Solution of Exercises
Lecture Optical design with Zemax for PhD – Part 1

1.1 Stair-mirror-setup

Setup a system with a stair mirrro pair, which decenters an incoming collimated ray bundel with 10 mm diameter by 40 mm in the -y direction. The wavelength of the beam is \( \lambda = 632.8 \) nm. After this pair of mirrors a decentered main objectiv lens with focal length \( f = 200 \) mm made of BK7 is located 25 mm below the optical axis and focusses the beam.

a) setup the system
b) generate layout drawings in 2D and in 3D
c) calculate the beam cross section on the second mirror, what is the size of the pattern ?
d) determine the optimal final sensor plane location. Calculate the spot of the focussed beam. Discuss the shape of this pattern.
e) now extend the separation between the two mirros to 200mm. The system now should be modified to have an intermediate focal point in the midpoint between the mirrors. Calculate the radii of the mirrors to recollimate the beam before the refractive lens. Determine again the best image plane. If the spot diagram is considered, what is the reason for the drastic change ?

1.2 Symmetrical 4f-system

Setup a telecentric 4f-imaging system with two identical plano-convex lenses made of BK7 with thickness \( d = 10 \) mm and approximate focal lengths \( f = 100 \) mm. The wavelength of the system is \( \lambda = 546.07 \) nm and the numerical aperture in the object space is \( NA = 0.2 \). The object has a diameter of 10 mm.

a) Determine the layout and the spot diagram of the system, if the setup is perfectly symmetrical.
b) Optimize the image location. Why is the spot size improved ?
c) If the starting aperture is decreased, the system becomes more and more diffraction limited. What is the value of the NA to get a diffraction limited system on axis ? Take in mind here, that the lowered spherical aberrations needs a re-focussing, which depends on the aperture.
1.3 System layout with ideal lenses

A collimated laser beam with wavelength 1.064 μm and diameter D = 2 mm should be expanded by a
Kepler-type afocal telescope made of ideal lenses with a first focal length f₁ = 50 mm and a factor of 5.
The enlarged collimated beam is then focussed down by a cylindrical lens with focal length f = 100
mm to get a line focus.
a) Setup the system described above by ideal lenses
b) Show the line focus graphically

1.4 Conic surface

A system with an ellipsoidal mirror should be installed. For this task, the following steps should be
performed:
a) A source with wavelength λ = 1.064 μm and numerical aperture NA = 0.1 is imaged by a spherical
mirror in a 1:1 setup with a mirror radius of 20 mm
b) The image distance is enlarged to 40 mm. The radius of the mirror and the conical constant is
optimized for this geometry
c) The coordinate system is rotated by 60° directly after the object. For a proper layout, the
subaperture of the mirror which is used should be explicitly defined. Make a shaded model layout with
this setup.
What is the bending angle of the central ray at the mirror? Determine the shape and the approximate
x/y-aspect ratio of the illuminated area on the mirror.