MEETINGS AND CONFERENCES

Scientific Session of the Division of General Physics and Astronomy, USSR Academy of Sciences (28-29 November, 1973)

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A scientific session of the Division of General Physics and Astronomy of the USSR Academy of Sciences was held on November 28 and 29 at the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. V. A. Krat, New Data for Solar Physics from Observations in the Stratosphere.

2. V. E. Zuev, Laser Sounding for Atmospheric Pollution.

3. G. A. Askar'yan, E. K. Karlova, R. P. Petrov, and V. B. Studenov, Vaporization, Burning Off, and Confinement of Oil and Other Films on Water Surfaces with the Aid of Powerful Laser Beams.

4. V. M. Agranovich, B. N. Mavrin, and Kh. E. Sterin, Effects of Strong Anharmonicity of Phonons and Their Damping in Polariton Raman Scattering Spectra.

5. I. M. Khalatnikov, Phase Transitions in He^3.

We publish below brief contents of the papers.

V. A. Krat. New Data for Solar Physics from Observations in the Stratosphere. The Soviet stratospheric solar observatory made its fourth flight on June 20, 1973. For this flight, the Cassegrain optical system of the telescope with 0.5-meter primary mirror was replaced by an optical train having a 1-meter primary. Scientific material of excellent quality (in regard to resolution of detail) was obtained.

Study of the scientific material of the first three flights and some of the material of the fourth flight permits the following conclusions:

1. There is practically no deuterium in the solar atmosphere.

2. The solar granulation can be traced down to objects approximately 100 km across. The average granule sizes are little more than half those determined from the best American stratospheric photographs. These facts, which were brought out by the record-high resolution obtained in our 1970—1973 photographs of the sun, indicate that it is not correct to identify the granules with autoconvection cells in the solar atmosphere. The manner in which the granules change with time, their shape, and their visibility at the limb of the solar disk indicate that they are of wave nature. They can only be combined magnetoacoustic waves and gravity waves.

3. Study of bright Secchi rings at the boundaries of the penumbra with the photospheric background and the sunspot nucleus indicates that they are extremely inhomogeneous (granularity with large discontinuities). The most probable cause of their appearance is dissipation of gravity waves on collision with the magnetic field of the spot.

4. Investigation of the fine structure of motions in the solar atmosphere on stratospheric spectrograms indicates not only the presence of strong shifts of the velocity grid with respect to the granulation, but also that the vertices of magnetic loops with their own energy sources are present in the atmosphere.

5. The magnetic loops broaden on emerging into the solar chromosphere, as evidenced by the observed existence of a lower size limit for chromospheric formations, on the order of 700 km. Facular elements (sizes 800 to 1000 km) are found to be even larger in the chromosphere.

The above does not by any means include all of the results obtained from processing of the stratospheric data; we have reported only those that can now be considered certain.

For purposes of synchronous analysis of photospheric processes at two levels (two effective temperatures) as the frequency of flights of the observatory is increased and its efficiency is improved, it will be necessary to complete, in the immediate future, the construction of a high-altitude stratospheric station that will photograph the sun from a height of 32 km in the 1800—2200 Å transparency window.

It is also necessary to exploit the advantages of observations in the height range from 1 to 20 km, in longer-wave regions of the spectrum, and in the submillimeter band for study of the sun, stars, and galactic and extragalactic infrared objects. The first step toward this goal would be to launch stations with telescopes having 1.5-meter-diameter primary mirrors with scanning mechanisms.

V. E. Zuev. Laser Sounding for Atmospheric Pollution. The wide variety of phenomena observed in the interaction of laser radiation with the atmosphere as a medium in which this radiation propagates forms an excellent basis for the development of laser sounding for atmospheric pollution by products of human industrial activity. These phenomena include aerosol and molecular scattering, resonant absorption by gases, Raman scattering, fluorescence, resonant scattering, the amplitude and phase fluctuations of the optical waves due to turbulent inhomogeneities, the Doppler effect, and various nonlinear effects.

The interaction cross sections for most of these phenomena are largest precisely in the optical band of the electromagnetic spectrum, and this opens up excellent opportunities for remote sounding of all physical parameters of the atmosphere, including the components that pollute it. Here it is easily understood that the higher the concentration of the pollutants, the more effectively can they be determined.

The significant advantages of laser pollution sounding methods are: 1) high spatial resolution (in the meter range when Q-switched lasers are used); 2) quick readout (the information is acquired in the form of a laser-pulse echo signal propagating at the velocity of light); 3) noise immunity, because of the high monochromaticity of the laser radiation (a narrow-band interference filter is placed in front of the receiver to cut out all noise outside of its passband); 4) the possibility of selecting the beamed object; 5) sounding does not disturb the medium sounded; 6) remote determination of the profiles of the various components.

The above advantages not only make possible quantitative determination of the concentrations of various atmospheric pollutants, but also permit detailed study of the dynamics of pollution processes.

All atmospheric pollutants belong to either of two classes: 1) aerosols (industrial hazes in particular), and 2) gases.

The phenomenon of aerosol scattering is used in aerosol sounding. The lidars that have been built and tested thus far reliably register laser-pulse echo signals that can be analyzed to extract information on the space and time distributions of industrial haze particle concentration with certain assumptions as to the particle size spectra. Below we shall review the possibilities for the additional extraction of data on the concentrations and particle size spectra without use of a priori information.

Gases polluting the atmosphere can be sounded by any of the following methods: 1) recording the echo signals of laser pulses the radiated wavelength in one of which coincides with the center of an absorption line of the gas being sounded, while the wavelength of the second pulse is not far from that of the first, which is not subject to absorption; 2) registration of laser-pulse echo signals at combination frequencies, which are different for each gas; 3) use of the resonant-scattering phenomenon.

The ceiling for laser sounding of atmospheric pollutants is determined on the one hand by the parameters of the lidar (pulse energy, receiving-dish diameter, passband and transparency of interference filter, bandwidth and sensitivity of display, etc.) and on the other hand by the concentrations of the pollutants and the interaction cross section. In industrial-haze sounding, one lidar with relatively modest parameters (ruby-laser pulse energy on the order of 1 J, receiving-dish diameter 0.5 m, interference filter half-width 10 Å at 50% transmission, display by a photomultiplier hand-picked from stock) can produce a space-time picture on the scale of the atmosphere of a large industrial city. The same lidar can be used to determine the concentrations of the gases directly at their sources (factory stacks, etc.) when Raman scattering is used. Two-frequency sounding offers substantially higher sensitivity.

The materials on which the paper was based have been published or submitted for publication: V. E. Zuev, Priroda, No. 10, 86 (1972); Problems of Laser Sounding for Atmospheric Parameters, Vestn. Akad. Nauk SSSR (1974); Lazer pokoryaet nebo (The Laser Conquers the Sky), Novosibirsk, Zapadno-Sibirskoe Khizhnoe Izdatel'stvo, 1972; Lazer-meteorolog (The Laser Meteorologist), Gidrometeoizdat, Leningrad, 1974.

G. A. Askar'yan, E. K. Karlova, R. P. Petrov, and V. B. Studenov. Vaporization, Burning Off, and Confinement of Oil and Other Films on Water Surfaces with the Aid of Powerful Laser Beams. The problem of clearing water surfaces of films of petroleum, oils, and other pollutants is of great practical interest. The paper[1] reported studies of the vaporization and burning off of such films on water by means of the beam from a powerful infrared laser used to scorch the surface. The use of infrared lasers in this application is most effective because of the short absorption path in the liquids ($l_a = 10^{-2}$–10^{-3} cm for a CO_2 laser radiating at $\lambda \approx 10\ \mu$m) and the high average powers developed in gas and gasdynamic lasers. These factors make possible strong heating of a thin surface layer over large areas with a small specific consumption of energy. Let us estimate the temperature of the burn. Given a surface energy density $q_1 \approx It$ from an absorbed flux of density I, the burn temperature under prevaporization conditions will be $T \approx q_1/C\rho l$, where $C\rho$ is the heat capacity of 1 cm^3 of the medium, l is the thickness of the heated layer, $l \approx \sqrt{l_a^2 + \kappa t}$ (l_a is the absorption depth and κ is the thermal diffusivity.

If $l_t = \sqrt{\kappa t} \ll l_a$, we have $l \approx l_a$ and $T \approx q_1/C\rho l_a$. For example, with $C\rho = 4$ J, $l_a \approx 10^{-2}$–10^{-3} cm, and $T \approx 300°$C we obtain $q_1 \approx C\rho l_a T \approx 10$–$1$ J/cm^2.

If the heating time is not small and $l_t = \sqrt{\kappa t} > l_a$ (with $\kappa \approx 10^{-3}$ cm^2/sec and $l_a \approx 10^{-3}$ cm, this is the case for $t \geq 10^{-3}$ sec), we have $T \approx I\sqrt{t}/C\rho\sqrt{\kappa}$.

For example, we obtain $T \approx 300°$C with $I \approx C\rho T\sqrt{\kappa}/\sqrt{t} \approx 30/\sqrt{t} \lesssim 30$ W/cm^2 if $t > 1$ sec, i.e., conditions adequate for strong vaporization or burnoff of the polluting layer can be created in comparatively simple fashion.

Experiments were set up in which a water surface was cleared of a polluting film. A film of kerosene, oil, petroleum, or some other material was formed on the surface of the water and the beam of a CO_2 laser was directed at it. Two types of lasers were used: a continuous laser with powers up to 50 W and a pulsed laser with a power of ≈ 1 MW, a pulse energy ≈ 1 J, and a repetition rate of 2 Hz. The unfocused beam was 12 mm in diameter; focusing by a lens of focal length $F \approx 30$ cm reduced the size of the beam spot to 1–2 mm ($r \sim F\varphi$, where the divergence angle $\varphi \sim \lambda/a \sim 2 \times 10^{-3}$ rad).

Strong vaporization, smoking, and burning off of the film were observed in the focused beam in both cases. If the film was thin (for example, a kerosene layer thinner than 1 mm), strong spattering and noise were observed and became more intense when the beam struck the surface of water that had been cleared of the polluting film. Since kerosene and gasoline absorb ten-micron radiation more weakly than does water, the noise and spattering were weaker when the beam struck a thick layer (the dark-colored petroleum fractions have larger absorption coefficients, and the processes described above take place more vigorously).

When the unfocused beam of the continuous laser was used on a layer of pure kerosene, we observed a mass decrease $dM/dt \sim 0.4$ g/min at a 50-watt power flux and a beam-spot area of 1 cm^2. The mass decrease of the layer was determined from the decrease in its thickness when observed from the side and from the decrease in the weight of the cell with water coated with a layer of kerosene. (To prevent heating of the cell as a whole, it was placed in a large water bath, from which it was removed for weighing or measuring.)

The flux density used in the unfocused beam was near that obtainable from a powerful modern gasdynamic laser at a spot area of 1 m^2. This area can easily be made hundreds and thousands of times smaller. The density used in the focused beam was comparable to the