Solution of Exercises
Lecture Optical design with Zemax for PhD – Part 5

5.1 Transverse aberration curve

Establish a system with an ideal lens of focal length f = 100 mm, a wavelength of 600 nm and a collimated input bundle of diameter 10 mm.

a) Define the slider option with the image distance as a variable. Open the transverse aberration chart with a fixed scale of 100 μm. What happens with the aberration curve, if the slider is moved?
b) Now introduce a thin glass plate in front of the perfect lens and define one side as a Zernike surface with coma as type (c8) of one wavelength. What is now the result for the moving slider?
   Explain the result, if c7 is taken instead of c8.
c) If now spherical aberration is introduced by the plate in selecting c9, what is seen for the defocus?
   Open also a spot diagram with fixed scale. Determine the best image plane for an overall small spot diameter?

5.2 Strehl ratio and geometrical vs Psf spot size

A single lens made of K5 with focal length f = 25 mm and thickness d = 5 mm is illuminated by a diverging beam with numerical aperture NA = 0.1. After the lens the light should be collimated. If the collimated beam is refocussed without further aberrations, the point spread function is not diffraction limited.

a) Calculate the accurate Strehl ratio, the estimated Strehl ratio and the geometrical and diffraction encircled energy inside the ideal Airy diameter.
b) If now the numerical aperture is reduced, the Marechal estimation becomes better. Calculate the largest NA, for which the relative error is smaller then 2%. What amount for the geometrical and diffraction encircled energy inside the Airy diameter is obtained here?
c) Show the Strehl ratio as a function of the numerical aperture as a universal plot. What is the maximum value for getting a diffraction limited correction with $D_S > 0.8$?

5.3 Aplanatic lens

Consider a collimated incoming beam with wavelength 500 nm and diameter 10 mm. This bundle should be focussed by a perfect lens of focal length f = 50 mm.

a) Place an aplanatic-concentric lens shortly behind the ideal lens with the material SF57. What is the resulting numerical aperture in the image space? Show at least two different methods to find the best image position.
b) Show that the spherical aberration of this setup is exactly zero for all orders.
c) Aplanatic means, that the linear coma vanishes and the imaging is free of coma for a small but finite field size. Show this property by using a small field of 2° for the current system. What is the largest present aberration?