EE 119 Lab 3: Aberrations in Lenses

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Objective

The purpose of this lab is to observe the five primary monochromatic aberrations and a chromatic aberration.

Experimental Setup

A bright, white light source is used to project an image through a 100-mm lens or a combination of 100-mm lens/cylindrical lens onto a screen. The object can be a simple diagram on a cut-out transparency (i.e. the Cal logo, etc.).

Experiments:

(a) Spherical Aberration: Use a 100-mm lens and an object. Place the lens 2f from the object, and place the image plane 2f from the lens. Observe how the focus of the image changes radially. Place an iris as an aperture stop at the half way between the image and the lens. Change the size of the aperture stop. Does the image quality improve as the diameter of the aperture stop decreases? Lower the light level in the lab if necessary.

(b) Coma: Use the same setup as part (a). Rotate the lens (~ 15-30°) in order to introduce some coma in the image. Move the image plane closer to the lens, to approximately 1f from the lens. What does the focal spot look like? Does it tell you clearly how this aberration was named? Move the image plane back to its original position (2f from the lens). Observe the image carefully as you change the diameter of the aperture stop. Does the image improve as the diameter of the aperture stop decreases? Lower the light level in the lab if necessary. What seems to be the cause of the comatic aberration?

(c) Astigmatism: Superpose a cylindrical lens on a 100-mm lens. Move the image plane to observe that two different focal lengths exist – one for the horizontal plane, and the other for the vertical plane.

(d) Distortion: Grab a 100-mm lens and observe the bricks of the lab wall through it. What kind of distortion (barrel or pin-cushion) does the image exhibits?

(e) Field Curvature: Use a 100-mm lens and an object. Observe how the focus of the image changes radially as the image plane is moved longitudinally. (It won't be easy, but give a try.)

(f) Chromatic aberration: Use a 100-mm lens to see how red light is magnified more than blue light. Go back to the same setup as part (a). Place an iris as an aperture stop at the half way between the image and the lens and minimize its opening. Place a piece of white paper in front of the iris (on the lens side). You will notice two rings, a blue ring and a red ring, and one ring is slightly larger than the other. Lower the light level in the lab if necessary. Move the iris so that only the blue light or the red light will make it to the image plane. Which light refracts more strongly through the lens? Does this agree with what you have expected?