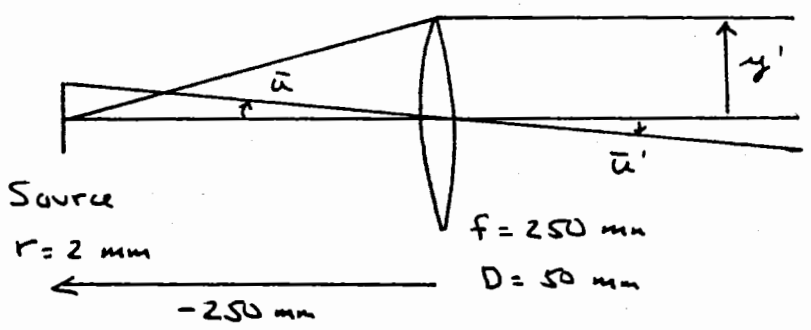
Spot on a Wall

a) Source at the front focal point:

The source defines a marginal and a chief ray for the system:



$y' = 25$ mm

$\bar{u}' = \bar{u} = \frac{2}{-250} = -.008$

$\bar{y}' = \bar{u}' z' = -.008\, z'$

The spot size on the wall will be given by the unvignetted aperture condition:

$a = |y| + |\bar{y}'|$ $\qquad z' = 25m \qquad \bar{y}' = -200$ mm

$a = 25\text{mm} + 200\text{ mm} = 225$ mm

$D_{spot} = 450$ mm

This diameter defines the aperture size that would pass all of the light reaching the wall — this is the total spot size.

b) Source imaged:

An imaging problem — $f = 250$ mm $z' = 25$ m

$\frac{1}{z'} = \frac{1}{z} + \frac{1}{f}$ $z = -252.52$ mm

$m = z'/z = -25000\text{ mm}/252.52\text{ mm} = -99$

$h' = mh = -99\,(2\text{ mm}) = -198$ mm

$D_{spot} = 2|h'| = \underline{396\text{ mm}}$

Focusing the spot on the wall reduces the spot size by about 10%.

c) Spot irradiance:

$\Phi = 10$ W $A_0 = \pi(2\text{ mm})^2 = 12.6\text{ mm}^2$

$M_0 = \Phi/A = .79\text{ W/mm}^2$ (Exitance)

Assum the source is Lambertian:

$L_0 = M_0/\pi$ (Radiance)

The spot irradiance is given by the camera equation:

$$E_{spot} = \frac{\pi L_0}{4(f/\#_w)^2} = \frac{M_0}{4(f/\#)^2(1-m)^2}$$

$f/\# = f/D = \frac{250\text{mm}}{50\text{mm}} = 5$

$m = -99$ (from above)

$$E_{spot} = \frac{.79\text{ W/mm}^2}{4(5)^2(100)^2}$$

$E_{spot} = .79\,\mu\text{W/mm}^2 = .79\text{ W/m}^2$