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Spectral Analysis of Coated Optic Phase Maps

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Summary:

The following phase maps were analysed

nuyp	the uncoated curved face
fig_2 fig_4 fig_5 fig_6	the phase maps for the coated surface
model	a model phase map using a “clean” witches hat coating perturbation

The results of the analysis, shown in the enclosed figures and tables, are summarized below.

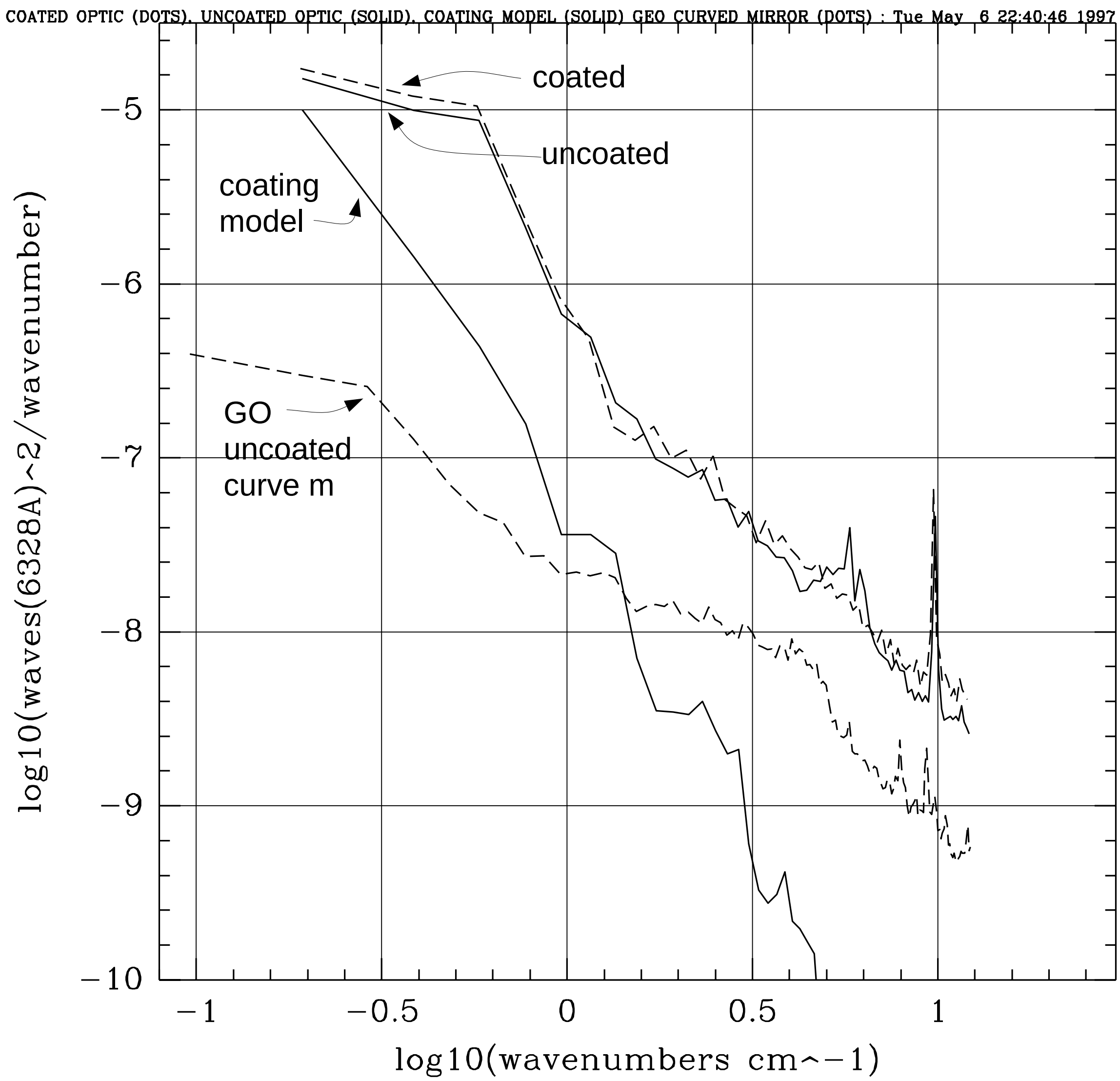
1) The substrate chosen to coat has 10 to 30 times the noise power of the Calflat at spatial frequencies lower than 0.5 cm^{-1}

2) The coating does not substantively change the power spectrum of the surface.

3) The non uniformity in the coating will dominate the power spectrum of the best CSIRO and GO surfaces at spatial frequencies lower than 1 cm^{-1}.

4) The coating non uniformity has a similar witches hat geometry as the coatings on the 4 inch test masses that were installed in the 40 meter prototype indicating that REO needs to better isotropize the motion of the sputtering guns.

5) A better substrate (preferably a flat) should be used in the next coating test.



All phase maps have the following Zernike functions removed:
Z(0,0), Z(1,1), Z(2,0), Z(2,2), Z(3,1), Z(3,3), Z(4,0)

Figure 1 One dimensional power spectra determined from the NIST metrology. The curve labeled *uncoated* (solid) is from the curved surface phase map designated as nuyp. The curve labeled *coated* is an average of fig_2, fig_4, fig_5, fig_6. It is derived from the high reflectivity coating on the surface nuyp. The curve labeled *coating model* is the power spectrum of the witches hat structure measured in the phase map of the coated surface and shown in **figure 2.** The curve labeled *GO* is the power spectrum of the uncoated curved surface of the GO mirror labeled m in prior plots.This mirror and the CSIRO mirror labeled k in prior plots have been the reference for the improvements in the mirrors over the Calflat. The structure in the coating will cause the final mirrors to be poorer than the uncoated GO and CSIRO mirrors. The coatings did , indeed, not increase the power spectrum much over the uncoated substrate, however, the uncoated substrate was one of our poorer mirrors. The model should give a good estimate of the perturbations from the coating imperfection and sets a lower limit to the mirror performance if not fixed in subsequent coating runs.

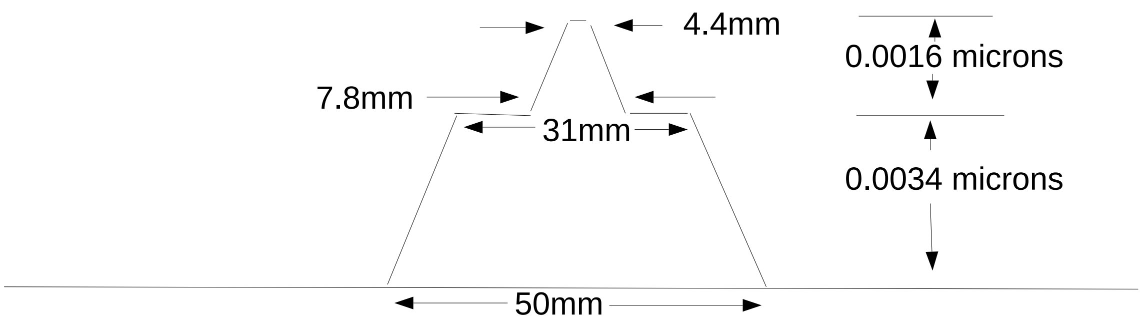


Figure 2 A model of the coating inhomogeneity used in determining the perturbation power spectrum from the coating alone in **figure 1**. The witches hat structure has been seen in the 4 inch mirrors coated for the 40 meter prototype.

Table 1: Zernike and Laguerre Gauss amplitudes in microns

function	uncoated	coated	model
σ p-p	1.6×10^{-3} 1.1×10^{-2}	1.7×10^{-3} 1.4×10^{-2}	8.6×10^{-4} 5.1×10^{-3}
Z(2,0)	8.6×10^{-5}	-1.8×10^{-4}	-7.6×10^{-4}
Z(4,0)	9.5×10^{-4}	1.45×10^{-3}	8.2×10^{-4}
Z(6,0)	-1.2×10^{-3}	-1.36×10^{-3}	-7.3×10^{-4}
Z(8,0)	-1.7×10^{-5}	1.26×10^{-4}	5.3×10^{-4}
Z(10,0)	4.9×10^{-4}	4.1×10^{-4}	-2.9×10^{-4}
Z(12,0)	-2.9×10^{-4}	-2.96×10^{-4}	6.9×10^{-5}
LG(1,0)	2.1×10^{-3}	2.99×10^{-3}	1.4×10^{-3}
LG(2,0)	1.8×10^{-3}	2.09×10^{-3}	1.3×10^{-3}
LG(3,0)	-1.4×10^{-3}	-1.50×10^{-3}	7.6×10^{-4}
LG(4,0)	-1.5×10^{-3}	-1.37×10^{-3}	2.6×10^{-4}
LG(5,0)	-1.4×10^{-3}	-1.15×10^{-3}	4.6×10^{-5}
LG(6,0)	-6.2×10^{-4}	-5.1×10^{-4}	-1.3×10^{-4}

The Zernike functions are defined over a 15 cm aperture, while the Laguerre Gauss functions use a Gaussian spot size of 3.63 cm. Typical rms noise in the Zernike and Laguerre Gauss amplitudes is 1×10^{-4} microns.

The optical field in the Laguerre - Gauss mode LG(i,j) in a single cavity resonant at the mode frequency when illuminated by a pure LG(0,0) of unity amplitude is given by 2π the amplitude given in the table when the input light is in the Laguerre - Gauss (0,0) mode

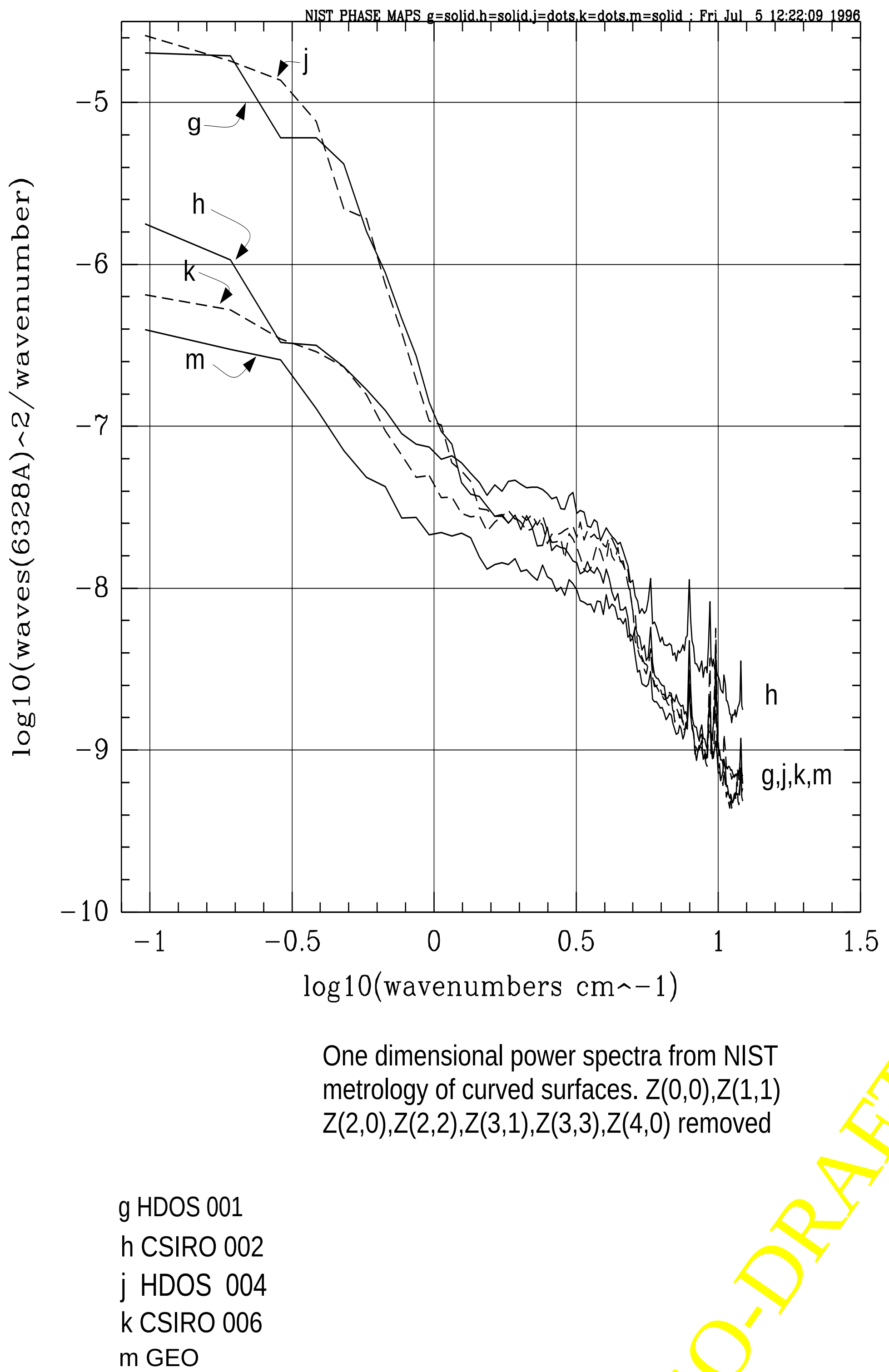


Figure 3 Intercomparison of curved surface NIST phase maps.