Optical design practicum

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In this practicum we will go through some illustrative steps of the optical design of a telescope and an attached spectrograph. We will use the optical design software Qioptiq WinLens 3D. Functions you may need are:

- System Parameter Editor
- System Data Editor
- Surface by Surface
- Zoom manager
- Lens Drawing
- Spot Diagrams Full Field
- Chromatic Aberration
- Number of wavelengths to be traced
- Number of rings for spot diagrams
- Sliders

1. The telescope is the VLT with the following parameters:
   - D_{M1} = 8115 mm
   - f_{M1} = 14487.5 mm
   - D_{M2} = 1113.1 mm (location of the aperture stop)
   - f_{M2} = -2276.8 mm
   - secondary magnification = -8.45

   Calculate the distance between the mirrors, and the location of the Cassegrain focus. What is the FOV if the detector is a 4k×4k CCD with 9 μm square pixels? Does this detector offer diffraction-limited sampling in the visible? Calculate the focal shift due to field curvature at the edge of the detector.

2. Implement the telescope in WinLens. First make both mirrors spherical, and explain the spot diagram. Then make M1 a parabola and make the conic constant of M2 variable, and optimize the spot at the edge of the FOV at the Cassegrain focus such that it has minimum spherical aberration. Repeat this M2 optimization with the optimum conic constant value of -1.0046 for M1. What is the major source of off-axis aberrations for the three set-ups?

3. We will design a lens-based 1:1 (collimator-camera) reimaging system, with two lenses of 100 mm diameter and 500 mm focal length. Start with a separate WinLens set-up for the design of an achromatic doublet lens, made out of BK7 and SF2. Think about the order of the two components if you come in with a collimated beam of 100 mm diameter. Fix the radius of the flint's outer surface at -970 mm and make the radii of the crown variable. Optimize the lens to have a focal length of ∼500 mm for the visible wavelength range (400–800 nm). Implement the reimaging system behind the telescope and assess the spot diagrams across the FOV at the detector, for different wavelengths. Where does the first real image of the pupil end up?

4. Implement an Amici prism consisting of the same materials as the lenses in the pupil plane in between the lenses. Optimize the crown's angles, such that the spectra are spread out over the entire detector for the spectral range 400–800 nm, whilst keeping the flint's outer surface perpendicular to the optical axis. Why do you need two prismatic elements?