IRAP, Toulouse, France; (3) UPMC (Sorbonne Univ.); UVSQ (UPSay); CNRS/INSU; LATMOS-IPSL, Paris, France, (4) Technische Universität Dresden, Dresden, Germany, (5) University of Bern, Physics Institute, Bern, Switzerland , (6) Univ. Grenoble Alpes, Grenoble, France

Abstract

With receivers and transmitters on-board both Rosetta's main spacecraft and the Philae lander, the CONSERT (Comet Nucleus Sounding Experiment by Radiowave Transmission) bistatic radar has been designed and operated to retrieve information about the internal structure of 67P/Churyumov-Gerasimenko nucleus [1].

CONSERT was successfully operated during the First Science Sequence (FSS) after Philae's landing on the nucleus. While the CONSERT's primary goal is to perform the tomography of the whole nucleus, in this paper, we specifically focus on the local variations in the nucleus shallow subsurface permittivity over depths ranging from tens to hundreds of meters and investigate a possible difference between the Eastern and Western side of the Philae's landing site.

A number of propagation simulations corresponding to the geometrical configurations at grazing angles have been performed for a variety of subsurface permittivity models. The effect of local vertical and horizontal variations of the permittivity values around the landing site as well as comparison with CONSERT's experimental data collected in the same configurations will be presented and discussed. A possible interpretation of the results will be presented

1. The model for the nucleus' shape and subsurface dielectric properties

The nucleus shape model for the simulations is derived from the images of the comet taken by the OSIRIS camera [2]. At CONSERT's 90 MHz frequency, the dielectric properties depend on the porosity, the composition and on the temperature of the nucleus. As a consequence, the data collected by CONSERT should provide information about these parameters values and their spatial variations inside the nucleus. The range of permittivity values we used for this study is based on experimental values available in the literature [3], [4]. These values have been obtained through measurements performed in laboratory on ice/dust mixtures at low temperature and for high porosity values around 70 - 80% commensurate with the information provided by the other instruments of the Rosetta payload.

2. Simulations tool and results

Electromagnetic simulations have been run on these nucleus models to simulate the propagation of the CONSERT waves at 90 MHz between Philae lander and the orbiter. A fast ray tracing method has been used to provide simulated data for a large number of nucleus dielectric constant configurations. It allowed us to study of the effects of the permittivity spatial variations in the shallow subsurface. We considered a variety of possible features such as: a gradient with depth either positive or negative or a random variability of the permittivity. Fig.1 and Fig. 2 illustrate the propagation of the waves from the lander's location. They show how a permittivity gradient in the shallow sub-surface has a potential strong effect on the wave propagation. In both cases, a permittivity gradient taking place within a 50-meters layer below the surface has been considered. Fig. 2 corresponds to a decrease of permittivity with depth while Fig. 2 illustrates the effect of an increase of permittivity with depth.

In this latter case, the rays' curvature clearly show that the refraction prevents the waves transmitted by the lander to propagate towards some given angular directions, which is consistent with the measurement performed by CONSERT during the FSS.

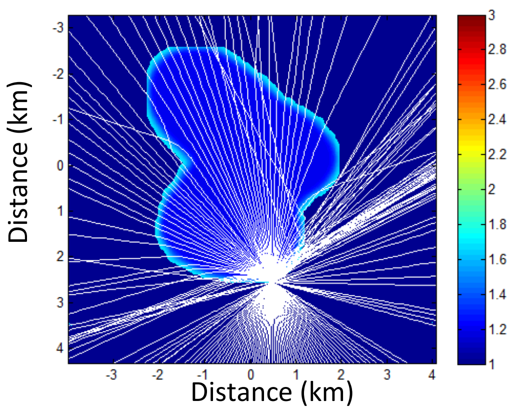

Fig.1: Results of the ray tracing method for a permittivity that decreases with depth. The color indicates the dielectric constant value.

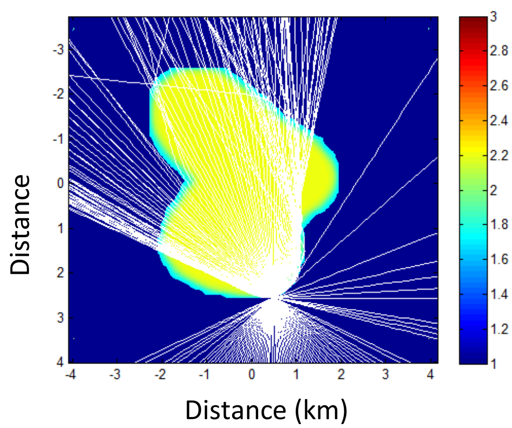

Fig.2: Results of the ray tracing method for a permittivity that increases with depth

3. Conclusions

Comparison between simulated data and experimental data allow us to exclude a situation where the permittivity significantly increases with depth and where the mean permittivity value is larger than 1.3**,** in agreement with a result obtained for an homogenous nucleus [5]

These results can be interpreted in terms of porosity and dust/ice ratio. A preliminary comparison with a model of the subsurface thermal and physical modifications induced by volatiles' sublimation and possible dust crust formation will also be presented.

Acknowledgment

Rosetta is an ESA Cornerstone Mission. Philae is a DLR/CNES lander. The research on the CONSERT experiment is supported by CNES and DLR.

The authors thank H. Sierks (Max-Planck-Institut für Sonnensystemforschung), L. Jorda (Laboratoire d'Astrophysique de Marseille) and F. Preusker (German Aerospace Center - DLR) for the nucleus shape model used in this paper

References

[1] Kofman, et al., Space Science Reviews, 128:413–432, 2007.

[2] Sierks, H., Barbieri, C., Lamy, P. L., et al. 2015, Science, 347, 10.1126/science.aaa1044

[3] Heggy et al., Icarus, vol. 221, Issue 2, 925-939, 2012

[4] Brouet, Y., Levasseur-Regourd, A.C., Encrenaz, P. and Gulkis, S. 2014, Planetary and Space Science, 103, 143

[5] Kofman, et al., Science, 2015 submitted