Table A1. Third Order Ray and Fourth Order Wave (OPD) Plots. \S

Aberration	Ourth Order Wave (OPD) Plots. OPD	Ray	Field
DEFOCUS = $W_{020} \rho^2$ OPD: Curvature @ origin	19y(2)	Ey(jab) Ex(jab) 2 1 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1	11_1
$W_y = W_{020}y_p^2$	0.2 0.7 x 0.7 x by(3)	-1.5 -2	H=1
$W_x = W_{020} x_p^2$	1	Ex (Jan) 2 1 -0.5	
Ray: Same slope	0.2 0.7 1 v 0.7 1 v 0.7 1 v 0.7 1 v	-1 -0.7	H=0.7
$\varepsilon_{y} = -2 \left(\frac{R}{r_{p}}\right) W_{020} \rho Cos \theta = -2 \left(\frac{R}{r_{p}}\right) \Delta W_{20} y_{p}$ $\varepsilon_{x} = -2 \left(\frac{R}{r_{p}}\right) W_{020} \rho Sin \theta = -2 \left(\frac{R}{r_{p}}\right) \Delta W_{20} x_{p}$	0.6 0.6 0.6 0.6 0.4 0.4 0.4 0.7 1 y 0.7	Ey (jah) 2 1 -1 -0.7 -1 -2 -2 Ex (jah) Ex (jah) 0.7 1 x -1.8 -2 -2	H=0
$ \begin{array}{c c} \mathbf{C}_{\mathbf{X}} & \mathbf{C}_{\mathbf{r}_p} & \mathbf{C}_{0} & \mathbf{C}_{0} & \mathbf{C}_{\mathbf{r}_p} \\ \hline \mathbf{TILT} & = \mathbf{W}_{111} \ \mathbf{HpCos\theta} \\ \end{array} $			
OPD:	θη(λ) θη (λ) 1 0.5	Σγ (μα) Σα (μα) -1 -0.7 0.5 0.7 1 7 1 0.5	
Different slope increasing with field (linearly)	-1 -0.7 0.7 1 7 0.7 1 = -0.8 -1 1 = -	-1.5 -0.5 -1.	H=1
$W_{y} = W_{111}Hy_{p}$ $W_{x} = 0$	₩y(λ) ₩n(λ) 0.6	Ey(tan) Ex(tan) -1 -0.7 0.7 1 7 1	
Ray: Distance from origin increases with field	0.6 0.4 0.2 -1 -0.7 -0.8 -0.8 -0.8	-1 -0.7 -0.2 0.7 1 0.5 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5	H=0.7
$\varepsilon_{y} = -\left(\frac{R}{r_{p}}\right) W_{111} H = -\left(\frac{R}{r_{p}}\right) \Delta W_{11} H$	Ψ ₇ (x) Ψ ₈ (x) 1 0.5 -1 -0.7 0.7 1 0	Ex(im) Description Ex(im)	H=0
$\varepsilon_{\rm X} = 0$	-0.8 -1 -0.8	-0.5 -1 -0.5	
DIST = $W_{311} H^3 \rho Cos\theta$ OPD:	by(λ) b _x (λ) 1 0.5	Ey(iiii) Ex(iiii) -1 -0.7 0.7 1 9 1 0.5	
Different slope increasing with field (cubically)	-1 -0.7 0.7 1 7 0.7 1 8 -0.8 -1 1 -0.8	-1.5 -0.5 -2 -1	H=1
$W_{\mathbf{y}} = W_{311}H^3 y_p$	$v_{y'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$ $v_{z'}(\lambda)$	Ey (jan) Ex (jan)	
$W_{\rm x} = 0$ Ray: Distance from origin increases with field	0.1 -1 -0.7 0.1 0.7 1 9 0.7 1 = -0.5 -0.2 -0.2 -1	-0.2 0.5 0.5 0.7 1 x -0.5 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5 -0.5	H=0.7
$\varepsilon_{y} = -\left(\frac{R}{r_{p}}\right)W_{311}H^{3}$ $\varepsilon_{x} = 0$	0y(3) Un(3) 1 0.5 -1 -0.7 0.7 1 7 -0.5 -1 -1 -1 -1 -1	Ex (pin) 1 0.8 -1 -0.7 0.5 -1 -1 -1 -1	H=0
$SA = W_{040} \rho^4$ OPD:	Φ ₇ (3) th ₁ (3) .	Ey (jah) (1) (2) (3) (4) (5) (7) (1) (1) (2) (3) (4) (5) (7) (1) (7) (8)	
No curvature @ origin; $W_y = W_{040} y_p^4$	0.4 0.8 0.1 0.7 1 y 0.7 1 x	-1 -0.7	H=1
$W_{\mathbf{x}} = W_{040} x_p^4$	Ψ ₇ (3) th ₁ (3) 1 0.6 0.6 0.6 0.6	Ex ((m)) 4 0.7 1	
Ray:	0.6 0.6 0.4 0.2 0.2 0.7 1 y	2 -1 -0.7 2 0.7 1 y -2 -0 -0 -0	H=0.7
$\varepsilon_{y} = -4 \left(\frac{R}{r_{p}}\right) W_{040} \rho^{3} Cos \theta = -4 \left(\frac{R}{r_{p}}\right) W_{040} y_{p}^{3}$ $\varepsilon_{x} = -4 \left(\frac{R}{r_{p}}\right) W_{040} \rho^{3} Sin \theta = -4 \left(\frac{R}{r_{p}}\right) W_{040} x_{p}^{3}$	0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0 0,0	Ep (jan) En (jan)	H=0

§ See below **Table A2** for explanation.

Table A2. Third Order Ray and Fourth Order Wave (OPD) Plots. §

OPD OPD	Rav	Field
θy(λ) Nε(λ) 1 / 1	Ey (Lm) Ex (Lm)	
0.5	-0.5 -1 0.5	
-1 -0.3 -0.5 -0.5	-1.5 -2 -2.5	H=1
	7 -2} -1} Ent(thi) Pr((thi))	
0.6 0.4 0.5	-1 -0.7 0.7 1 1	
-1 -0.7 -0.8 0.7 1 Y 0.7 1 X	-1 0.7 1 x	H=0.7
-0.4 -0.6	-1.5 -2 -0.5 -1	
Φ ₇ (λ) N ₆ (λ) 1 0, 5 0, 5	E ₇ (12m) E ₈ (12m)	
-1 -0.7 0.7 1 Y 0.7 1 ×	0.5	H=0
-0.5 -0.5 -0.5 -1	-1 -0.7 -0.5 -0.5 -1	11-0
by(λ) bc(λ) 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Εγ(μm) Εκ(μm) 2 μ μ	
0.5 0.6 0.4	0.5 0.5 ×	
0.2	-1 -0.5	H=1
-1 -0.7 U.7 I -47	- Z - 1) Ey(jan) Ex(jan)	
0.5	0.5	
0.2 0.7 x	-1 -0.7 0.7 1 Y 0.7 1 X	H=0.7
-1 -0.7 0.7 1 7 -1	-1	
1 0.5 0.5	Ey (jm) Ex (jm) 1 0.5	
-1 -0.7 0.7 1 7 0.7 1 8 -0.5 -0.5 -1	-0.5 -1 -1	H=0
Ψ _γ (λ) Ψ _α (λ)	0.7 1 2	
0.6		TT 1
0.2	-1 -1.5	H=1
-1 -0.7 0.7 1 0.7 1 by(\(\lambda\) 0.5 \(\lambda\) 0.5 \(\lambda\) 0.5 \(\lambda\)	E _V ((dn)) E _N ((dn)) 1	
0.4 0.2	0.5	
0.2 0.1	-1 -0.7 0.7 1 9 -0.6 -0.8	H=0.7
-1 -0.7 0.7 1 y	-1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -1 -	
υ _γ (λ) Νε(λ) 1 1 1	1 1 0.5 0.5	
0.5 0.5 0.5 0.7 1 y 0.7 1 x	-1 -0.7 0.7 1 y 0.7 1 ×	H=0
-0.8 -1	-0.5 -1 -0.5 -1	
	## OPD ***Property ***Pro	OPD Ray 1

§ Represented plots: Tangential on left $(x_p=0)$ and Sagittal on right $(y_p=0)$. OPD axes: W vs. y_p & W vs x_p and Ray axes: ε_y vs.

 y_p & ε_x vs. x_p . R = radius of reference sphere, r_p = radius of pupil, y_p = aperture, H = field, $\left(\frac{R}{r_p}\right) \approx 2F/\#$,

$$y_p = \rho \text{Cos}\theta$$
, $x_p = \rho \text{Sin}\theta$, $\rho^2 = x_p^2 + y_p^2$. Ray Fan plots: $\varepsilon_y = -\frac{R}{r_p} \frac{\partial W}{\partial y_p}$ and $\varepsilon_x = -\frac{R}{r_p} \frac{\partial W}{\partial x_p}$

Combined equations for plotting OPD and Ray Fans with multiple aberrations present: (For plots F/1, λ = 0.5 μ m and $W_{aberration}$ = 1)

$$\begin{split} W_y &= W_{020} y^2 + W_{111} H y + W_{311} H^3 y + W_{040} y^4 + W_{131} H y^3 + W_{222} H^2 y^2 + W_{220} H^2 y^2 \\ W_x &= W_{020} x^2 + W_{040} x^4 + W_{220} H^2 x^2 \\ \varepsilon_y &= -\frac{R}{r_p} \Big[2W_{020} y + W_{111} H + W_{311} H^3 + 4W_{040} y^3 + 3W_{131} H y^2 + 2W_{222} H^2 y + 2W_{220} H^2 y \Big] \\ \varepsilon_x &= -\frac{R}{r_p} \Big[2W_{020} x + 4W_{040} x^3 + 2W_{220} H^2 x \Big] \end{split}$$

Table A3. Wavefront Maps (3 waves of aberration).

Table A3. Wavefront Maps Aberration	Density Plot	Cylindrical 3D Plot
DEFOCUS = $W_{020} \rho^2$ $W_y = W_{020} y_p^2$ $W_x = W_{020} x_p^2$	-0.5 -0.5 0.5 0.5	
TILT = W_{111} HpCos θ $W_y = W_{111}Hy_p$ $W_x = 0$	-1 -0.5 0 0.5 1	
$SA = W_{040} \rho^4$ $W_y = W_{040} y_p^4$ $W_x = W_{040} x_p^4$	-0.5 -1 -1 -1 -0.5 0 0.5 1	
COMA = $W_{131} H \rho^3 Cos\theta$ $W_y = W_{131} H y_p^3$ $W_x = 0$	0.5	
ASTIG = $W_{222} H^2 \rho^2 Cos^2 \theta$ $W_y = W_{222} H^2 y_p^2$ $W_x = 0$	-0.5 -0.5 -1 -1 -2,5 0 0,5 1	

Table A4. Wavefront Maps for combinations of spherical, coma and astigmatism.

