Equation Summary

Numerical aperture and $f/\#$:

$$NA = n' \sin u' \qquad f/\# = \frac{f}{EPD}$$

Rayleigh criterion:

$$\Delta X = \frac{0.61\lambda}{NA}$$

Image height as a function of field angle:

$$h' = f \tan\theta$$

Transverse ray error:

$$\varepsilon'_y = \frac{1}{n'u'_a}\frac{\partial W}{\partial \rho_y} \qquad \varepsilon'_x = \frac{1}{n'u'_a}\frac{\partial W}{\partial \rho_x}$$

Strehl ratio:

$$Strehl \cong \left(1 - 2\pi^2\omega^2\right) \qquad \omega = RMS_{OPD}$$

Wavefront aberration polynomial:

$$W_{IJK} \Rightarrow H^I \rho^J \cos^K \theta$$

$$W(H,\rho,\theta) = W_{020}\rho^2 + W_{111}H\rho\cos\theta + W_{040}\rho^4 + W_{131}H\rho^3\cos\theta + W_{222}H^2\rho^2\cos^2\theta + W_{220}H^2\rho^2 + W_{311}H^3\rho\cos\theta + O(6)$$

Contrast:

$$Contrast = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

Equation Summary

Focal lengths of any two thin lens system:

$$f_a = \frac{d\,f}{f - BFL} \qquad f_b = \frac{d\,BFL}{f - BFL - d}$$

Zero-Petzval solution for two thin lenses:

$$f_a = -f_b = f - BFL \qquad d = \frac{(f - BFL)^2}{f}$$

Two-mirror solution:

$$c_1 = \frac{BFL - f}{2d\,f} \qquad c_2 = \frac{BFL + d - f}{2d\,BFL}$$

Schwarzchild solution:

$$d = 2f \qquad c_1 = \left(\sqrt{5} - 1\right)f \qquad c_2 = \left(\sqrt{5} + 1\right)f$$

Aplanatic condition:

$$i = -u'$$

Bending and shape factors:

$$\beta = \frac{c_1 + c_2}{c_1 - c_2} \qquad C = \frac{u_a + u'_a}{u_a - u'_a}$$

Thin lens bending for minimum spherical:

$$\frac{c_2}{c_1} = \frac{2n^2 - n - 4}{n(2n + 1)}$$

Equation Summary

Thin lens bending for minimum coma:

$$\frac{c_2}{c_1} = \frac{(n^2 - n - 1)}{n^2}$$

Achromatic doublet:

$$\Phi = \phi_1 + \phi_2 \qquad \phi_1 = \Phi \frac{V_1}{V_1 - V_2} \qquad \phi_2 = -\Phi \frac{V_2}{V_1 - V_2}$$

Petzval sum:

$$\sum_j \frac{\phi_j}{n_j}$$

Thick lens power:

$$\phi = \phi_1 + \phi_2 - \frac{t}{n}(\phi_1 \phi_2)$$

Minimum clear aperture for no vignetting:

$$\mathrm{CA}_{\min} = |y_a| + |y_b|$$

Aspheric sag equation:

$$sag = z(r) = \frac{c r^2}{1 + \sqrt{1 - (\kappa + 1)(c r)^2}} + d r^4 + e r^6 + f r^8 + g r^{10} + \ldots$$

Gradient index profiles:

$$n(r) = N_{00} + N_{10} r^2 + N_{20} r^4 + \ldots$$
$$n(z) = N_{00} + N_{01} z + N_{02} z^2 + \ldots$$

Equation Summary

Merit function:

$$\phi = \sum_{i=1}^{m} w_i^2 (c_i - t_i)^2$$

Athermalization condition:

$$\frac{df_{Lens}}{dT} = CTE_1 d_1 \quad CTE_2 d_2$$

Bireflectance scattering distribution function:

$$BSDF(\theta_i, \phi_i; \theta_o, \phi_o) = \left(\frac{L}{E}\right) sr^{-1}$$

Sellmeier dispersion:

$$n(\lambda) = \sqrt{1 + \frac{c_1 \lambda^2}{\lambda^2 - c_4} + \frac{c_2 \lambda^2}{\lambda^2 - c_5} + \frac{c_3 \lambda^2}{\lambda^2 - c_6}}$$

Schott dispersion:

$$n(\lambda) = \sqrt{c_1 + c_2 \lambda^2 + \frac{c_3}{\lambda^2} + \frac{c_4}{\lambda^4} + \frac{c_5}{\lambda^6} + \frac{c_6}{\lambda^8}}$$

Snell's law:

$$n \sin\theta = n' \sin\theta'$$

Paraxial ray tracing:

$$n'u' = nu - y\phi$$

$$y' = y + n'u'\left(\frac{d}{n'}\right)$$

$$\phi = c(n' - n)$$

Equation Summary

Lens maker's equation and linear magnification:

$$\frac{1}{s'} = \frac{1}{f} + \frac{1}{s} \qquad m = \frac{h'}{h} = \frac{f}{s+f}$$

Thin lens power:

$$\Phi = \frac{1}{f} = (c_1 - c_2)(n-1)$$

Diffraction gratings:

$$m\lambda = d\left[\sin(\theta_m) - \sin(\theta_i)\right] \qquad \lambda_{blaze} = 2d\sin\alpha$$

Sampling ratio:

$$Q = \frac{\lambda(f/\#)}{pixel\ pitch}$$

Lagrange invariant and étendue:

$$H = n\bar{u}y - nu\bar{y} \qquad n^2 A\Omega = \pi^2 H^2$$

$$Etendue = \iint_{surface} dA\,a\Omega$$

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