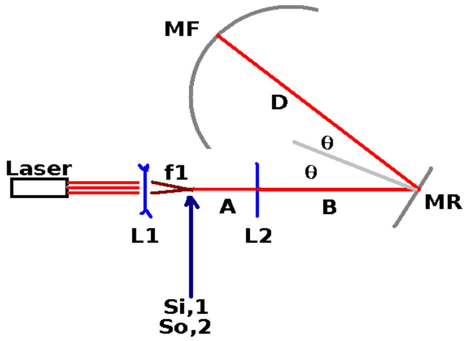
Measurement of the speed of light

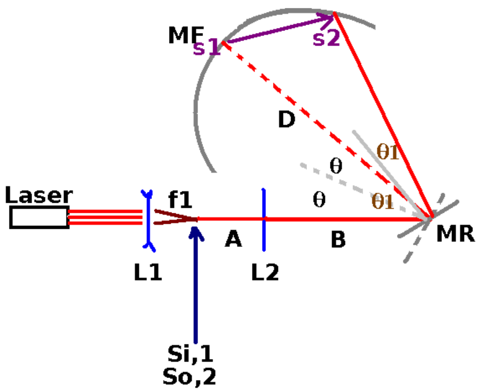


(1) Find $S_{i,1}$:Thin Lens Equation:

$\frac{1}{s_{i,1}} + \frac{1}{s_{o,1}} = \frac{1}{f_1} : s_{o,1} = \infty \Rightarrow \frac{1}{s_{i,1}} = \frac{1}{f_1} \Rightarrow s_{i,1} = f_1$

(2) Find A.

$f_1 > 0 : s_{o,2} = f_1 : f_1 + A = |L_2 - L_1| \Rightarrow A = |L_2 - L_1| - f_1$



(3) Find s_2-s_1=Δs:
Use: $\Delta s = D\Delta\phi$ from the measurement of an arc. Here, the included angle is 2θ and $2\theta_1$. The actual angles are from the law of reflection.
So: $\Delta s = 2D\Delta\theta$.
Ultimately,$s_{o,2}$ will be an image in the beam splitter which is viewed with a microscope.

(4) Find $\Delta\theta$:
In the time it takes a pulse of light to go from MR to s_2 and back, it travels through the distance 2D. We find the mirror rotation in this time: $\Delta\theta = \omega\Delta t$. We further find the time for the light to travel this distance as: $\Delta t = \frac{2D}{c}$ .Putting it together, we have the result: $\Delta\theta = \frac{2D\omega}{c}$.This gives then: $\Delta s = \frac{4D^2\omega}{c}$.

(5) Imagine that the arrow s1 to s2 above is an object. We ultimately look at the reflection of this in the eyepiece. These two can be thought of as a virtual source. From this we find the magnification of the image of this imagined arrow as:

$$M = \frac{d_i}{d_o} = -\frac{\Delta s'}{\Delta s} \Rightarrow \Delta s' = -\Delta s\left(\frac{d_i}{d_o}\right).$$

Ignore the – sign since it is not important here and refers to image inversion. The result we obtain is:

$$\Delta s' = \Delta s\left(\frac{d_i}{d_o}\right).$$

We identify:

$$d_o = D + B : d_i = A .$$

The identification of A is because originally the system would be optically aligned to make this so. We have, after putting it all together:

$$\Delta s' = \frac{4D^2\omega}{c}\left(\frac{A}{D+B}\right) = \frac{8\pi D^2 f}{c}\left(\frac{A}{D+B}\right).$$

To make the actual measurements, we rotate 2 different directions: ccw and cw, and then subtract the 2 positions. However note that one frequency is positive while the other is negative. This gives the shift in position which I will call Δs_{spots}.

$$\Delta s_{spots} = \frac{8\pi D^2}{c}\left(\frac{D+B}{A}\right)\left(f_{ccw} + f_{cw}\right)$$

We solve this for c to obtain the result which will provide us with the speed of light:

$$c = \frac{8\pi D^2}{\Delta s_{spots}}\left(\frac{A}{D+B}\right)\left(f_{ccw} + f_{cw}\right)$$