Sparse source configurations in radio tomography of asteroids

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Our research targets at progress in non-invasive imaging of asteroids to support future planetary research and extra-terrestrial mining activities. This presentation concerns principally radio tomography in which the permittivity distribution inside an asteroid is to be recovered based on the radio frequency signal transmitted from the asteroid's surface and gathered by an orbiter. The focus will be on a sparse distribution (Pursiainen and Kaasalainen, 2013) of signal sources that can be necessary in the challenging in situ environment and within tight payload limits.

The general goal in our recent research has been to approximate the minimal number of source positions needed for robust localization of anomalies caused, for example, by an internal void. Characteristic to the localization problem are the large relative changes in signal speed caused by the high permittivity of typical asteroid minerals (e.g. basalt), meaning that a signal path can include strong refractions and reflections.

This presentation introduces results of a laboratory experiment in which real travel time data was inverted using a hierarchical Bayesian approach combined with the iterative alternating sequential (IAS) posterior exploration algorithm. Special interest was paid to robustness of the inverse results regarding changes of the prior model and source positioning. According to our results, strongly refractive anomalies can be detected with three or four sources independently of their positioning.

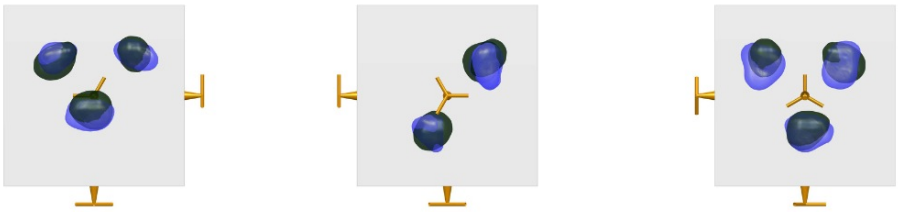

Figure: Visualization of localization accuracy obtained with the source configuration corresponding to the three yellow antenna symbols. Light blue and dark green colors mark the exact and recovered anomalies, and images from left to right correspond to xy-, yz- and zx-views, respectively.

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References: Pursiainen S and Kaasalainen M 2013, Planetary and Space Science, Volume 82, p. 84–98.