Optical Design Software: General Philosophy

Optical design programs are powerful tools; they make optical design of basic - moderately challenging systems accessible to researchers without requiring a degree in optical science.

But, they are so powerful it is easy to be a 'monkey at a typewriter'.

Challenge yourself to learn (and re-learn) fundamental optics –

- Choose better starting points in design programs
- Better use of the tools in the software
- Better insight
- Be a better sceptic

Optical Design Software: Overview

System Design

- Sequential v. Non-sequential
- Prescription entry: Spreadsheet
- Constraint tools: Solves, Pick-ups, Variables
- Performance evaluation: image analysis, vignetting, ray tables, etc.
- Optimization: balancing aberrations, local v. global minima, merit function construction

Tolerancing

Procurement assistance

Export to Mech Design Software

Thermal Analysis

Also … coatings, stray light analysis

Optical Design Software: In particular

OSLO software by Lambda Research:
http://www.lambdares.com/products/oslo/

Education Copy available free:
http://www.lambdares.com/downloads/index.phtml

Window's versions getting loaded on pc's in computer labs

- Download OSLO Optics Reference manual from documentation section of OSLO-EDU download area.
- Do Landscape Lens Exercise in Optics Reference manual, pp. 37-47.

Optical Design Software: Zemax v. OSLO

Zemax more widely used in ground-based astronomy, but …

both programs use similar language, philosophies

experience with one system translates directly to the other

Achromats with OSLO (ref Geary, Walker)

Achromat: Doublet (two elements in close proximity) composed of different materials that gives no Primary Axial Color (PAC).

Constraints (see Geary ch 16):

1. Doublet has same power as original singlet

$$\phi = \phi_a + \phi_b$$

2. Determine powers of the two lenses for removal of PAC

$$\phi_a = \left(\frac{\nu_a}{\Delta \nu} \right) \phi$$

$$\phi_b = -\left(\frac{\nu_b}{\Delta \nu} \right) \phi$$

Example

Desire system with

- EFL = 400 mm (ϕ = 0.0025 1/mm)
- Entrance Beam Radius = 40 mm
- FOV = 10 deg
- Passband: F (0.4861 µm), d (0.5876 µm), C (0.6563 µm)

Try two materials:

- BK7 (crown, e.g. Abbe # > 50): Abbe # = 64.17, n_d = 1.5168
- SF2 (flint, e.g. Abbe # > 50): Abbe # = 33.85, n_d = 1.64769

Opto-mechanical constraints

- Use small (say 0.05 mm) airspace between elements
- Set reasonable element thicknesses, e.g. 12.5 mm and 5 mm, resp
- $R_2 = R_3$
- Start with equiconvex first lens: $R_1 = - R_2$

"Pre-design"

1. Derive element powers. $\phi_a = 0.005291$, $\phi_b = - 0.002791$
2. Using Thin Lens Equation derive radii.

   $R_1 = - R_2 = -R_3 = 195.3506$ mm

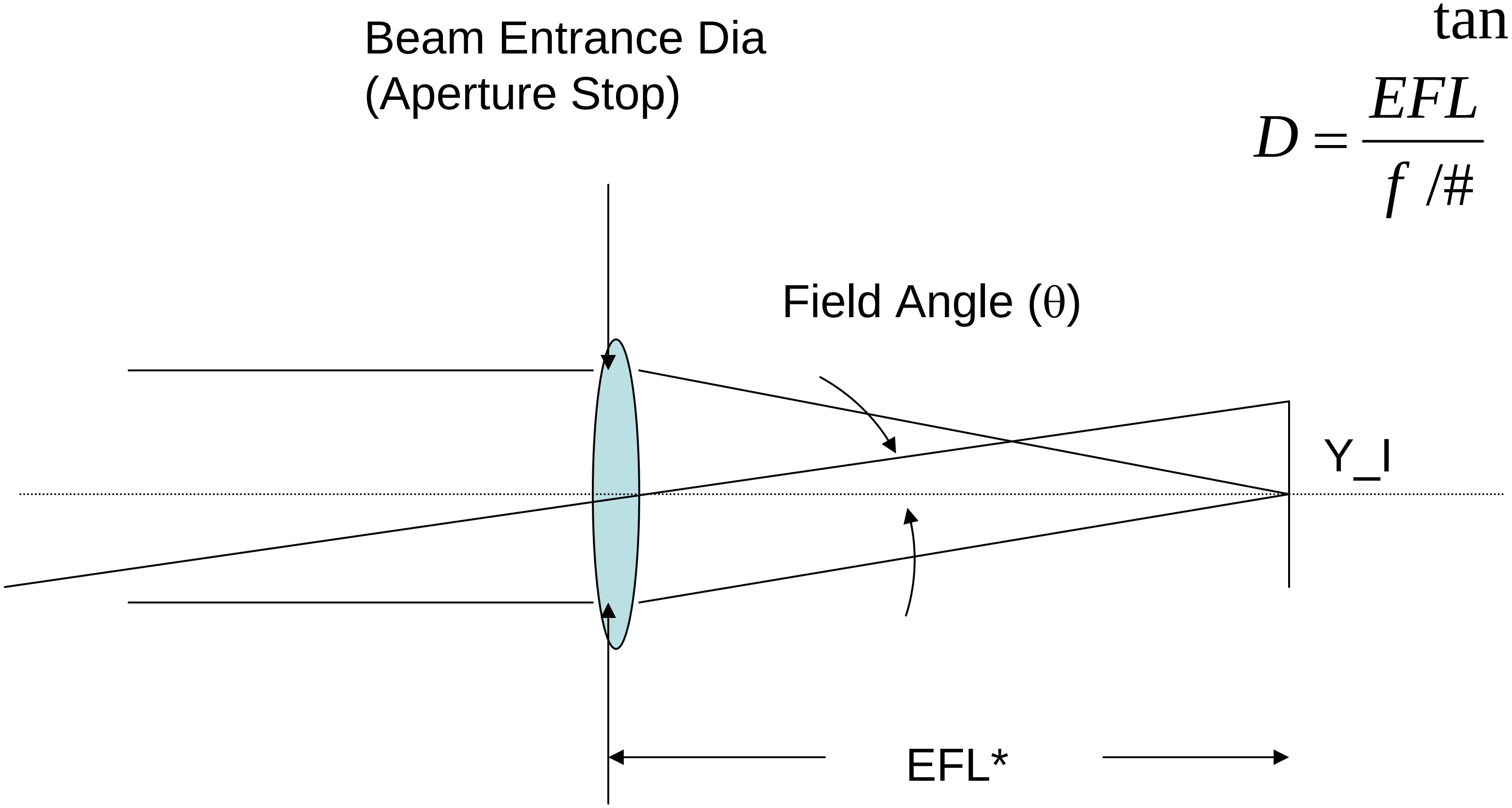
   $R_4 = -1234.81$ mm

Entry into OSLO

Paraxial Constraints (Setup Menu): Aperture Stop, FOV

$$EFL = \frac{y_I}{\tan\theta}$$

$$D = \frac{EFL}{f/\#}$$



*Controlled by elements, enforced by marginal ray angle solve

Notice:

EFL close (but not quite) = 400

Use of pick-up for R_3

Use of marginal ray height solve for BFD

Where wavelengths are defined

Chromatic Focal Shift, Spherical Aberration

Re-optimize for color correction (due to thicknesses)

Set R_1, R_2, R_4 as variables

Optimize -> Generate Error Functions -> Aberration Operands …

PU_ERR = OCM2+0.1, WGT = 2.

PAC = OCM5, WGT = 1.

But don’t delete the rest – helpful to see values even if not optimizing other aberrations

(To edit again use Optimize -> Operands)

Optimize for third order spherical aberration (SA3)

Bend the lenses to reduce spherical without affecting system power. (Enforced with our PU solve.)

Set R_1, R_2, R_4 as variables

PU_ERR = OCM2+0.1, WGT = 2.

PAC = OCM5, WGT = 1.

SA3 = OCM9, WGT = 1.

Iterate by hand to find the second solution for minimal spherical

Remove ‘variable’ tag from R_1

Change R_1 slowly (in increasing direction) and re-optimize

Repeat until SA3 starts to decrease again

Re-set R_1 as variable

Re-optimize

Note new lens format

Re-optimize to remove third order coma (CMA3)

PU_ERR = OCM2+0.1, WGT = 2.
PAC = OCM5, WGT = 1.
SA3 = OCM9, WGT = 1.
CMA3 = OCM10, WGT = 1.

Notice difference in spots for off-axis rays

Element Thickness as Variable

1. Remove variable tag from radii
2. Make element 1 thickness variable
3. → Need a way to constrain the thickness to only get reasonable shaped elements

Airspace Thickness to address spherochromatism

1. Cements used in contact doublets not transparent in IR
2. But use airspace thickness as extra degree of freedom to control spherochromatism