MEASURING THE WAVELENGTH OF LIGHT USING A RULER

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A simple and dramatic measurement that’s an exercise in trigonometry.

Figure 1 shows the arrangement that might be called a grazing incidence diffraction grating. It is easy to see many orders of interference. The hard part is quantifying how near to grazing incidence.

The ruler should have a scale that is either raised or indented and at least as fine as 1 mm. We used a machinist’s vernier caliper scale. The light source was a green laser pointer.

Figure 1. The incident plane-wave arrives on the grating surface at an angle $\theta_i$. The $m^{\text{th}}$ diffracted order leaves the grating at an angle $\theta_r^{(m)}$. The grating period $P$ is the distance between points $A$ and $B$. The line $AA'$ is perpendicular to the incident rays; the distance between $A'$ and $B$, which is given by $P\sin\theta_i$, is the extra path-length covered by the upper incident ray relative to the lower incident ray. Similarly, $BB'$ is perpendicular to the $m^{\text{th}}$ order diffracted rays; the distance between $A$ and $B'$, which is given by $P\sin\theta_r^{(m)}$, is the extra path-length covered by the upper diffracted ray relative to the lower diffracted ray. The difference between $AB'$ and $A'B$ must be an integer-multiple of the wavelength $\lambda_o$, that is,

$$P\sin\theta_r^{(m)} - P\sin\theta_i = m \lambda_o.$$

This is the grating equation for the $m^{\text{th}}$ diffracted order. In the experiment with the ruler, $P=0.635$ mm, $\theta_i=88.5^\circ$, $\theta_r^{(m)}=87.2^\circ$, and $m=-1$, yielding $\lambda_o=0.54$ $\mu$m.

It is a pleasure to acknowledge publication of a similar analysis by a great teacher, Arthur L. Schawlow.