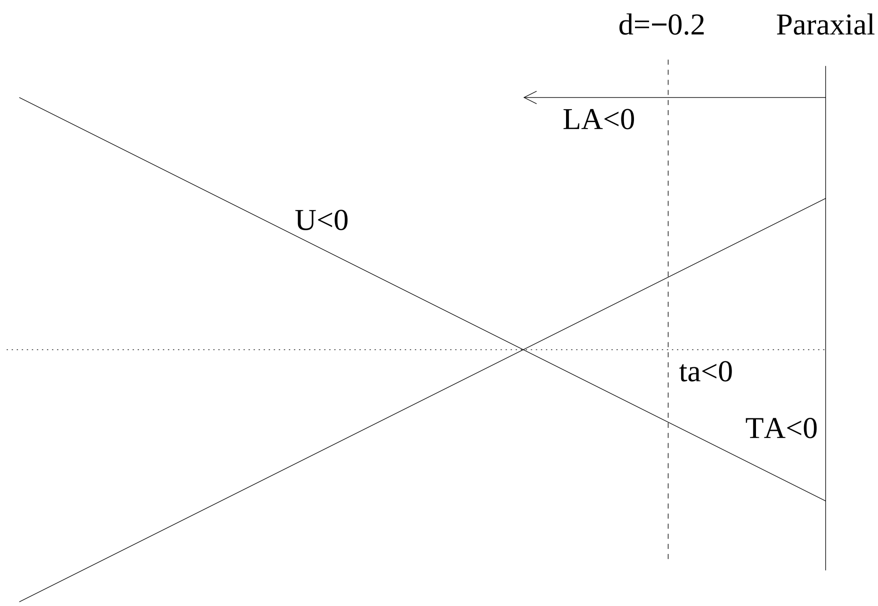
Solutions to homework #4 due 2007/2/20

Problem 1
When longitudinal spherical aberration is negative, it means that the rays focus nearer to the lens than the paraxial plane. The relationshipo between longitudinal aberration and transverse aberration is



With the sign conventions as in the figure, the relationships are

$$TA = -LA \tan U \qquad\qquad ta = -(LA - d) \tan U$$

These sign conventions agree with the problem statement.
(a)
At the paraxial plane we get for ray 1

$$\mathrm{TA}_1 = -(-1) \times (-0.5) = -0.5$$

and for ray 2

$$\mathrm{TA}_2 = -(-0.5) \times (-0.35) = -0.175$$

(b)
At the plane -0.2 closer to the lens than the paraxial plane we get for ray 1

$$\mathrm{ta}_1 = -(-1 - (-0.2)) \times (-0.5) = -0.4$$

and for ray 2

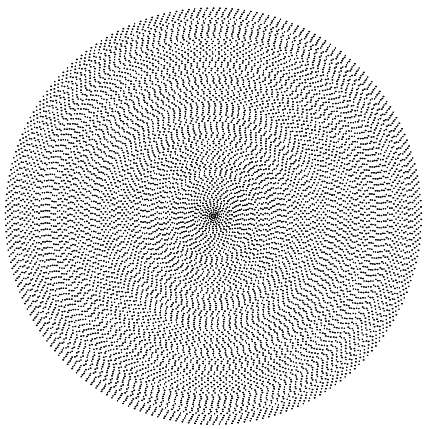
$$\mathrm{ta}_2 = -(-0.5 - (-0.2)) \times (-0.35) = -0.105$$

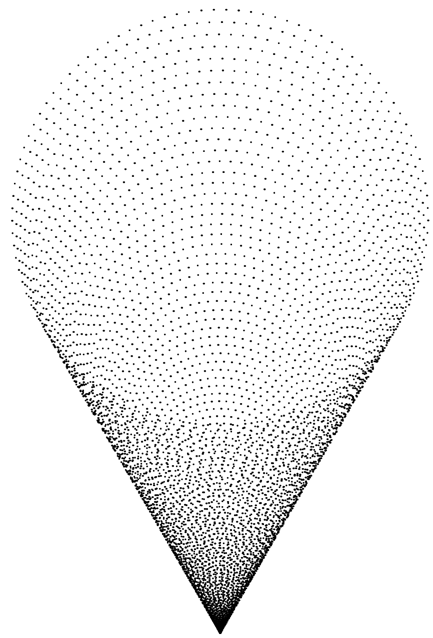
Problem 2

The equations for the aberrations from coma are

$$\Delta x' = B_2 s^2 h(2 + 2\cos 2\theta) \qquad \Delta y' = B_2 s^2 h \sin 2\theta$$

I am going to plot these for many radii and angles.





Problem 3

The lens has $f = 100$, $y = 10$, and FOV $= \pm 5°$. The aberrations are LA $= 1.0$ (longitudinal spherical aberration), Coma$_T$ $= 1.0$ (transverse coma), $X_T = 1.0$ (tangential longitudinal curvature).

We can see how they scale as we scale different measures of the lens, by looking at Table 3.16 page 79.

Longitudinal spherical aberration scales as y^2

Transverse coma scales as $y^2 h$

Tangential curvature scales as h^2

(a)

We double f, which can be viewed as doubling the size of the lens (which doubles the size of the aberrations), followed by cutting the aperture (y) in half. We also cut the FOV (h) in half.

So the longitudinal spherical aberration will be scaled to $1.0 \times 2 \times 0.5^2 = 0.5$, the transverse coma will be scaled to $1.0 \times 2 \times 0.5^2 \times 0.5 = 0.25$, and the tangential curvature will be scaled to $1.0 \times 2 \times 0.5^2 = 0.5$.

(b)

We cut f in half, which can be viewes as halfing the size of the lens (which cuts the aberrations in half), followed by doubling the aperture, and doubling the FOV.

So the longitudinal spherical aberration will be scaled to $1.0 \times 0.5 \times 2^2 = 2.0$, the transverse come will be scaled to $1.0 \times 0.5 \times 2^2 \times 2 = 4.0$, the tangential curvature scales to $1.0 \times 0.5 \times 2^2 = 2.0$.

Problem 4

When we have unit transverse spherical aberration, unit come and unit tangential curvature. The spherical aberration varies as y_L^3 (where y_L is the y-coordinate of the ray in the lens). Coma varies as y^2, and curvature varies as y. y varies as $\tan U'$.

$$H' = \tan U' + 2\tan^2 U' + \tan^3 U'$$