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V. M. Eleonskiĭ, L. G. Oganes'yants, and V. P. Silin. Vector Structure of Electromagnetic Field in Self-Focused Waveguides. Self-focused distributions of the electromagnetic field in nonlinear media were first investigated theoretically in[1]. Progress from the simplest single-component structure of the localized field to more complicated ones was made in recent years[2,3]. Field structures up to general three-component type have by now been investigated.

The equations of nonlinear electrodynamics (see[3]) admit of solutions $E(x)\exp(ik_z z)$ in the case of planar geometry, and make it possible to separate two types of exact solutions with single-component $(0, E_y, 0)$ and two-component $(E_x, 0, E_z)$ electric vectors, as well as the more general case of three-component solutions (E_x, E_y, E_z). The system of equations of nonlinear electrodynamics includes the conservation law

$$H = P^2 - k_z^2 E_y^2 + [(k^2\varepsilon - k_z^2)^2 - k_z^4]\, k_z^{-2} E_x^2 + k^2 \int_0^{E^2} \varepsilon(q)\, dq,$$

where $k = \omega/c$, $P = d\dot{E}_y/dx$, and $\epsilon(E^2)$ the nonlinear dielectric constant. This makes it impossible to determine in the space (E_x, E_y, E_z) at $H = 0$, which is essential for self-channeling, a boundary surface $P(E_x, E_y, E_z) = 0$ inside of which all the localized solutions are located. The boundary conditions for the self-channeling fields are

$$\lim_{E\to 0} (E_z/E_x) = \pm [k_z^2 - k^2\varepsilon(0)]^{1/2} k_z, \quad \lim_{E\to 0} (E_y/E_x) = C,$$

where C is a parameter of the problem proper. A qualitative analysis and numerical integration indicate that there exists a sequence of three-component fields localized in space. The results of a numerical integration, performed for $\epsilon = \epsilon_0 + \epsilon_2 E^2 E_N^{-2}$, are shown in Figs. 1 and 2, where the projections of the electric-vector motion are shown together with the spatial distribution of the field. The self-channeling three-component fields are characterized by a unique structure with low symmetry. The localization region of the obtained self-channeling

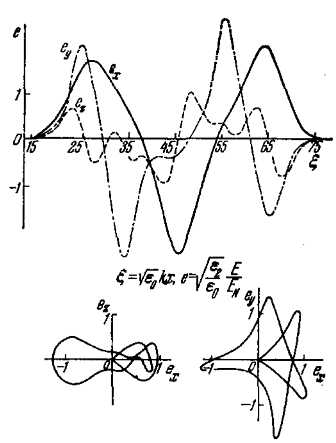

FIG. 1

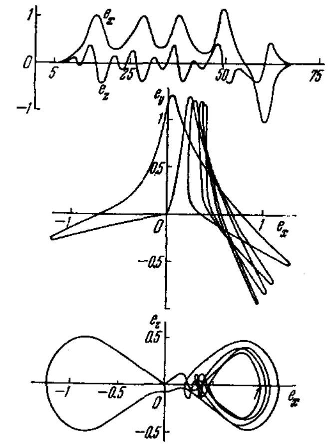

FIG. 2

waveguides exceeds the characteristic dimension of the localization region of the one- and two-component states by several times. However, the largest projections E_y and E_x, E_z for the three-component localized states do not exceed the largest values of the corresponding projections for the localized one- and two-component states. The reason is that the characteristic dimensions of the boundary surface $P(E_x, E_y, E_z) = 0$, which is a degenerate torus, are determined by the parameters of one- and two-component localized states. Localized three-component states of the field can be ordered in accordance with the number of tangencies of the electric vector, which describes a closed curve in the space (E_x, E_y, and E_z), with the boundary surface. For example, for the states shown in Figs. 1 and 2, the number of tangencies between the entry and departure points of the 0-field regions is six and ten, respectively. A single-component localized state (waveguide of TE type) corresponds to one tangency, and a two-component state (waveguide of type TM) corresponds to motion over a curve lying on the boundary surface. We note that three-component self-focused waveguides correspond to allowance for both the transverse and longitudinal degrees of freedom of the electromagnetic field.

In the case of cylindrical geometry, the equations of nonlinear electrodynamics admit of solutions $E(\rho)\exp(ik_z z + im\varphi)$. At $m = 0$, i.e., for fields that do not depend on the azimuthal angle, it becomes possible to separate not only two types of exact solutions with one- and two-component vectors $(0, E_\varphi, 0)$ and $(E_\rho, 0, E_z)$, but also a more general three-component solution (E_ρ, E_φ, E_z). A feature of such a three-component solution is that at $m = 0$ the connection between the electric-vector projections E_φ, E_ρ, and E_z is only via a nonlinearity, namely the dielectric constant. The problem is to find the eigenvalues of a pair of parameters, namely, the z-projections of the electric and magnetic fields on the axis of the self-focused waveguide. Numerical integration leads to a three-component localized state with the field distribution shown in Fig. 3. The same figure shows the projections of the motion of the electric vector, characterizing the peculiar polarization structure of the electromagnetic field. We note that the characteristic dimension of the localization region in space, the characteristic values of the projections of the electric vector, and also the energy flux are all of the same order as for the first non-fundamental one- and two-component states[3]. We indicate that in the case of cylindrical self-focused waveguides, the longitudinal fields turn out to be comparable with the transverse ones in magnitude.

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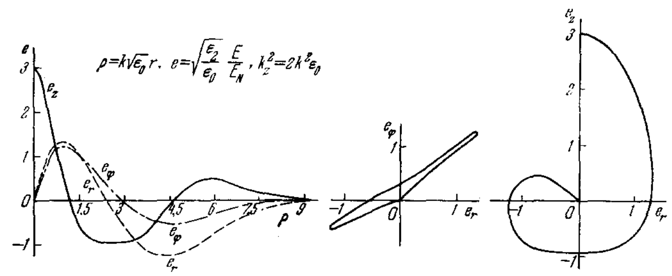

FIG. 3

SCIENTIFIC SESSION OF THE DIVISION OF GENERAL PHYSICS AND ASTRONOMY AND OF THE DIVISION OF NUCLEAR PHYSICS OF THE USSR ACADEMY OF SCIENCES (23–24 February, 1972)

A scientific session of the division of General Physics and Astronomy and of the Division of Nuclear Physics of the USSR Academy of Sciences was held on 23 and 24 February, 1972 in the conference hall of the Physics Institute of the USSR Academy of Sciences. The following papers were delivered at the session:

1. S. É. Frish, Role of Atom-Atom and Atom-Molecule Collisions in the Excitation and Ionization of Atoms.
2. V. E. Zuev, Laser Sounding of the Atmosphere.
3. M. A. Markov, Global Properties of Collapsing Matter.
4. I. D. Novikov, Gravitational Field and Metric of Collapsing Object.

We publish below brief summaries of three of the papers.

S. É. Frish. Role of Atom-Atom and Atom-Molecule Collisions in the Excitation and Ionization of Atoms. The paper describes a group of investigations performed under the direction of the author at the Optics Department of the Leningrad State University. The investigations pertain to inelastic collisions of particles having thermal velocities, one or both particles being in the excited state. The observations show that such collisions are characterized by large effective cross sections that reach values on the order of 10^{-16}–10^{-15} cm^2. Their role in the aggregate of processes that occur in a gas-discharge plasma can therefore be appreciable in those cases when the particle concentrations are low.

In the main, processes of the following types were considered:

$$A^* + B \rightarrow A + B^* + \Delta E, \qquad (1)$$

$$A^* + B^* \rightarrow A + B^{**} + \Delta E, \qquad (2)$$

$$A^* + B^* \rightarrow A + B^{+*} + e + \Delta E, \qquad (3)$$

$$A^* + B_2 \rightarrow A + B_2^* + \Delta E, \qquad (4)$$

$$A^* + B_2^* \rightarrow A + B_2^{+*} + e + \Delta E. \qquad (5)$$

The process (1) constitutes collisions of the second kind between excited and unexcited atoms. An experimental investigation of such a process is usually carried out by one of two methods, sensitized fluorescence or stationary glow of the plasma. However, in spite of the large number of performed investigations, many aspects of process (1) remain unclear. We have used in our investigations two other methods, namely, excitation with an electron beam and observation of the cross section of a decaying plasma.

Bogdanova and Marusin[1] have shown that when luminescence is excited in gases or liquids by electron beams, under conditions of sufficiently good monokinetization and single collisions, the brightness of certain lines increases selectively, and this increase can be explained by means of process (1). The character of the decrease of the brightness of such light is after the electron is turned off confirms this point of view. Further, if the electron velocity is varied, it is possible to observe the optical excitation function of the lines that are amplified by collisions of the second kind. It was shown, e.g., that in a mixture of sodium and mercury vapors the optical excitation function of the doublet Na I, $9^2S \rightarrow 3^2P$, $\lambda 442.3/2.0$ nm coincides with the excitation function of the mercury line $6^3P_1 \rightarrow 6^1S_0$, $\lambda 253.7$ nm. This confirms directly that the indicated doublet of sodium is excited by transfer of energy from the sixth $^3P_1$ state of mercury. Thus, the electron-beam method affords additional possibilities of investigating collisions of the second kind.

Observation of afterglow of the plasma also offers many advantages in comparison with observation of a stationary discharge. In the latter it is difficult to separate the excitations due to atom-atom and atom-electron collisions. In the afterglow, on the other hand, different processes are characterized by different relaxation times, and this makes it possible to separate them from one another. If, e.g., an excited atom is in a metastable state, then the damping of the processes due to collisions with them will be much slower than that of processes due to collisions with fast electrons.

Bochkova and Tolmachev[2] have investigated the afterglow of a mixture of argon with krypton. It was shown that several krypton lines have a damping time that coincides with the disintegration time of metastable argon atoms. Similar observations were carried out for a mixture of helium with xenon. In this case, the process follows the scheme (3). The metastable He atoms 2^1S or 2^3S collide with metastable xenon atoms, as a result of which excited xenon ions are produced. The spectrum reveals a number of Xe II lines, which show a large damping time. In this case, the effective cross sections are large also at considerable excess energies ΔE. The excess energy is carried away by the produced free electron.