T1300421 Ghost Beam Scatter in Signal Recycling Cavity
8/24/11

BRDF of porcelainized steel, sr^-1 $BRDF_{bd} := 0.05$

BRDF of chamber wall, sr^-1 $BRDF_{wall} := 0.1$

Motion of HEPI @ 200 Hz, m/rt Hz $x_{hepi} := 2 \cdot 10^{-10}$

Motion of HAM table @ 100 Hz, m/rt Hz $x_{ham} := 3.7 \cdot 10^{-14}$

Motion of HAM flange @ 100 Hz, m/rt Hz $x_{hamflange} := 1.7 \cdot 10^{-11}$

laser wavelength, m $\lambda := 1.064 \cdot 10^{-6}$

wave number, m^-1 $k := 2 \cdot \frac{\pi}{\lambda}$ $k = 5.905 \times 10^{6}$

IFO waist size, m $w_{ifo} := 0.012$

solid angle of IFO mode, sr $\Delta_{ifo} := \pi \cdot \left(\frac{\lambda}{\pi \cdot w_{ifo}} \right)^2$ $\Delta_{ifo} = 2.502 \times 10^{-9}$

Transfer function @ 100 Hz, ITM AR $TF_{itmar} := 3.16 \cdot 10^{-11}$

Transfer function @ 100 Hz, BS from SR $TF_{srbs} := 4.46 \cdot 10^{-11}$

Transfer function @ 100 Hz, SRM $TF_{srm} := 4.22 \cdot 10^{-10}$

Ref. T070247

transmissivity of SRM HR $T_{srmhr} := 0.2$

Transmissivity of ITM HR $T_{itmhr} := 0.014$

Reflectivity of ITM HR $R_{itmhr} := 1 - T_{itmhr}$ $R_{itmhr} = 0.986$

Transmissivity of ETM HR $T_{etm} := 5 \cdot 10^{-6}$

ETM transmitted power, W $P_{etmtr} := 4.4$

input laser power, W $P_{psl} := 125$

arm cavity gain $G_{ac} := 13000$

arm cavity power, W $P_a := \frac{P_{psl}}{2} \cdot G_{ac}$ $P_a = 8.125 \times 10^5$

Ref. Hiro e-mail 8/29/11

power in power recycling cavity both arms, W $P_{rc} := \frac{2P_a \cdot T_{itmhr}}{4}$ $P_{rc} = 5.688 \times 10^3$

Gaussian power parameter in recycling cavity arm $P_{0rc} := \frac{P_{rc}}{2}$ $P_{0rc} = 2.844 \times 10^3$

Power recycling cavity gain $G_{rc} := \frac{P_{rc}}{P_{psl}}$ $G_{rc} = 45.5$

refl port signal ratio $G_{refl} := 0.001$

as port signal ratio $G_{as} := 0.00108$

output signal power, W $P_{srm} := P_{psl} \cdot G_{as}$ $P_{srm} = 0.135$

power in signal recycling cavity, W $P_{src} := \frac{P_{srm}}{T_{srmhr}}$ $P_{src} = 0.675$

Asymmetry coefficient for common mode field rejection $C_{assy} := \sqrt{\frac{P_{src}}{P_{rc}}}$ $C_{assy} = 0.0109$

Gaussian irradiance parameter from ITM $P_{0itm} := 2 \cdot P_{0rc}$ $P_{0itm} = 5.688 \times 10^3$

reflectivity of BS HR $R_{bshr} := 0.5$

reflectivity of BS AR	$R_{bsar} := 50 \cdot 10^{-6}$	
Reflectivity of ITM HR	$R_{itmhr} := 1 - T_{itmhr}$	$R_{itmhr} = 0.986$
Reflectivity of ITM AR	$R_{itmar} := 50 \cdot 10^{-6}$	
Reflectivity of CP AR	$R_{cpar} := 50 \cdot 10^{-6}$	
reflectivity of AS septum port	$R_{sp} := 0.0025$	
reflectivity of SRM HR	$R_{srmhr} := 1 - T_{srmhr}$	$R_{srmhr} = 0.8$
reflectivity of SRM AR	$R_{srmar} := 50 \cdot 10^{-6}$	
transmissivity of SRM AR	$T_{srmar} := 1 - R_{srmar}$	$T_{srmar} = 1$
reflectivity of PR2 HR	$R_{pr2hr} := 0.9999$	
transmissivity of PR2 HR	$T_{pr2hr} := 1 - R_{pr2hr}$	$T_{pr2hr} = 10 \times 10^{-5}$
reflectivity of PR2 AR	$R_{pr2ar} := 50 \cdot 10^{-6}$	
transmissivity of PR2 AR	$T_{pr2ar} := 1 - R_{pr2ar}$	$T_{pr2ar} = 1$
reflectivity of SR2 HR	$R_{sr2hr} := R_{pr2hr}$	$R_{sr2hr} = 1$
reflectivity of SR2 AR	$R_{sr2ar} := R_{pr2ar}$	$R_{sr2ar} = 5 \times 10^{-5}$
transmissivity of SR2 HR	$T_{sr2hr} := T_{pr2hr}$	$T_{sr2hr} = 10 \times 10^{-5}$
transmissivity of SR2 AR	$T_{sr2ar} := T_{pr2ar}$	$T_{sr2ar} = 0.99995$
reflectivity of PR3 HR	$R_{pr3hr} := 0.9999$	
transmissivity of PR3 HR	$T_{pr3hr} := 1 - R_{pr3hr}$	$T_{pr3hr} = 10 \times 10^{-5}$
reflectivity of PR3 AR	$R_{pr3ar} := 50 \cdot 10^{-6}$	

transmissivity of PR3 AR	$T_{pr3ar} := 1 - R_{pr3ar}$	$T_{pr3ar} = 1$
reflectivity of SR3 HR	$R_{sr3hr} := R_{pr3hr}$	$R_{sr3hr} = 1$
reflectivity of SR3 AR	$R_{sr3ar} := R_{pr3ar}$	$R_{sr3ar} = 5 \times 10^{-5}$
transmissivity of SR3 HR	$T_{sr3hr} := T_{pr3hr}$	$T_{sr3hr} = 10 \times 10^{-5}$
transmissivity of SR3 AR	$T_{sr3ar} := T_{pr3ar}$	$T_{sr3ar} = 1$
reflectivity of FM HR	$R_{FMhr} := R_{pr3hr}$	$R_{FMhr} = 1$
reflectivity of Hartmann dichroic bs	$R_{hartbs} := 0.0025$	
reflectivity of BS AR	$R_{bsar} = 5 \times 10^{-5}$	
Reflectivity of SR3	$R_{SR3} := 1$	
Reflectivity of dichroic HWSY M1	$R_{HWSYM1} := 0.01$	
Reflectivity of dichroic HWSY M2	$R_{HWSYM2} := 0.01$	
Reflectivity of HPY-F1	$R_{HPYF1} := 1$	
Reflectivity of HWSY M3	$R_{HWSYM3} := 1$	
Reflectivity of HWSY M4	$R_{HWSYM4} := 1$	
Reflectivity of HWSY M5	$R_{HWSYM5} := 1$	
Reflectivity of viewport	$R_{vp} := 0.0025$	
Reflectivity of dichroic HWSX M1	$R_{HWSXM1} := 0.01$	
Reflectivity of dichroic HWSX M2	$R_{HWSXM2} := 0.01$	
Reflectivity of HWSX M3	$R_{HWSXM3} := 1$	

Reflectivity of HWSX M4 $R_{HWSXM4} := 1$

Reflectivity of HWSX M5 $R_{HWSXM5} := 1$

Reflectivity of HPX-F1 $R_{HPXF1} := 1$

transmissivity of SR2 HR $T_{sr2hr} = 10 \times 10^{-5}$

BRDF of HPY-F1 @ 3 deg, sr^-1 $BRDF_{hartm} := 0.01$

BRDF of viewport $BRDF_{vp} := 0.005$

BRDF of HPX-F1 @ 3 deg, sr^-1 $BRDF_{hartm} = 0.01$

Beam Waist after SR3 $w_{sr30} := 0.000114$

Beam waist after SR2 $w_{sr20} := 0.000094$

Beam waist after SRM $w_{srm0} := 0.000841$

Beam Waist after HPYF1 $w_{hpyf10} := 0.0000850$

Beam waist after HPXF1 $w_{hpxf10} := 0.0000650$

ITM Ghost Beams

ITM_GBAR1_BD H1

Power incident on SR2 Scraper Baffle from both arms, W

$$P_{itmar1bd} := P_{rc} \cdot R_{bshr} \cdot R_{itmar}$$

$$P_{itmar1bd} = 0.142$$

both ITM AR1 BD scattered power into BS from SR2 Scraper baffle, W

$$P_{itmar1bds} := P_{itmar1bd} \cdot BRDF_{bd} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot \Delta_{ifo} \cdot R_{bshr}^{0} \cdot R_{itmar}$$

$$P_{itmar1bds} = 9.857 \times 10^{-12}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{itmar1bd} := TF_{srbs} \cdot \left(\frac{P_{itmar1bds}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{itmar1bd} = 5.473 \times 10^{-24}$$

ITM_GBAR3_BD H1

power incident on SR2 Scraper Baffle from both arms, W

$$P_{itmar3bd} := P_{rc} \cdot R_{bshr} \cdot R_{itmhr}^{2} \cdot R_{itmar} \cdot \left(1 - R_{itmar}\right)^{2}$$

$$P_{itmar3bd} = 0.1382$$

power scattered from SR2 Scraper Baffle, W

$$P_{itmar3bds} := P_{itmar3bd} \cdot BRDF_{bd} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot \Delta_{ifo} \cdot R_{bshr}^{0} \cdot R_{itmhr}^{2} \cdot R_{itmar} \cdot \left(1 - R_{itmar}\right)^{2}$$

$$P_{itmar3bds} = 9.314 \times 10^{-12}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{itmar3bd} := TF_{srbs} \cdot \left(\frac{P_{itmar3bds}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{itmar3bd} = 5.32 \times 10^{-24}$$

BS_GBAR3P H1

The stray light from both arms are almost anti-resonant, and the wavefronts overlap; their coherent sum is reduced by the square of the asymmetry coefficient for common mode field rejection

power incident on SR2 Scraper Baffle from both arms, W

$$P_{bsar3sr2baf} := P_{rc}\cdot\left[\left(1 - R_{bsar}\right)\cdot R_{bshr} + \left(1 - R_{bshr}\right)\cdot R_{bsar}\right]\cdot R_{bshr}\cdot\left(1 - R_{bsar}\right)\cdot C_{assy}^{2}$$

$$P_{bsar3sr2baf} = 0.169$$

power scattered from SR2 Scraper Baffle, W

$$P_{bsar3sr2bafs} := P_{bsar3sr2baf}\cdot BRDF_{bd}\cdot\frac{w_{ifo}^{2}}{w_{sr30}^{2}}\cdot\Delta_{ifo}\cdot\left(1 - R_{bsar}\right)\cdot R_{bshr}\cdot R_{bsar}\cdot\left[\left(1 - R_{bshr}\right) + R_{bshr}\cdot\left(1 -\right.\right.$$

$$P_{bsar3sr2bafs} = 5.848 \times 10^{-12}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{bsar3sr2baf} := TF_{itmar}\cdot\left(\frac{P_{bsar3sr2bafs}}{P_{psl}}\right)^{0.5}\cdot x_{ham}\cdot 2\cdot k$$

$$DN_{bsar3sr2baf} = 2.987 \times 10^{-24}$$

CP_GBAR1

power incident on SR2 Scraper Baffle from both arms, W

$$P_{cpar1sr2baf} := P_{rc}\cdot R_{bshr}\cdot R_{cpar}$$

$$P_{cpar1sr2baf} = 0.142$$

power scattered from SR2 Scraper Baffle, W

$$P_{cpar1sr2bafs} := P_{cpar1sr2baf}\cdot BRDF_{bd}\cdot\frac{w_{ifo}^{2}}{w_{sr30}^{2}}\cdot\Delta_{ifo}\cdot R_{bshr}^{0}\cdot R_{cpar}$$

$$P_{cpar1sr2bafs} = 9.857 \times 10^{-12}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{cpar1sr2baf} := TF_{itmar}\cdot\left(\frac{P_{cpar1sr2bafs}}{P_{psl}}\right)^{0.5}\cdot x_{ham}\cdot 2\cdot k$$

$$DN_{cpar1sr2baf} = 3.878 \times 10^{-24}$$

CP_GBAR3

power incident on SR2 Scraper Baffle from both arms, W

$$P_{cpar3sr2baf} := P_{rc} \cdot R_{bshr} \cdot R_{itmhr} \cdot R_{cpar}$$

$$P_{cpar3sr2baf} = 0.14$$

power scattered from SR2 Scraper Baffle, W

$$P_{cpar3sr2bafs} := P_{cpar3sr2baf} \cdot BRDF_{bd} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot \Delta_{ifo} \cdot R_{bshr}^{0} \cdot R_{itmhr} \cdot R_{cpar}$$

$$P_{cpar3sr2bafs} = 9.583 \times 10^{-12}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{cpar3sr2baf} := TF_{itmar} \cdot \left(\frac{P_{cpar3sr2bafs}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{cpar3sr2baf} = 3.823 \times 10^{-24}$$

SR3 GBHR3

power incident on SR3 GBHR3 (forward and backward beams), W

$$P_{sr3gbhr3} := 2 \cdot P_{src} \cdot T_{sr3hr} \cdot R_{sr3ar} \cdot T_{sr3hr}$$

$$P_{sr3gbhr3} = 6.75 \times 10^{-13}$$

power scattered from SR3 GBHR3 toward BS, W

$$P_{sr3gbhr3bss} := \frac{P_{sr3gbhr3}}{2} \cdot BRDF_{wall} \cdot \Delta_{ifo} \cdot T_{sr3hr} \cdot R_{sr3ar} \cdot T_{sr3hr}$$

$$P_{sr3gbhr3bss} = 4.223 \times 10^{-35}$$

power scattered from SR3 GBHR3 toward SR2 W

$$P_{sr3gbhr3sr2s} := \frac{P_{sr3gbhr3}}{2} \cdot BRDF_{wall} \cdot \Delta_{ifo} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot \left(T_{sr3hr} \cdot R_{sr3ar} \cdot T_{sr3hr}\right)$$

$$P_{sr3gbhr3sr2s} = 4.679 \times 10^{-31}$$

total power scattered from SR3 GBHR3

$$P_{sr3gbhr3s} := P_{sr3gbhr3bss} + P_{sr3gbhr3sr2s}$$

$$P_{sr3gbhr3s} = 4.68 \times 10^{-31}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{sr3gbhr3} := TF_{srbs} \cdot \left(\frac{P_{sr3gbhr3s}}{P_{psl}}\right)^{0.5} \cdot x_{hamflange} \cdot 2 \cdot k$$

$$DN_{sr3gbhr3} = 5.479 \times 10^{-31}$$

SR3 GBAR3

power incident on GBAR3 AR Baffle (forward and backward beams), W

$$P_{sr3gbar3} := 2 \cdot P_{src} \cdot T_{sr3hr} \cdot R_{sr3ar} \cdot R_{sr3hr} \cdot T_{sr3ar}$$

$$P_{sr3gbar3} = 6.749 \times 10^{-9}$$

power scattered from SR3 AR Baffle toward BS, W

$$P_{sr3gbar3bss} := \frac{P_{sr3gbar3}}{2} \cdot BRDF_{bd} \cdot \Delta_{ifo} \cdot T_{sr3hr} \cdot R_{sr3ar} \cdot R_{sr3hr} \cdot T_{sr3ar}$$

$$P_{sr3gbar3bss} = 2.111 \times 10^{-27}$$

power scattered from SR3 AR Baffle toward SR2, W

$$P_{sr3gbar3sr2s} := \frac{P_{sr3gbar3}}{2} \cdot BRDF_{bd} \cdot \Delta_{ifo} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot T_{sr3hr} \cdot R_{sr3ar} \cdot R_{sr3hr} \cdot T_{sr3ar}$$

$$P_{sr3gbar3sr2s} = 2.339 \times 10^{-23}$$

total power scattered from SR3 AR Baffle, W

$$P_{sr3gbar3s} := P_{sr3gbar3bss} + P_{sr3gbar3sr2s}$$

$$P_{sr3gbar3s} = 2.339 \times 10^{-23}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{sr3gbar3} := TF_{srbs} \cdot \left(\frac{P_{sr3gbar3s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{sr3gbar3} = 8.431 \times 10^{-30}$$

SR3 AR Baffle

power incident on SR3 AR Baffle (forward and backward beams), W

$$P_{sr3arbaf} := 2P_{src} \cdot T_{sr3hr} \cdot T_{sr3ar}$$

$$P_{sr3arbaf} = 1.35 \times 10^{-4}$$

power scattered from SR3 AR Baffle toward BS, W

$$P_{sr3arbafbss} := \frac{P_{sr3arbaf}}{2} \cdot BRDF_{bd} \cdot \Delta_{ifo} \cdot T_{sr3hr} \cdot T_{sr3ar}$$

$$P_{sr3arbafbss} = 8.445 \times 10^{-19}$$

power scattered from SR3 AR Baffle toward SR2 W

$$P_{sr3arbafsr2s} := \frac{P_{sr3arbaf}}{2} \cdot BRDF_{bd} \cdot \Delta_{ifo} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot T_{sr3hr} \cdot T_{sr3ar}$$

$$P_{sr3arbafsr2s} = 9.357 \times 10^{-15}$$

power scattered from SR3 AR Baffle, W

$$P_{sr3arbafs} := P_{sr3arbafbss} + P_{sr3arbafsr2s}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{sr3arbaf} := TF_{srbs} \cdot \left(\frac{P_{sr3arbafs}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{sr3arbaf} = 1.686 \times 10^{-25}$$

SRM_GBHR3

power of SRM GBHR3, W

$$P_{srmhr3} := P_{srm} \cdot R_{srmar} \cdot T_{srmhr}$$

$$P_{srmhr3} = 1.35 \times 10^{-6}$$

power scattered from SRM GBHR3 Mode Cleaner Tube Baffle, W

$$P_{srmhr3bafs} := P_{srmhr3} \cdot BRDF_{bd} \cdot \frac{w_{ifo}^{2}}{w_{srm0}^{2}} \cdot \Delta_{ifo} \cdot R_{srmar} \cdot T_{srmhr}$$

$$P_{srmhr3bafs} = 3.439 \times 10^{-19}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{srmhr3bafs} := TF_{srm} \cdot \left(\frac{P_{srmhr3bafs}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{srmhr3bafs} = 9.673 \times 10^{-27}$$

SRM_GBAR3

power incident on SRM AR Baffle, W

$$P_{srmarbaf} := P_{srm} \cdot R_{srmar} \cdot R_{srmhr} \cdot T_{srmar}$$

$$P_{srmarbaf} = 5.4 \times 10^{-6}$$

power scattered from SRM AR Baffle, W

$$P_{srmarbafs} := P_{srmarbaf} \cdot BRDF_{bd} \cdot \frac{w_{ifo}^{2}}{w_{srm0}^{2}} \cdot \Delta_{ifo} \cdot R_{srmar} \cdot R_{srmhr} \cdot T_{srma}$$

$$P_{srmarbafs} = 5.502 \times 10^{-18}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{srmarbafs} := TF_{srm} \cdot \left(\frac{P_{srmarbafs}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{srmarbafs} = 3.869 \times 10^{-26}$$

SR2 GBHR3

power incident on SR2 GBHR3 (forward and backward beams), W

$$P_{sr2gbhr3} := 2 \cdot P_{src} \cdot T_{sr2hr} \cdot R_{sr2ar} \cdot T_{sr2hr}$$

$$P_{sr2gbhr3} = 6.75 \times 10^{-13}$$

power scattered from SR2 GBHR3 toward SR3, W

$$P_{sr2gbhr3sr3s} := \frac{P_{sr2gbhr3}}{2} \cdot BRDF_{wall} \cdot \frac{w_{ifo}^{2}}{w_{sr30}^{2}} \cdot \Delta_{ifo} \cdot T_{sr2hr} \cdot R_{sr2ar} \cdot T_{sr2hr}$$

$$P_{sr2gbhr3sr3s} = 4.679 \times 10^{-31}$$

power scattered from SR2 GBHR3 toward SRM, W

$$P_{sr2gbhr3srms} := \frac{P_{sr2gbhr3}}{2} \cdot BRDF_{wall} \cdot \frac{w_{ifo}^{2}}{w_{srm0}^{2}} \cdot \Delta_{ifo} \cdot T_{sr2hr} \cdot R_{sr2ar} \cdot T_{sr2hr}$$

$$P_{sr2gbhr3srms} = 8.598 \times 10^{-33}$$

total power scattered from SR2 GBHR3

$$P_{sr2gbhr3s} := P_{sr2gbhr3sr3s} + P_{sr2gbhr3srms}$$

$$P_{sr2gbhr3s} = 4.765 \times 10^{-31}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{sr2gbhr3} := TF_{srbs} \cdot \left(\frac{P_{sr2gbhr3s}}{P_{psl}} \right)^{0.5} \cdot x_{hamflange} \cdot 2 \cdot k$$

$$DN_{sr2gbhr3} = 5.529 \times 10^{-31}$$

SR2 GBAR3

$$w_{sr20} = 9.4 \times 10^{-5}$$

power incident on SR2 GBAR3 AR Baffle (forward and backward beams), W

$$P_{sr2gbar3} := 2 \cdot P_{src} \cdot T_{sr2hr} \cdot R_{sr2ar} \cdot R_{sr2hr} \cdot T_{sr2ar}$$

$$P_{sr2gbar3} = 6.749 \times 10^{-9}$$

power scattered from SR3 AR Baffle, W

$$P_{sr2gbar3s} := P_{sr2gbar3} \cdot BRDF_{bd} \cdot \frac{w_{ifo}^{2}}{w_{sr20}^{2}} \cdot \Delta_{ifo} \cdot T_{sr2hr} \cdot R_{sr2ar} \cdot R_{sr2hr} \cdot T_{sr2ar}$$

$$P_{sr2gbar3s} = 6.88 \times 10^{-23}$$

displacement noise @ 100 Hz, m/rtHz

$$DN_{sr2gbar3} := TF_{srbs} \cdot \left(\frac{P_{sr2gbar3s}}{P_{psl}} \right)^{0.5} \cdot x_{ham} \cdot 2 \cdot k$$

$$DN_{sr2gbar3} = 1.446 \times 10^{-29}$$

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