tions 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.

[1] T. F. Volkov, in: "Fizika plazmy i problema upravlyaemykh termoyadernykh reaktsii" (Plasma Physics and the Problem of Controlled Thermonuclear Reactions), vol. 3, AN SSSR, 1958, p. 336; V. I. Talanov, Izv. vuzov (Radiofizika) 7, 564 (1964); R. Y. Chiao, et al., Phys. Rev. Lett. 13, 479 (1964).
[2] A. G. Litvak, Izv. vuzov (Radiofizika) 9, 675 (1966).
[3] V. M. Eleonskiĭ et al., Zh. Eksp. Teor. Fiz. 62, 81 (1972) [Sov. Phys.-JETP 35, 44 (1972)].

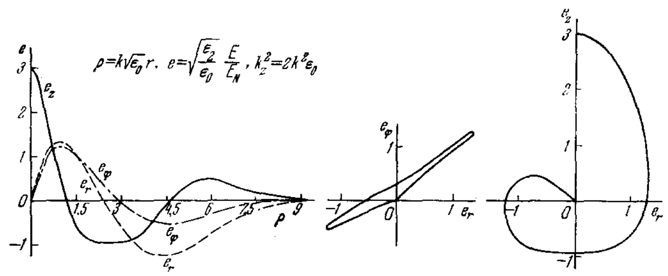

FIG. 3

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:

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

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

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

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

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

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.

The process (2) was observed in pure mercury vapor. The sum of the excitation energies of two mercury atoms in the states $6^3P_{0,1,2}$ is somewhat smaller than the ionization energy of the mercury atom. Therefore collisions produce a strongly excited mercury atom. Indeed, the afterglow revealed a large damping time (on the order of 100 μsec) for a number of lines excited in accordance with the scheme (2). By way of example, we indicate the collision

$$\mathrm{Hg}\,(6^3P_0) + \mathrm{Hg}\,(6^3P_0) \rightarrow \mathrm{Hg}\,(6^1S_0) + \mathrm{Hg}\,(8^1S_0).$$

The production of a mercury atom in the state 8^1S_0 is manifest by the presence in the afterglow of a 491.6 nm line of Hg I, with a large damping time and a quadratic dependence of the brightness on the concentration of the excited atoms.

The excitation of a molecule as the results of collisions with metastable atoms was observed by Bochkova and Chernysheva[3] in the luminescence of a mixture of argon and nitrogen. A selective intensification of the brightness of the second positive system of N_2 took place. In this case, the excess energy of the colliding particles was transformed into rotational energy of the N_2 molecule, a fact manifest by an enhancement of the rotational structure of the bands. In the collision of metastable helium atoms with N_2 molecules, an enhancement of the brightness of the negative system of molecular bands of nitrogen was observed, indicating the presence of the process (5).

[1] I. P. Bogdanova and V. D. Marusin, Opt. Spektr. 26, 154; 27, 724 (1969); 31, 339 (1971).

[2] O. P. Bochkova and Yu. A. Tolmachev, ibid. 25, 342 (1968); 32, 827 (1972).

[3] O. P. Bochkova, and N. V. Chernysheva, ibid. 28, 35 (1970); 31, 677 (1971).

V. E. Zuev. Laser sounding of the atmosphere. The capabilities of the existing standard methods of investigating in the atmosphere have been practically exhausted, and these methods can not provide the necessary information with sufficient spatial and temporal resolution, on the atmospheric parameters, needed for the solution of many scientific and applied problems. The laser-sounding method is a fundamentally new method of remote determination of the parameters of the atmosphere, and is destined to replace completely, in final analysis, the existing methods of investigating on the atmosphere. The idea of the method of laser sounding of the atmosphere consists in the following. A laser pulse propagating in the atmosphere leaves behind it a trail of absorbed, scattered, and re-radiated photons resulting from the interaction with the material of the atmosphere. The interaction of the laser pulse with the atmosphere can be manifest in the phenomena of aerosol and molecular scattering, molecular absorption, Raman and resonant scattering, and also echo-signal fluctuations due to atmospheric turbulence.

By registering and interpreting the trails of the interaction of laser pulses with the atmosphere, it is possible in principle to extract information on different parameters of the atmosphere. Laser meteorological locators are called lidars in analogy with radars. The potential capabilities of lidars depend on which phenomenon in the interaction of the radiation with the atmosphere is being used, as well as on the parameters of the lidars themselves. The largest interaction cross sections is possessed by resonant absorption, and the smallest by Raman scattering. The difference between the interaction cross sections of these two phenomena can reach many orders of magnitude.

The main elements of a lidar are a laser, a receiving mirror antenna, a system of filters, a radiation receiver, a signal amplifier, and a recording unit. Most lidars employ Q-switched ruby lasers with pulse energy up to 25 J and pulse durations of several times 10 nanoseconds.

If molecular scattering is used in the sounding then, using a ruby-laser pulse energy of several joules, a receiving-antenna diameter 1 m, a radiation receiver in the form of a photomultiplier with dark current 100 photons/sec, and an interference filter of width 10 Å at a transmission of 50% it is possible under nighttime conditions to obtain a continuous profile of the echo signal up to altitudes of 30–40 km. When the atmosphere is sounded at higher altitudes, a series of pulses is used in order to accumulate the information. The best of the presently known lidars makes it possible to sound the density of the atmosphere up to altitudes of 100 km.

A quantitative analysis of the interaction of optical waves with the atmosphere leads to the conclusion that it is possible potentially to use lidars to sound all the gaseous components of the atmosphere, aerosol structures (stratification of layers, size spectra, particle concentrations in haze, clouds, fogs, smoke, dust, and precipitation), temperature, density, pressure, wind velocity and direction, and the turbulent structure of the atmosphere.

Experiments on laser sounding of the atmosphere yielded data on the stratification of aerosol layers, on the density, pressure, and temperature of the atmosphere at high altitudes, on the concentration profiles of nitrogen, oxygen, water vapor, and sodium vapor, and on the radial component of the wind velocity.

Further progress in the method of laser sounding of the atmosphere can follow the line of development of new technology and the solution of the inverse problems of the optics of the atmosphere. One should expect the appearance of the first commercially produced lidar in the next 4–5 years.

The paper is based on the following materials now in press: V. E. Zuev, Lazer-meteorolog (Meteorology Laser), Gidrometeoizdat; Lazernoe zondirovanie atmosfery (Laser Sounding of the Atmosphere), article in "Priroda."

I. D. Novikov. Gravitational Field and Metric of Collapsing Object. Modern theory of gravitation and the theory of the evolution of stars predict the existence in the universe of collapse stars ("black holes"), which are stars whose nuclear evolution has terminated, compressed by the gravitational force to dimensions of the order of their gravitational radii $R_g = 2GM/c^2$. Recently, in connection with the searches for these objects, interest of the theoreticians in the problem of gravitational collapse has greatly increased.

The main properties of the collapse of a spherical