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

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

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 sphere were described more than 30 years ago. It was shown that after compression to the gravitational radius, the star should become compressed with catastrophic large velocity, passing through an infinite curvature of space time, a singularity. The gravitational field does not emit any radiation from a region smaller than R_g, and what happens to the star after compression to R_g will never be knwon to an external observer. Such objects are called "black holes." Relatively recently, it was shown that in addition to "black holes," there can exist in nature also "white holes," or bodies that expand out of their gravitational radius.

Analysis has shown that when asymmetrical bodies contract, they form "black holes" only if their dimensions in all the directions are smaller than R_g. During the course of compression of non-rotating bodies, the resultant gravitational field of the "black hole" turns out to be spherically symmetrical, and all the deviations from the symmetry are radiated in the form of gravitational waves.

In the case of the collapse of a rotating body, the field of the "black hole" is described by the so-called Kerr metric. The main feature of this metric is the presence near R_g of an "ergosphere," a region in which all the bodies should rotate about the "black hole." The physical processes in the "ergosphere" make it possible, in principle, to draw rotational energy from the "black hole." It is possible, in principle, to remove up to $\Delta E \approx 0.29\ mc^2$ of the total energy of a "black hole" rotating with maximum velocity.

It is shown that collapse of even an asymmetrical body after compression to below R_g leads inevitably to a singularity of the gravitational field. The subsequent evolution of the body depends not only on the conditions in the entire infinite space outside R_g, from which the collapse of the body takes place, but also on additional conditions that occur in the space-time region inside R_g.

It is important to emphasize that when stars and more massive bodies collapse, the physical conditions in all of space, up to R_g, are described completely by modern physics (at densities less than nuclear and temperatures below 10^{10} °K), the tidal forces for bodies with the quasar mass $10^8 M_\odot$, for example, do not exceed those on earth, and there is no need to take quantum effects or some other forces into account.

Several methods are proposed for searching for "black holes" by astronomic methods. It is proposed to search for "black holes" occurring at the end of the evolution of massive stars among binary stars, and among x-ray and γ sources.

These questions are dealt with in greater details in the book Teoriya tyagoteniya i evolyutsiya zvezd (Theory of Gravitation and the Evolution of Stars), Nauka, 1971.

Translated by J. G. Adashko