Lecture demonstrations with an argon laser

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1. Demonstration of light interference and diffraction phenomena. We have previously described[1] certain lecture demonstrations of interference and diffraction of light, performed with a gas He-Ne laser having an optical power 10–15 mW. To demonstrate these phenomena in a large auditorium, however, requires careful prior darkening of the auditorium and preliminary adaptation of the observers' eyes. This is due, first, to the low power of the He-Ne laser and, second, to the insufficient sensitivity of the eye to the red light of this laser.

Argon lasers have much higher optical power. We used an argon laser with power from 0.5 to 2 W, depending on the operating conditions. In addition, the emission of this laser lies in a spectral region more favorable for the human eye. Using the schemes described in[1], we obtained with an argon laser patterns of diffraction by a round hole and by a sphere. The dimensions of the patterns observed on the screen reached 40–50 cm in diameter and could be photographed on "Orvo Chrom" reversible color film with an exposure of approximately one second, thus evidencing good illumination of the screen. When demonstrating these phenomena, we did not separate one of the two most intense emission lines of the argon laser (4880 and 5145 Å), since the intensity of one of the lines, depending on the laser regime, greatly exceeds that of the other and the diffraction pattern corresponding to the weaker line did not interfere with the observation of the brighter pattern.

2. Demonstration of the three-dimensional properties of a holographic image. We have previously described[2] a lecture demonstration that makes it possible to display in a large auditorium the reconstruction of the holographic image of a flat object and to illustrate certain properties of Fourier holograms.

We have now used an argon laser to reconstruct the image of a three-dimensional object. The hologram of the demonstrated object (a miniature souvenier samovar measuring $6 \times 6 \times 10$ cm) was prepared by the usual Fresnel technique. During that stage we used an He-Ne laser with one transverse mode separated by means of a diaphragm. All the components used in the setup (with the exception of the laser) were mounted on a glass plate measuring 1×1 m and weighing ~80 kg. The plate was placed on a rubber vacuum hose, which provided the necessary shock absorption. The laser was on an optical bench placed on a shock-absorbing rubber sheet ~1 cm thick. With this setup it was possible to obtain holograms of quite satisfactory quality on photographic plates of VRL and VRM type.

To reconstruct the image we used an argon laser. The reconstruction scheme was the following: A lens of focal length ~30 cm was placed in the path of the laser beam and the beam was focused in a point ~11–12 cm in front of the hologram. Thus, the hologram was illuminated by a diverging light beam, and only a small area of the hologram, of ~2 mm diameter, took part in the reconstruction of the image. At a distance ~1 m from the hologram was located a screen on which the real magnified image of the object was observed. The coefficient of linear magnification was in this case[3] $M = (\lambda'/\lambda)(q/f)$, where λ and λ' are the wavelengths of the light used to produce and reconstruct the hologram, respectively, f is the distance from the object to the photographic plate during the course of production of the hologram, and q is the distance from the hologram to the image of the object during the course of its reconstruction. Since $f = 10$ cm in our case, the magnification is ~10.

The three-dimensional properties of the image (the parallactic-shift effect) were demonstrated in the following manner: By moving the lens perpendicular to the laser-beam direction we displaced the illuminating light beam, and different parts of the hologram took place in the production of the image. The reconstructed images corresponding to different sections of the hologram differ from one another, because different parts of the photographic plates "have seen" the object from different points of view. When the illuminating beam is scanned over the hologram plane, a complete illusion is created that the observed image rotates and the mutual positions of individual parts of the object change. The observer views the object, as it were, from different sides. Photographs obtained from the screen and corresponding to two different positions of the illuminating light beam relative to the hologram reveal the parallax effect quite clearly.

[1] O. A. Shustin et al., Usp. Fiz. Nauk 105, 359 (1971) [Sov. Phys.-Usp. 14, 666 (1972)].
[2] O. A. Shustin, ibid. p. 361 [transl. p. 668].
[3] G. W. Stroke, Introduction to Coherent Optics and Holography, Academic, 1966.

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