PHOTOPOLARIMETRIC STUDIES OF RESIDENT SPACE OBJECTS; W.I. Beavers, S. Tapia, and James Y-K. Cho, M.I.T. Lincoln Laboratory.

Ground-based photopolarimetric observations of the light reflected by orbiting objects are being tested as a means of monitoring the status of the orbiting objects or debris, identifying the reflecting material, and detecting changes in the optical properties of the surfaces due to prolonged exposure to high vacuum, solar UV, and particle bombardment.

Over a quarter century ago LCS-1, the Lincoln Calibration Sphere of polished Aluminum was placed into orbit. In recent photopolarimetric measurements of the calibration sphere during two separate orbital passes at ranges of approximately 2900-4100 km, the brightness implied an albedo of $\rho = 0.78 \pm 0.07$. The photometric phase curves (Fig. 1) reveal that 88% of the reflected light is specular in nature, and 12% is diffuse. Although it is not possible to make a quantitative comparison with the original optical properties of the surface, the pre-launch photographs of the sphere show that it was a highly polished, primarily specularly reflecting object. The measured polarization versus phase for LCS-1 (Fig. 2) shows it to be significantly more polarized at all phases than can be produced by reflections off polished aluminum. The best fit to the polarization phase curves is obtained with the combination of indices $n = 3.20$, $k = 5.25$. (Polished aluminum has values of $n = 0.98$, $k = 5.23$). The difference in refractive indices strongly suggests that the surface has lost some of its metallic properties, possibly due to surface changes. Contamination after the launch or gradual micrometeoritic impacts and low fluxes of atomic oxygen may have produced a thin surface film of aluminum oxide in a protracted version of the processes suspected to have been present in the LDEF experiment (1).

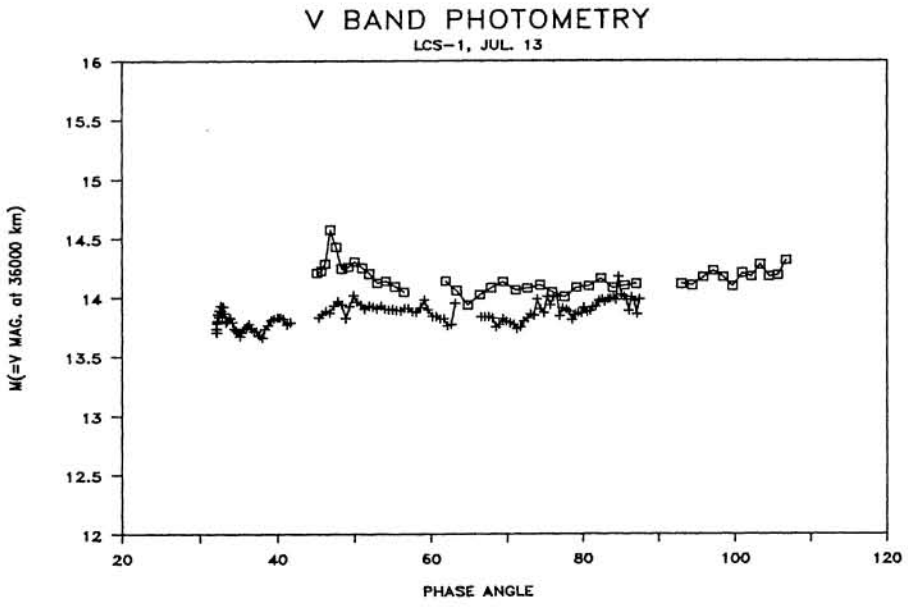

FIG. 1 Photometric phase curves for two orbital passes of LCS-1.

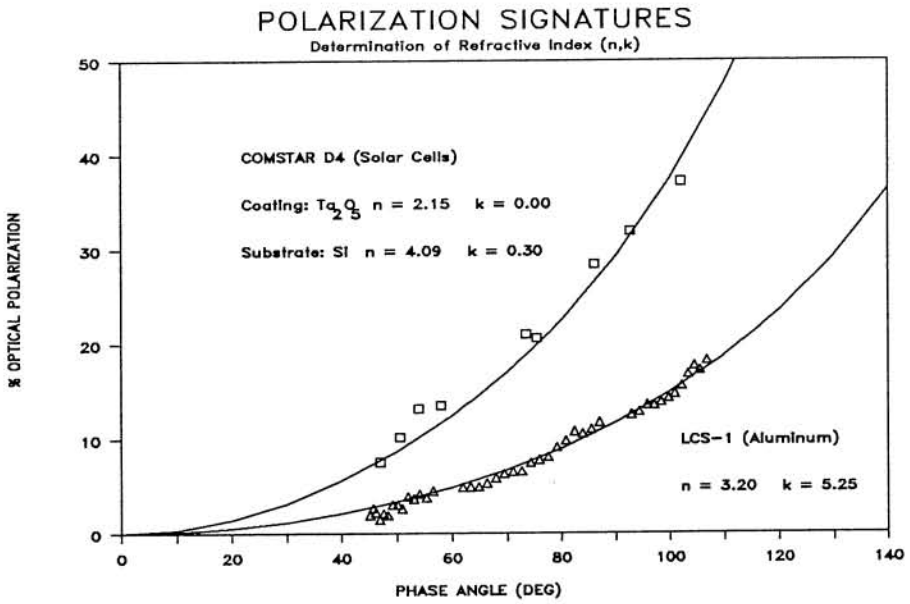

FIG. 2 Polarization phase curves for two types of satellite surfaces.

Measurements of a large debris piece with rapid brightness variations due to rotation and tumbling do reveal 100% polarization appropriate for dielectric materials, in this case believed to be a painted plastic shroud with $n = 1.35$, $k = 0$.

Solar panel reflections produce a degree of polarization which is intermediate between the pure metallic and pure dielectric surfaces. Fig.2 displays measured polarization phase curve for a satellite with reflections dominated by solar cell contributions. In this case the measurements fit the predictions of an optical model consisting of a silicon substrate and tantalum penta-oxide layer of anti-reflection coating. Some satellites with reflections dominated by solar cell configurations produce photometric phase curves which show no detectable changes over a two year period.

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REFERENCES: (1) Crutcher, R. (1990) *LDEF Spaceflight Environmental Effects Newsletter*, **I** ,No. 7, 11 .