Small Aperture HWPSS

1 Intro

Here is a brief description on the small aperture HWPSS calculation. The majority of the work is identical to the calculation of the large aperture HWPSS, with the exception of the IP coefficients.

2 Calculating IP

Unlike the large aperture system, rays hitting a given pixel enter the optics parallel to one another. Because of this a simple plane wave analysis should be reasonably accurate to calculate the IP of each element. This can be done by applying the Fresnel equations at each boundary. For stacks of thin films, this can easily be done using the transfer matrix method described in [] using the python tmm package. We calculate the IP coefficient by taking the transmission of s and p-waves separately and calculating the polarized fraction:

$$\mathrm{IP} = \frac{T_p - T_s}{T_p + T_s}.$$

We can then average this over the bandwidth of the detectors. The major sources of $I \to P$ leakage that we consider are the window and the two aluminum filters which are on the sky-side of the HWP.

One issue with the calculation is the presence of Fabry-Pèrot interference between filters. Because of this the IP coefficient of the two Aluminum filters is dependent on the distance between them, as seen in Figure 1. For the time being since the distances are not final, and the amplitude of the interference dies down with distance, I am simply taking the average as the distance increases and dividing the IP equally among the two aluminum filters.

θ	Aluminum Filter IP		Aluminum Filter IP	
	95 GHz	150 GHz	95 GHz	150 GHz
7.5°	6.69×10^{-4}	2.86×10^{-5}	3.88×10^{-4}	3.86×10^{-4}
10.0°	1.20×10^{-3}	5.14×10^{-5}	6.79×10^{-4}	7.03×10^{-4}
12.5°	1.90×10^{-3}	8.10×10^{-5}	1.04×10^{-3}	1.13×10^{-3}
15.0°	2.79×10^{-3}	1.17×10^{-4}	1.47×10^{-3}	1.72×10^{-3}

Table 1: Above are the band averaged IP coefficients for the window and aluminum filters at 93 and 150 GHz. θ is the incident angle of the light on the surface.

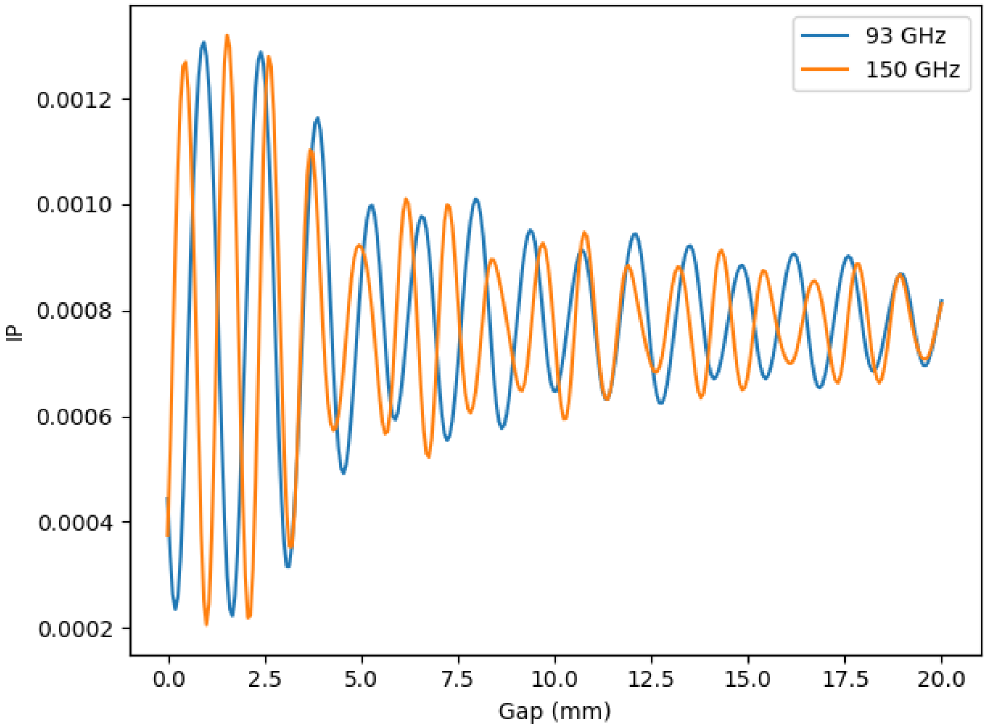

Figure 1: IP coefficient as a function of distance for a system with just two aluminum filters separated by a gap. The incident angle is 7.5°, and frequencies of both 93 and 150 GHz are shown.

3 Optical Chain

The optical chain being used for the small aperture is given in table **??**.

4 Results

$A^{(4)}$ for a detector at the edge of the array for various FOV's are given below. I am only giving results in K_{CMB} because the HWPSS in pW is proportional to the efficiency of the aperture, which depends on the F-Number. Because you can have different F-numbers for the same FOV, this would add another dimension to the input. The aperture efficiency cancels out when converting to K_{CMB}, so we only get one value for each FOV. I can include different F-Numbers in the future if people are interested.

Name	Temp	Abs [93 GHz, 150 GHz]	Refl
Window	300.0	[0.005,0.010]	0.010
IRShader1	298.0	[0.001,0.001]	0.000
IRShader2	293.0	[0.001,0.001]	0.000
IRShader3	290.0	[0.001,0.001]	0.000
IRShader4	276.0	[0.001,0.001]	0.000
AluminaF	82.00	NA	0.020
IRShader1	76.00	[0.001,0.001]	0.000
IRShader2	70.00	[0.001,0.001]	0.000
IRShader3	65.00	[0.001,0.001]	0.000
IRShader4	61.00	[0.001,0.001]	0.000
AluminaF	42.00	NA	0.020
HWP			
AluminaF	40.00	NA	0.020
AluminaF	5.000	NA	0.020
LowPass1	4.000	[0.010,0.010]	0.050
Aperture	1.000	NA	NA
Lens	1.000	NA	0.006
Lens	1.000	NA	0.006
LowPass1	0.100	[0.010,0.010]	0.050

Table 2: Above are the band averaged IP coefficients for the window and aluminum filters at 93 and 150 GHz. θ is the incident angle of the light on the surface.

θ	$A^{(4)}$ ($\mathrm{mK_{CMB}}$)	
	Aluminum Filter IP	Window IP
15°	4.52	5.88
20°	13.9	18.1
25°	43.6	57.1
30°	95	124.1

Table 3: $A^{(4)}$ for various incident angles