



## LightMachinery

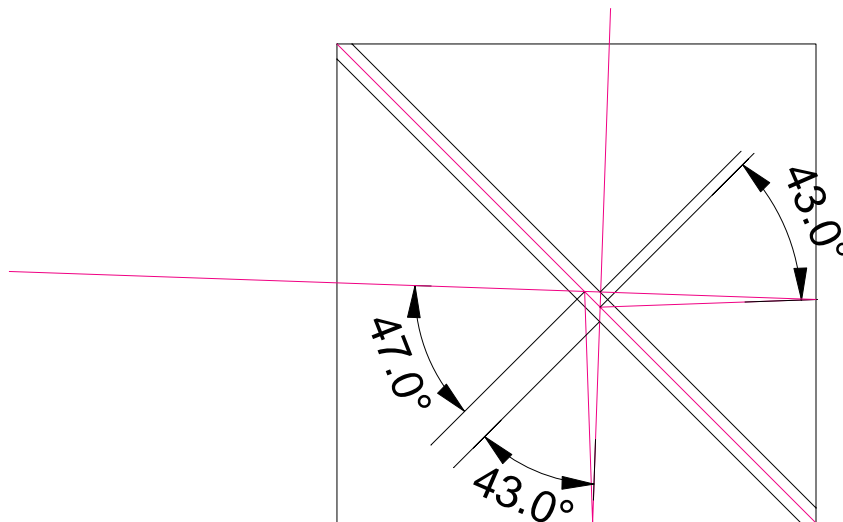
### HMI Group Index and Beam Splitter Phase Notes

This note has some initial thoughts on these two issues. I have not gone through the math rigorously to confirm everything, but I thought the issue should be flagged, as it may affect some of our design choices. Please feel free to comment and correct as necessary.

During the Michelson PDR we discussed the effect of phase from the beam splitter. I have looked at the variation of phase as a function of angle for both the transmitted and reflected components.

There are two main effects to think about. First, the phase of the transmitted component is proportional to the thickness of the coating, and inversely proportional to the cosine of the incident angle. So a thicker coating has a greater phase delay, and as the angle of incidence increases, the phase also increases. There should be a correction for the refractive index of the coating as well, but I think that is a second order effect.

The second effect is for the reflected portion of the beam. The angle dependence is very similar to the transmitted phase, but the phase due to the thickness is relatively insensitive to the overall thickness of the coating. Extra layers in the coating do not substantially affect the reflected phase, except close to angles where the reflectivity drops.



The beam that is reflected then transmitted has phase from a 47° reflection and 43° transmission and the beam that is transmitted then reflected has phase from 47° transmission and 43° reflection.

Because the reflected and transmitted phase have substantially different slope with respect to angle, the phase difference between the reflected and transmitted beams in the Michelsons depends on the incident angle in the sagittal plane. There is a variation in

phase in the Tangential plane with angle, but it is the same for reflected and transmitted beams.

The test coating that we showed at the PDR has a phase variation in transmission of about  $200^\circ$  over the field of view of the instrument. The variation in reflected phase is only  $35^\circ$ . I have not yet figured out what the effect of this variation is on intensity for a given image pixel.

The test coating was “over designed” to ensure good intensity performance, and we could certainly reduce the overall coating thickness to minimize the phase variations. Very roughly, the comparable figures for the MDI beam splitter were  $90^\circ$  in transmission and  $25^\circ$  in reflection.

I have thought about the  $dn/d\lambda$  correction, and based on our experience with Fabry-Perot interferometers, I think the group index of the glass should be used when calculating the path difference between the two arms. The first term with this correction is twice the factor that Alan had added. The attached spreadsheet calculates the correction factor for both MDI and HMI. I can't give a coherent explanation for why the group index is correct for this calculation, but it is routinely used for Fabry-Perot calculations where it correctly predicts their FSR.