

BISTATIC (GOLDSTONE 70-M to ARECIBO) OBSERVATIONS OF THE NORTH POLAR REGIONS OF MERCURY IN SEPTEMBER 2003

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INTRODUCTION AND SCIENCE RATIONALE FOR TWO-STATION RADAR:

Upgraded Arecibo radar imaging of the Mercury North Polar region (Harmon, Perillat, and Slade, 2001) has resulted in the accurate measurement of the radar albedos and the circular polarization ratios for at least five large craters close to the North Pole. With the advent of an X-band capability at the Arecibo Observatory, it is now possible to measure these same parameters at a very different wavelength for these craters near the Pole via two-station observations with Goldstone transmitting and Arecibo receiving at 3.5-cm. (See Figure 1.) One primary goal for obtaining 3.5-cm (X-band) wavelength observations is measurements of (or limits to) the thickness of the crater regolith covers. Dual-wavelength observations of the craters' radar albedos provide, with some plausible assumptions, their regolith cover thicknesses, which must be protecting the water ice from being destroyed by hydrogen Lyman- α radiation from the Very Local Interstellar Medium (Morgan and Shemansky, 1991). The needed assumptions are 1) the loss tangent for the Mercury regolith can be assumed to be that measured by the VLA observations of Mitchell and de Pater (1994); 2) the albedos (at least of the crater floors) would be the same at the two frequencies for the coherently backscattered (Hapke and Blewitt, 1991; Peters, 1992) echoes. Experimental evidence supporting this second assumption comes from observations of the icy Galilean satellites comparing radar albedos and circular polarization μ_C ratios at 3.5-cm and 13-cm (Ostro et al., 1992; Black et al., 2001), in which the μ_C require that the radar echoes are dominated by coherent backscatter. Evidence that water ice is the predominant constituent of the Galilean satellites (excluding Io, obviously) is abundant (see, e.g., Calvin et al., 1995). (While other constituents other than water ice such as sulfur [Sprague et al., 1995] have been proposed, Butler (1997) has shown that sulfur has no need to hide in permanently shadowed craters near the pole, and would be deposited in a true polar cap, which is not observed.)

The thicknesses of the regolith covers will constrain scenarios about how the ice layers were deposited, and also provide more information on the thermal environment of the deposits in the permanently shadowed craters (and regions thereof). Small icy deposits appear to exist at low (81 deg. N.) latitudes, which are not stable on the surface, and confirmation of their regolith burial would strengthen the case for water ice. Thus this work will provide important constraints on the evolution of the water ice deposits in Mercury shadowed craters.

The regolith cover thicknesses also are very important for the MESSENGER Mission to Mercury. The MESSENGER neutron spectrometer cannot penetrate deeper than a few tens of centimeters of regolith. Knowledge of which large craters near the Mercury North Pole have thin regolith covers and deep deposits of ice (thus accessible hydrogen) will be very important for the MESSENGER mission planners to target the footprints of their neutron spectrometer observations. The depths of the ice deposits can be estimated in a model-dependent way from depth-diameter crater relationships, and the larger of the areas of the deposits at 3.5-cm and 13-cm. (Complete coverage for all craters will likely require another 3.5-cm experiment from a very different subradar longitude.) The region on Mercury that could be radar-imaged at 3.5-cm in Sept. 2003 is shown in Figure 2.

TABLE 1. F11 is the limb-to-limb bandwidth in Hz; Latitude and Longitude are of the subradar point of date, RTLTL is round-trip light time.

YEAR	Month	Day	Longitude	Subradar Lat	RTLTL (min)	FLL (HZ)	Mutual vis. (min)	Dec. (deg)
2003	SEP	8	332.21	9.95	10.53	396.159	55.	0.15
2003	SEP	9	339.36	9.83	10.55	397.876	65.	0.70
2003	SEP	10	346.53	9.69	10.61	398.421	75.	1.28
2003	SEP	11	353.69	9.51	10.69	397.706	88.	1.89
2003	SEP	12	0.82	9.30	10.82	395.686	95.	2.50
2003	SEP	13	7.90	9.07	10.99	392.369	101.	3.12
2003	SEP	14	14.90	8.81	11.17	387.809	107.	3.72
2003	SEP	15	21.80	8.53	11.40	382.110	113.	4.29

Based on Table 1 above, we hope to utilize five days near maximum North subradar latitude on Mercury: Sept. 11 through Sept. 15, inclusive. The observing times are:

Sept. 11, 2003 1530-1700 UT
Sept. 12, 2003 1520-1650 UT
Sept. 13, 2003 1500-1700 UT
Sept. 14, 2003 1450-1650 UT
Sept. 15, 2003 1440-1640 UT

Goldstone/Arecibo X-band Observations of Mercury's North Polar Ice-Filled Craters

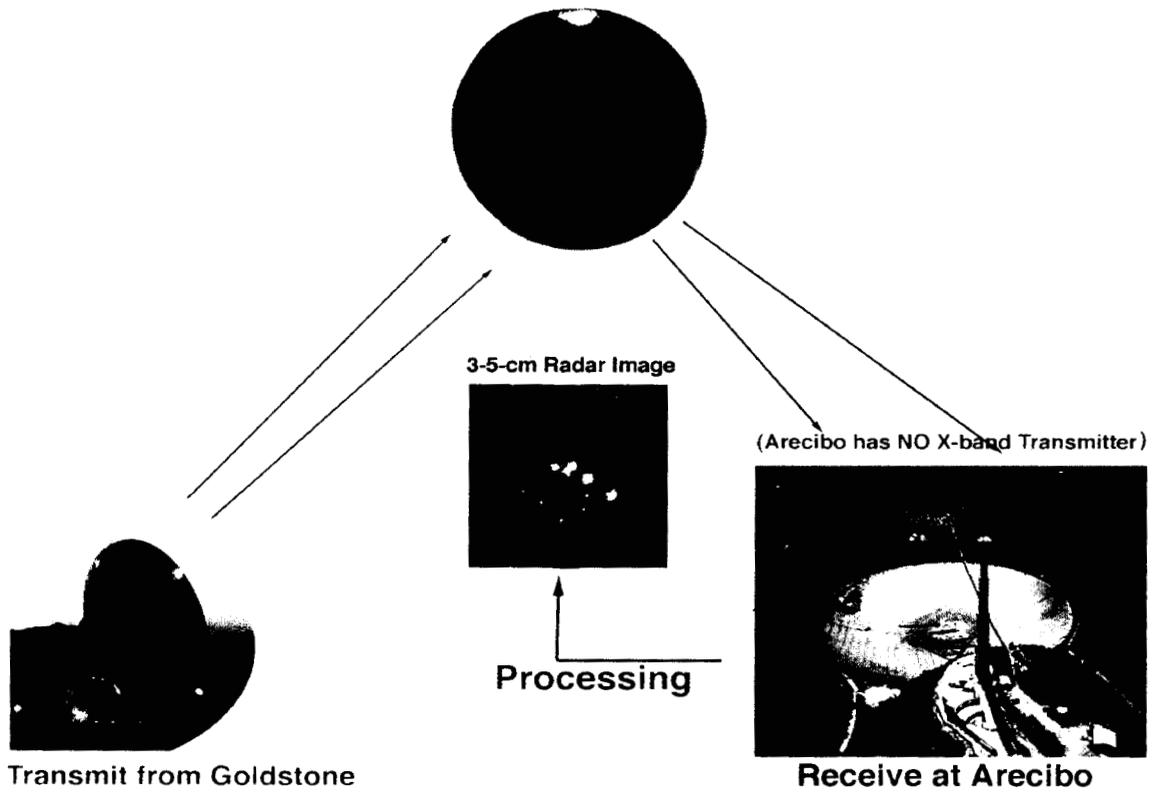


Figure 1. The Bistatic Experiment Concept

CONCLUSION:

September 2003 may see the first X-band (3.5-cm wavelength) bistatic radar experiment with Arecibo receiving and Goldstone transmitting at Mercury with the goals as described above.

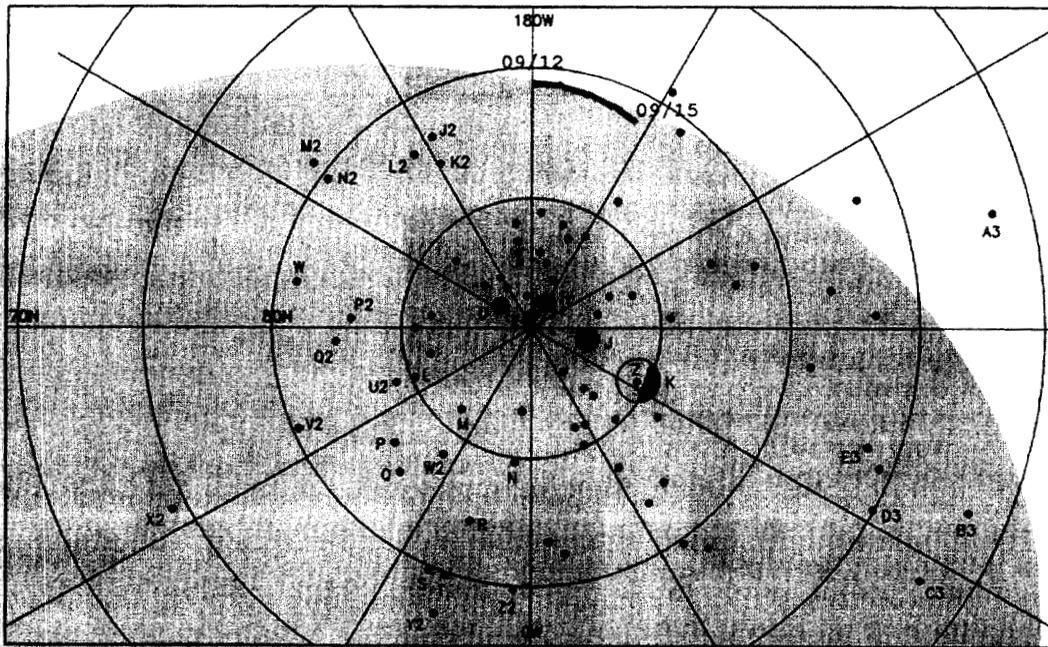


Figure 2: The shaded area shows the region of the Mercury North Polar region imageable in Sept.2003

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