THE ICY GALILEAN SATELLITES: 70cm WAVELENGTH RADAR PROPERTIES; G. J. Black, D. B. Campbell, Space Sciences Bldg, Cornell University, Ithaca, NY 14853; S. J. Ostro, JPL/Caltech, Pasadena, CA 91109.

The radar properties of the icy Galilean satellites at cm wavelengths are dramatically different from those of most inner solar system objects. For the terrestrial planets, the Moon, and most smaller objects, specific radar cross sections are typically on the order of 0.1 while circular polarization ratios, defined to be the ratio of the echo power received in the same circular sense (SC) as transmitted to that received in the opposite sense (OC), range from ~ 0.1 to 0.4. As shown in Table I, at wavelengths of 3.5cm and 13cm, total radar albedos for Europa, Ganymede, and Callisto, are $\sim$2.5, ~ 1.5, and ~ 0.7 respectively, and circular polarization ratios lie in the range $\sim 1.2 - 1.5$ [1]. In addition, reflections from terrestrial planets include specular reflection from near the sub-radar point. No such specular return is seen in the echoes from the icy Galilean satellites; the scattering closely follows a diffuse $\cos^n\theta$ law at all incident angles, with $n \sim 1.6$ [1]. These measurements show no significant variation with wavelength from 3.5cm to 13cm. Here we report on the reduction of measurements made at a much longer wavelength, 70cm, in 1988 with the Arecibo telescope. Observations were made on 7 days, one day on Europa and three each on Ganymede and Callisto, with ~ 1 hour of integration time on each day. Single-day signal-to-noise ratios were very small and all three days were averaged to obtain significant detections of Ganymede and Callisto. Even so, Callisto was not detected in the OC channel. Europa was not detected in either circular polarization on the single day in which it was observed. Good detections of Ganymede were obtained in both channels.

The measured mean cross sections, $\hat{\sigma}$, and circular polarization ratios, μ_C, for the 70cm observations are given in Table I. The most surprising result is that the 70cm cross sections are substantially lower than those for the shorter wavelengths. Since there was no clear detection of Europa in either channel, only an upper limit on both cross sections at three standard deviations of the noise are given. These upper limits are an order of magnitude lower than the cross sections at 3.5cm and 13cm wavelengths. For Ganymede, the cross sections are lower than at the shorter wavelengths by a factor of ~ 4 in each polarization. Finally, Callisto also shows a low 70cm cross section with no detection in the OC channel and only a marginal detection in the SC. The OC cross section is the upper limit at three standard deviations of the noise, and is an order of magnitude lower than the 3.5cm and 13cm wavelength cross sections.

The circular polarization ratio for Ganymede is consistent with the ratios at shorter wavelengths. The detection of Callisto in only the SC channel allows the possibility that the circular polarization ratio is much larger at 70cm. Given only upper limits for both cross sections, no polarization ratio could be calculated for Europa.

The unusual radar properties of the icy Galilean satellites are thought to be due to the low absorption of cm wavelength radiation in ice. This low loss medium allows long path lengths, resulting in volume scattering from subsurface structures. A coherent backscatter effect arising from subsurface multiple scatterings may explain the radar data. First applied to this problem by Hapke [2], this effect greatly enhances the

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fraction of radiation backscattered and gives large polarization ratios; i.e. the incident sense of polarization is largely preserved (see [3] and [4]).

Current work is aimed at determining if any observed wavelength dependence (or independence) can place constraints on the sizes, separation, or composition of these scatterers. The lower cross sections at 70cm relative to those measured at 3.5cm and 13cm wavelengths may be indicative of a change in the distribution or properties of the scatterers between those wavelengths. For example, density heterogeneities may be relatively uncommon at larger scales.

Long wavelength data has the potential to improve our understanding of the wavelength dependence of the icy Galilean satellites' radar scattering properties. Additional 70cm data was taken in 1990, and is currently being reduced. Beginning in 1999 when Jupiter is again observable from Arecibo, additional 70cm (and 13cm) data will be obtainable.

References:

[1] Ostro S. J. et. al. (1992) *JGR*, **97**, 18227.

[2] Hapke B. (1990) *Icarus*, **88**, 407.

[3] Mishchenko, M. I. (1992) *Earth, Moon, Planets*, **58**, 127.

[4] Peters K. (1992) *Phys. Rev. B*, **46**, 801.

Table I†

Target	λ(cm)	$\hat{\sigma}_{OC}$	$\hat{\sigma}_{SC}$	μ_C
Europa	3.5	0.91 ±0.13	1.40 ±0.13	1.43 ±0.24
Europa	13	1.03 ±0.08	1.58 ±0.14	1.53 ±0.03
Europa	70	<0.14*	<0.12*	
Ganymede	3.5	0.65 ±0.10	0.90 ±0.10	1.40 ±0.10
Ganymede	13	0.57 ±0.06	0.82 ±0.09	1.43 ±0.06
Ganymede	70	0.16 ±0.06	0.24 ±0.04	1.50 ±0.61
Callisto	3.5	0.32 ±0.02	0.40 ±0.04	1.22 ±0.08
Callisto	13	0.32 ±0.03	0.37 ±0.03	1.17 ±0.04
Callisto	70	<0.03*	0.12 ±0.08	>1.33

†3.5 and 13 cm results are from [1].

* values represent three standard deviations of the noise