XI.—*Diffraction Rings due to a Circular Aperture.*

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IN a paper by Mr. E. M. Nelson read in March 1906 and printed in the October No. of the Society's Journal, 1906, occurs the following sentence in reference to the diffraction rings formed when light from practically a point source is received after passing through a circular aperture: "If the radius of the first dark ring be experimentally determined, it will be found to be 32 p.c. smaller than its theoretical value. What would be thought of the Newtonian theory of gravitation if the calculated distance of Mars from the Sun was 32 p.c. too great?" This somewhat sweeping criticism of the diffraction theory seemed to call for further experimental tests before it could be accepted, especially as in the early days of the subject experimental verification of the theory was obtained. It is true that Fraunhofer's measurements were made with white light only, and in that respect are imperfect; however, when his values for rectangular and circular apertures are compared, the factor of proportionality between the diameters of the first dark ring in the two cases is found to be exactly $1 \cdot 22$, as required by the theory. These experimental values are conveniently found quoted in Knochenhauer's *Undulations-theorie des Lichtes*. According to Mr. Nelson, this factor turns out experimentally to be $0 \cdot 8266$. The question is therefore not merely one of disagreement between theory and experiment, but also one of disagreement between Fraunhofer's and Mr. Nelson's experimental values.

The following measurements were made with the object of obtaining a test possessing as great a precision as possible with the modern means at our disposal.

The method adopted was that of direct measurement of the diameters of the rings, using a micrometer eyepiece. An artificial star was set up 23 metres away from a telescopic object-glass of good quality of between 2 and 3 inches aperture giving an image at 670 mm. behind the lens; and diffraction rings of a suitable size were produced by placing a small aperture in front of the telescope. The greatest difficulty was the faintness of the rings when made large. An aperture of 2·23 mm. diameter was found to be the most suitable, and the diameter of the first dark ring was then about 0·2 mm. The artificial star used was a

pinhole 0·3 mm. diameter in a piece of thin brass placed in front of the condenser of an optical lantern, arranged so as to project a parallel beam of light. The angular width of the bright object was therefore only about 4 per cent. of the angular diameter of the first dark ring, and the uncertainty of setting would therefore be considerably less than this. The light was required as nearly as possible monochromatic and very intense for obvious reasons. These results were obtained by using an electric arc, the positive carbon having its core bored out and replaced by finely ground dry salt; this carbon was placed below the negative carbon. This arrangement gives an intense sodium light, consisting mainly of the D-lines, but containing also the other pairs of lines emitted by sodium in the arc. The light from the latter was too feeble to sensibly modify the diffraction figure formed by the much preponderating D light present. The accuracy of the micrometer eye-pieces was well within the errors entailed in setting the cross-wire on the rings.

The measured diameters were reduced to give the constant for each ring for comparison with the theoretic values. Of the first dark ring 7 series of 4 measurements were taken; of the first bright ring 2 series of 4 measurements each; and of the second dark ring, 3 series of 4 measurements each. The mean values of these determinations are given below with Airy's values for comparison:—

	AIRY.	PRESENT EXPERIMENTS.
1st dark ring	1·22	1·21
1st bright ring	1·64	1·68
2nd dark ring	2·23	2·20

The outcome of these measurements is to show practical agreement between theory and experiment; this is especially so in the case of the first dark ring, for which the possible precision of measurement is certainly the greatest. The error is greatest in the case of the first bright ring, but here amounts only to $2\frac{1}{2}$ per cent.