TESTING THE RESOLVING POWER OF TWO SLITS WITH A BIPRISM

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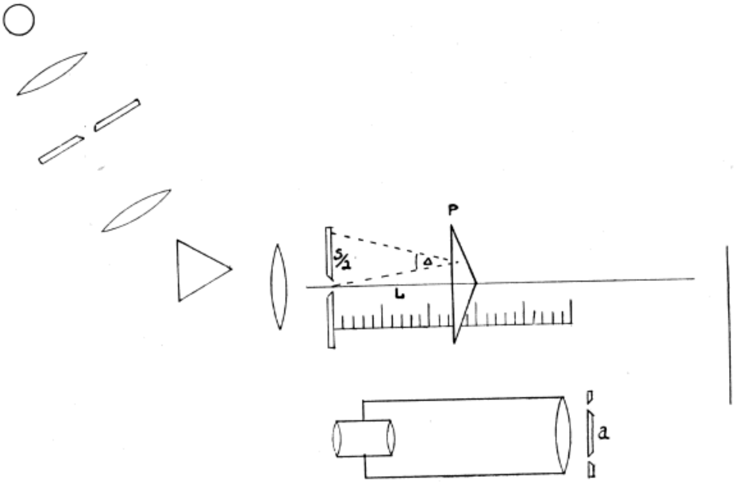
The study of the interference pattern formed by two rectangular openings in a screen makes an interesting experiment for a college course in light because of its historical interest, its relation to resolving power, and its application to the measurement of stellar diameters. The parallel slit experiment, as it is commonly performed, consists of a measurement of the width of a distant slit source in terms of its distance, the wave-length of light, and that separation of the diffracting slits which will just resolve the source. The interference fringes are seen through a telescope focused on the source.

Two sources are said to be resolved if the maxima in the diffraction pattern of one coincide with the minima of the other. It is shown in treatises on light that the resolving power of two slits, i. e., the smallest angular separation of the two sources for which they can be distinguished as two, is $R=l/2a=s/d$; where l is the wave-length of light, a the distance between the centers of the diffracting slits, s the separation of the two sources, and d their distance from the slits. Since, in resolving a single slit, one must distinguish one-half from the other, it follows that the width of such a source when just resolved is $w=dl/a$.

If the interference fringes are to be distinct, the color must be pure and the source narrow, which makes a direct measurement of its width, for a check, difficult. Resolution, or blurring of the fringes due to superposition of maxima and minima, occurs for integral multiples of the separation, $n\,a$. Now if w is small, the number of observed resolutions must be small, and the smallest distance between the diffracting slits, a, which will resolve the source must be large. Which means that the fringes, whose angular width is $l/2a$ must be very fine.

The author has found the following modification of the experiment an improvement. As shown in the accompanying figure, a Fresnel biprism, *P*, is mounted on an optical bench in front of the slit source, *S*, thus producing two virtual sources, whose separation is found to be approximately proportional to the distance, *L*, between the source slit and biprism. It is shown in the theory of refraction through a prism that the rays which form the image lie close to the path of minimum deviation. It is seen from the figure that if the angle of deviation, D is a small angle, that the proportionality constant S/L will very nearly equal $2D$ provided the prism is thin and L is sufficiently large. The constant $2D$ may be determined directly by the measurement of the separation of the images for two or more positions of the prism with the aid of an auxiliary lens as described in Taylor's College Manual of Optics, page 102; or it may be measured with a collimator, a rotating telescope with mirror attached and a reading telescope and scale.



The constant $2D$ for the prism used was found to be 0.0158. So, on a 1.5 m. bench the separation of the virtual sources can be varied continuously from 0 to 2.4 cm. The diffracting slits do not need to be so widely separated as in the original experiment but may be so placed that the fringes are so broad and distinct as to be easily counted. One seeks now the position of the biprism for which the minima of the two overlapping patterns coincide. When the prism is near the source, the images are too near together to be resolved. Suppose five fringes are counted. If the prism is removed, there are still five. Now advance the prism slowly. Presently the central fringe splits in two. There are now six. Let n be the order of the resolution. L/n is found to be a constant, and $(L/n)\ (2D/d)=l/a$, or twice the resolving power. By reflecting back the light with a plane mirror, the telescope may be placed by the optical bench and the observer may also adjust the prism. If finer fringes are used, the disturbance of the pattern due to the shifting of the fringes takes place more suddenly and extends to several of the central fringes or even to all. In this case the point where maxima coincide with minima is the most critical and the resolving power is expressed by the formula: $(L/n)\ (2D/d)=l/2a$.

The phenomena may be observed with white light with the addition of interesting chromatic effects. The experiment may be performed with a white light and color filters. However, it was found much better to focus the spectrum of a 200-watt electric lamp on the plane containing the source slit, because the resolution points are much more sharply defined if the color is pure than if it is mixed. This has the additional important advantage that the apparatus may be calibrated with a known wave-length. Even better results are obtained with a mercury-vapor lamp and color filters.

This modification of the parallel-slit interference experiment has several advantages. It is much more flexible, allowing a much greater range of resolving powers and much lower resolving powers with broader fringes and an opportunity to watch the motion of the individual fringes. It allows a much greater range of measurable source-breadths and a larger number of resolving points (as many as 10 or more); which considerably improves the accuracy of the check measurements. It may be performed with less-expensive apparatus. No traveling microscope is needed. An ordinary reading telescope is sufficient for viewing the fringes. Fixed instead of movable slits may be used. An incandescent lamp and alternating current give nearly as good results as a monochromatic source and direct current.