University of Surrey  
Department of Physics

Level 1 Laboratory – Autumn Semester  
Experiment N – Measuring the Wavelength of Light  
with a Ruler

AIM

In this experiment you will measure the wavelength of a helium-neon laser using simple equipment. The measurement is surprisingly accurate and you should make a careful estimate of this accuracy.

EXPERIMENT

This experiment, first devised by the Nobel Prize winning physicist, A L Schawlow, shows how it is not always necessary to have elaborate equipment to make “elaborate” measurements. It also introduces the idea of diffraction from a reflection grating.

Light from a laser has such a high degree of spatial and temporal coherence (what do these terms mean?) that if it is allowed to impinge on a steel ruler, the ruler markings act as a diffraction grating and the diffraction orders enable the wavelength of the laser light to be simply determined.

It should be remembered that the visible wavelength range is from about 4000Å to about 7000Å so that it is necessary to use very small grazing angles in order for the relatively widely spaced markings to appear close enough together.

Set up the equipment as shown in the figure.

Adjust the ruler so that the beam impinges on the finest scale. The steel ruler markings act as a reflection grating producing a series of bright spots on the wall. The distance to the wall and the height of the spots can be measured with the metre rule.
The incident angle $\alpha$ and the diffracted angle $\beta_n$ satisfy the grating equation

$$n\lambda = d(\sin \alpha - \sin \beta_n)$$

where $d$ is the grating spacing, $n$ is the diffraction order and $\lambda$ the wavelength of the laser light. In order to determine which spot corresponds to specular reflection ($y_o$) and hence to determine $\beta_o$, which by simple geometry is equal to $\alpha$, shift the ruler sideways slightly so that the beam impinges on an unmarked portion. Note that the spot corresponding to $y_o$ may not be the lowest spot you observe. Moreover, the distances $y_o$ are measured from the height corresponding to the distance from the ruler level, which is slightly above the bench top.

Now

$$\sin \beta_o = \frac{x}{(x^2 + y_n^2)^{1/2}}.$$

If $y_n << x$ this may be approximated by

$$\sin = 1 - \frac{y_n^2}{2x^2},$$

Therefore

$$n\lambda = \frac{d}{2}\left(\frac{y_n^2 - y_0^2}{x^2}\right).$$

Plot a graph of $y_n^2$ against $n$. The gradient is $\frac{2\lambda x^2}{d}$.

Hence, calculate the wavelength.

If time permits, qualitatively describe the effect of changing the laser light incident angle and the rule scale. Account for your observations.

Reference:
A L Schawlow, American Journal of Physics 33 922 (1965)