1.1 Grin lens

Establish a grin rod focusing Wood lens. A component of diameter D = 8 mm, a length L = 25 mm and a refractive index n₀ = 1.5 on axis has circular symmetric a radial gradient profile with quadratic coefficient n₂ = -0.0046262. The lens should be illuminated by a centered collimated beam with wavelength λ = 500 nm and diameter 4 mm.

a) Determine the paraxial pitch length of the lens. It is defined by the length of the periodically sine-wave path of the marginal ray.

b) Cut the lens exactly in the focal point and determine the spot diameter in this location. Compare the diameter with the diffraction limited Airy diameter. Why is the spot so large? What is the smallest spot radius rms value and where is this optimal focus position?

c) Compare the marginal ray path in the paraxial approximation with the real ray. What is the size of the numerical aperture in the focal point?

d) Now give the lens a length of 60 mm. Introduce a finite field angle of 25°, the front surface of the lens should be the stop location. Discuss the ray path in the lens drawing considering the diameter and the field ray bundle.

1.2 Grating spectrometer

A linear grating with a line density of 0.3 Lp/µm is illuminated by a collimated beam with a spectral broad wavelength between 400 nm and 700 nm. The grating is blazed and is used in the +1st order. The spectrum is observed in a sensor plane, which is obtained after a symmetrical bi-convex lens with focal length f = 100 mm, a thickness of 10 mm and SF6 as material in a telecentric arrangement.

a) Set the system in Zemax

b) What is the spreading of the spectrum in the sensor plane?
1.3 Alvarez Lens

An Alvarez lens pair is a special system to change the focal position by transverse translating two lenses. The first lens is a plate of thickness 1 mm made of BK7. The front surface is plane, the rear surface has an aspherical shape, which is described by the polynomial

\[ z(x, y) = 0.02 \cdot (x^3 + 3xy^2) \]

The second lens has the same thickness and material, the same aspherical surface on the front side and is plane on the rear side. The air distance between the two components is 1 mm. The system is illuminated by a collimated beam with diameter 2 mm and wavelength 550 \( \mu \text{m} \). After the pair of plates an ideal lens with focal length \( f = 20 \) mm is places 1 mm behind. The final distance to the image plane should be 19.5 mm.

a) Establish the system. The aspherical surfaces should be modelled by an extended polynomial surface type with 8 terms and a normalization radius of 2 mm. The data of the aspherical surfaces can be seen in the extra data editor. The system should be prepared for a later movement of the plates in the x-direction by the same amount in different directions (first plate in +x and 2nd plate in -x).

b) Calculate the spot vs defocus option with a relative delta focus of 500 \( \mu \text{m} \). Where is the focus point?

c) Now shift the first plate by 0.24 mm in the positive x direction and calculate the spot vs defocus again. What is observed?