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FAST OVERLAP OF MICROWAVE RADIATION BY AN IONIZATION AUREOLE OF A SPARK IN A LASER BEAM

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We report in this article microwave investigations of a fast photonionization aureole from a light spark in a laser beam. These investigations were carried out in a range of tens and hundreds of nanoseconds, unlike in [1] and in the usual cases of microwave diagnostics, when much longer times are investigated. In [1] we investigated ionization behind a shock wave. In this article we investigate ionization from a flash of ionizing radiation that leads the shock wave from the spark.

The spark from a focused Q-switched laser beam was flashed in front of a radiating antenna fed from a magnetron generating at 8 mm. The receiving antenna was placed either behind the spark (in overlap investigations) or at different angles (in reflection investigations).

Figure 1 shows typical oscillograms (sweep duration 500 nsec) of an overlap signal with a rise time of 30 nsec (upper beam) and a 45° backward reflection signal (lower beam) from a spark in air. The magnitude of the overlap signal made it possible to estimate the dimensions of the aureole (by comparison with the change of the current in the receiving detector following introduction of bodies modulating the plasma). Its radius was a ≃ 1.5 - 2 cm. Investigations of the area of the microwave-radiation overlap by the aureole from the spark were also carried out by comparing the overlap signal at different distances from the spark to the antenna axis. The distances at which the overlap signal changed by several times agrees with the dimensions of the overlap area given above, obtained by comparison with models. The values of the reflection signal at different large angles, including back reflection, were commensurate with the overlap signal.

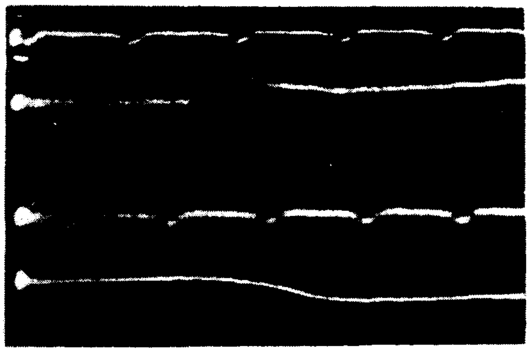
Fig. 1

This shows, apparently, that the scattered radiation is due not only to absorption diffraction, but also to the high reflectivity of the aureole plasma. This allows us to assume that the concentration of the plasma of the fast aureole from the light spark is $n_e \gtrsim 10^{13}$ cm^{-3}, which is two orders of magnitude stronger than the inequality $n_e > 10^{10} - 10^{11}$ cm^{-3}, obtained from the time of perturbation of the external electric field by the polarization of the light-spark aureole [2].

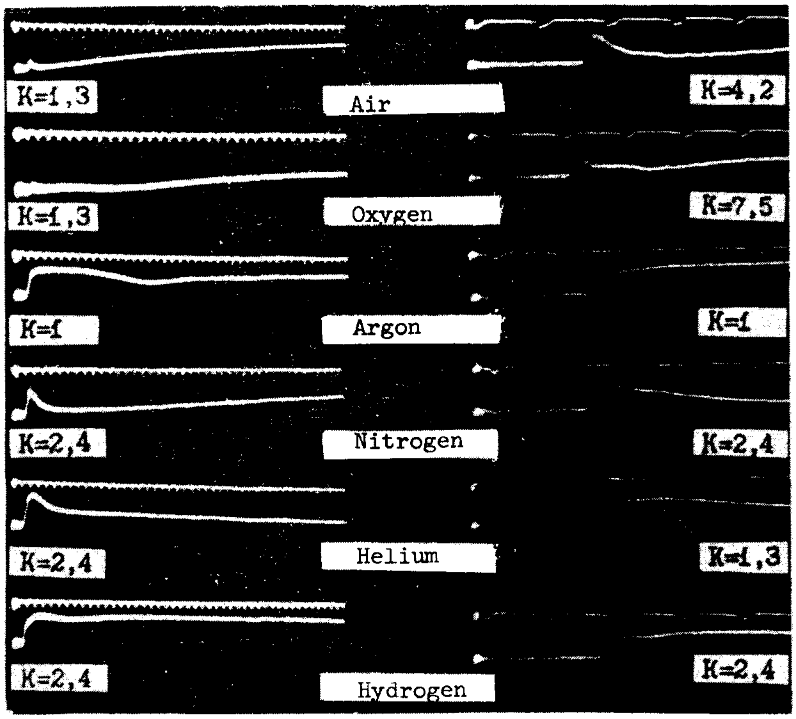

Fig. 2

Different sparks with different ionization aureoles are obtained for different gases. Figure 2 shows, for different gains K, overlap signals from a light spark in air, oxygen, argon, nitrogen, helium, and hydrogen, with sweep durations 4 and 0.5 μsec. In some gases we can see separation of the ionization flash of the fast aureole from the slowly growing ionization behind the shock wave. The decrease in the overlap after production of the fast aureole is caused both by the decreased electron density, due to their "adhesion," and by the decrease in the collision and recombination frequency. We note that the lifetime of the electron prior to "adhesion" in air and the time of energy transfer to the elastic collisions are commensurate with the lifetime of the fast aureole. In argon we observed a powerful light spark and a more concentrated ionization aureole of large dimensions. No decrease in overlap was observed, this being apparently due to the absence of electron "adhesion." In oxygen, the magnitude and duration of the fast-overlap pulse are small, and this can be attributed to strong "adhesion." The conditions and dynamics of the "adhesion" in the fast aureole may differ from the case of unperturbed gas, in view of the presence of metastable atoms (thus, for example, the presence of the metastable state of nitrogen can intensify the "adhesion" process).

The essential data obtained are the high speed of the strong overlap of the radiation by the fast aureole after a time ~10 nsec, and the large overlap areas. These data raise the hope that the fast aureole will be usable for sharp overlap, modulation, or diversion of a microwave beam.

In conclusion, we thank D. K. Akulina and A. D. Smirnova for valuable advice, and L.

Kolomeitsev for help with the work.

[1] G. A. Askar'yan, M. S. Rabinovich, M. M. Savchenko, A. D. Smirnova, and V. P. Studenov, JETP Letters 1, No. 6, 18 (1965), transl. 1, 162 (1965).

[2] G. A. Askar'yan, M. S. Rabinovcih, A. D. Smirnova, and V. B. Studenov, JETP Letters 2, 503 (1965), transl. p. 314.

TWO-CAVITY LASER AS HIGH-RESOLUTION SPECTROSCOPE

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It is customarily assumed that the resolving power of a spectroscope is limited by the width of the spectral line. Feld et al. [1] have shown that it is possible to resolve spectral components inside a Doppler (inhomogeneously broadened) line, so that the limit of resolution is determined by the homogeneous broadening. It will be shown below that in a laser it is possible to resolve spectral components within the limits of a homogeneously broadened line, so that the resolution limit of such a spectroscope is apparently determined by the width connected with the monochromaticity and stability of the radiation source.

To resolve the components within a homogeneously broadened spectral line it is expedient to use a laser with two cavities in tandem.

The idea of the spectroscope consists in the following. As is well known, a beam of active molecules passing through the first cavity is polarized there under the influence of the monochromatic signal. The polarized beam, on entering the second cavity, produces there "molecular ringing" (coherent spontaneous emission) having the same frequency as the signal frequency in the first cavity. The phase of the signal in the second cavity depends on the frequency difference between the signal and the peak (center of gravity) of the spectral line and on the distance between cavities [2]. If this distance is modulated, the phase of the signal in the second cavity is also modulated, but if the signal frequency coincides exactly with the peak of the line, then the modulation of the distance between resonators does not cause phase modulation.

On the other hand, owing to the saturation effect, the position of the line peak changes with the magnitude of the signal in the first cavity. By measuring the generation frequency at which the phase in the second cavity does not depend on the modulation of the distance between the resonators, at different values of the signal in the first cavity, we can obtain as many independent relations as there are hyperfine structure components in the line. Simultaneous solution of these relations makes it possible to determine the position of the hyperfine structure components.

The calculation was carried out for illustrative purposes in the case of a line with two spectral components, although it can be readily generalized to include an arbitrary number