

MOIRE PATTERNS FOR THE ADVANCED UNDERGRADUATE LABORATORY

G. KESSLER and M. HAWTHORNE
Physics Department, Illinois Wesleyan University

In trying to find open ended advanced optics experiments, the determination of index of refraction gradients by use of Moire patterns is often overlooked. While the literature (Oster, Wasserman and Zwerling, 1964) contains many articles there is invariably a lack of information on experimental procedure or detail. We have found that the following arrangement yields good results.

To make quantitative measurements it is necessary to have a sample cell, 15.0cm x 15.0cm x 1.0cm will do, with the resulting interface between the two diffusing liquids horizontal. The Moire fringes should be vertical and to accomplish this, usually, two plates of very nearly the same rulings per centimeters are used, one on each side (Van Oss, 1964). Since these are difficult to make or expensive, we used two standard 4" Ronchi rulings of the same number of lines. Light from a collimated monochromatic source was sent through the first ruling, then through the sample cell and finally by use of a lens was projected on the second ruling. This magnification allowed for a variable relative difference in the lines per centimeter. The entrance ruling is aligned so its lines are horizontal (i.e.: parallel to the liquid interface) while the second ruling is tilted at some angle to the first. This angle is adjusted so the fringes are vertical (i.e.: perpendicular to the liquid interface). In this configuration all displacements in the pattern due to diffusion at the interface are perpendicular to the pattern and yield, generally, a gaussian shape. If the two liquids have indices of refraction N_0 , N_1 and their difference is small we have

$$N(x) = N_0 \pm K \int_0^x y dx$$

where x is the distance measure along the base line or original fringe, and y the displacement from the base line. The constant K is complex and depends on the angle of rotation and number of lines on the Ronchi rulings, the cell wall thickness, the focal length of the lens and the wavelength. To find this constant a calibration was done with the following standard solution, which was found to be best after

many combinations were tried; pure butanol and a saturated mixture of butanol and water. Since water is only slightly soluble in butanol the gradient is not too sharp. The indices of refraction of the two solutions were measured with a refractometer and then a photograph of the fringes allowed the determination of K , and of the plus and minus sign. The sign varies depending on whether the upper or lower liquid has the larger index of refraction, which in turn produces a pattern shift to the left or right. This value was found to yield good results when water and various glycerol-water solutions were allowed to diffuse. For example, a 10% glycerol-water solution yielded $n = 1.3477$ compared to a refractometer reading of 1.3473. (Figure 1)

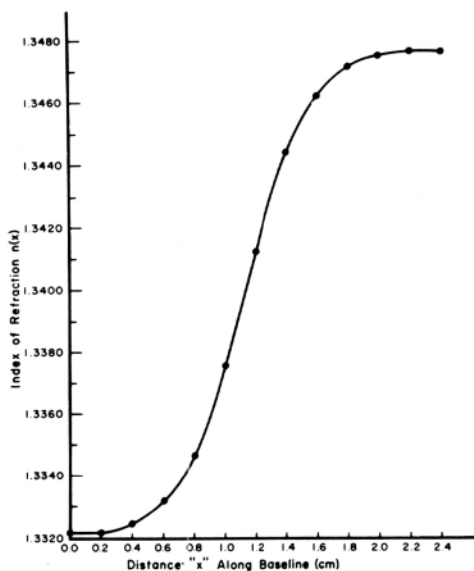


FIGURE 1. Refractive index across the boundary of a mixture of 10% glycerol-water and pure water 75 minutes from start of diffusion.

The experimental set-up is therefore: 1) a strong monochromatic source (Osram Sodium Lamp), 2) collimator, 3) first Ronchi ruling, 4) sample cell, 5) lens of long focal length, 6) second Ronchi ruling, and 7) a standard spectroscopic plate. Exposure times were less than $\frac{1}{2}$ second. The distance between the two Ronchi rulings should be four times the focal length of the lens.

Temperature gradients in flames are easily measurable as are "temperature waves" propagated through carbon tetra-

chloride as the surface is cooled rapidly by forced evaporation.

LITERATURE CITED

- OSTER, G., M. WASSERMAN, and C. ZWERLING. 1964. Theoretical interpretation of Moire patterns. *J. Opt. Soc.* 54: 169-175.
VAN OSS, C. J. 1964. Use of gratings producing moire patterns for measuring refractive index gradients. *J. Sci. Instr.* 41: 227-8.

Manuscript received December 18, 1969.