EGU23-10075, updated on 02 Aug 2023
https://doi.org/10.5194/egusphere-egu23-10075
EGU General Assembly 2023

Cassini Bistatic Radar Observations of Titan's Seas: Results about Dielectric Properties and Capillary Waves Detection

Giancorrado Brighi[1], Valerio Poggiali[2], Paolo Tortora[1,3], Marco Zannoni[1,3], Alexander Hayes[4], Daniel Lalich[4], Lea Bonnefoy[5], Shannon MacKenzie[6], Phil D Nicholson[4], Kamal Oudrhiri[7], Ralph D Lorenz[8], and Jason M Soderblom[9]

[1]Dipartimento di Ingegneria Industriale, Alma Mater Studiorum - University of Bologna, 47121 - Forlì (FC), Italy (giancorrado.brighi@unibo.it)
[2]Cornell Center for Astrophysics and Planetary Science, Ithaca NY, United States (vpoggiali@astro.cornell.edu)
[3]Centro Interdipartimentale di Ricerca Industriale Aerospaziale, Alma Mater Studiorum - University of Bologna, 47121 - Forlì (FC), Italy
[4]Cornell Center for Astrophysics and Planetary Science, Ithaca NY, United States
[5]LERMA, Observatoire de Paris, Paris, France
[6]University of Idaho, Moscow ID, United States
[7]NASA Jet Propulsion Laboratory, California Institute of Technology, Pasadena, United States
[8]JHU/APL, Laurel, MD 20723, USA
[9]MIT, Cambridge MA 02139-4301, United States

Between 2006 and 2016, the Cassini spacecraft carried out 13 bistatic radar observations of the surface of Saturn's largest moon, Titan. Unmodulated right circularly polarized radio signals were transmitted by the spacecraft to the moon's surface. Cassini's high gain antenna was pointed so that specular reflections from Titan's surface were received on Earth. Proper processing of right (RCP) and left circularly polarized (LCP) echoes from the moon can provide information about surface roughness and near-surface relative dielectric constant (ϵ_r) of the illuminated terrains.

During Titan flybys T101, T102, T106, and T124, the track of the bistatic observations crossed the main stable liquid bodies of the north pole of Titan: Ligeia, Kraken, Punga Mare, and their estuaries. Strong and narrowband X-band (λ=3.6 cm) echoes were successfully detected from the seas at the Deep Space Network 70-meter station in Canberra.

Reflected spectra feature Dirac-like shapes, with a spectral broadening around 1 Hz and lower bounded by the processing time resolution. Compared to bistatic observations of other planets, this implies unprecedentedly low RMS slope values for Titan's seas on an effective length-scale of a few meters. Profiles of reflected LCP and RCP power are in general consistent with purely coherent reflections from the Fresnel area around the moving specular point, indicating a very flat surface.

In addition, from the circular polarization power ratio, the surface dielectric constant can be derived. This can enrich our current understanding of the chemistry of Titan's liquid hydrocarbon seas, further constraining their methane-ethane mixing ratio. From Cassini RADAR, VIMS, and ISS,

Titan's seas are expected to be ternary mixtures of methane, ethane and nitrogen ($\epsilon_r \approx 1.6$-1.9). From bistatic radar data, significant relative variations in liquid hydrocarbon composition are seen, and an unexpected correlation between the dielectric constant and incidence angle of observation seems to arise. The absolute values of permittivity are somewhat lower than expected.

From the computed dielectric constant values, physical optics models are used to constrain the RMS height of the surface. This analysis provides meaningful insights into the presence of small capillary waves in the order of millimeters over the liquid surfaces of Titan, as already detected by Cassini monostatic RADAR.