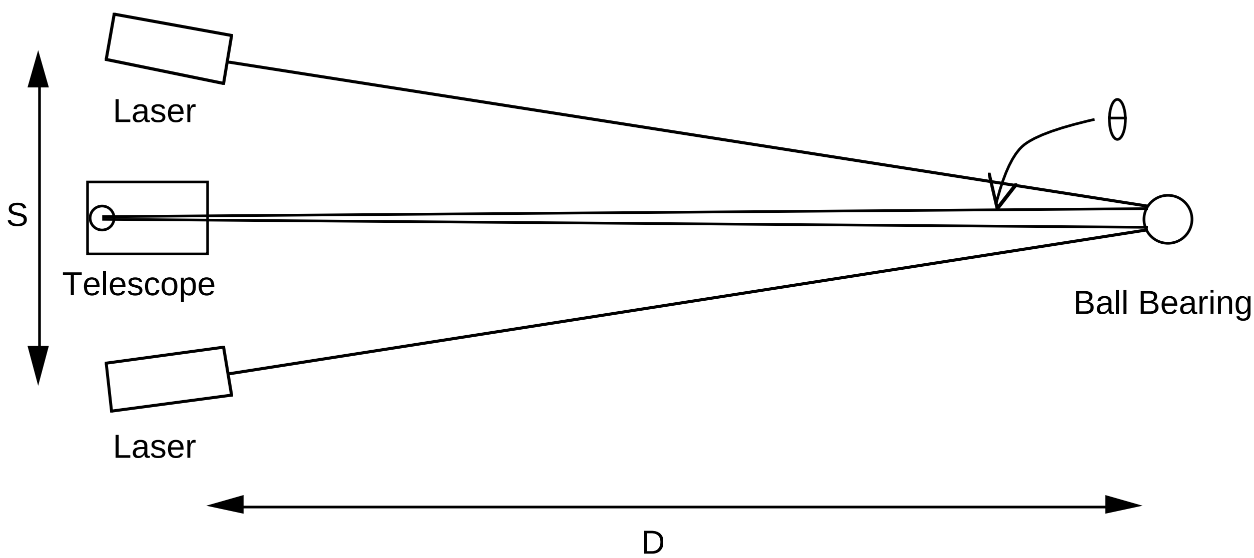
Resolution of a Telescope

When light enters an optical instrument, diffraction occurs because the aperture is finite. If the aperture is round, then the image of a point source is actually a Fraunhofer diffraction pattern for a circular aperture. This diffraction pattern shrinks as the aperture of the instrument increases, so larger instruments are (in principle) capable of greater resolution.

<u>Before You Come to Lab</u>

Review Halliday, Resnick, and Walker section 37.5 and HL section 11.7. Crawford discusses stellar interferometers and should be available in the library.

I) Resolution of a Telescope



In order to study this effect experimentally, you need a telescope with an adjustable aperture and two point sources of light whose separation is very small but can be easily measured. The telescope has a maximum aperture of 8.9 cm, and masks are provided for stopping it down. The point light sources are produced by reflecting two laser beams from a polished ball bearing. The bearing acts as a convex mirror with a short focal length, so one is actually observing the virtual images of the two lasers. The angular separation of these images is very small, but can be calculated from easily measured large quantities as follows:

$$\theta = \frac{SR}{2D^2}$$

where

- θ = angular separation of the sources (in radians)
- S = physical separation of the lasers
- R = radius of the ball bearing (= 1.11 cm)
- D = distance from the lasers to the ball

(OVER)

You should derive this expression for yourself. (Approximations are involved.) Although there will be errors in this angle due to the approximations, these errors are small compared with the uncertainty in judging whether the Rayleigh criterion has been met. Find a way to estimate this error.

Measure the resolution (according to the Rayleigh criterion) of the telescope for several apertures. As always, compare your results to theory. You should also try using the two matched apertures as a "Michelson stellar interferometer."

II) The Eye

You should also see how well this analysis applies to your eye. Place a couple of black spots on a piece of paper and tape it to a wall. If you observe this pattern through a series of apertures of decreasing size, how does the resolution change? Plot the angular separation of the dots at the furthest resolvable distance versus the aperture size. Does this agree with the Rayleigh prediction? (Note: If you wear corrective lenses, keep them on for this exercise. This is a test of aperture function, not lens quality.)

R.R.C. 4/26/82
S.J.H. rev. 1/16/91
R.R.C. rev. 4/19/93
C.E.C. rev. 4/1/96