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Mini-RF S- and X-band Bistatic Observations of South Polar Craters on the Moon

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Abstract

Mini-RF S-band bistatic observations of Cabeus crater floor materials display a clear opposition response consistent with the presence of water ice. Initial X-band bistatic observations of Cabeus and Amundsen crater floor materials do not show a similar response. This could indicate that, if water ice is present in Cabeus crater floor materials, it is buried beneath ~0.5 m of regolith that does not include radar-detectible deposits of water ice.

1. Introduction

Mini-RF aboard NASA's Lunar Reconnaissance Orbiter (LRO) is a hybrid dual-polarized synthetic aperture radar (SAR). Its receiver operates in concert with transmitters at either the Arecibo Observatory (AO) or the Goldstone deep space communications complex 34 meter antenna DSS-13 to collect S- and X-band bistatic radar data of the Moon, respectively [1]. Bistatic radar data provide a means to probe the near subsurface for the presence of water ice, which exhibits a strong response in the form of a Coherent Backscatter Opposition Effect (CBOE). Here we present S- and X-band bistatic radar observations for the floors of the south-polar craters Cabeus and Amundsen and discuss their potential for harboring water ice.

2. Background

Radar observations of planetary surfaces provide important information on the structure (i.e., roughness) and dielectric properties of surface and buried materials [2-5]. A common product used in the analysis SAR data is the Circular Polarization Ratio (CPR). CPR is a representation of surface roughness at the wavelength scale of the radar. Surfaces that are smoother at the wavelength scale will have lower CPR values and surfaces that are rougher will have higher CPR values. High CPR values can also serve as an indicator of the presence of water ice.

Laboratory data and analog experiments at optical wavelengths have shown that the scattering properties of lunar materials (e.g., CPR) can be sensitive to variations in phase angle [6-8]. This sensitivity manifests as an opposition effect and likely involves contributions from shadow hiding at low angles and coherent backscatter near 0°. Analog experiments and theoretical work have shown that the scattering properties of water ice are also sensitive to variations in phase angle, with an opposition effect that it is tied primarily to coherent backscatter [9-11]. Differences in the character of the opposition response of these materials offer an opportunity to differentiate between them, an issue that has been problematic for radar studies of the Moon that use a monostatic architecture [12,13].

3. Observations

Mini-RF bistatic observations of south polar crater floors currently include Cabeus (84.9°S, 35.5°W; 98 km dia.) and Amundsen (84.5°S, 82.8°E; 103 km dia.). Mini-RF monostatic data of the craters does not show evidence for radar-detectible deposits of water ice in the top meter(s) of the surface [e.g., 14]. However, an initial Mini-RF bistatic observation of the crater showed scattering characteristics for its floor that differed from the surrounding terrain [15]. Cabeus was targeted at S-Band on 4 subsequent occasions but a ground issue at AO limited the collection of data for one of the observations to regions outside the crater floor. The purpose of those observations was to provide additional data on the scattering characteristics of its floor materials and to characterize and compare the CPR response of those materials to surrounding highland terrain and radar-facing slopes in the vicinity of the crater. The floor of Cabeus crater was also targeted at X-band on 3 occasions in the previous year and the floor of Amundsen crater was also targeted on 3 occasions. The purpose of these observations is to constrain the depth to and thickness of materials with similar scattering characteristics.

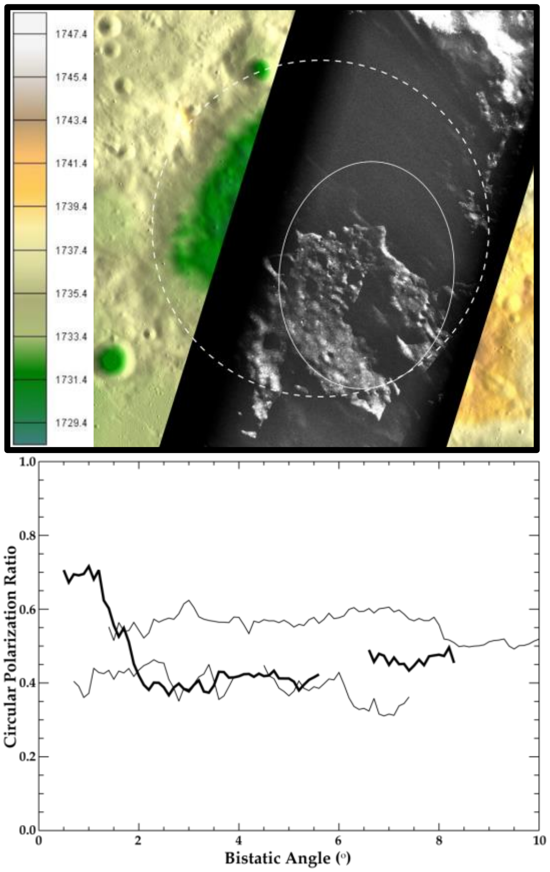

Figure 1: *(above) Portion of backscatter data for S-band bistatic observation 2013-346, overlain on LOLA topographic information (scale shown in km of radius). Dashed circle represents approximate location of crater rim and solid oval represents approximate area sampled in all bistatic observations of the crater floor. (below) Plot of mean CPR versus bistatic angle for Cabeus floor materials sampled in 5 bistatic observations targeting Cabeus at incidence angles ranging from 82.4° to 86.6° (bold line), highland materials observed at incidence angles ranging from 64° to 81.5°, (upper solid line), and radar-facing slopes observed at incidence angles ranging from 76.5° to 82° (lower solid line).*

4. Results

Mini-RF S-band observations of the floor of Cabeus cover bistatic angles of 0.5° to 8.6° for incidence angles ranging from 82.4° to 86.6° (*Fig. 1*). CPR measurements for the floor of the crater, as a function of bistatic angle, show a clear opposition surge; something not observed for the floors of nearby, similar-sized craters that were sampled at S-band wavelengths (e.g., Casatus, Klaproth, Blancanus, and Newton A and G) [1]. The opposition peak of Cabeus floor materials has a width of ~2° and features a ~30% increase in CPR. The bistatic observations of the region surrounding Cabeus indicate that mean CPR values for the portion of its floor that was imaged by Mini-RF are less than that of the surrounding highlands for bistatic angles > ~1.8° but similar to that of nearby radar-facing slopes. Mean CPR values for the imaged floor of Cabeus are higher than that of surrounding highlands and nearby radar-facing slopes for bistatic angles of 0.5° to 1.8°. Mini-RF data for bistatic angles < 0.5° were not acquired during the bistatic campaign. However, Mini-RF monostatic data (i.e., bistatic angle of 0°) of the crater floor were acquired at an incidence angle of 48° [14] and ground-based CPR measurements at a bistatic angle of 0.37° and large (> 80°) incidence angles have been made [e.g., 16]. Elevated CPRs were not observed in either case.

Mini-RF X-band observations of the floor of Cabeus cover equivalent incidence angles but a smaller range of bistatic angles than are currently sampled at S-band. Based on these observations, there is no indication of an opposition response. Data for the floor of Amundsen crater similarly does suggest an opposition response but its character is distinctly different from the S-band response observed for Cabeus. This could indicate that, if water ice is present in Cabeus crater floor materials, it is buried beneath ~0.5 m of regolith that does not include radar-detectible deposits of water ice.

References

[1] Patterson et al., 2017, Icarus, 283, 2-19; [2] Campbell et al. (2010), Icarus, 208, 565-573; [3] Raney et al. (2012), JGR, 117, E00H21; [4] Carter et al. (2012), JGR, 117, E00H09; [5] Campbell (2012), JGR, 117, E06008; [6] Hapke et al. (2012), JGR, 117, E00H15, doi:10.1029/2011JE003916; [7] Nelson et al. (2000), Icarus, 147, 545-558; [8] Piatek et al. (2004), Icarus, 171, 531-545. [9] Hapke and Blewett (1991), Nature, 352, 46-47; [10] Mishchenko (1992), Astrophys. and Space Sci., 194, 327-333; [11] Mishchenko (1992), Earth, Moon, and Planets, 58, 127-144; [12] Spudis P.D. et al. (2010) GRL [13] Spudis et al. (2013), JGR 118, 1-14; [14] Neish et al., 2011, JGR (Planets), 116, E01005, doi:10.1029/2010JE003647; [15] Patterson et al., 2013, 44th LPSC, #2380; [16] Campbell et al., 2006, Nature 443, 835-837.