Geophysical Research Abstracts,
Vol. 11, EGU2009-3763, 2009
EGU General Assembly 2009

Simulation of Radar-Backscattering from Phobos - A Contribution to the Experiment MARSIS aboard MarsExpress

D. Plettemeier (1), R. Hahnel (1), S. Hegler (1), A. Safaeinili (2), R. Orosei (3), A. Cicchetti (4), J. Plaut (2), and G. Picardi (4)

(1) University of Dresden, Radio Frequency and Photonics, Dresden, Germany (dirk.plettemeier@tu-dresden.de), (2) Jet Propulsion Laboratory, Pasadena, CA, USA, (3) Istituto Nazionale di Astrofisica, Rome, Italy, (4) University of Rome La Sapienza, Italy

Abstract — MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding) on board MarsExpress is the first and so far the only space borne radar that observed the Martian moon Phobos. Radar echoes were measured for different flyby trajectories. The primary aim of the low frequency sounding of Phobos is to prove the feasibility of deep sounding, into the crust of Phobos. In this poster we present a numerical method that allows a very precise computation of radar echoes backscattered from the surface of large objects. The software is based on a combination of physical optics calculation of surface scattering of the radar target, and Method of Moments to calculate the radiation pattern of the whole space borne radar system. The calculation of the frequency dependent radiation pattern takes into account all relevant gain variations and coupling effects aboard the space craft. Based on very precise digital elevation models of Phobos, patch models in the resolution of lambda/10 were generated. Simulation techniques will be explained and a comparison of simulations and measurements will be shown.

SURFACE BACKSCATTERING SIMULATOR FOR LARGE OBJECTS
The computation of surface scattering of the electromagnetic wave incident on Phobos is based on the Physical Optics method. The scattered field can be expressed by the induced equivalent surface currents on the target.
The Algorithm: The simulation program itself is split into three phases. In the first phase, an illumination test checks whether a patch will be visible from the position of the space craft. If this is not the case, the patch will be excluded from the simulation. The second phase serves as a preparation stage for the third phase. Amongst other tasks, the dyadic products for the Js and Ms surface currents are calculated. This is a time-memory trade-off: the simulation will need additional 144 bytes of RAM for every patch that passes phase one. However, the calculation of the dyads is expensive, so that considerable savings in computation time can be achieved by pre-calculating the frequency independent parts. In the third phase, the main part of the calculation is executed. This involves calculating the backscattered field for every frequency step, with the selected frequency range and resolution, and source type.
Requirements for the Simulation of Phobos: The model of Phobos contains more than 104 million patches, occupying about 12GiB of HD space. The model is saved as an HDF5 container file, allowing easy cross-platform portability. During the calculation, for every patch that passes the ray tracing test, nearly 400 bytes of RAM will be needed. That adds up to 40GB RAM, considering the worst case (computational-wise), making the simulation very memory intensive. This number is already an optimized case, due to memory reuse strategies.

RESULTS
The simulations were performed with a very high discretization based on a high resolution digital elevation model. In the results of the simulations the signatures in the radargrams are caused by the illuminated surface topography of Phobos, so that the precession of position and orientation of MarsExpress related to Phobos has a significant influence on the radargrams.
Parameter studies have shown that a permittivity change causes only a brightness change in the radargrams, while a radial distance change will jolt the signatures of the radargrams along the time axis. That means that the small differences detected between simulations and measurements are probably caused by inaccuracies in the trajectory calculations regarding the position and orientation of Phobos. This interpretation is in line with the difference

observed in the drop of bright lines in the measured and simulated radargrams during the gap in measurements, e.g. around closest approach for orbit 5851. Some other interesting aspect seen in the measurements can perhaps be explained by simulations.

CONCLUSIONS

We successfully implemented a Radar-Backscattering simulator, using a hybrid Physical Optics and Method of Moments approach. The software runs on a large scale cluster installation, and is able to produce precise results with a high resolution in a reasonable amount of time. We used this software to simulate the measurements of the MARSIS instrument aboard MarsExpress, during flybys over the Martian moon Phobos, with varying parameters regarding the antenna orientation and polarization. We have compared these results with actual measurements. These comparisons provide explanations for some unexpected effects seen in the measurements.