Aspherical Singlet

Aspheres are suitable for correction of spherical aberration, although the performance for finite field sizes is critical. A problem is the conventional Taylor expansion representation of aspheres, which is not orthogonal and therefore sometimes hard to optimize.

a) Establish an imaging setup with a magnification of m = 0.2, a wavelength λ = 0.55 μm, a numerical aperture of NA = 0.6 with a setup, which has an overall length not larger than 50 mm with a single spherical lens made of the plastics material PMMA.

b) Now define the second surface to be aspherical. How many coefficients are necessary to obtain a diffraction limited performance on axis ?

c) What is the largest field size, which guarantees a performance not worse than a factor of two in comparison to the axis point.

d) Now try to install an asphere on both sides of the lens. Can the field behavior be improved ?

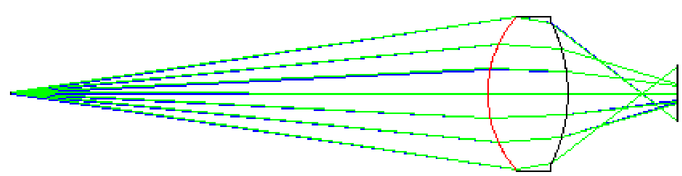
Solution:

a) The paraxial magnification, the F-number as F# = 1/(2NA) = 0.833 and the overall length (operand TTHI) together with the spot optimization are used to find the spherical system. To establish a magnification, it is necessary to set a small finite field size. Here we use y = 0.1 mm.
For the default merit function, 9 rings seems to be necessary to guarantee a dense sampling.

Lens Data Editor

Edit Solves View Help

Surf:Type		Comment	Radius		Thickness		Glass		Semi-Diameter
OBJ	Standard		Infinity		35.7465884	V			0.1000000
1	Standard		8.6701014	V	6.0000000		PMMA		5.7634149
STO	Standard		-11.869736	V	8.2529871	V			5.2764679
IMA	Standard		Infinity		-				2.1252591



Merit Function Editor: 1.484525E-001

Edit Design Tools View Help

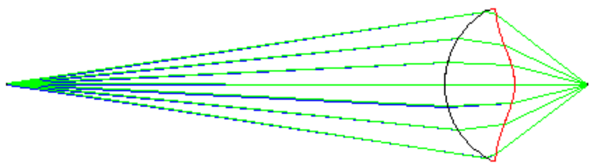
Oper #	Type							Target	Weight	Value
1: DMFS	DMFS									
2: BLNK	BLNK	Sequential merit function: RMS spot radius centroid GQ 9 rings 6 arms								
3: WFNO	WFNO							0.8330000	100.0000000	0.8192869
4: PMAG	PMAG		1					-0.2000000	100.0000000	-0.4257895
5: TTHI	TTHI	0	2					50.0000000	100.0000000	49.9995755
6: BLNK	BLNK									
7: BLNK	BLNK	Operands for field 1.								
8: TRAC	TRAC		1	0.0000000	0.0000000	0.1261740	0.0000000	0.0000000	0.1276655	0.2309047
9: TRAC	TRAC		1	0.0000000	0.0000000	0.2863293	0.0000000	0.0000000	0.2837615	0.4969380
10: TRAC	TRAC		1	0.0000000	0.0000000	0.4396752	0.0000000	0.0000000	0.4093663	0.6855548

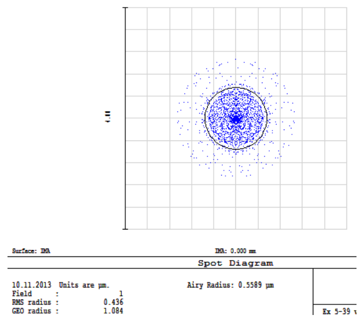
b) The asphericity is increased step by step with conic constant, 4th order, 6th order, 8th order. Here we get diffraction limited performance on axis.

Lens Data Editor

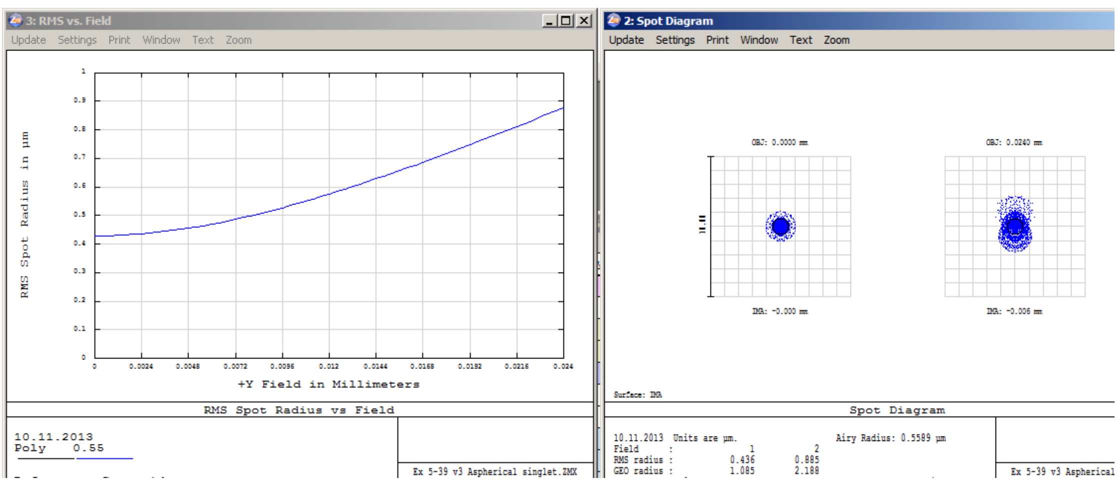
Edit Solves View Help

Surf:Type		Comment	Radius		Thickness		Glass		Semi-Diameter		Conic		Par 0 (unused)		2nd Order Term		4th Order Term		6th Order Term		8th Order Term	
OBJ	Standard		Infinity		37.6939622	V			0.1000000		0.0000000											
1*	Standard		7.2908107	V	6.0000000		PMMA		6.5000000	U	0.0000000											
*	Even Asp..		-4.5032836	V	6.3060378	V			6.2000000	U	-3.7315064	V			0.0000000		6.815E-004	V	-3.65E-006	V	1.228E-008	V
IMA	Standard		Infinity		-				0.0203403		0.0000000											





c) The spot rms size on axis is 0.44 µm. A diameter in the field of 0.88 µm is obtained for an object size of y = 0.024 mm. It should be noticed, that due to the large coma, a reference of the spot size to the centroid makes sense and should be set for the spot diagram and the rms vs field. Otherwise, the results are different.



d) Now a field of y = 0.04 mm is fixed , the merit function is re-calculated and the first surface is made aspherical too. The result shows,that now it is diffraction limited for both field point. This means, aspheres for both sides are in this case helpful to correct the field related aberrations.

	Surface Type		Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia	Conic	TCE x 1E-6	2nd Order Term	4th Order Term	6th Order Term	8th Order Term
0	OBJECT	Standard		Infinity	38,900 V			0,400	0,000	0,400	0,000	0,000				
1	STOP	Even Asphere		4,427 V	6,000	PMMA		5,119	0,000	5,119	-0,809 V	-	0,000	0,000	0,000	0,000
2		Even Asphere		-7,566 V	5,100 V			4,481	0,000	5,119	-9,429 V	0,000	0,000	3,231E-04 V	-7,508E-06 V	8,644E-08 V
3	IMAGE	Standard		Infinity	-			0,080	0,000	0,080	0,000	0,000