Exploration of Planetary Surfaces Using Spacecraft Bistatic Radar

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Use of a nearby spacecraft to conduct simple bistatic radar (BSR) observations is a cost-effective way to survey centimeter-wavelength scattering properties of remote planetary surfaces. Not only does proximity mitigate the R^{-4} factor in the monostatic radar equation, but polarization variations of the quasi-specular echo with incidence angle can be used to determine the surface dielectric constant without requiring absolute amplitude calibration of the end-to-end system. Frequency dispersion of the echo provides a measure of rms surface tilts.

Since 2004, ESA's Mars Express has been conducting BSR experiments at wavelengths of 3.6 and 13 cm. In most cases, the longer wavelength indicates a higher dielectric constant, consistent with deeper surface penetration to a more compacted regolith. But in northern plains, the situation is reversed; the higher dielectric constant at 3.6 cm may result from the presence of a surface duricrust or gravel layer averaging about 1 cm in thickness, which is transparent at 13 cm. Echoes have been detected from Mars' Stealth region and the results are consistent with presence of large decimeter scale surface slopes; whether Stealth has unusually low dielectric constant (and density) is not yet clear because the echoes are weak and at poor incidence angles for measuring polarization ratios.

Experiments have been conducted over Maxwell Montes in an attempt to revisit the question of why the radar reflectivity at high altitudes on Venus is so large. A new record for BSR distance was set in 2006 when bistatic echoes were detected from Titan during Cassini flybys. Uplink experiments, in which transmissions from Earth are reflected and received by a spacecraft, were successfully completed during 2003 through an innovative use of existing hardware onboard the 2001 Mars Odyssey spacecraft.

Uplink equipment has been built into New Horizons, scheduled for a Pluto flyby in 2015; although the rationale for the New Horizons hardware lies in atmospheric science, it is possible that transient surface echoes may be detected near the occultation times. Near-backscatter spacecraft-to-spacecraft BSR is being considered as part of a search for water ice if both Chandrayaan-1 and Lunar Reconnaissance Orbiter are successful in achieving lunar polar orbits in 2008.