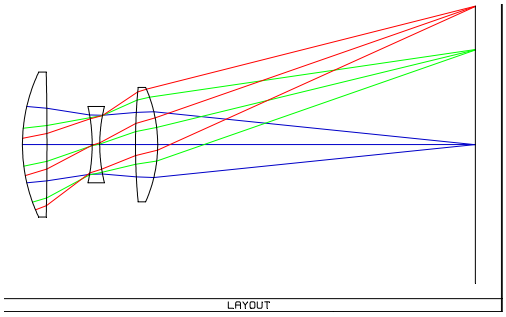
OPTI 421/521 – Introductory Opto-Mechanical Engineering

Homework 4: Image quality, Tolerancing for alignment

Part 1) Short answer

1) Consider a 50 mm diameter plano-convex lens with 300 mm focal length. For ETD of 0.1 mm, determine wedge, deviation, decenter, optical axis, and mechanical axis. Show these on a sketch.
2) Consider the system from HW2 below with 10 mm entrance pupil diameter, 50 mm EFL, with object at infinity. (*Working F-number = 5*). Assume each lens surface is finished to 2 waves PV irregularity (at 587 nm).
   Determine the degradation to the rms image size due to the lens surface irregularity.



L1: 34 mm focal length
L2: -17 mm focal length
L3: 24 mm focal length

3) Consider the same optical design as 2), but use better lenses, finished to 0.1 waves P-V (at 587 nm). Estimate the contribution to rms wavefront error from the lens surfaces. Assume 587 nm operating wavelength.
4) Consider a 25 mm beamsplitter with refractive index inhomogeneity of +/- 0.00001. Determine the P-V and rms wavefront variation due to the glass. For 0.5 μm wavelength, calculate the Strehl ratio assuming this is the only error in the system.
5) A pitch polished aspheric mirror will typically have surface roughness of 20 angstroms rms. This causes wide angle scatter. Calculate the total amount of scatter from one of these mirrors at 400 nm light.

Part 2) Rules of Thumb

Provide three rules of thumb using the format provided.

Part 3) Tolerance Analysis

Undergraduate OPTI421 students can work in pairs for this assignment, jointly submitting one report per team.

The reports must be submitted separately from Parts 1) and 2).

For the doublet from HW 3, develop a tolerance analysis for the optical elements which contributes less than 0.04 λ rms to the system wavefront error budget. Errors should include:

- Surface radii of curvature
- Lens thickness
- Wedge
- Surface irregularity
- Refractive index error
- Refractive index variation (inhomogeneity)

Assume focus compensation as you did for HW3.

You should use a ray trace program such as Zemax, CodeV, Oslo, to determine the sensitivities for the geometric parameters. You can use rules of thumb and calculations to determine the affect of surface figure and index variations. Then create a spreadsheet to help set the tolerances to sensible values. If you do not have access to a ray trace program, Dr. Burge can provide the sensitivities.

Specify the tolerances so that the lenses could be manufactured. Specify the grade of glass so it could be purchased from Schott.

You should write a report called “Lens requirements for focusing doublet.”