Astronomical Telescopes and Instruments 2014: Exercises on Optical Design (Due on 22 October 2014 at 13:45)

C.U.Keller

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1 Achromatic Lens

An achromatic lens is made of two different glasses to minimize the change in focal length as a function of wavelength. The properties of an achromatic lens can be calculated from 1) the focal length f of the combined lens

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} \ ,$$

where $f_{1,2}$ are the focal lengths of the individual lenses, and 2) the minimization of the chromatism

$$\frac{f_1}{n_1(\lambda_1) - n_1(\lambda_2)} + \frac{f_2}{n_2(\lambda_1) - n_2(\lambda_2)} = 0$$

where $n_{1,2}(\lambda_{1,2}) =$ are the indices of refracion of glass 1 and 2 at wavelengths λ_1 and λ_1.

1. Design an achromatic lens with a focal length of 500 mm at wavelengths of 486.1 nm and 656.3 nm and an F-number of 4. Use http://refractiveindex.info to obtain the indices of refraction. Use a biconvex BK7 lens with the same front and rear radii of curvature and an F2 lens with one surface having the same radius of curvature as the BK7 lens. Using the thin-lens equation, determine the radii of curvature of the two lenses.

2. Enter the derived properties into the optical design software and compare the rms spot radii at the two wavelengths with those of a single BK7 lens with the same focal length (at 656.3 nm) and diameter.

3. Reverse the arrangement of the two lenses and compare the rms spot radii with the original achromat.

2 Positioning Tolerances for Cassegrain Telesope

Design a 200-mm diameter Cassegrain telescope (parabolic primary, hyperbolic secondary, focal plane) with a focal length of 1200 mm.

1. Determine the pixel size of a camera in the focal plane that provides diffraction-limited images at 500 nm.

2. Determine the maximum allowed axial motion of the detector to remain diffraction limited (rms spot diameter = 1.22 λ/D)

3. Determine the maximum allowed axial motion of the secondary mirror to remain diffraction limited when the focal plane stays in the same position.

4. Determine the maximum allowed axial motion of the secondary mirror to remain diffraction limited when the focal plane is allowed to move to the best focus position.