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RADIATION OF AN INTENSE SHOCK WAVE IN A FINITE LAYER OF XENON

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Strong shock waves in gases are powerful radiation sources [1-3]. During motion of such a shock wave a region of heated gas is formed ahead of the front, which screens the energy of radiation leaving the front surface [1]. This screening effect hinders achievement of high brightness temperatures and radiation fluxes, restricting the possibilities for using intense shock waves as radiation sources.

The experiments of [4] showed that in neon at normal density, brightness temperatures $T = 10^5$ K and radiant flux densities $\Phi = 200$ MW/cm^2 can be achieved, although requiring a high (~50 km/sec) shock wave velocity, which can be achieved only by using cascaded equipment [5]. When heavy gases such as xenon and krypton are used high temperatures behind the front can be achieved at lower shock wave velocities but the screening effect which has practically no influence in experiments using neon, because of the high first ionization potential, significantly reduces the maximum values of T and Φ. Thus for xenon at normal density recorded values of T do not exceed $6 \cdot 10^4$ K, with $\Phi - 18$ MW/cm^2 [3].

In order to create more powerful radiation sources [6] proposed a method for attenuation of the screening effect by limiting the thickness of the working gas layer through which the powerful shock wave moves. Then after arrival at the target of the heated layer practically all the radiation departing from the shock wave front succeeds in striking the target.

In the present experiments the possibility of attenuating the screening effect was investigated using a strong shock wave moving in xenon with an initial pressure of $3 \cdot 10^3$ Pa. The pressure was chosen so that the characteristic dimensions of the experimental device (Fig. 1) were comparable to the radiation path length in the heated layer. The strong shock wave was generated using an explosive gas compressor 1, then gradually expanded in diffusor 2, arriving in glass tube 3, which contained a diaphragm 4, glass target 5 with strips of aluminum coating of various masses 6, and a mirror 7. The diffusor provided a smooth transition of the shock wave from the compressor to the glass tube, while the diaphragm was used to cut off turbulence near the wall [3]. The mass of the aluminum coating varied from 0.15 to 1.89 mg/cm^2. By recording the time of appearance of scintillation at the point where a band of

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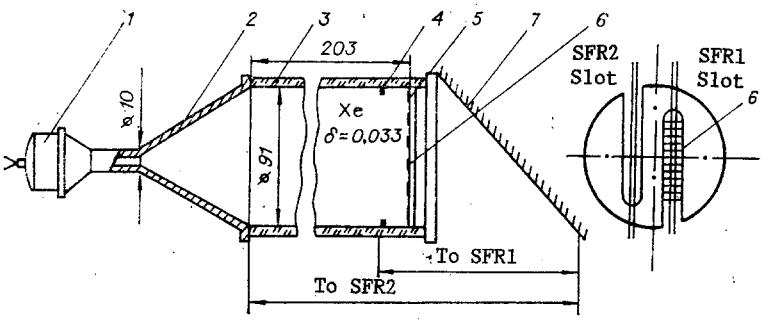

Fig. 1

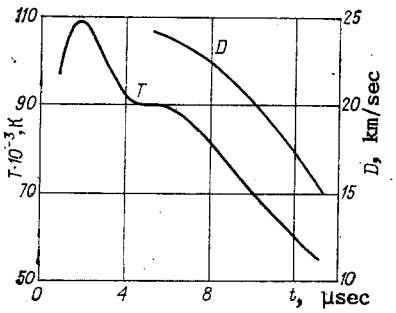

Fig. 2.

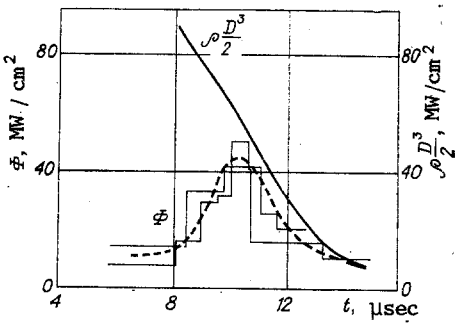

Fig. 3

known mass had been evaporated with consideration of the position of the shock wave front relative to the target, it was possible to determine the radiant flux density from the front arriving at the target as a function of time. We used the experimental dependence of [2] of aluminum evaporation on high power continuous spectrum radiation. The time of appearance of scintillation at the point where the aluminum band evaporated, the motion of the shock wave front, and the brightness temperature at a wavelength of 430 nm (filter half-width 20 nm) were measured by optical methods using SFR high speed photorecorders.

Figure 2 shows the time dependences of brightness temperature T and shock wave velocity D. The shock wave velocity changes smoothly from 24 km/sec at exit from the diffusor (t = 5 μsec) to 15 km/sec when the wave arrives at the target (t = 15 μsec), while front brightness temperature changed from $9 \cdot 10^4$ to $5.5 \cdot 10^4$ R. At the initial moment when the shock wave moved with an average velocity of 45 km/sec in the gas compressor tube, the front brightness temperature reached $11 \cdot 10^4$ K. Uncertainty in brightness temperature measurement did not exceed 9%. No intrinsic scintillation from the heated layer was recorded in the experiments.

Figure 3 shows the time dependence of radiant flux density Φ departing from the shock wave front and falling on the target, together with the hydrodynamic energy flux density $\rho D^3/2$ through the shock wave front (the dashed line is the result of averaging experimental data). The radiant flux density departing the shock wave front and arriving at the target at the moment of shock wave exit from the diffusor ~10 MW/cm^2. Then with approach of the front to the target at a distance of 100 mm the flux first increases, reaching its maximum value of 45 MW/cm^2 at a distance of 70 mm from the target, then decreases because of shock wave attenuation. After reaching its maximum the radiant flux density comprises 0.7-0.9 times the density of the hydrodynamic energy flux $\rho D^3/2$ through the shock wave front, where ρ is the gas density ahead of the front.

The results obtained indicate that by limiting the thickness of the xenon layer through which the strong shock wave passes a significant improvement in the shock wave parameters is possible. The brightness temperatures and radiant fluxes recorded at significant distances from the shock wave front are 1.5 and 2.5 times the corresponding maximum values obtained for a shock wave in xenon of normal density.

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CORRELATION SPECTROSCOPY METHODS FOR STUDY OF VELOCITY PROFILES IN THIN FLOWS

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The study of velocity profiles of laminar and turbulent flows by correlation spectroscopy methods has demonstrated the broad possibilities of that approach [1-3], both as regards the accuracy of resolution over coordinates (of the order of hundreds of μm) and with respect to the time required to gather data and the range of velocities studiable (from μm/sec to hundreds of m/sec).

The recent development of new processes based on use of materials in the monodispersed phase [4] has stimulated study of the mechanism underlying forced capillary decay of liquid jets – a phenomenon upon which creation of monodispersed microparticles is based, i.e., particles having small scattering of parameters and dimensions in the range 10-1000 μm [5].

In studying monodispersed decay of a jet, questions arise regarding relaxation of the velocity field and increase in perturbation within the flow. To study these effects we will use correlation spectroscopy methods. The experimental technique is then quite simple, consisting of measurement of the correlation function (CF) of coherent light scattered on the flow (for example, helium laser light).

The goal of the present study is to briefly analyze the possibilities of correlation spectroscopy for the study of velocity distribution profiles in thin jets.

The correlation function of the scattered light is defined by the expression [1]

$$G^{(1)}(\tau) = \langle \varepsilon^*(0)\varepsilon(\tau)\rangle,$$

where $\varepsilon(\tau)$ is the electric field intensity at time τ, and the angular brackets denote averaging over the ensemble or over time. In our case the scattered light has Gaussian statistics*, i.e., the Siegert relationship

$$g^{(2)} = 1 + |g^{(1)}|^2.$$

*In principle the effects of non-Gaussianness of the scattered light can produce additional information on nonsteady-state flows.

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