Handed: March 31, 2015 On-line March 25, 2015

Due: April 7 (Tue), 2015, In Class

**Design Project 6: The Landscape Lens**

**Introduction**

The landscape lens was used as one of the earliest forms of photographic lenses. It was initially used in a “camera obscura,” basically a dark room with a small hole in one wall wherein an image is formed of the outside world on the opposite wall. This concept was improved upon in the 16th century with the addition of a simple convex lens into the aperture. It was also used in early photographic cameras for its ability to produce images over moderate fields-of-view. As you’ll see, stop position relative to the lens can affect certain aberrations. The landscape lens also provides us with an example with the concept of a “local minima” in a simple merit function and how typical lens design optimization (damped least-squares) arrives at these solutions.

Our previous design projects demonstrated that spherical aberration changes as a function of pupil size. The current design project will focus on coma and astigmatism, field dependent aberrations to demonstrate how aperture stop position affects these aberrations. As such we’ll use a very “slow” lens so that spherical aberration will not be the dominate aberration.

The landscape lens will satisfy the following conditions:

* Focal length: 120mm
* F/number: 15
* Wavelength: 633nm
* FOV: ± 15°
* Glass: Schott, NK-5
* **Thickness: 4 mm**
* Object: at infinity
* Distortion: < 2% (goal)
* Evaluate at best RMS spot focus

For each of these designs, you’ll want to provide the following analyses:

Lens layout

Ray fan plot

Spot diagram plot

Field curve plot

Third order aberration contribution list

You may want to create a macro to produce these analyses.

**A) Aperture in front of landscape lens**

Construct a plano-convex lens (plano side toward object) to satisfy the design parameters above. Insert a surface between the object and lens and make this the aperture stop. Use a marginal ray angle solve to set the rear surface radius of curvature. Use a paraxial image solve to set the image distance and specify the required entrance pupil diameter to produce an F/15 lens.

* Provide a layout and lens prescription for this lens
* Generate a ray fan diagram, spot diagram, and field curve plot
* List the third-order transverse ray aberration.
* What is/are the dominate aberration(s) of this lens?

Optimize the lens to minimize spherical aberration and coma with the following parameters as variables:

Front lens radius of curvature

Aperture stop thickness

Image thickness

Solves

Marginal ray angle solve on rear lens surface to maintain f/15, 120mm efl

Paraxial image distance

Construct a simple optimization macro:

Define the following optimization constraints using the GUI Optimization window:

* Error Function Definitions and Controls Tab
  + Error Function Content: CODE V error function only
* Specific Constraints Tab

*(Insert Specific Constraint)*

* + Third order spherical aberration
    - Minimize

Target = 0; weight = 0.001

* + Third-order tangential coma
    - Minimize

Target = 0; weight = 0.001

* User Constraints/ray definitions

*Define a balanced astigmatism constraint*

Ast = (tas)- (sas)

*Now go to Specific Constraints Tab and add a User Defined Constraint*

* + @ast
    - Minimize

Target = 0; weight = 0.001

* Optimize your system

Now evaluate this design and compare it to the starting lens performance.

* How has the aberration content of the lens changed?
* What is the shape factor of the lens?
* Where is the aperture stop in relation to the lens?

**B) Aperture stop behind landscape lens**

Construct a lens to satisfy the design parameters above. Insert a surface between the image and lens and make this the aperture stop

Use the same optimization constraints as in Part A and re-optimize the lens. Now evaluate this design and compare it to the Part A optimized lens performance.

* How has the aberration content of the lens changed?
* Which lens has better optical performance?

What you’ve just found are two local minima for the landscape lens to minimize spherical aberration and astigmatism. Depending on the starting conditions of lens, the position of the aperture stop relative to the lens, one or the other local minima was found. Can CODE V find both of these solutions?