EPSC Abstracts
Vol. 6, EPSC-DPS2011-924, 2011
EPSC-DPS Joint Meeting 2011

ASSERT : a radar Tomography of Asteroids

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Abstract

The ASSERT tomographic radar is a unique opportunity to achieve the tomography both in transmission and in reflexion of an asteroid in order to determine its fracturing, its stratigraphy and its heterogeneity at different scales for a better understanding of accretion and evolution phenomena's.

This talk reviews all the aspect of the proposed instrument: tomography geometry, instrument concept and present design.

1. Introduction

The internal structure of NEAs is a key point for the understanding of the asteroid accretion and dynamical evolution. This structure remains largely unknown although there are some indirect evidences that a rubble pile structure is really common. Radar tomography is the most promising way to probe the NEA internal structure in order to characterise its composition and its heterogeneity from decimetric to global scale.

2. Radar Tomography

Bistatic radar tomography is an original technique, developed with the CONSERT Experiment in the frame of the Rosetta / ESA mission to image the internal structures and characterize the heterogeneity scales of 67P/Churyumov-Gerasimeko [1],[2]. The signal is transmitted by the lander and acquired by the orbiter after propagation throughout an asteroid and the measurement is repeated for different positions of the orbiter with respect to the lander (Fig 1). By regards to a more classical monostatic radar (like LRS onboard Selene/JAXA or Marsis onboard MarsExpress/ESA), this bistatic configuration requires limited resources (mass, power and dataflow) and increases the capacity of deep sounding.

So ASSERT (ASteroid Sounding Experiment by Radiowave Transmission) [3] is proposed to instrument a MASCOT-type lander [4], e.g. as payload of the ESA Marco Polo R mission.

On ASSERT, we consider 3 different geometries corresponding to different sensitivities and performances: the tomography in transmission when the orbiter is "on the other side" by regards to the lander, the tomography in reflection when the orbiter flies over the lander and the extinction when the orbiter goes down to the horizon.

A pure monostatic secondary mode can be envisaged using the orbiter alone, before landing and after the lander's lifetime is over. This configuration doesn't constraint the instrument design and its performances will be "as is". It allows the near surface characterisation of body with a degraded sensitivity and resolution especially for the landing site selection.

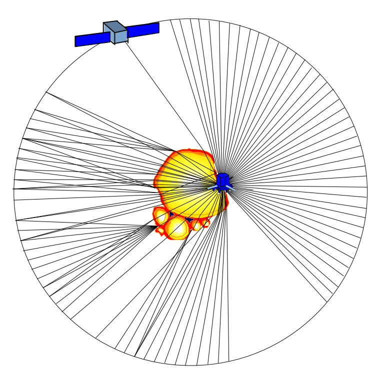

Figure 1: Radar Tomography in transmission

3. Instrument concept

The proposed radar tomography instrument inherits from the concept and from the design of CONSERT onboard Rosetta / ESA. This instrument, its concept, its design have been detailed in several papers [1],[2]

The instrument consists in two separate electronics, one the orbiter and one the lander in order to acquire the signal propagated from the lander to the orbiter throughout the asteroid.

In order to have an accuracy of about 5% on the dielectric constant, the time accuracy has to be better than 100ns on the propagation delay. So, for each sounding, the synchronization is achieved by the transponder structure of the instrument that requires more complicated electronics design. This in-time transponder structure corresponds to a two-way propagation named "ping-pong" (Fig 2). As a consequence, both lander and orbiter electronics are very similar.

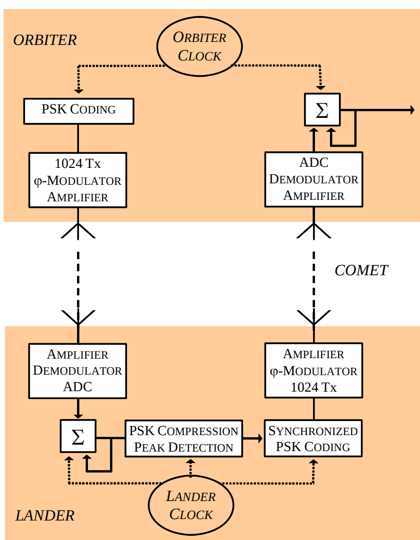

Figure 2: Block diagram of the instrument [2]

4. Instrument design

By regards to the CONSERT heritage, a new design is under study in order to introduce more versatility and additional modes and also in order to reduce mass and power budgets.

ASSERT Characteristics

Mass Objectives 2kg

Mean Power 4 W

Resolution 30 m (vacuum)

Transmitted power ~1W

References

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[2] Kofman W. et al, "The Comet Nucleus Sounding Experiment by Radiowave Transmission (CONSERT): A short Description of the Instrument and of the Commissioning Stages", Space Science Reviews, vol 128, pp. 413 – 432, 2007.

[3] Herique A. et al " Radar Tomography of Asteroids" in 2011 IAA Planetary Defense Conference 09-12 May 2011 Bucharest, Romania.

[4] Krause C. et al "MAGIC – Mobile Autonomous Generic Instrument Carrier for the in-situ Investigation of NEO Surfaces and Interior" in 2011 IAA Planetary Defense Conference 09-12 May 2011 Bucharest, Romania