LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Profiles of ETM11 and ETM14 latest ETM coating by LMA

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1 Introduction

The effects of the new ETM coatings on ETM11 and ETM14 for aLIGO have been studied. The PSD of the spiral pattern around 8mm is down by factor 3 or so. The power in the cone with the opening angle of 0.14mrad is also down by a similar amount. The phasemap of ETM11 shows some asymmetry, but the degradations of the contrast defect (CD) on the dark port and the higher order mode (HOM) in the bright port are reasonably small.

2 Mirror profiles

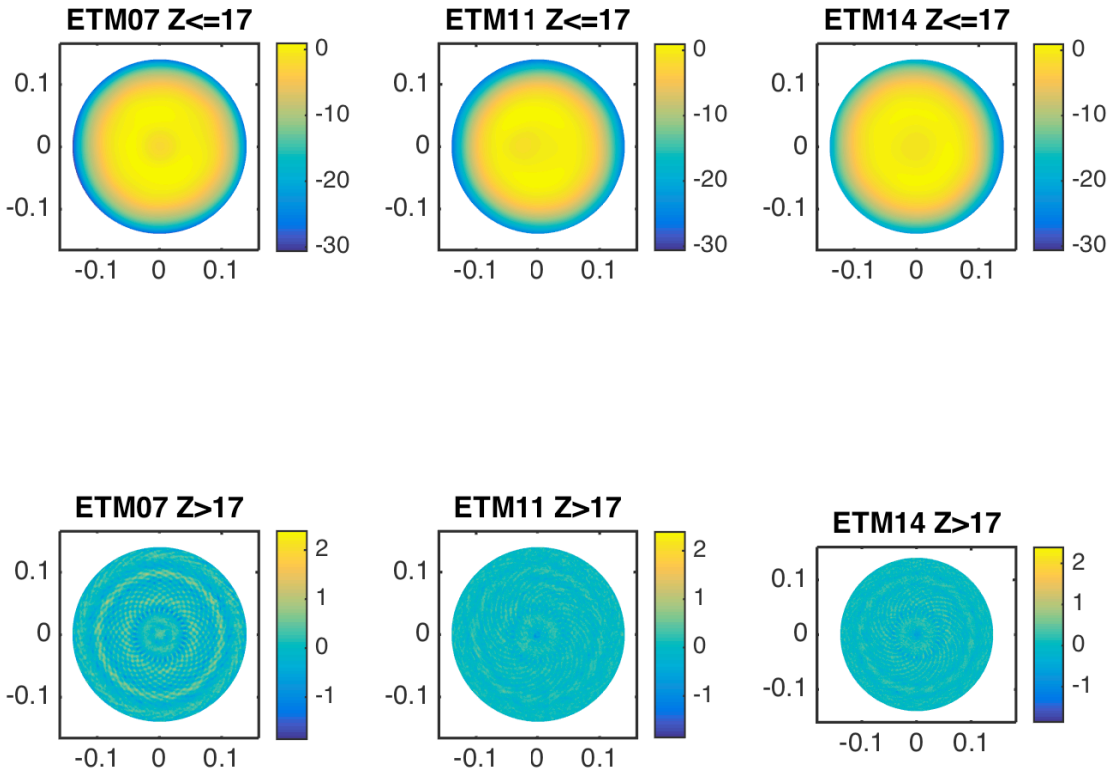

Figure 1 Phasemaps with previous coating (ETM07) and with new coatings (ETM11, ETM14)

Figure 1 shows the phasemaps of ETMs with previous coating (ETM07) and with new coatings (ETM11 and ETM14). The top group are the maps with zernite(n,m) amplitudes with $n \leq 17$ using data within aperture of 32cm, i.e., low frequency and smooth components, and the bottom with $n>17$, high frequency components. The color ranges are chosen to be the same in each top and bottom group. The smooth component of the ETM11 shows some symmetry, but the high frequency components of ETM11 and ETM14 are equally better than ETM07.

Fig.2 compares the cross sections of these maps along the axis, i.e., map(x, y=0). In the low frequency components, the dip at the center in the old coating is reduced, and the asymmetry in the ETM11 map is visible. The high frequency components show reduction of amplitudes in general, but the new coatings seem to be a little noisier.

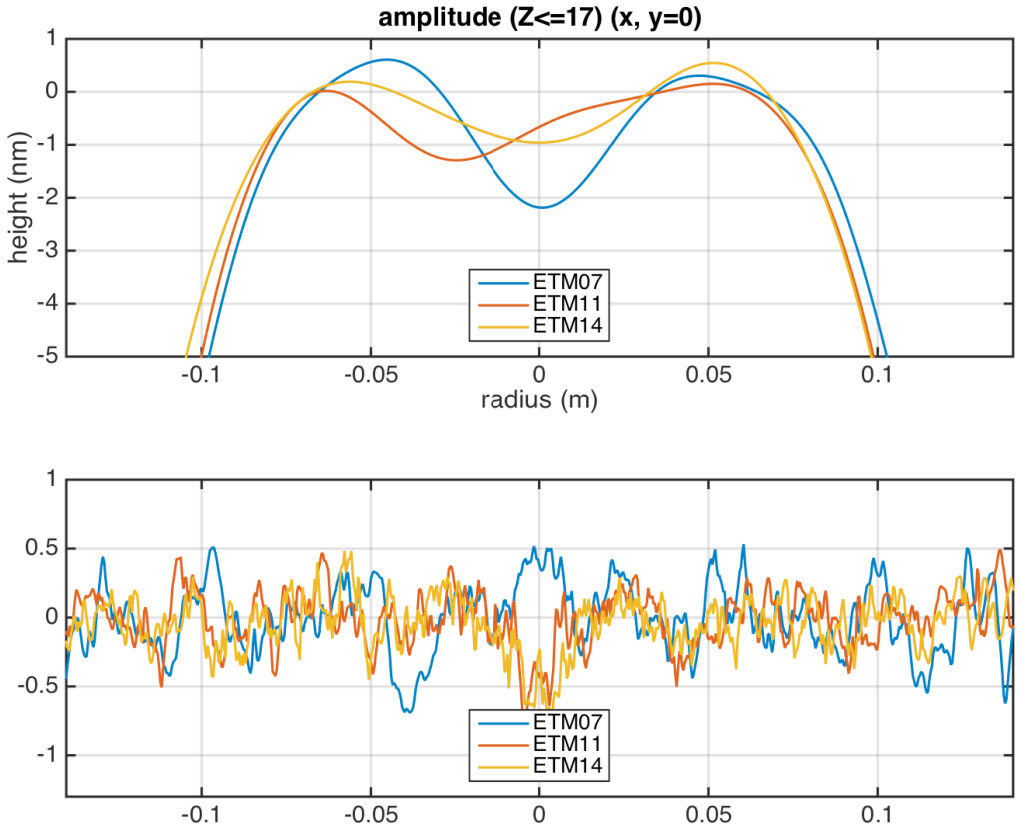

Figure 2 Cross sections of ETM maps

Fig.3 compares the PSDs of ETMs with previous coatings used at LLO and LHO and the new pair, red lines. The peaks at 8mm is clearly down, and the high frequency part is higher than old PSDs.

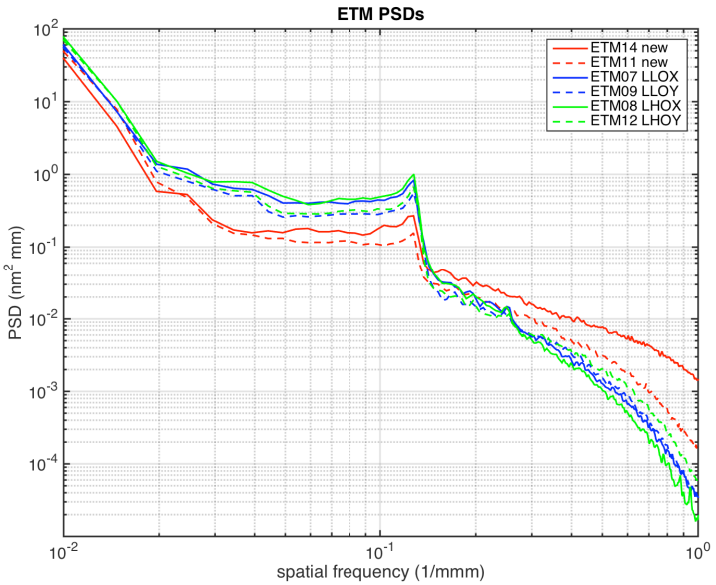

Figure 3 ETM PSDs

Fig.4 compares the PSDs around the 8mm peak by the spiral pattern. Magenta data points are the PSDs of the new maps scaled by factor 3. These are comparable to the PSDs of ETMs used at LLO. Two PSDs with the same color are coated together and, for all three cases, the magnitudes are different.

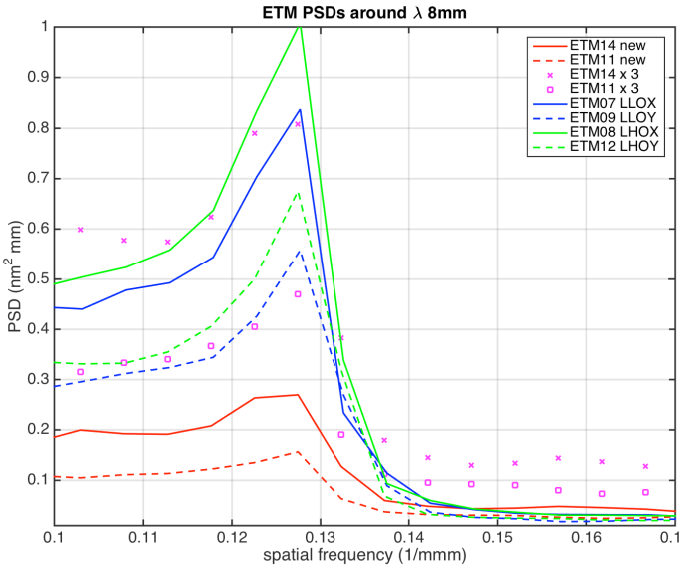

Figure 4 ETM PSDs around the 8mm peak

3 Simulation setup

FFT simulation was done using FOGP13 to study the effects of the ETM maps. The power recycled FP Michelson configuration for L1 was used with the following two changes.

1. The RoC of the ETMs are set to be 2250m, which is the measured RoC of new mirrors.
2. The BS05 maps are used, instead of BS02, which has large aberrations and may hide some problems by the ETM coating.
3. An adhoc loss of 40ppm per arm is added by hand to make the arm round trip loss to close to the measurement at LLO.

All other parameters and maps of ITMs and CPs are the ones of L1. MICH is adjusted so that the power in the dark port becomes minimal. The power terms in the ITM transmission maps are canceled by adding simple lens terms to each ITM maps, but other aberrations are included in the simulation.

4 Effects of the phasemaps on the IFO performance

Fig.5 shows the power distribution of the field on the ITM plane, coming from the ETM. The effects of the spiral pattern on the ETM coating shows up at around 55cm from the center of the beam. As can be perceived from the reduction of the PSDs at 8mm, the power in this region is appreciably down.

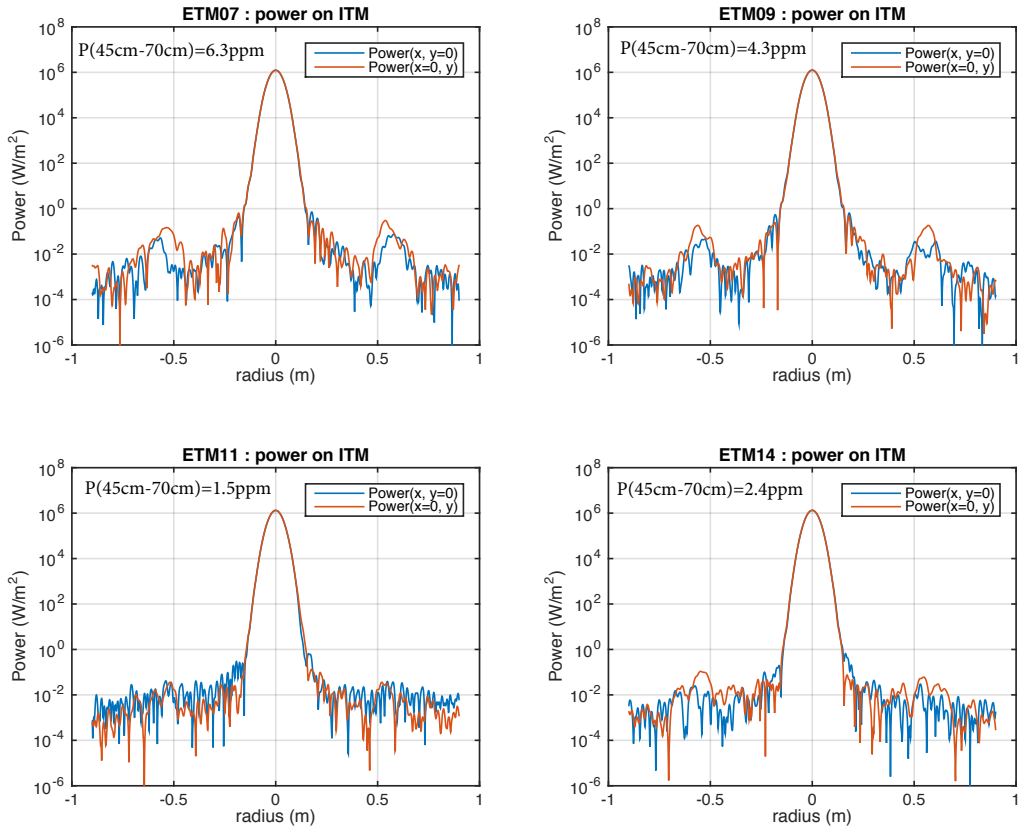

Figure 5 Power in the ITM plane with different ETM maps

	ETM14	ETM11	ETM07	ETM09	ETM08	ETM12
power (45cm~70cm)	2.4	1.5	6.3	4.3	7.7	5.2
round trip loss	74	73	80	78	80	80
HOM	226	283	208	288	227	312

Table 1 Field in a FP arm with different ETMs (units in ppm)

Table 1 shows some of the characteristics of fields in the FP arm cavities. ETM11, ETM07 and ETM08 are placed in the x arm with ITM04 as ITM, and other 3 ETMs are placed in the y arm with ITM08 as ITM.

The second row is the fraction of the power within the radius of 45cm to 70cm in the ITM place. Compared to the old coatings, the power in this band is reduced by factor 2.5 to 3.

The round trip is the sum of various absorptions, micro roughness loss and the loss by the figure, and the adhoc loss of 40ppm is included. As is seen from the third and fourth rows, the overall loss and the loss of the TEM00 mode are improved when ETMs with new coatings are used.

	ETM11-ETM14	ETM07-ETM09	ETM08-ETM12
PRG	44	41	41
Contrast Defect	93ppm	84ppm	75ppm
HOM on bright port	975ppm	976ppm	1000ppm

Table 2 Power Recycled FP Michelson performance with different ETM sets

Table 2 compares characteristics of the power recycled FP Michelson cavity explained in Sec.3 when different pairs of ETMs are used. The overall performance almost stays the same..