Observation of optical inhomogeneities induced in xenon by shock-wave radiation

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An interferometric method has been used to observe the change in refractive index of xenon arising from the action of the radiation of a shock wave propagating in the gas under study. A decrease in the refractive index begins from the moment of appearance of shock-wave luminescence. Reduction of the xenon pressure leads to a slower change of the refractive index. On screening of the investigated region by a quartz glass which does not transmit radiation with $\lambda < 2000$ Å, the optical inhomogeneities are significantly reduced. The observed in change in refractive index is associated with absorption by xenon of shock-wave radiation in the region $\lambda = 1470$–1570 Å.

Absorption of radiation by a gas can result in a change of its optical properties. The present work was undertaken to investigate this phenomenon. The gas chosen for study was xenon, whose absorption band[1] lies in the region $\lambda = 1470$–1570 Å, and the source of radiation chosen was a shock wavefront propagating in xenon.

To record the change in refractive index arising in the Xe as the result of shock-wave radiation, we used a Michelson interferometer with fringes of equal width and an arm length of about 1.5 m. The essential elements are shown in the diagram of Fig. 1. In one of the arms of the interferometer was placed a xenon-filled cell of length 50 cm, with windows through which the measuring beam was passed. The source of light for the interference pattern was a helium-neon laser of type LG-36. The interference fringes were horizontal, and the pattern obtained was rotated by the rotating mirror of a high-speed moving-image camera (MIC) using type 15 film with a velocity of 1.5 mm/μsec. The slit width of the MIC was 0.5 mm, which produced a time resolution of ~0.3 μsec. In addition to the interference pattern, the shock-wave radiation was recorded on the film. To limit the blackening of the film from the shock-wave light, we placed in the detecting channel a narrow-band interference filter with a spectral width of ~40 Å. The shock wave was excited by a charge of explosive material and propagated in Xe with a velocity ~8km/sec. Its brightness temperature[2, 3] amounted to about 35 000°K. Observation of the optical inhomogeneities was carried out a distance 4–5 cm from the surface of the explosive charge.

The interference patterns obtained under various experimental conditions are shown in Fig. 2. As can be seen, for a pressure of Xe in the cell of ~1 atm, a change in refractive index arises at the moment at which the shock wave reaches the volume with the Xe. The displacement of the interference fringes corresponds to a decrease in refractive index and is observed for a period $\lesssim 0.3$ μsec. Then the optical inhomogeneities increase rapidly, as indicated by the disappearance of the interference pattern.

A decrease of the xenon pressure leads to a slowing down of the change in refractive index (see Fig. 2b). In this case the refractive index also decreases, beginning with the passage of the shock wave into the gas. A monotonic change of refractive index is observed for a period of ~1.2 μsec, reaching a value $\Delta n \approx -1.4 \times 10^{-6}$. Then the interference pattern disappears as a result of the large inhomogeneities in the gas.

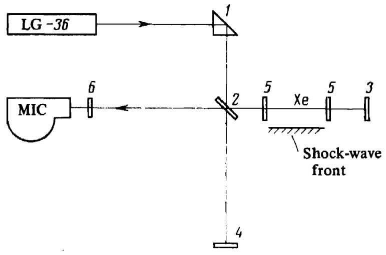

FIG. 1. Diagram of the measurement. 1—deflecting prism; 2, 3, 4—interferometer mirrors; 5—cell windows; 6—narrow-band filter.

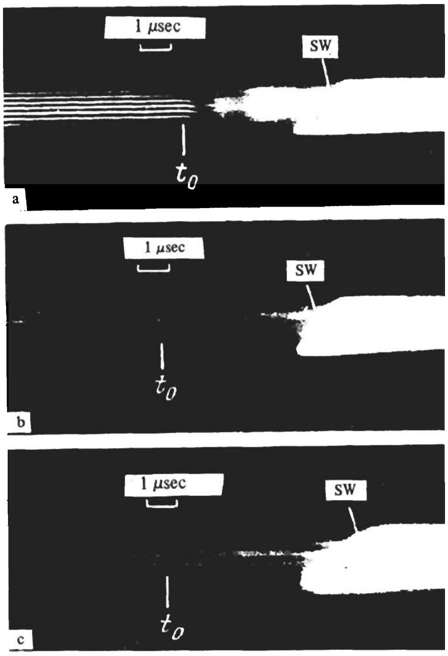

FIG. 2. Observed shift of interference fringes on irradiation of xenon by light from a strong shock wave (SW): a—Xe pressure 760 Torr; b—Xe pressure 100 Torr; c—Xe pressure 760 Torr, with the xenon placed in a quartz tube transmitting radiation with $\lambda > 2000$ Å. t_0 is the time at which the shock wave begins to propagate in the xenon.

On shielding of the measured region by quartz glass which does not transmit radiation from the shock wave with $\lambda < 2000$ Å, the interference pattern is preserved up to the arrival of the shock wave (see Fig. 2c).[1)] A small change in refractive index ($\Delta n \approx -1 \times 10^{-7}$) is observed when the shock wave passes into the xenon, which is located beyond the quartz glass.

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On comparing the interference patterns shown, we can note that the optical inhomogeneities in the xenon arise on action on the gas of radiation in the ultraviolet region with $\lambda < 2000$ Å. The decrease in refractive index indicates a process occurring with a decrease of optical polarizability of the Xe atom induced by radiation or the occurrence of some collision process which becomes possible as the result of action of the radiation. We can suggest that the optical inhomogeneities are produced by appearance of Xe molecules in the course of ultraviolet irradiation (see ref. 1). The association of Xe atoms in molecules apparently leads to a decrease in refractive index.

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1) Addition to the cell containing the Xe of an insignificant quantity of a polyatomic gas which absorbs strongly in the region $\lambda < 2000$ Å has an effect similar to that of the quartz glass, decreasing the inhomogeneities in the Xe.

[1] I. V. Kosinskaya and L. P. Polozova, Optika i spektroskopiya **30**, 853 (1971) [Optics and Spectroscopy **30**, 458 (1971)].

[2] I. Sh Model', Zh. Éksp. Teor. Fiz. **32**, 714 (1957) [Sov. Phys. JETP **5**, 589 (1957)].

[3] S. B. Kormer, A. I. Kuryapin, and M. V. Sinitsyn, in Pervyĭ vsesoyuznyĭ simpozium po goreniyu i vzryvu (First All-Union Symposium on Combustion and Explosion), Nauka, 1968, p. 174.

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102