1973

Wire Diffraction Gratings

Tom Greenslade
Kenyon College, greenslade@kenyon.edu

Recommended Citation

"Wire Diffraction Gratings", American Journal of Physics, 41, 730-731 (1973)

AAPT PHYSICS EDUCATION
AMERICAN JOURNAL of PHYSICS

Wire Diffraction Gratings

Thomas B. Greenslade Jr.

Citation: American Journal of Physics **41**, 730 (1973); doi: 10.1119/1.1987350
View online: http://dx.doi.org/10.1119/1.1987350
View Table of Contents: http://scitation.aip.org/content/aapt/journal/ajp/41/5?ver=pdfcov
Published by the American Association of Physics Teachers

calibrate the sound power actually emitted, so as to compare it with the 1-mW change in battery output between the null in sound power and that emitted into free space?

One crude way is to look in a book to find what sound intensity feels painful to the average human ear. Then move the Sonalert closer to your ear until it begins to feel uncomfortable. I found I could put the Sonalert right over my ear and barely stand it. Assuming my electrical measurement was right, and taking the Sonalert area as 3 cm^2, that gives 0.3 $\text{mW/cm}^2\text{-sec}^1$ as my pain threshold at 2900 Hz. Some books give 1 $\text{mW/cm}^2\text{-sec}^1$ as a typical pain threshold. Thus, very crudely, the measured 1 mW of sound power is shown to be reasonable, without any use of equipment.

Finally, one may turn the student loose to see what other interesting demonstrations he can devise. For example, a hard flat table top can serve as a Lloyd's mirror for a Sonalert situated several inches above the table. He can explore the two-point source (the source and its virtual image in the mirror) interference pattern with one ear. Is the central fringe (the one in the plane of the table) a minimum or maximum? Is there a phase change upon reflection? Is it the pressure or the velocity that the ear responds to? As another example, suppose you are located between two separated Sonalert packages emitting slightly different frequencies. (Any two independent ones will have slightly different frequencies.) Without moving your head you hear beats. Now move your head towards one or the other Sonalert. What happens to the beat frequency? Can you tell which one has the higher and which the lower frequency simply by the behavior of the beats?[4]

---

* This work was supported by the A.E.C.

[1] Vincent Mallette, Phys. Teach. **10**, 283 (1972).

[2] I bought one Mallory SC 628 Sonalert for $5.60, one 9-V battery (RCA VS323) for $0.50, and a battery clip for $0.13, at Al Lasher's Electronics, 1734 University Ave., Berkeley.

[3] I could have achieved a slightly smaller package and more than twice the sound power by using a 15-V battery, RCA VS083.

[4] This particular experiment was inspired by a demonstration at the Exploratorium (see Ref. 5) that uses low tones emitted by loudspeakers. I found the corresponding experiment using Sonalerts almost impossible to do inside a room, because of the ubiquitous standing waves due to reflections from walls. Even outside, the reflections from the ground gave standing waves and hence undesired spurious beats when moving one's head towards one source or the other.

[5] Frank Oppenheimer, Amer. J. Phys. **40**, 978 (1972).

Wire Diffraction Gratings

THOMAS B. GREENSLADE, JR.*
Department of Physics
Kenyon College
Gambier, Ohio 43022

(Received 18 August 1972)

Wire diffraction gratings,[1] made after the approximate specifications of those first made by Joseph von Fraunhofer (1787–1826) about 1820,[2] have been found to give surprisingly good results in the visible region. Unlike conventional diffraction gratings, the grating space is large enough to be seen by the unaided eye. The gratings may be made rapidly and inexpensively, and it is possible for students to construct their own.

One grating which was tested was made by placing #42 wires across two parallel rods of about $\frac{1}{4}$-in. diam and 2 in. apart which were threaded 80 to the inch on a lathe. The wires were held down temporarily at the ends with masking tape to hold them taut until a bead of epoxy could be laid across them to secure them to the rods.

With this grating, which had only 24 wires, about 15 maxima could be seen clearly on either side of the central maximum. A sodium source was used because of its simple spectrum and historical interest. Fraunhofer first used wire diffraction gratings to measure the wavelengths of the absorption lines in the solar spectrum. The diffraction angles are small enough so that the small angle approximation is appropriate. The condition for a maximum may then be written as

$n\lambda = a\theta$, where a is the center to center distance between the wires. The value of a may be obtained with a measuring microscope, or, to a first approximation, the calibration of the lathe used to make the screw may be trusted.

This experiment was developed while attending the History of Physics Institute at Barnard College (supported by the National Science Foundation) during the summer of 1972.

* On leave during 1972–73 at Department of Physics, University of the West Indies, Kingston 7, Jamaica, West Indies.

[1] K. L. Warren and T. E. Graedel, Amer. J. Phys. **34**, 1056 (1966); J. S. Hall, Astrophys. J. **84**, 369 (1936) and **94**, 71 (1941).

[2] L. Bell, Phil. Mag., s. 5 **25**, 245 (1888).

On Shadow Bands Accompanying Total Solar Eclipses

A. L. STANFORD, JR.
School of Physics
Georgia Institute of Technology
Atlanta, Georgia 30332
(Received 16 October 1972)

The phenomenon known as shadow bands or "flying shadows" has been observed repeatedly preceding and following total solar eclipses. Shadow bands are regions on the Earth's surface displaying alternating linear bands of relative darkness and light and moving slowly relative to the Earth's surface.

A few explanations of shadow bands have been suggested, notably by Wood[1] in his famous treatise on physical optics and by Gaviola[2] over 20 yr ago. The theoretical basis for shadow bands has usually been a scintillation effect or other atmospheric refractive process that ultimately places the origin of the bands on atmospheric inhomogeneities, density gradients, inversion layers, or discontinuities. Unfortunately these possible causes are almost impossible to measure with any accuracy, particularly in correlation with simultaneously measured characteristics of shadow bands.

Here is presented a simple model for production of shadow bands that is consistent with observed data, and which is also relatively easy to subject to experimental verification. The model further predicts a second type of shadow band—a giant variety—that has not as yet been observed.

Much of the data relating to shadow bands has been reported by amateurs. These data have been summarized recently[3] and may be stated briefly as follows:

1. The bands are essentially linear, low-contrast alternations of bright and darker regions, nearly equally spaced, with intensity variations of 1% to 3%.
2. The separation between minima in the bands is typically a few centimeters, but occasionally over 10 cm.
3. The bands occur roughly parallel to the exposed solar crescent from several minutes before totality up to the time of totality and sometimes during a similar period following totality.
4. The patterns move over the Earth's surface with velocities whose magnitudes vary between zero and several meters per second and whose directions seem to be arbitrary—sometimes toward and sometimes away from the geometric shadow. Separate patterns have been observed to cross each other.

A successful model for the production of shadow bands must be essentially consistent with all of the foregoing observations. Persistent patterns of dark and light bands immediately suggest an interference or diffraction phenomenon or both, the former of which requires the effective presence of coherent beams (though of course not necessarily a coherent source).

Recall that one of the routine methods for producing coherent beams uses the Lloyd mirror as illustrated in Fig. 1. Here the direct beam proceeds from the source of light S to the point P, and the beam reflected toward P from the mirror M appears to come from an effective coherent source S'.