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Preliminary Transfer Function of the LARES Satellite

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Abstract: *This paper presents preliminary calculations of the range correction and cross section of the LARES satellite. In particular the calculations look for any systematic variations of the range correction. The average range correction is about .128 meters with an uncertainty of about 1 mm.*

Contents

1. Introduction.

The design of the LARES satellite is patterned after LAGEOS and its properties are similar. Since the radius of LARES is 18.2 cm and the radius of LAGEOS is 30 cm there are fewer cube corners. This results in more variation in the transfer function with incidence angle on the satellite. However, the smaller radius of the satellite reduces the spread in range between the active cube corners so that the variations in range are about the same as for LAGEOS. As with LAGEOS the orientation of each cube corner in its holder is varied to avoid anomalous effects due to loss of total internal reflection at certain incidence angles. The satellite has two hemispheres. Each hemisphere has a pole cube and 4 rings of cubes containing 5, 10, 14, and 16 cubes at latitude 70, 50, 30, and 10 degrees respectively. There are 4 bolt holes along the equator for handling the satellite. The front face of each cube corner is recessed 3.5 millimeters below the surface of the satellite. The distance from the front face to the center of the satellite is 178.5 millimeters.

2. Types of simulations.

These preliminary calculations have concentrated on looking for any systematic variations in the transfer function resulting from the design of the array. The design attempts to cover the satellite as uniformly as possible with cube corners and distribute the orientations of the cube corners in their holders as uniformly as possible to eliminate anomalous effects due to loss of total internal reflection at certain incidence angles. Simulations have been done for the following conditions. In order to test for variations with latitude simulations have been done varying the latitude at fixed longitude. Simulations have been done varying the longitude at fixed latitude. Simulations have been done with circular polarization, linear polarization, computing the whole diffraction pattern, and computing a single point in the far field pattern.

3. Variation with latitude.

Three simulations have been done varying the colatitude from 0 to 90 degrees in 2 deg increments at longitude 0, 30, and 60 degrees. The input polarization is circular. The quantity studied is the average over the velocity aberration annulus from 30 to 45 microradians. There does not seem to be any systematic variation of the transfer function with Latitude.

4. Variation with longitude

Simulations have been done every 2 deg from 0 – 360 deg in longitude at latitudes 45 and 0 deg (equatorial).

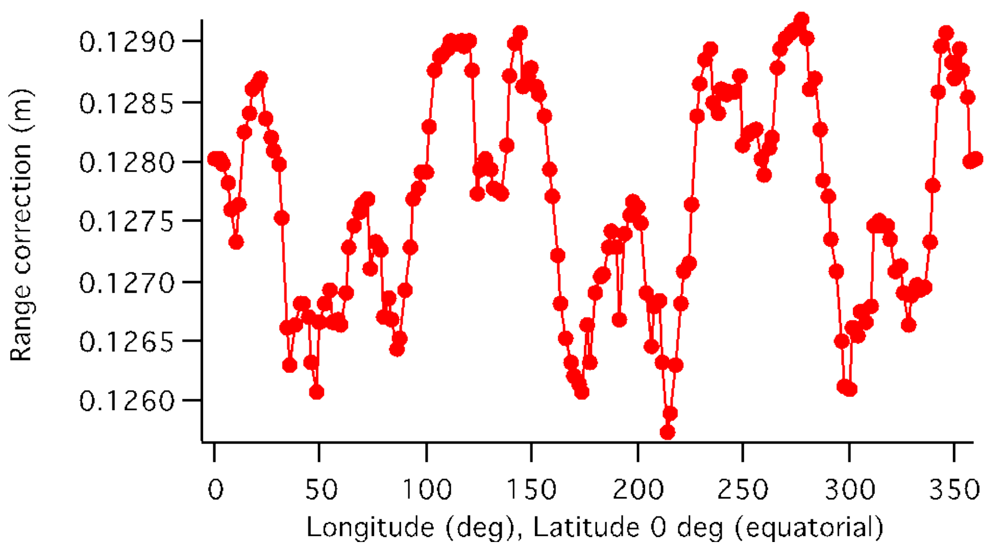

Figure 1. Variation of the range correction (meters) at the equator.

The quantity plotted is the average range correction in the velocity aberration annulus from 30 to 45 microradians.

5. Linear polarization.

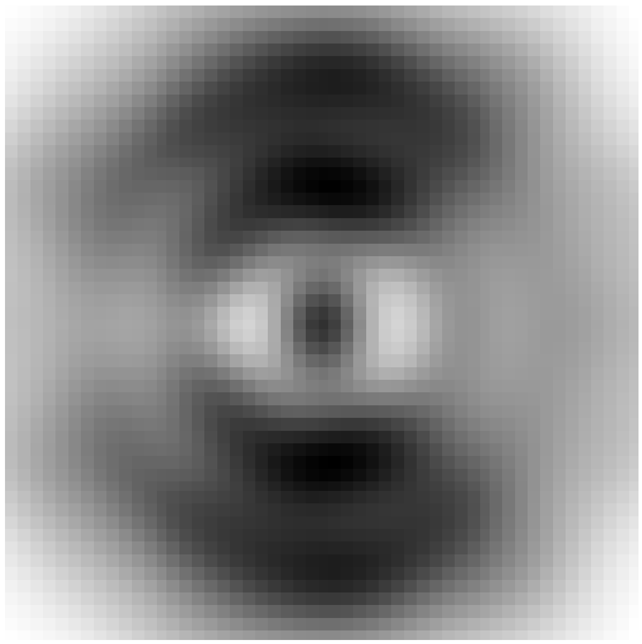

Figure 2. Cross section matrix averaged over 180 simulations along the equator with linear polarization. The pattern has a dumbbell shape aligned with the polarization.

6. Single point in the far field.

The following calculations have been done with a program that computes only a single point in the far field diffraction pattern.

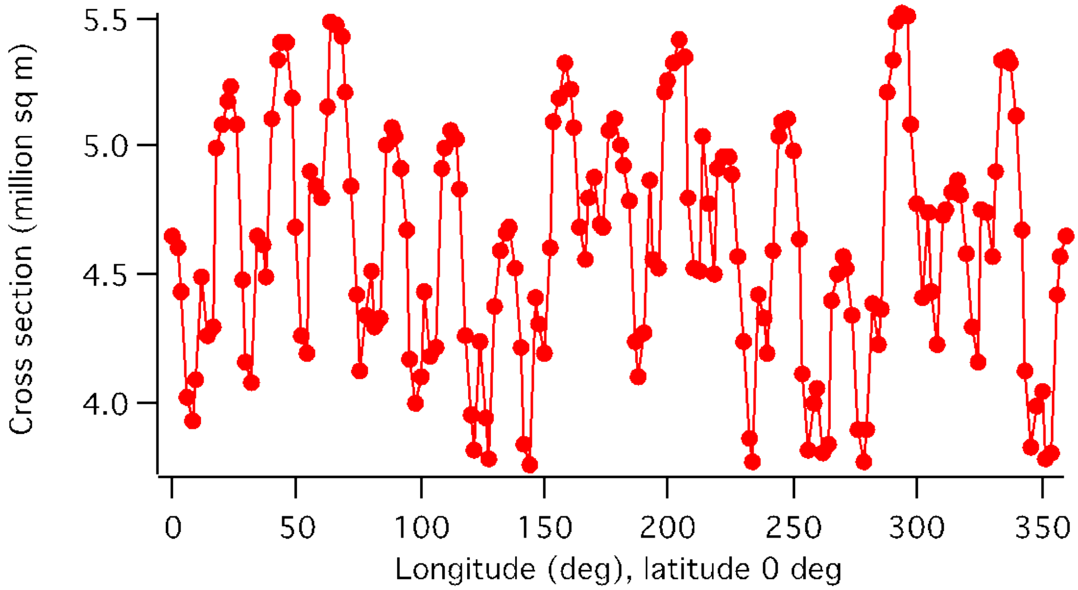

Figure 3a. Cross section vs longitude at field point (0,36) μrad, linear polarization.

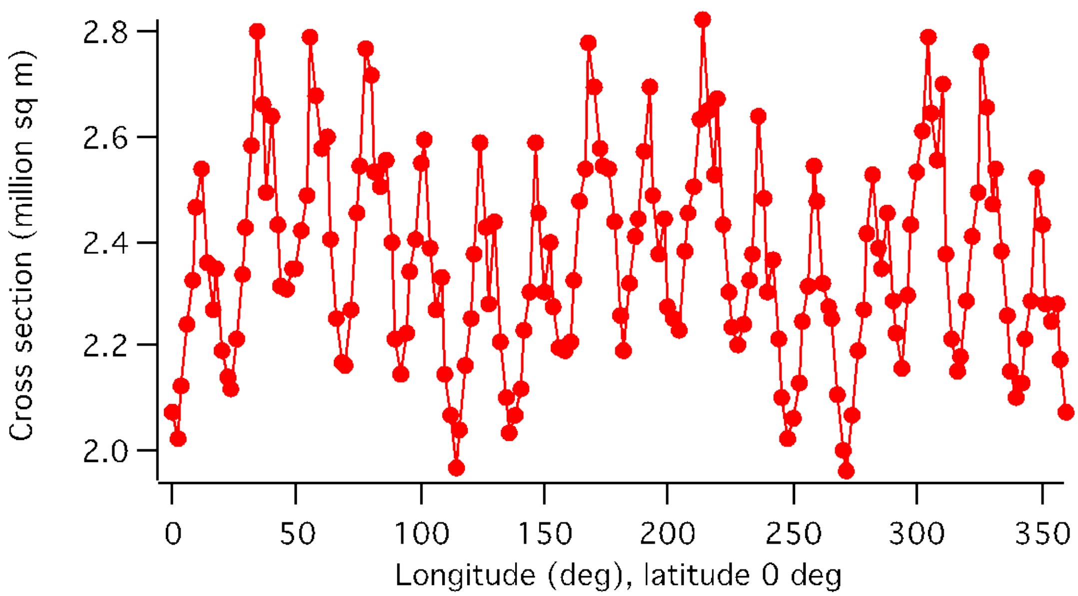

Figure 3b. Cross section vs longitude at field point (36,0) μrad, linear polarization.

The cross section is much higher in figure 3a than in figure 3b. This is because the field point is on the bright section of the diffraction pattern (see figure 2).

7. Pulse histogram.

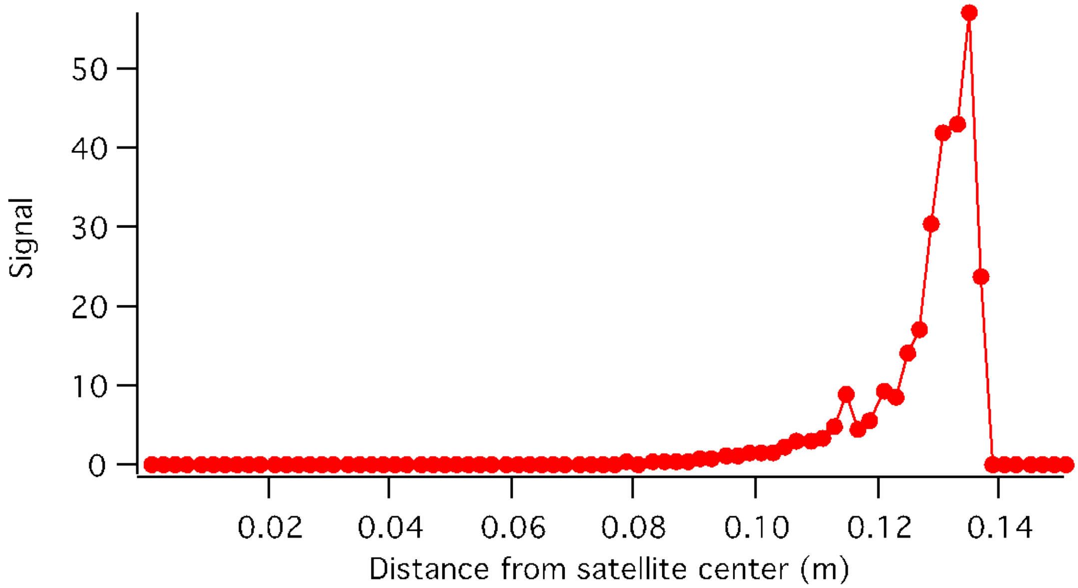

Figure 4. Histogram of the distribution of the signal along the line of sight constructed from all the simulations where the whole pattern is computed. The signal is accumulated in .2 millimeter bins using the average signal in the velocity aberration annulus between 30 and 45 microradians for each active cube corner. The signal is in arbitrary units.

8. Summary of simulations

Range Correction

Circular polarization

Long	CoLat	Vel. Ab.	Minimum	Maximum	Diff	Average	S.D.
0	0-90	annulus	0.1260	0.1289	0.0028	0.1273	0.0008
30	0-90	annulus	0.1256	0.1298	0.0042	0.1282	0.0011
60	0-90	annulus	0.1266	0.1298	0.0032	0.1283	0.0008
0-360	45	annulus	0.1253	0.1298	0.0044	0.1277	0.0009
0-360	90	annulus	0.1257	0.1291	0.0034	0.1276	0.0008

Linear vertical polarization

Long	CoLat	Vel. Ab.	Minimum	Maximum	Diff	Average	S.D.
0-360	90	annulus	0.1258	0.1290	0.0032	0.1275	0.0008
0-360	90	(0,36)	0.1247	0.1304	0.0057	0.1283	0.0012
0-360	90	(36,0)	0.1255	0.1293	0.0038	0.1275	0.0009

Table 1. Summary of range corrections (meters) for all simulations.

The average range correction is about .128 meters with an uncertainty of about one millimeter. The range correction matrix is slightly asymmetric for linear polarization with the same average value as for circular polarization. The annulus is 30 – 45 microradians.

Cross Section

Circular polarization

Long	CoLat	Vel. Ab.	Minimum	Maximum	Diff	Average	S.D.
0	0-90	annulus	2.5864	4.1247	1.5382	3.5414	0.3441
30	0-90	annulus	2.2151	3.7519	1.5368	3.0181	0.3353
60	0-90	annulus	2.4964	3.8214	1.3250	3.2482	0.3887
0-360	45	annulus	2.3859	4.4988	2.1129	3.2421	0.4611
0-360	90	annulus	2.6704	3.9568	1.2863	3.3281	0.3094

Linear vertical polarization

Long	CoLat	Vel. Ab.	Minimum	Maximum	Diff	Average	S.D.
0-360	90	annulus	2.7182	3.9787	1.2605	3.3526	0.3042
0-360	90	(0,36)	3.7628	5.5172	1.7544	4.6227	0.4630
0-360	90	(36,0)	1.9622	2.8221	0.8599	2.3625	0.1930

Table 2. Summary of cross sections (million sq meters) for all simulations

The average cross section is about 3.5 million sq meters with an r.m.s. variation of about .35 million sq meters for circular polarization. Linear polarization produces an asymmetric cross section matrix with the same average signal as for circular polarization. The annulus is 30 – 45 microradians.

9. Summary and conclusions.

The average range correction is about .128 meters with an uncertainty of about one millimeter. The average cross section is about 3.3 million sq meters with an uncertainty of about .35 million sq meters. The cross section is relatively constant for circular polarization. For linear polarization the cross section is about 4.6 million sq meters if the polarization is parallel to the velocity aberration and about 2.4 million sq meters if the polarization is perpendicular to the velocity aberration.