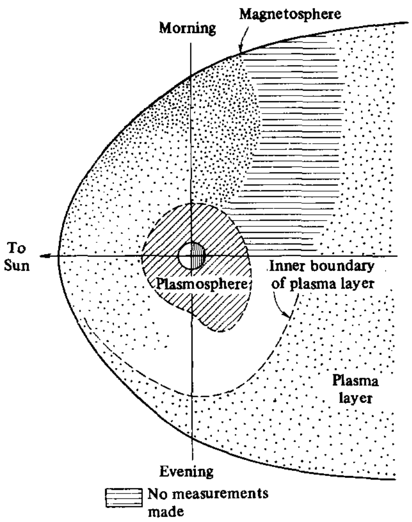

FIG. 1

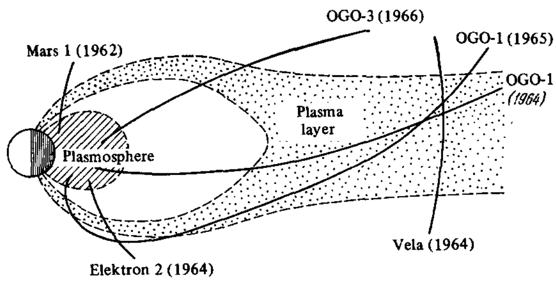

FIG. 2

$0.3\ cm^{-3}$. The individual values of the electron energy and their concentration can change by a factor of several times ten. The sum of the magnetic and plasma pressures over the cross section of the tail of the magnetosphere is constant and corresponds to the pressure of the solar wind on the magnetopause (the boundary of the magnetosphere).

A fact of fundamental significance is the observation of low-energy protons in the magnetosphere, by L. Frank (University of Iowa) in 1966, with the aid of an electrostatic analyzer with a canalotron on the OGO-3 satellite. Frank has shown that in the case of a geomagnetic storm there is a sharp increase in the streams of protons with energy < 50 keV at geocenter distances (3–5) R_E in the equatorial plane, forming a current ring producing a storm.

Rocket measurements by Chase (U.S.A.) carried out directly in auroras, have shown that the energy spectra and the electron fluxes producing the auroras are quite close to the electron spectra in the plasma layer of the tail of the magnetosphere. Vasyliunas (1969), projecting on the upper atmosphere a plasma layer of the magnetosphere tail along the geomagnetic force lines, reached the conclusion that this projection coincides with the aurora oval of Feldstein–Starkov.

Following the paper, films were demonstrated, with results of measurements of the energy spectra of the electrons and protons with $E < 50$ keV, performed by L. Frank on the satellites OGO-3 and IMP-4. The volume of the scientific information obtained in these experiments is so large that it cannot be represented with sufficient detail and clarity in the usual form of a scientific paper (for example in the form of an article or a report). Therefore the results of these experiments are given in the form of film, making it possible to present the dynamics of the investigated phenomena. The film with the results obtained from OGO-3 during one revolution of the satellite, from $13^h 30^m$ UT on 14 July 1966 to $15^h 21^m$ UT on 16 July 1966 involved 18,000 frames showing (condensed) approximately 550,000 individual measurements. On each of the frames are shown the position of the satellite relative to the boundaries of the magnetosphere and two simultaneously obtained energy spectra, of the electrons and of the protons. The rate of information transmission during the time of flight of OGO-3 reached 160 kilobit/sec.

The main content of the paper was published in the journal Izv. Vuzov, Radiofizika, v. 12, No. 9, 1. 1276, in an article by K. I. Gringauz, "Low-Energy Plasma in the Earth's Magnetosphere").

G. A. Smolenskiĭ and V. V. Lemanov, Hypersonic Waves in Crystals.

Hypersound is defined as elastic oscillations with frequencies exceeding 100 MHz. Experimentally, such oscillations, like ultrasonic oscillations, are obtained principally with the aid of the piezoelectric effect.

"From the point of view" of the crystal, hypersonic oscillations are none other than phonons, and in this lies the key to understanding the possibilities of hypersonic methods of investigation in solid-state physics. The phonon-phonon interactions, the interactions of phonons with free carriers and with magnons, the scattering of phonons by defects, the time of relaxation of phonons and their dispersion characteristics, the anharmonicity of the interaction forces in crystals, the behavior of soft modes under phase transitions—this is but a brief list of the phenomena that can be investigated with the aid of hypersonic methods.

The paper considers the results of certain investigations of the propagation of hypersonic waves in crystals of different types (dielectrics, ferroelectrics, semiconductors, ferrites), carried out at the Semiconductor Institute of the U.S.S.R. Academy of Sciences.

The investigations were carried out in a wide range of frequencies, 50–2000 MHz, and at temperatures 77–900° K.

Using as an example a large number of dielectric crystals, it has been shown that in the indicated frequency range, in sufficiently perfect crystals, the damping of hypersonic waves is due to the Akhiezer mechanism, the mechanism of the so-called phonon viscosity. It is shown that the damping correlates with the Debye temperature, and the anisotropy of the damping is determined by the anisotropy of the elastic moduli of third order.

The interaction of the hypersonic phonons with free carriers has been investigated with the piezoelectric semiconductor tellurium as an example. It is shown that at the corresponding polarizations and directions of propagation, the damping of the hypersonic waves is due practically entirely to the interaction with the free carriers and agrees well with the theory (V. L. Gurevich, Hutson and White).

In cubic crystals of yttrium iron garnet, investigations were made of the magnon-phonon interactions. Natural magnetoelastic resonance was observed; it constitutes resonant interaction of hypersonic phonons with magnons in equivalent fields of magnetic crystallographic anisotropy.

Magnetoelastic resonance and the accompanying phenomena were investigated in external magnetic fields. With the aid of thin plates, measurements were made of the absorption of hypersonic phonons at resonance. An investigation was made of the acoustic Faraday effects and of birefringence under conditions of homogeneous internal magnetic fields, in the propagation of hypersonic waves in different directions. Direct experiments have shown that in the case of the Faraday effect the spin waves interact with circularly-polarized elastic waves with a corresponding direction of rotation.

The anharmonicity of the interatomic interaction forces in crystals leads to nonlinear effects in the propagation of elastic waves. One of the manifestations of such a nonlinearity is the generation of acoustic harmonics. The generation of the second acoustic harmonic was investigated with an example of lithium-niobate crystals in the propagation of longitudinal waves with fundamental frequency 500 MHz along a threefold axis.

The diffraction of laser radiation by hypersonic waves in crystals is briefly considered. This phenomenon can be used to measure the characteristics of the propagation of hypersonic phonons, and also for the investigation of certain physical properties of crystals (photoelastic constants, polarizability of electron shells, the character of the chemical bond). The contents of the lecture were published in part in the following papers:

1. V. V. Lemanov, G. A. Smolenskii, and A. B. Sherman, Fiz. Tverd. Tela 11, 653 (1969) [Sov. Phys.-Solid State 11, 524 (1969)].

2. A. V. Pavlenko, Yu. M. Yakovlev and V. V. Lemanov, ibid. 11, 3300 (1969) [11, 2672 (1970)].

3. V. V. Lemanov and A. V. Pavlenko, Zh. Eksp. Teor. Fiz. 57, 1528 (1969) [Sov. Phys.-JETP 30, 826 (1970)].

4. V. V. Lemanov, V. Ya. Avdonin, and A. V. Pavlenko, Fiz. Tverd. Tela 11, 3635 (1960) [Sov. Phys.-Solid State 11, 3051 (1970)].

S. A. Akhmanov, Nonlinear Optics of Picosecond Pulses.

1. One of the most important accomplishments of laser physics of the last two or three years is the development of solid-state lasers that generate trains of ultrashort pulses or individual pulses with duration down to 10^{-12} sec and a power density in the collimated beam up to 100 GW/cm^2.[1-3] In spite of the fact that the dynamics of the radiation of such lasers is not yet fully understood and there are a number of obscure spots in the procedure for the measurement of the parameters of short pulses, many laboratories in the U.S.S.R. and abroad use them in their experimental work. It is only possible to speak now with full justification of new physical results obtained with picosecond-pulse lasers. Mention should be made here primarily of the new results obtained in the case of strong action on matter,[4] and various investigations of nonstationary optical phenomena. A discussion of the last group of questions is the subject of the present lecture.

2. Linear nonstationary phenomena which occur when short electromagnetic pulses propagate were discussed already by Brillouin. This pertains to the so-called precursors and dispersion spreading of wave packets (see, for example, [5]). Laser technology has expanded the possibilities of observing linear nonstationary effects; successful experiments were performed on the compression of phase-modulated optical signals,[6] and the lifetimes of the excited states in the picosecond region have been measured. On the basis of the technique of picosecond pulses, it is possible to develop pulsed methods of measuring the resolving power of optical instruments. Recently, new results were obtained in this field, as well as in the theory; very compact formulation of problems of nonstationary phenomena in the propagation of amplitude- and phase-modulated packets in a linear medium is possible on the basis of the formalism of parabolic equations.

3. Numerous nonstationary problems arise in nonlinear optics of picosecond pulses. Besides the nonstationarities due to the propagation effects (these "wave" nonstationarities are determined, as a rule, by the linear dispersion properties of the medium, i.e., by the inertia of the linear response), a broad class of nonstationary phenomena occurs also as a result of the inertia of the mechanism that realizes the energy exchange between the waves, the inertia of the nonlinear polarization ("local" nonstationarity).

4. For processes of the type of harmonic generation and nonresonant parametric amplification, the nonstationarities usually have a wave character (the settling time of the electronic part of the nonlinear polarization is $\sim 10^{-15}$ sec). A very important circumstance, characteristic of nonstationary and nonlinear optical effects, is in general the strong mutual influence of the spatial and time modulation of the beam, which becomes clearly manifest in the generation of optical harmonics by picosecond pulses. This circumstance can serve as the basis for methods of modulating picosecond pulses.[7, 8]

5. The use of picosecond pulses in experiments on stimulated Raman scattering has made it possible to investigate the dynamics of transient processes in the excitation of vibrational and rotational levels. Under conditions when the motion of the level populations can be neglected and the ratio of the pump pulse duration τ_p to the transverse relaxation time T_2 is $\tau_p/T_2 \ll \Gamma_0 l$ (where Γ_0 is the static gain and l is the length of the interaction region), the line width $\Delta\nu_S$ of the Stokes components increases with increasing $\Gamma_0 l$ for $l < L_{gr} = \tau_p |1/u_p - 1/u_S|^{-1}$ ($u_{p,S}$—group velocities) due to impact excitation of molecular oscillations. The foregoing is illustrated by the diagram of Fig. 1, obtained in the excitation of SRS in benzene by the second harmonic of a neodymium laser operating in the mode-locking regime ($\tau_p \simeq 3\times 10^{-2}$ sec, $P_p \simeq$ 100 GW/cm^2). The rate of growth of $\Delta\nu_S$ can be determined from the nonstationary theory of scattering.[11-13] Measurements of the dependence of $\Delta\nu_S$ on l, carried out in a wide range (for both $l < L_{gr}$ and for $l > L_{gr}$) have enabled us to trace the nonmonotonic dependence of $\Delta\nu_S$ on l. When