Luminescence of Powerful Plasma Formations in Air

S.M. Slobodjan, S.A. Shishigin
Tomsk Polytechnical University, Institute of Atmospheric optics SB RAS
sms_46@ngs.ru, shansss@mail2000.ru

The up-to-date powerful lasers allow to create in air plasma formations with parameters, close to plasma parameters in a lightning and a nuclear detonation.

Nonadiabatic interactions of particles with powerful laser weed in a resonance leads to occurrence of group of the accelerated electrons with energy 60 кеV at density 5 $10^{12}cm^{-3}$ [1] that changes optical properties of air round plasma because of chemical responses under the influence of an ionising radiation and a shock wave of the centre of a disruption. The strong restriction of duration of a luminescence occurs for radiation of a red spectroscopic gamut which at a medial power density of laser radiation more (5 - 7) $*10^8$ W/cm^2 are not registered (Fig. 1в). Power of a luminescence in blue field of a spectrum fluctuates in time damping.

In photos Fig. 2 laser-induced spark images are given. Medial on traversal section of a beam the radiation power density changed from $5*10^7$ W/cm^2 (а) to 10^9 W/cm^2 (д). The gauge of images in photos is above specified, and in the upper picture by an arrow the direction of propagation of laser radiation is shown. The photo 2 (а) corresponds to a time dependence of power of a luminescence of the centre figured on Fig. 1а. The subsequent photos of the centres with a time dependence of power of a luminescence are similar Fig. 1в, г, д.

Any ionisation of air leads to formation of ions of oxygen (section of a photodissociation $6,5*10^{-16}cm^2$) and nitrogen dioxides (impairment section $2*10^{-19}cm^2$) [2,3] which considerably attenuate visible radiation. Intensity of an irradiation of air, necessary for making of gas halo NO_2 in radius 5 cm, makes the order of 500 W/cm^3.

In Fig.3а, dependences of concentration NO_2 on distance before plasma formation for two intensities of laser radiation (10^8 W/cm^2, 10^9 W/cm^2) during time moments 10^{-7}s., $5*10^{-7}$s. are given, gained taking into account peakly observable equilibrium concentration NO_2 in air at action of an ionising radiation of 6 % [4]. Dependence of optical thickness D of halo NO_2 for radiation with a wave length 0,4 microns is constructed. (Impairment section $2*10^{-19}cm^2$ molecule of dioxide of nitrogen) from a power density of laser radiation for two moments of time 10^{-7}s., $5*10^{-7}$s. Fig. 4. It is visible that at the power density of laser radiation exceeding $10^9W/cm^2$, the halo optical density sharply increases in time $5*10^{-7}$s., considerably exceeding 1, practically screening a thermal luminescence of the plasma centre.

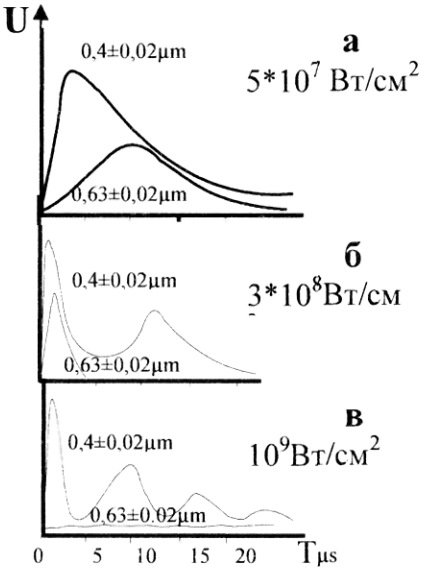


Fig. 1. Typical oscillograms of a luminescence of the centres of an optical disruption in visible sites of a spectrum at the different power density of laser radiation

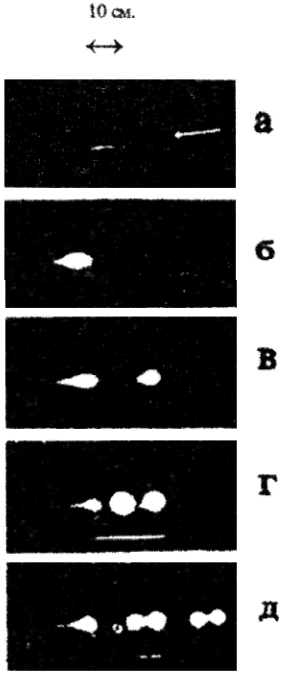
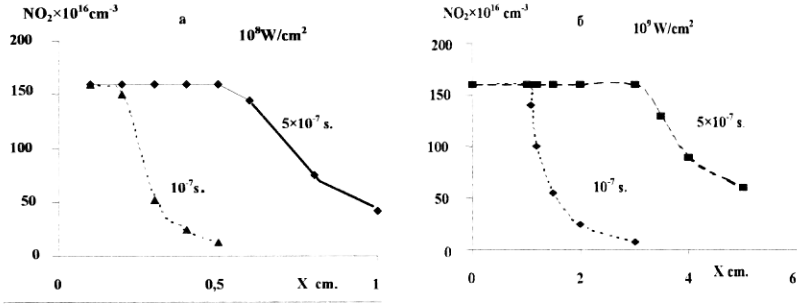


Fig. 2. Photos of the centres of an optical disruption sparks

Excitation of Langmuir waves in plasma of an optical disruption of gas leads to volume growth of the plasma centre of an optical disruption (Fig. 2 б,в,г,д), in comparison with linear light-detonation a mode of distribution of plasma towards to a laser beam at lower power densities of laser radiation (Fig. 2a).

Observable changes of power of a luminescence of the plasma centres in various sites of the spectrum, related to formation of a gas halo with raised concentration NO_2, specify about threshold character of occurrence of a powerful stream of radiative radiation from plasma formations with energy of particles of the order 10^4 eV.



It is necessary to score that local ionisation of molecules of air in atmosphere in a visible gamut of electromagnetic waves (at photographing) is a transient radiant of a luminescence or opaque microscopic objects for transiting light [5]. Air ionisation can be related with space radiative radiation, decay of radioactive substances, electrical discharges.

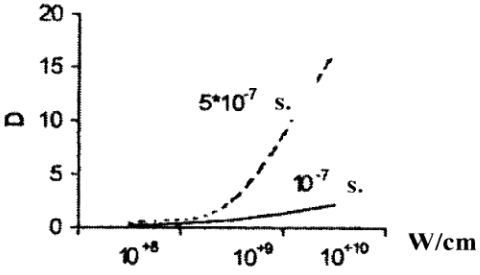


Fig.4. Dependence of optical thickness D of gas halo NO_2 for radiation with a wave length 0,4 μm from intensity of laser radiation I

1. I.R.Gekker. *Interaction of the strong electromagnetic fields with plasma.* 1978, pp. 312.

2. M T Dmitriev. *Fiz. athmosph. and ocean,* 1965, v.1, № 3, pp.302-312.

3. Yu.P. Raizer. Physics of a discharge through gases. 1987, pp. 592.

4. S.JA.Pshezhetsky, M.T.Dmitriev. *Radiative physicochemical processes in aerial medium.* 1978, p.182.

5. A.P.Godlevsky, Yu.D.Kopytin. The Quantum electronics, **9**, № 6, 1280 (1982).