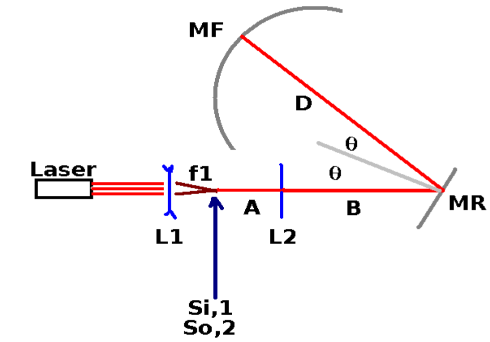
Measurement of the speed of light Revised 2016



(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.

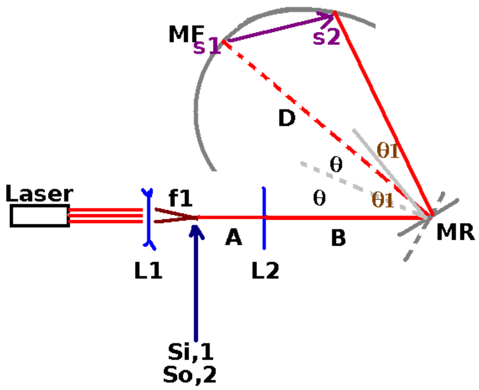
$$f_1>0:s_{o,2}=f_1:f_1+A=|L_2-L_1|\Rightarrow A=|L_2-L_1|-f_1$$

(3) Find s_2-s_1=Δs:

Use: $\Delta s=D\,\Delta\theta$ 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:

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