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Exercises
Lecture Optical design with Zemax– Part 7

7 Correction

7.1 Fourier filtering and Imaging

Set up a telecentric 4f-system with a magnification of m = 4. The system should be arranged by two appropriate achromates from conventional vendor catalogs with the focal lengths f_1 = 25 mm and f_2 = 100 mm. The wavelength of the application is the e-line, the object size is 3 mm and the numerical aperture should be NA = 0.1.

a) Set up the system with telecentric behavior in the object and the image space. In particular adjust the system and a rectangular stop with approporiate size in the intermediate focal plane. The adjustment should be performed on axis only.

b) Check the magnification of the realized lens.Calculate the performance of the system in the center and the edge of the field size. Is the system diffraction limited ? What are the dominant aberrations in the field ?

c) Show, that the resolution of the system in the field is anisotropic due to the elongated shape of the spot by inspecting the MTF of the system.

d) Calculate a diffraction based imaging of the complete object field. Take a rectangular grid as an object. Can the anisotropic resolution be seen ?
Now calculate a geometrical imaging model of the same grid. What is the difference between the results of both models ?

e) To demonstrate the Fourier filtering in the pupil plane, removechange the rectangular pupil stop by a slit with dimensions D_x = 5 mm , D_y = 0.15 mm. What changes with the diffraction limited image ? What is the consequence for the geometrical image ?

f) Calculate the Airy diameter of the system and constitute an object with size 10 times the Airy diameter. Put this small object in the center and at the edge of the field. Discuss the results and compare them. Is the grid resolved ?

7.2 Ring illumination with axicon

Establish an illumination system with a ring shaped profile with the help of an axicon.
First load an achromatic lens with focal alength f = 100 mm out of a vendor catalog und create a collimated monochromatic beam with diameter D = 20 mm and the wavelength 632.8 nm of HeNe as a laser source. The axicon consists of a plane an a conic surface. The conic surface can be approximated by a classical hyperbolic conic section with an extremme small radius of curvature. The conic constant must have a large negative value.
What happens, if the 'Quick focus' option is used ?
Now insert between the lens and the axicon a 'negative axicon', which diverges the light. What happens, if negative axicon is moved along the optical axis ?

7.3 Fiber coupling and radiation

An initial collimated laser beam of an Ar-Laser at λ = 505 nm and diameter D = 4 mm has to be coupled into a fiber of diameter 4 μm, length L = 20 mm and numerical aperture of NA = 0.1. As a second step, the light should be re-collimated.
a) Extract an appropriate achromate out of a vendors catalog and check, if a good and efficient coupling can be achieved.
b) Estimate the coupling efficiency in the geometrical and the diffraction model.
c) Establish a fiber component with length 20 mm length as a non-sequential component and calculate the radiation profile at the exit surface in the geometrical optical model.
d) Now the emitted light should be collimated again by an achromate with focal length of f = 50 mm.
e) Discuss the homogeneity of the light behind this lens in the spatial domain. Are the rays perfectly collimated ?