EPSC Abstracts
Vol. 6, EPSC-DPS2011-920, 2011
EPSC-DPS Joint Meeting 2011

Radar Tomography of Asteroids

Alain Herique (1), Antonella Barucci (2), Jens Biele (3), Tra-Mi Ho (4), Wlodek Kofman (1), Christian Krause (3), Patrick Michel (5), Dirk Plettemeier (6), Jean Yves Prado (7), Jean Claude Souyris (7), Stephan Ulamec (3), Sonia Zine (1) and ASSERT Team

(1) Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), France , (2) LESIA, Meudon, France (3) DLR, Cologne, Germany, (4) DLR, Bremen, Germany, (5) Cassiopée, Observatoire de la Côte d'Azur, Nice, France, (6) Technische Universität Dresden, Germany, (7) CNES, Toulouse, France

Abstract

The internal structure of NEAs is a key point for the understanding of 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.

1. Near Earth asteroid structure

The internal structure of NEAs remains largely unknown. Yet, it is a key point of risk management and mitigation: indeed, knowledge of the structure is required to characterize whether a small asteroid will survive the transit through the atmosphere, in the range of sizes for which this is uncertain. Moreover, this information is also required to define a deflection policy by an impactor or thermal action. There are some indirect evidences (from dynamical/collisional models, density estimates of real asteroids compared to meteorite analogues, and models of formation of binary objects), that a rubble pile structure is really common at least for objects larger than a few hundreds of meters in diameter. But risk mitigation requires a more precise characterisation of the internal structure, such as the size and the structure of the main blobs and their distribution within the NEAs main body as well as a statistical characterisation of the surface regolith in term of density and size distribution. This knowledge is valuable for a global characterisation of the NEA population. It is also essential to investigate known risks, like 99942/Apophis and to define efficient mitigation strategies. From a science point of view, the internal structure is also a key point for the understanding of asteroid accretion and dynamical evolution.

2. Radar Tomography

Radar tomography is the only way to image the internal structure from decimetric to global scale in order to better understand the nature of the primary object and its posterior alterations. It is also a way to estimate the ratio between micro- and macro-porosity.

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.

The first addressed question is a rubble pile or a monolithic body:
- For a rubble pile, the tomography will allow to estimate the size distribution of the boulders by direct imaging or statistical analysis of the scattered signal, depending on the blobs size and contrast. The estimation of the mean permittivity of the blobs is a way to estimate the macro- versus micro-porosity. Its spatial variations highlight the heterogeneity of the parent bodies and segregation mechanism during re-accretion.
- And for a monolithic object, we can expect only micro-porosity. Then images of the body interior and

spatial distributions of the permittivity give the heterogeneity.

In a further analysis, the characterization of the heterogeneity by statistical or imagery approach is a key point to understand asteroid accretion and evolution:
- is this body accreted or re-accreted from the same material or not, from similar parent bodies or not?
- is there some evidence of collisional metamorphism with change in the porosity and or mineralogy?
- is there some evidence of metamorphism per hydration?

This advanced interpretation will be based on the sample return analysis and constitutes a complete recontextualization of the analyzed samples at the global body scale

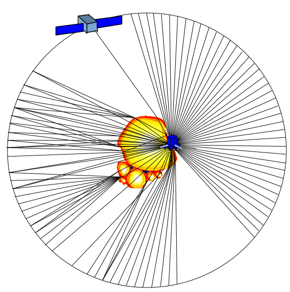

Figure 1: Radar Tomography in transmission

References

[1] Kofman W.et al, "The New Rosetta Targets", Kluwer Academic, ISBN 1–4020–2572–6, 2004.

[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.