OPTI 421/521 – Introductory Opto-Mechanical Engineering

Homework 4B:

Derive the relationships that couple surface irregularity to image performance.

For diffraction limited case, determine contribution to rms wavefront error from surface irregularities.

1. Start with fringes irregularity. This is always P-V
2. Determine rms surface irregularity (2 fringes per wave, PV/rms ~ 4)
3. Determine rms wavefront irregularity : $\Delta W = \Delta S(n-1)\cos(\phi)$
4. Scale by $\alpha_i = B_i/D_i$ for case where the beam footprint is smaller than the element.
5. For lens with M elements, 2 surfaces per element, each with 1 fringe irregularity, average $\alpha = 0.7$, determine total rms wavefront error due to the surfaces.

For system in geometric limit, determine contribution to rms image size from surface irregularities.

1. Start with fringes irregularity. This is always P-V.
2. Determine PV surface irregularity in µm (2 fringes per wave, 0.546 µm wavelength for green Hg lamp illumination)
3. Determine rms surface slope variation, ∇S_{rms}
   a. Use RoT (PV surface in µm)/(rms slope in µm/radius) = 1.
   b. Convert from µm/radius to radians by multiplying by $\left(\frac{1\ radius}{D/2}\right)$
4. Determine wavefront slope variation. $\Delta\theta_{rms} = \nabla W_{rms} = \nabla S_{rms}(n-1)\cos(\phi)$
5. Use relationship between image position and slope to get the degradation in image sharpness $\varepsilon_{rms} = \left(\nabla W\right)_{rms} B_i F_n$
6. Simplify by defining $\alpha_i = B_i/D_i$
7. For lens with M elements, 2 surfaces per element, each with 1 fringe irregularity, average $\alpha = 0.7$, determine total rms image blur due to the surfaces. Compare this with the diffraction blur.