

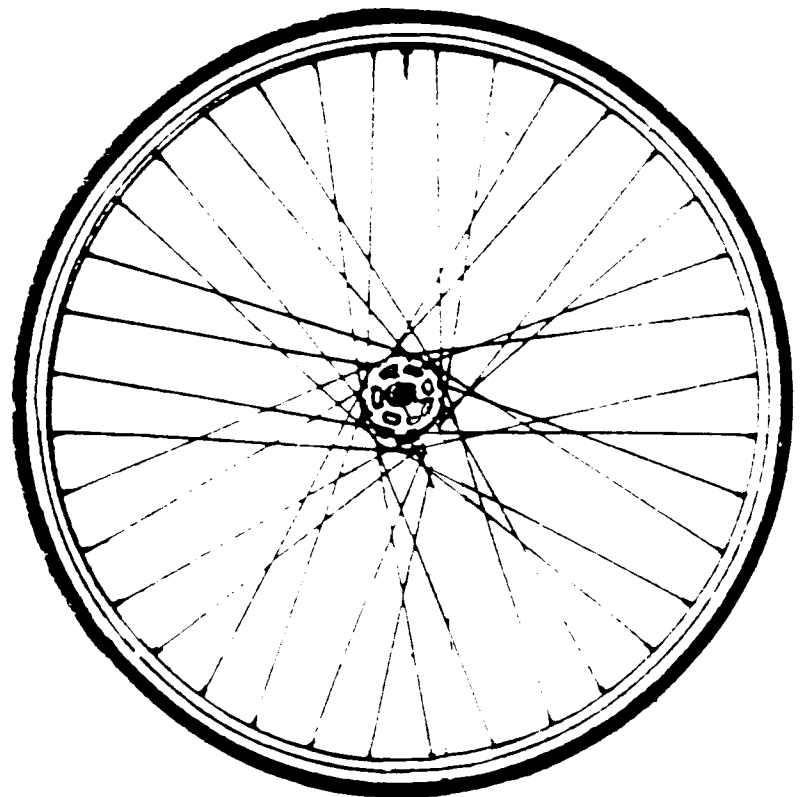
COLUMBUS PROJECT

MIRROR BLANK 8.4 mt diam F/1.14

CORRECTION OF LOW SPATIAL FREQUENCY ABERRATIONS

PRELIMINARY APPROACH

Report N. 135 Rev.0 - ADDENDUM
Milano, 1991, October



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1. INTRODUCTION

In the revision N° 0 of technical note N° 135 we reported only few coefficients of the Zernike series expansion of the cases analysed.

We considered only the following polynomials:

$$\left[+2 \rho^2 - 1 \right]$$

$$\left[+6 \rho^4 - 6 \rho^2 + 1 \right]$$

$$\left[+20 \rho^6 - 30 \rho^4 + 12 \rho^2 - 1 \right]$$

$$\left[+70 \rho^8 - 140 \rho^6 + 90 \rho^4 - 20 \rho^2 + 1 \right]$$

In the following pages we report the coefficients for all the polynomials up to the 8-th order.

Moreover we want to correct two banal mistakes:

the first one is at page 23 of rev. 0 where the phrase:

"If we project these components along the normal to the mirror surface, we have approximately:

$$v_{n.est} = 0.027 \sin(12^\circ) + 0.052 \cos(12^\circ) = 0.056 \text{ mm}$$

$$v_{n.int} = 0.004 \sin(12^\circ) - 0.064 \cos(12^\circ) = -0.062 \text{ mm}$$

So the peak to valley is:

$$0.056 - (-0.062) = 0.118 \text{ mm} "$$

must be changed in:

"If we project these components along the normal to the mirror surface, we have approximately:

$$v_{n.est} = 0.027 \sin(12^\circ) + 0.052 \cos(12^\circ) = 0.056 \text{ mm}$$

$$v_{n.int} = 0.004 \sin(0^\circ) - 0.064 \cos(0^\circ) = -0.064 \text{ mm}$$

So the peak to valley is:

$$0.056 - (-0.064) = 0.120 \text{ mm} "$$

The second mistake is a misprint. it is at page 24: the defocusing of the bestfit paraboloid of the case considered isn't ~~-25.0~~ as reported, but -2.5 mm.

2. ZERNIKE POLYNOMIAL COEFFICIENTS

In the following tables we report the coefficient of the expansion in Zernike polynomial series of the distorted shapes due to the defects and to the corrector force effects, we measured residual displacements from bestfit paraboloid.

Obviously we reported only the meaningful coefficients.

ZERNIKE POLYNOMIAL	ORIGINAL DISTORTED SHAPES			
	$-2\rho^2 - 1$ [μ m]	$+6\rho^4 - 6\rho^2 + 1$ [μ m]	$+20\rho^6 - 30\rho^4 + 12\rho^2 - 1$ [μ m]	$+70\rho^8 - 140\rho^6 + 90\rho^4 - 20\rho^2 + 1$ [μ m]
$[+1\rho^0]$	0.	0.	0.	0.
$[+1\rho^1] \sin 1\theta$	0.	0.	0.	0.
$[+1\rho^1] \cos 1\theta$	0.	0.	0.	0.
$[+2\rho^2 - 1\rho^0]$	9.5 E-06	8.39 E-05	2.22 E-04	3.58 E-04
$[+1\rho^2] \sin 2\theta$	0.	0.	0.	0.
$[+1\rho^2] \cos 2\theta$	1.19 E-05	-3.67 E-05	-4.12 E-04	4.94 E-05
$[+3\rho^3 - 2\rho^1] \sin 1\theta$	0.	0.	0.	0.
$[+3\rho^3 - 2\rho^1] \cos 1\theta$	0.	0.	0.	0.
$[+1\rho^3] \sin 3\theta$	0.	0.	0.	0.
$[+1\rho^3] \cos 3\theta$	0.	0.	0.	0.
$[+6\rho^4 - 6\rho^2 + 1\rho^0]$	1.08 E-03	9.53 E-03	2.52 E-02	4.07 E-02
$[+4\rho^4 - 3\rho^2] \sin 2\theta$	0.	0.	0.	0.
$[+4\rho^4 - 3\rho^2] \cos 2\theta$	-2.09 E-04	-1.48 E-03	-3.09 E-03	-5.64 E-03
$[+1\rho^4] \sin 4\theta$	0.	0.	0.	0.
$[+1\rho^4] \cos 4\theta$	2.21 E-05	7.86 E-05	-5.54 E-05	3.52 E-04
$[+10\rho^5 - 12\rho^3 + 3\rho^1] \sin 1\theta$	0.	0.	0.	0.
$[+10\rho^5 - 12\rho^3 + 3\rho^1] \cos 1\theta$	0.	0.	0.	0.
$[+5\rho^5 - 4\rho^3] \sin 3\theta$	0.	0.	0.	0.

ZERNIKE POLYNOMIAL	ORIGINAL DISTORTED SHAPES			
	$+2\rho^2 - 1$ [μ m]	$+6\rho^4 - 6\rho^2 + 1$ [μ m]	$+20\rho^6 - 30\rho^4 + 12\rho^2 - 1$ [μ m]	$+70\rho^8 - 140\rho^6 + 90\rho^4 - 20\rho^2 + 1$ [μ m]
$[+5\rho^5 - 4\rho^3] \cos 3\theta$	0.	0.	0.	0.
$[+1\rho^5] \sin 5\theta$	0.	0.	0.	0.
$[+1\rho^5] \cos 5\theta$	0.	0.	0.	0.
$[+20\rho^6 - 30\rho^4 + 12\rho^2 - 1\rho^0]$	3.97 E-03	3.53 E-02	9.46 E-02	1.55 E-01
$[+15\rho^6 - 20\rho^4 + 6\rho^2] \sin 2\theta$	0.	0.	0.	0.
$[+15\rho^6 - 20\rho^4 + 6\rho^2] \cos 2\theta$	-7.24 E-04	-5.92 E-03	-1.48 E-03	-2.08 E-02
$[+6\rho^6 - 5\rho^4] \sin 4\theta$	0.	0.	0.	0.
$[+6\rho^6 - 5\rho^4] \cos 4\theta$	8.26 E-05	1.05 E-03	3.52 E-03	3.29 E-03
$[+1\rho^6] \sin 6\theta$	0.	0.	0.	0.
$[+1\rho^6] \cos 6\theta$	1.85 E-04	1.18 E-03	2.09 E-03	8.17 E-04
$[+35\rho^7 - 60\rho^5 + 30\rho^3 - 4\rho^1] \sin 1\theta$	0.	0.	0.	0.
$[+35\rho^7 - 60\rho^5 + 30\rho^3 - 4\rho^1] \cos 1\theta$	0.	0.	0.	0.
$[+21\rho^7 - 30\rho^5 + 10\rho^3] \sin 3\theta$	0.	0.	0.	0.
$[-21\rho^7 - 30\rho^5 + 10\rho^3] \cos 3\theta$	0.	0.	0.	0.
$[-7\rho^7 - 6\rho^5] \sin 5\theta$	0.	0.	0.	0.
$[-7\rho^7 - 6\rho^5] \cos 5\theta$	0.	0.	0.	0.
$[+1\rho^7] \sin 7\theta$	0.	0.	0.	0.
$[-1\rho^7] \cos 7\theta$	0.	0.	0.	0.
$[-70\rho^8 - 140\rho^6 + 90\rho^4 - 20\rho^2 + 1\rho^0]$	7.76 E-03	6.97 E-02	1.89 E-01	3.16 E-01
$[-56\rho^8 - 105\rho^6 + 60\rho^4 - 10\rho^2] \sin 2\theta$	0.	0.	0.	0.
$[-56\rho^8 - 105\rho^6 + 60\rho^4 - 10\rho^2] \cos 2\theta$	-1.32 E-03	-1.10 E-02	-2.78 E-02	-3.67 E-02
$[+28\rho^8 - 42\rho^6 + 15\rho^4] \sin 4\theta$	0.	0.	0.	0.
$[+28\rho^8 - 42\rho^6 + 15\rho^4] \cos 4\theta$	3.95 E-04	3.19 E-03	7.90 E-03	1.24 E-02
$[+8\rho^8 - 7\rho^6] \sin 6\theta$	0.	0.	0.	0.

ORIGINAL DISTORTED SHAPES				
ZERNIKE POLYNOMIAL	$+2\rho^2 - 1$ [μ m]	$+6\rho^4 - 6\rho^2 + 1$ [μ m]	$+20\rho^6 - 30\rho^4 + 12\rho^2 - 1$ [μ m]	$+70\rho^8 - 140\rho^6 + 90\rho^4 - 20\rho^2 + 1$ [μ m]
$[+8\rho^8 - 7\rho^6] \cos 6\theta$	9.31 E-04	5.85 E-03	1.00 E-02	3.07 E-03
$[+1\rho^8] \sin 8\theta$	0.	0.	0.	0.
$[+1\rho^8] \cos 8\theta$	-2.81 E-04	-2.08 E-03	-4.57 E-03	-5.68 E-03

ORIGINAL DISTORTED SHAPES	
ZERNIKE POLYNOMIAL	$V_a(\rho, \theta) = \frac{r^2}{R_c} \left[\frac{1}{2} - \frac{1}{1 + \sqrt{1 + \Delta k \frac{r^2}{R_c^2}}} \right]$ [μ m]
$[+1\rho^0]$	0.
$[+1\rho^1] \sin 1\theta$	0.
$[+1\rho^1] \cos 1\theta$	0.
$[+2\rho^2 - 1\rho^0]$	2.88 E-05
$[+1\rho^2] \sin 2\theta$	0.
$[+1\rho^2] \cos 2\theta$	0.
$[+3\rho^3 - 2\rho^1] \sin 1\theta$	0.
$[+3\rho^3 - 2\rho^1] \cos 1\theta$	0.
$[+1\rho^3] \sin 3\theta$	0.
$[+1\rho^3] \cos 3\theta$	0.
$[+6\rho^4 - 6\rho^2 + 1\rho^0]$	3.27 E-03
$[+4\rho^4 - 3\rho^2] \sin 2\theta$	0.
$[+4\rho^4 - 3\rho^2] \cos 2\theta$	-5.46 E-04
$[+1\rho^4] \sin 4\theta$	0.
$[+1\rho^4] \cos 4\theta$	3.88 E-05

		ORIGINAL DISTORTED SHAPES
ZERNIKE		$V_a(\rho, \theta) = \frac{r^2}{R_c} \left[\frac{1}{2} - \frac{1}{1 + \sqrt{1 + \Delta k \frac{r^2}{R_c^2}}} \right]$
POLYNOMIAL		[μ m]
$[+10\rho^5 - 12\rho^3 + 3\rho^1] \sin 1\theta$		0.
$[+10\rho^5 - 12\rho^3 + 3\rho^1] \cos 1\theta$		0.
$[+5\rho^5 - 4\rho^3] \sin 3\theta$		0.
$[+5\rho^5 - 4\rho^3] \cos 3\theta$		0.
$[+1\rho^5] \sin 5\theta$		0.
$[+1\rho^5] \cos 5\theta$		0.
$[+20\rho^6 - 30\rho^4 + 12\rho^2 - 1\rho^0]$		1.22 E-02
$[+15\rho^6 - 20\rho^4 + 6\rho^2] \sin 2\theta$		0.
$[+15\rho^6 - 20\rho^4 + 6\rho^2] \cos 2\theta$		-2.09 E-03
$[+6\rho^6 - 5\rho^4] \sin 4\theta$		0.
$[+6\rho^6 - 5\rho^4] \cos 4\theta$		3.34 E-04
$[+1\rho^6] \sin 6\theta$		0.
$[+1\rho^6] \cos 6\theta$		4.52 E-04
$[+35\rho^7 - 60\rho^5 + 30\rho^3 - 4\rho^1] \sin 1\theta$		0.
$[+35\rho^7 - 60\rho^5 + 30\rho^3 - 4\rho^1] \cos 1\theta$		0.
$[+21\rho^7 - 30\rho^5 + 10\rho^3] \sin 3\theta$		0.
$[+21\rho^7 - 30\rho^5 + 10\rho^3] \cos 3\theta$		0.
$[+7\rho^7 - 6\rho^5] \sin 5\theta$		0.
$[+7\rho^7 - 6\rho^5] \cos 5\theta$		0.
$[+1\rho^7] \sin 7\theta$		0.
$[+1\rho^7] \cos 7\theta$		0.
$[+70\rho^8 - 140\rho^6 + 90\rho^4 - 20\rho^2 + 1\rho^0]$		2.40 E-02
$[+56\rho^8 - 105\rho^6 + 60\rho^4 - 10\rho^2] \sin 2\theta$		0.

	ORIGINAL DISTORTED SHAPES
ZERNIKE	$V_n(\rho, \theta) = \frac{r^2}{R_c} \left[\frac{1}{2} \frac{1}{1 + \sqrt{1 + \Delta k \frac{r^2}{R_c^2}}} \right]$
POLYNOMIAL	[μ m]
$[+56\rho^8 - 105\rho^6 + 60\rho^4 - 10\rho^2] \cos 2\theta$	-3.86 E-03
$[+28\rho^8 - 42\rho^6 + 15\rho^4] \sin 4\theta$	0.
$[+28\rho^8 - 42\rho^6 + 15\rho^4] \cos 4\theta$	1.14 E-03
$[+8\rho^8 - 7\rho^6] \sin 6\theta$	0.
$[+8\rho^8 - 7\rho^6] \cos 6\theta$	2.25 E-03
$[+1\rho^8] \sin 8\theta$	0.
$[+1\rho^8] \cos 8\theta$	-7.54 E-04