differs sharply from the behavior of a system of identical particles.

All the indicated paradoxes are similar to the Gibbs paradox. If the properties of the gases or particles under consideration can vary only discretely, the situation cannot be considered as paradoxical: a discrete change in causes leads to a discrete change in the effects. We would have paradoxes if the behavior varied discontinuously as the "similarity parameters" varied continuously; however, in this case the behavior also changes continuously. This was shown above for internal energy. Concerning the jump in the temperature (and pressure) when real gases are mixed, the same conclusion follows from similar arguments. It seems to us that the behavior of a system of two particles can also be analyzed in similar fashion (see[17-19]).

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SOME DEMONSTRATIONS IN WAVE OPTICS PERFORMED WITH A GAS LASER

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We describe below a few lecture demonstrations of the principal interference and diffraction phenomena using a gas laser as the light source. The directionality of a laser radiation, its monochromaticity, and high intensity allow us to demonstrate these phenomena to a large audience.

1. DEMONSTRATIONS OF THE INTERFERENCE PHENOMENON FOR LIGHT REFLECTED FROM THE BOUNDARIES OF A PLANE-PARALLEL GLASS SHEET

We have found two ways of setting up such demonstrations. The scheme of the first method is shown in Fig. 1. A He—Ne laser 1 is placed facing the audience in the auditorium and shielded from them by a screen 2 of dimensions 30 × 30 cm. There is at the center of the screen an aperture large enough to pass the laser light beam. A converging lens of focal length 10 cm is placed opposite the center of the aperture in the screen on the reverse side facing the laser.

The diverging light beam from the focus of the lens falls on a plane-parallel glass plate 4 of diameter 100 mm and thickness 15 mm situated 2 m from the screen. The non-parallelism angle between the faces of the plate is of the order of one second. Its surface is polished to within "one tenth of an interference fringe." The possibility of a fine adjustment of the plate, to set the surfaces of the plate perpendicular to the axis of the light cone incident on it, is provided for by its holder. Figure 1 shows two interfering rays produced by reflection from the front and rear surfaces of the plate. These rays may be conceived as coming from two virtual images (S_1 and S_2) of a point light source S, which is the focal point of the lens used to produce the diverging beam of rays. These virtual images are formed as a result of the reflection of light from the two surfaces of the plate, and are located on the axis of the system.

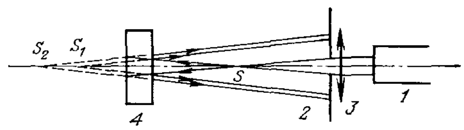

FIG. 1

The distance between the virtual sources of light is equal to 2d/n, where d is the thickness of the plate and n is its refractive index. A system of interference rings is observed on the screen 2.

At a large distance between the plate and the screen, the interfering rays will practically be parallel to each other and the interference rings observed on the screen will be fringes of equal inclination.

The second way of obtaining an interference pattern is a modification of the first method and allows a smooth variation of the distance between the light sources producing the interference pattern. Figure 2 shows the scheme of this experiment. A light beam from the laser 1 is deviated through an angle of 90° in the horizontal plane by a total internal reflection prism. A prism of minimal dimensions was used (just big enough for its face to contain the cross section of the laser light beam). This prism is mounted on the ball head of a thin vertical rod, permitting adjustment of the orientation of the prism. A lens 3, whose optical axis is inclined in the vertical plane at a small angle to the horizontal beam of light propagating through the prism, is placed at a distance of 2 m from the prism. The axis of the lens is thus inclined, so that the light beams reflected from the two surfaces of the lens fall on the upper part of the screen 5, and not on that part where the interference pattern is observed. The focal length of the lens is 12 cm. The plane-parallel glass plate 4 is mounted on the same holder, as in the first method, at a distance of 30 cm from the lens. The diameter of this plate is 50 mm and its thickness is 10 mm. The quality requirements for this plate are the same as for the plate described above.

The light rays emerging from the lens undergo reflection at the two surfaces of the glass plate and propagate backwards through the same lens, producing an interference pattern of ring fringes on the screen. The pattern is cut across by the shadow of the deflecting prism and the rod supporting it. The interference rings attain a diameter of 1 m when the distance from the glass plate to the screen is 3 m.

In this method of production of the interference pattern the lens plays a double role. First, it produces the diverging beam of rays incident on the plate. Secondly, the passage through the same lens of the reflected—from the plate—rays leads to the formation to the right of the lens of two real images (S_1', S_2') of the virtual light sources S_1 and S_2. The distance between S_1' and S_2' depends on the distance from the lens to the plate and decreases as this distance increases. This leads to the formation on the screen of interference rings, the distances between which are considerably larger than in the first method.

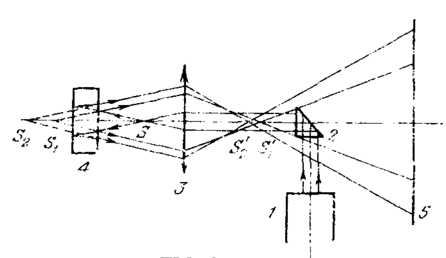

FIG. 2

2. DEMONSTRATION OF THE DIFFRACTION OF LIGHT BY AN OPAQUE SPHERE AND CIRCULAR APERTURES

A demonstration of the Poisson spots was performed in the following fashion. Ball bearings were used as the round objects on which the diffraction of the laser radiation took place. The diameter of a ball was 2 mm. The ball was glued on to the surface of a lens of focal length 5 cm. The magnified diffraction pattern was observed on a screen situated at a distance of 4 m from the lens. In this case the diameter of the region of the geometrical shadow of the ball on the screen was equal to 25 cm and the diameter of the Poisson spot at the center of the region was equal to 25 mm. Beyond the region of the geometrical shadow lay the outer diffraction rings, the visibility of which was not high.

In view of the nonuniformity in the distribution of light over the cross section of the primary laser beam, it is necessary to provide the lens, and the ball fixed to it, with micrometer transverse (with respect to the direction of propagation of the light) adjustment devices, and search for the optimum qualities of the diffraction pattern with their help.

For observation of diffraction by circular apertures, we introduce into the laser light beam by turns, with the aid of a micrometer adjustment screw feed, metallic plate-diaphragms with circular apertures of diameters 0.5 and 0.75 mm. The apertures were knife-edged just like the collimator entrance slits of spectrographs. The deviation from circular form of the apertures after drilling, $\Delta R/R$, should not exceed 0.01.

The diaphragms are glued to diverging lenses of focal length 2 cm. The screen for the observation of the diffraction pattern was placed perpendicular to the axis of the aperture of the diaphragm at a distance of 4 m from the diaphragm. To increase the dimensions of the diffraction pattern from a diameter of 10–15 cm to large dimensions, we could have placed another lens with f = 3.5 cm behind the diverging lens. The position of the diaphragm and the lens in the cross section of the light beam can be carefully adjusted by means of a micrometer feed.

By alternating in the course of the experiment diaphragms with apertures of different diameter, we essentially show that the center of the axially symmetric diffraction pattern can be a bright as well as a dark spot. These variations are the characteristic signs of a Fresnel diffraction pattern.