Digest of Translated Russian Literature

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SOVIET PHYSICS—JETP (*Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*). Published by American Institute of Physics, New York

Volume 14, Number 1, January 1962

Disintegration of Nonevolutional Shock Waves, R. V. Polovin and K. P. Cherkasova, pp. 190–191.

Disintegration of a magnetohydrodynamic shock wave with a small density discontinuity is investigated. The initial shock wave is a compression wave for which all boundary conditions are satisfied and the entropy increases. If the initial shock wave is evolutional, it cannot disintegrate. A non-evolutional shock wave can disintegrate into six magnetohydrodynamical waves (shock or self-similar waves, depending on the magnitude and direction of the initial magnetic field).

In magnetohydrodynamics, satisfaction of the boundary conditions on the discontinuity surface and an increase in the entropy are not sufficient to insure existence of a shock wave. It is necessary also that the evolutionarity conditions be satisfied, namely, that the number of outgoing waves be equal to the number of independent boundary conditions on the discontinuity surface. In the opposite case, the problem of small perturbations of the shock wave has no solution, indicating that the initial shock wave disintegrates into several shock and self-similar waves.

The non-evolutionarity regions apparently coincide with the regions where the initial shock wave can disintegrate. A direct proof of this theorem was given only for the particular case when the velocity of the shock wave is close to the Alfven velocity, and the magnetic field on both sides of the shock wave makes a small angle with the normal to the discontinuity surface.

In the present paper we prove this theorem for another particular case, that of a shock wave with a small density jump. Such a shock wave will be evolutionary if the jumps of all the magnetohydrodynamic quantities are small, or non-evolutionary if it is close to a 180° Alfven discontinuity (these waves were investigated in detail by Bazer and Ericson.

Possibility of Registration of Gravitational Radiation under Laboratory Conditions, V. B. Braginskii and G. I. Rukum, pp. 215–216.

Volume 14, Number 2, February 1962

Evolutionality Conditions of Stationary Flows, R. V. Polovin, pp. 284–288.

Analysis of magnetohydrodynamic shock waves has shown that not all shock waves on which the conservation laws are satisfied and the entropy increases can be realized in practice. For magnetohydrodynamic shock waves to exist it is necessary, in addition, that the evolutionality conditions be satisfied, i.e., that the number of outgoing waves be equal to the number of independent boundary conditions on the discontinuity surface.

An account of the evolutionality conditions is essential also in the investigation of the possibility of existence of several gasdynamic flows in the absence of a magnetic field. The present article is devoted to this subject.

We investigate the evolutionality conditions of continuous flows and of moving and attached discontinuities. An account of these conditions enables us to conclude that a continuous transition from supersonic to subsonic flow is impossible. In particular, shock waves must occur in the reversed Laval nozzle (which converts supersonic flow into subsonic). Similar shock waves must also occur in transonic flow about a bounded body. We shall advance later on certain arguments in favor of concluding that an attached oblique shock wave is a weak one.

Volume 14, Number 3, March 1962

Energy Spectrum and Time Dependence of the Intensity of Solar Cosmic-Ray Protons, A. N. Charakhch'yan, V. F. Tulinov, and T. N. Charakhch'yan, pp. 530–537.

Data obtained in the stratosphere are presented on the energy spectrum and time dependence of the total intensity of solar flare protons.

Conclusions:

1) The energy spectra of primary protons from the sun were measured during the burst of April 28, May 4, May 13, and September 3, 1960. The spectra were similar and underwent no essential change throughout the two- to three-day duration of each burst. It follows that solar generation of primary protons occurs during a time considerably shorter than the duration of

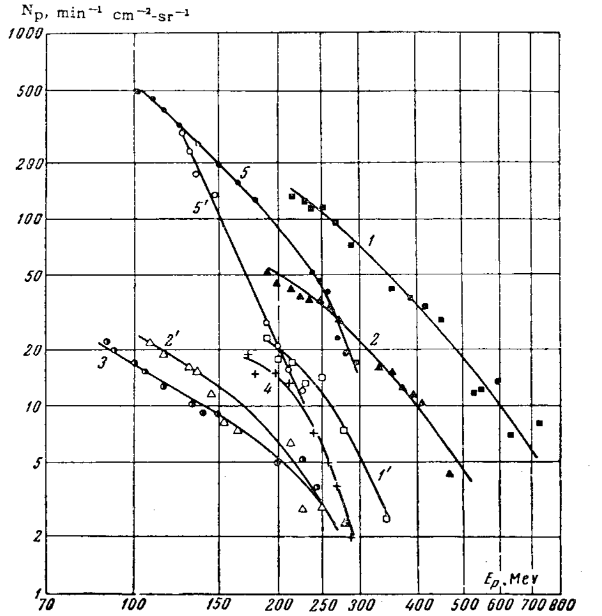

Fig. 3 Integral proton spectra. Curves 1 and 1') September 3 and 4, 1960; 2 and 2') May 4 and 5, 1960; 3) May 13, 1960; 4) April 28, 1960; 5 and 5') July 11 and 12, 1959. N_p is number of protons and E_p is proton kinetic energy.

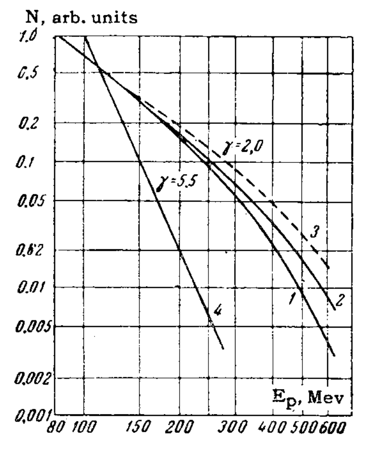

Fig. 4 Integral proton energy spectra. 1) average spectrum in the absence of magnetic storms and Forbush decrease; 2) the same, allowing for proton absorption resulting from nuclear collisions in air, as well as ionization losses; 3) derived from curve 2 by taking into account approximately the proton diffusion time in space as a function of velocity; 4) average spectrum during magnetic storms and Forbush decrease.

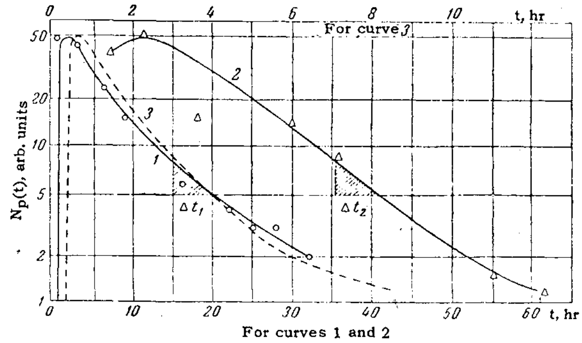

Fig. 5 Flare proton intensities during bursts in the stratosphere. Curve 1) May 4, 1960; curve 2) September 3, 1960; curve 3) burst registered February 23, 1956 at sea level in Chicago.

the observed bursts. The proton generation mechanism also seems to be the same in all of these bursts. The integral proton energy spectrum as a function of their kinetic energy E_p can be described by a power law with the exponent $\gamma = 2.0$ for E_p from 100 to 400 Mev.

2) The energy spectrum of solar flare protons was moderated during a Forbush decrease ($\gamma \approx 5.5$). This effect combined with the simultaneous harder spectrum of cosmic ray of galactic origin during the Forbush decrease shows that solar corpuscular streams carrying frozen-in magnetic fields are carriers of solar-generated protons. In accounting for this effect we must assume the existence of magnetic traps in the solar corpuscular streams.

3) During a Forbush decrease the stratosphere is penetrated by other particles with ranges under 7 mm Al, in addition to protons. The origin of these short-range particles appearing in the stratosphere only during a Forbush decrease is not clear.

4) The time dependence of primary-proton intensity in stratosphere bursts agrees satisfactorily with the theory of proton diffusion in interplanetary space containing magnetic clouds as scattering centers. Data were obtained characterizing the density and magnetic fields of magnetic clouds responsible for the scattering of ~0.2-Bev protons in interplanetary space.

Transport Phenomena in a Paramagnetic Gas, Yu. Kagan and L. Maksimov, pp. 604–610.

A kinetic theory is developed for a paramagnetic gas in an arbitrary magnetic field. A transport equation is derived with account of rotational degrees of freedom, discreteness of the magnetic momentum, and dependence of the scattering cross section on the angle between the direction of the molecular moment and the direction of the relative velocity, which is of decisive importance for the problem under consideration. With the thermal conductivity problem taken as an example, a general method for solving the kinetic equation is developed. An explicit expression for the thermal conductivity tensor in a magnetic field is deduced and comparison is made with the experimental results on the Senftleben effect.

Absorption of Electromagnetic Waves in Plasma, V. I. Perel' and G. M. Éliashberg, pp. 633–637.

The absorption coefficient of electromagnetic waves in a plasma is calculated for $e^2/\hbar v \ll 1$. Application of the temperature diagram technique makes it possible to take systematic account of collective effects and to obtain exact values of the factors in the Coulomb logarithm.

Volume 14, Number 4, April 1962

Some Observations on the Solidification of Helium, A. I. Shal'nikov, pp. 753–754.

Visual observations of the solidification of helium have been made. The difficulty of obtaining large blocks, even under conditions when the crystallization process can be controlled, is noted.

Motion of Charges in Liquid and Solid Helium, A. I. Shal'nikov, pp. 755–758.

The motion of charges in liquid and solid helium has been investigated over the temperature range between 4.2° and 1.5°K. A dependence of the currents in solid helium upon the quality of the crystals produced has been established.

Particle Acceleration by Passage of a Hydromagnetic Shock Wave Front, V. P. Shabanskii, pp. 791–793.

An expression for the momentum increment of a high-energy particle (compared with the particles comprising the bulk of a plasma) due to passage of a hydromagnetic shock wave is derived and discussed.

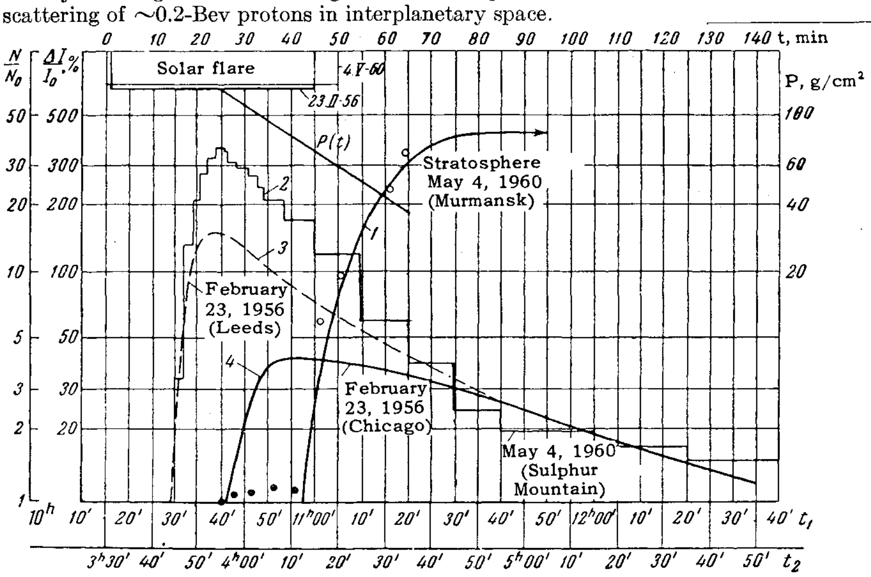

Fig. 6 Time dependence of the relative increase of cosmic ray intensity in stratosphere (N/N_0, curve 1) and at sea level ($\Delta I/I$, curves 2, 3, 4). t_1 is time of stratosphere measurements on May 4, 1960; t_2 is time of neutron monitor measurements; and t is time after onset of solar flare. Rectangular steps represent duration of solar flares. Straight line represents pressure vs time on May 4, 1960.

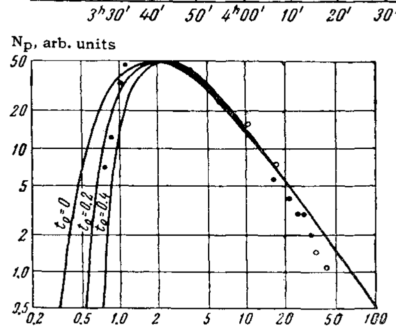

Fig. 7 Primary-proton intensity calculated from Eq. (1) for $D = 5.5 \times 10^{21}$ cm²/sec and $t_0 = 0$, 0.2, and 0.4 ●—May 4, 1960; ○—September 3, 1960.

Shift of Atomic Energy Levels in a Plasma, L. É. Pargamanik, pp. 794–798.

A diagram technique is used for analyzing level shifts in single-electron atoms in an equilibrium plasma at a finite temperature. The level shifts are computed to first and second order in the coupling constant $e^2/2aT$ (a is the Bohr radius). Debye shielding is taken into account by summing over diagrams. At high temperatures ($T \gtrsim 10^6$°K) the shift is determined by the electron-electron exchange interaction and increases as $T^{1/2}$. The problem of calculating level widths is discussed.

Effect of External Fields on the Motion of Growth of Bubbles in Boiling Liquids, G. A. Askar'yan, pp. 878–879.

It is noted that the growth of bubbles and boiling conditions of heated or saturated liquids can be controlled by employing external fields, which influence the bubble motion on which the thermodynamic growth conditions depend. The growth of bubbles in an accelerated bubble chamber can either be hindered or enhanced. Local inhomogeneous electric or magnetic fields which keep the bubbles near the vessel walls or repel them can be used to change the boundary conditions for boiling and heat exchange with the wall. The effects considered can be used, for example, to improve storage conditions of liquefied gases, heat exchange control, control of boiling, etc.

Transport Equation for a Degenerate System of Fermi Particles, G. M. Eliashberg, pp. 886–892.

Applying the temperature-dependent diagram technique and the method of analytic continuation, we give a derivation of the transport equation for the distribution function of excitations in a degenerate Fermi system. The analytic properties of the four-vertex part are studied and the equation for it is extended. We consider briefly whether the results obtained can be applied to the microscopic theory of a Fermi liquid.

A More Precise Determination of the Kinetic Coefficients of a Plasma, O. V. Konstantinov and V. I. Perel', pp. 944–945.

Kinetic coefficients containing the exact values of the Coulomb logarithm are derived for a plasma. The case $\omega\tau \ll 1, e^2/\hbar v \ll 1$ is considered.

Volume 14, Number 5, May 1962

Injection of a Plasma from a Powerful Pulsed Discharge into Vacuum, Yu. D. Klebanov and V. I. Sinitsyn, pp. 953–958.

Experiments are described in which plasma is ejected from a powerful pulsed discharge in hydrogen. The plasma parameters are investigated under various conditions of operation of the injector by photographic, photoelectric, and thermal probe methods. A plasma formation containing a total of the order of 10^{16} charged particles is shown to move in vacuum with a velocity $\backsim 10^7$ cm/sec. The injection time is 2—5 μsec.

Irregular Conditions of Oblique Collision of Shock Waves in Solid Bodies, L. V. Al'tshuler, S. B. Kormer, A. A. Bakanova, A. P. Petrunin, A. I. Funtikov, and A. A. Gubkin, pp. 986–994.

A method for producing and recording irregular modes of shock-wave collisions in solids is described. The parameters of three-shock configurations due to the collision of 300–400 thousand atm and 1.0–1.8 million atm shock waves are presented for four metals. In the first series of experiments a six- to eightfold pressure increase was observed at angles close to the critical angles of appearance of the leading waves. For waves of greater amplitude the pressure increased to 4 million atm for aluminum and to 7 million atm for steel, copper, and lead in the collision region when the waves cross at right angles.

The results obtained are analyzed by the method of shock-wave polar curves. It is shown that the model with a single tangential discontinuity cannot describe irregular modes of oblique collision of "weak" shock waves in metals. A method is described for determining the pressure and density behind the reflected wave front from the parameters of the three-shock configurations. As an example, the pressures and densities are calculated for the collision of strong shock waves in aluminum. Consecutive compression by the incident and reflected waves increased the density of aluminum by 2.26 times, i.e., to 6.12 g/cm³.

Dispersion Equation for an Extraordinary Wave Moving in a Plasma Across an External Magnetic Field, Yu. N. Dnestrovskii and D. P. Kostomarov, pp. 1089–1095.

A general qualitative study has been carried out on the nonrelativistic dispersion equation for extraordinary and plasma waves propagating in a plasma transversely to an external magnetic field. Frequency regions are established in which these waves can propagate without damping. An error is pointed out in the conclusion drawn by a number of authors that gaps of zero transmission can exist for waves of a given type in the vicinity of each cyclotron resonance. The laws of behavior that are established are illustrated by the results of a numerical solution of the dispersion equation.

Kinetic Theory of Gases with Rotational Degrees of Freedom, Yu. Kagan and A. M. Afanas'ev, pp. 1096–1101.

The kinetic theory of gases with internal degrees of freedom is still in a rudimentary stage of development. The difficulties in setting up such a theory are mainly the sharp increase in the number of parameters characterizing the collisions between the molecules and the trouble in finding the explicit form of the collision integral taking into account inelastic processes. All these difficulties show up particularly clearly in a comparison with the kinetic theory developed for the monatomic gas.

The number of papers devoted to the study of the kinetic equation for molecules with internal degrees of freedom, in particular, rotational ones, is very small. Besides the traditional references to be found in the well-known monographs, the papers of Curtiss and Muckenfuss deserve mention.

The papers in which the attempt is made to take account of the rotational degrees of freedom, start with assuming simple models of solid bodies for the description of the collisions and proceed then to translate the Chapman-Enskog-Barnett method, developed for the monatomic gas, to this case.

Difficulties and actual errors to which this can give rise may be seen by the example of the paper of Curtiss and Muckenfuss. Regarding the molecule as a solid body with a center of symmetry, these authors keep as independent variables in the kinetic equation the phase angles, which vary strongly during the free flight. This leads, obviously, to an extremely complicated problem. On the other hand, when considering the problem of thermal conductivity and viscosity, the forementioned authors choose the solution in a form which contains tensors that are constructed entirely from components of the vector of the molecular velocity **V**. This is obviously wrong, since now the problem deals with two independent vectors, **V** and the angular momentum of the molecule **M** (more precisely, a vector and a pseudovector), and the general solution should contain all tensors of corresponding rank which can be formed from the components of these vectors.

In the present paper we investigate the kinetic theory of a diatomic gas in a region of temperatures where the vibrational degrees of freedom can be neglected. We make use of a kinetic equation which does not contain rapidly varying phases and solve the problem of thermal conductivity and of first and second viscosity.

Some Characteristics of Extensive Air Showers, A. A. Pomanskii, pp. 1109–1112.

The hypothesis that a decreasing fraction of energy is transferred to pions as the primary-particle energy increases is shown to be inconsistent with experimental data on the altitude dependence of extensive air showers. It is also shown that the number of nuclear-active particles depends strongly on the relative number of baryons among all secondary particles produced in an elementary nuclear interaction.

Equation of State at Ultrahigh Densities and Its Relativistic Limitations, Ya. B. Zel'dovich, pp. 1143–1147.

The most rigid equation of state compatible with the requirements of relativity theory is $p = \epsilon \sim n^2$, $D \rightarrow c$, where p is the pressure, ϵ the volume density of energy, n the density of baryons, D the speed of sound, and c the speed of light. This differs from the previously proposed asymptotic behavior $3p = \epsilon \backsim n^{4/3}$, $D \rightarrow 3^{-1/2}c$. The case of interaction of the baryons through a vector field is considered and it is shown (both by considering the interaction of pairs of baryons and by using the stress tensor of the field) how in this case the equation $p = \epsilon \sim n^2$ is realized and how the transition to the equation $3p = \epsilon$ occurs as the mass of the field quanta goes to zero.

Acceleration of a Cloud of Ionized Gas Whose Own Magnetic Field Scatters an Electron Beam, G. A. Akar'yan, pp. 1159–1160.

We consider acceleration of a plasma with its own magnetic field in the scattering of an incident electron beam. Two ways of increasing the amount of energy extracted from the electrons are indicated: multiple scattering of the electron beam by the magnetized plasma, and application of induction inertia ("increasing the weight") of electrons in a powerful current. It is noted that the effect can be employed in plasma accelerators and that it may occur in astronomical processes.

Heating of a Gas by Radiation, A. S. Kompaneets and E. Ya. Lantsburg, pp. 1172–1176.

The problem considered is that of the radiative propagation in a cold gas of heat originally confined in some finite region of the gas itself. It is assumed that the temperature of the hot gas is so high that the gas inside the region is transparent for the radiation. The expansion of the heated region occurs on account of radiative heat exchange with the outer, nontransparent, layer adjacent to the cold gas, and the transfer of the energy of the radiation in this layer is assumed to be diffusive. The process of expansion is regarded as a quasi-stationary propagation of the boundary of the heated region in the form of a plane wave moving through the cold gas. A method is indicated for calculating the speed of propagation of the boundary, which takes into account the nonequilibrium state of the radiation in the internal, transparent part of the heated region in the gas.

Volume 14, Number 6, July 1962

Electrical Properties of Thin Nickel Films at Low Temperatures, O. S. Galkina, L. A. Chernikova, Chang Kai-Ta, and E. I. Kondorskii, pp. 1254–1255.

The electrical properties of thin nickel films of very high purity, obtained by thermal evaporation in a vacuum inside a vessel kept in a helium bath during the deposition, have been investigated. Films with thicknesses from 30Å and upward had a residual resistivity and Hall emf of the order of magnitude close to that of bulk nickel specimens.

Superconducting Solenoids for Strong Magnetic Fields Using Nb_3Sn, N. E. Alekseevskii and N. N. Mikhailov, pp. 1287–1288.

Data are presented on superconducting solenoids constructed of Nb_3Sn, and the critical current vs external magnetic field curve for this superconducting compound is discussed.

Neutrino Production in the Atmosphere, G. T. Zatsepin and V. A. Kuz'min, pp. 1294–1300.

The energy spectra and angular distribution of neutrinos produced in the atmosphere in the $\pi \rightarrow \mu + \nu$ and $\mu \rightarrow e + \nu + \bar{\nu}$ decays are calculated taking the μ-meson energy losses at neutrino energies $\mathcal{E} = 10^9$–3×10^{11} ev into account. It is shown that the neutrino flux from the $\mu \rightarrow e + \nu + \bar{\nu}$ decay is comparable with that from the $\pi \rightarrow \mu + \nu$ decay. μ-meson energy losses only weakly affect neutrino production. K mesons produce neutrinos more efficiently than do π mesons. An experimental arrangement for detecting high-energy cosmic ray neutrinos is proposed.

Hydrodynamics of a Nonisothermal Plasma, E. E. Lovetskii and A. A. Rukhadze, pp. 1312–1314.

The single-fluid magnetohydrodynamic equations with particle collisions taken into account are obtained for a nonisothermal plasma. The effect of particle collisions on the spectrum of magnetohydrodynamic and magnetic-sound plasma waves is investigated.

Three Particles with Point Interactions, R. A. Minlos and L. D. Faddeev, pp. 1315–1316.

An integral equation for the wave function of three particles with point interactions is considered. It is shown that the discrete spectrum of the equation is infinite and extends to $-\infty$.

Theory of Quantization of Space-Time, V. G. Kadyshevskii, pp. 1340–1346.

The hypothesis is proposed that the geometric structure of x space "in the small" and correspondingly of p space "in the large" is closely connected with weak interactions of elementary particles. Furthermore, a scheme is investigated in which momentum space is one of constant curvature and x space is quantized. It is shown that there are reasons in the new geometry for rejecting the requirement of invariance under space inversion and "strong" time inversion, providing that the CPT theorem is correct.

Ambiguity in the Definition of the Interpolating Field, D. A. Slavnov and A. D. Sukhanov, pp. 1379–1384.

The question of the ambiguity in the definition of the interpolating field is considered; this ambiguity is shown to be connected with that in the definition of the T product for a given S matrix, and also with the ambiguity in the determination of the S matrix outside the energy surface. The possibility of going over from one interpretation to the other is discussed.

Comment on N. V. Pleshivtsev's Article 'Sputtering of Copper by Hydrogen Ions with Energy up to 50 kev,' Yu. V. Bulgakov, pp. 1431–1432.

Volume 15, Number 1, July 1962

Shock Adiabats and Zero Isotherms of Seven Metals at High Pressures, L. V. Al'tshuler, A. A. Bakanova, and R. F. Trunin, pp. 65–74.

Shock compression of seven metals to 9×10^6 atm was investigated experimentally. The density was found to increase 1.94–2.01 times in copper, iron, and nickel, 2.21–2.36 in zinc and cadmium, and 2.58–2.66 in tin and lead. A transition was effected from the shock adiabats to zero isotherms for the metals investigated. The shock compression temperatures are calculated. For the upper experimental points on the adiabats they are equal to (15–35) $\times 10^{3\circ}$ for slightly compressible metals and (50–70) $\times 10^{3\circ}$ for zinc, tin, cadmium, and lead. Extrapolated formulas are given for the zero isotherms.

Gravitational Radiation by a Relativistic Particle, V. I. Pustovoit and M. E. Gertsenshtein, pp. 116–120.

Gravitational radiation from a charged relativistic particle moving in a magnetic field is calculated. The gravitational waves are due not only to the mass tensor of the particle itself but also to the electromagnetic stresses caused by the charge, the contributions from which to the radiation are of the same order as that of the mass. The small additions to the metric tensor correspond to two processes of gravitational wave formation: to the usual type of charge and mass emission, and to resonance emission of gravitational waves by the electromagnetic field in the presence of a constant external magnetic field. The latter effect is considered by one of the authors elsewhere. It is shown that in the ultrarelativistic case the energy dependence of the intensity of gravitational wave radiation is the same as that of an electromagnetic field.

Interpretation of the Two-Center Model within the Framework of the Hydrodynamical Theory, A. A. Emel'yanov, pp. 121–122.

For the description of "two-humped" showers within the framework of the hydrodynamical theory it is suggested that the dissipation of energy of a simple wave because of viscosity should be taken into account.

Estimates of the Effective Interaction Radius of Particles, M. I. Shirokov, pp. 123–126.

Methods for estimating the effective strong-interaction radius are discussed: 1) the estimate from the degree of the last term in the expansion of the angular distribution in Legendre polynomials; 2) the estimate from a known total cross section for a channel and the value of the angular distribution at one point; 3) the estimate from the total cross section for all channels and that for the elastic-scattering channel; and 4) the estimate from the mean square of the transverse momentum and the uncertainty relation. The first two of these are extended to the case of inelastic reactions of the most general type, $a + b \rightarrow c + d + e + \ldots$ (the spins of the particles are arbitrary). All of the methods have no connection with any particular model of the interaction (potential well, optical model).

Shock Wave Structure in a Dense High-Temperature Plasma, V. S. Imshennik, pp. 167–174.

The structure of a plasma shock wave of arbitrary intensity is considered in the two-temperature hydrodynamic approximation with the electronic thermal conductivity and the energy exchange between ions and electrons taken into account. Radiation effects are also included. Two kinds of solutions are obtained: a continuous solution and a discontinuous solution with an isothermal electron jump. The nature of the solution depends on the wave intensity and the fractional radiation pressure in the initial state of the plasma in front of the shock. The appearance of the discontinuity also depends on the plasma parameters (ion charge Z, adiabaticity index γ) and has a simple physical meaning.

Finite Amplitude Waves in Magnetohydrodynamics, Z. A. Gol'dberg, pp. 179–181.

One-dimensional waves moving perpendicularly to a magnetic field in a viscous heat- and electricity-conducting medium are considered. Exact solutions are obtained for the magnetohydrodynamic equations and terms linear and quadratic in the Mach number are retained. It is demonstrated that all results of ordinary hydrodynamics apply to the case under consideration.

Theory of Fluctuations of the Particle Distributions in a Plasma, Yu. L. Klimontovich and V. P. Silin, pp. 199–206.

We obtain expressions for the correlations in the phase densities in different points in phase space and at different times for a nonequilibrium plasma. We use the general formulas to obtain expressions for the field correlations, the charge density, the particle-distribution correlations, and the charge-density correlations. We consider the case where the plasma is in a constant uniform magnetic field.

Volume 15, Number 2, August 1962

Measurement of Electron Mobility According to the Variation of Plasma Resistance in a Magnetic Field, G. E. Pikus, N. S. Skvortsov, and V. G. Yur'ev, pp. 225–230.

The study of electron mobilities in gases presents great interest both for the theory of electron interaction with atoms and ions and for practical purposes. The Townsend method, which is usually applicable for the direct measurement of the mobility, does not give sufficient accuracy, since it is necessary to make a number of inadequately based assumptions in the treatment of the measurement results.

The mobility can also be computed from a knowledge of the scattering cross section. However, direct measurement of these cross sections encounters great difficulties, especially for electrons with thermal velocities.

We have developed a direct method for the measurement of the electrical conductivity of the plasma. For calculation of the mobility by this method, it is necessary to know the electron concentration, and also the area of the working surface of the electrodes.

Although theoretical estimates show that the electron concentration (if the necessary conditions are satisfied) is equal to the equilibrium concentration at a gas temperature equal to the electrode temperature, satisfaction of these conditions cannot, however, always be verified. Therefore, it is desirable to have an independent method which does not require a knowledge of the concentrations and exact geometric dimensions of the working surface of the electrodes. For this purpose, it proves to be possible to use the method of measurement of the mobility from a measurement of the resistance in a magnetic field, a method which has been widely used in the physics of semiconductors.

Plasma Instability in a Toroidal Discharge Excited by a Traveling Electromagnetic Wave, R. A. Demirkhanov, N. I. Leont'ev, I. A. Kosyi, and T. M. Filatova, pp. 231–235.

The stability of a plasma excited in a toroidal chamber by a traveling TE wave has been investigated experimentally. It is shown that this system is subject to beam-type instabilities due to the interaction between the azimuthal current and the plasma.

Application of Similitude Relations to Ignition of a Gas Discharge in Hydrogen, A. S. Pokrovskaya-Soboleva and B. N. Klyarfel'd, pp. 297–298.

Additional verification is given for the deviations from the similitude relations found earlier in hydrogen for the left branch of the Paschen curve; these deviations are found with electrodes made of copper, stainless steel, and nickel. Deviations are also observed in deuterium.

Theory of Transition Radiation, E. A. Kaner and V. M. Yakovenko, pp. 330–335.

The problem of the transition radiation of a charged particle in a plasma is solved in the kinetic approximation, with spatial dispersion taken into account. Mirror reflection of the electrons from the plasma-vacuum boundary is assumed. The limiting cases of weak and strong spatial dispersion are treated for both nonrelativistic and relativistic plasmas. With weak dispersion the radiative energy loss of a particle is composed of the transition radiation and Cerenkov radiation from longitudinal waves which emerge into the vacuum. The latter radiation has a comparatively narrow spectrum. With strong spatial dispersion the expressions for the radiation field and the energy loss of the particle can be obtained in the surface-impedance approximation. The radiative energy loss of a particle moving along the axis of a gyrotropic substance without spatial dispersion is calculated. The problem of the features of the transition and Cerenkov radiations of an electron in a transparent medium are discussed.

Choice of Invariant Variables for the "Many-Point" Functions, V. E. Asribekov, pp. 394–401.

Relations are found which connect the invariant variables of an amplitude for a Feynman diagram with n free lines ("n-point" function) and which allow one to express all possible invariant variables in terms of the $3n - 10$ independent ones. It is shown that these relations reduce to a linear system of kinematic conditions, arising from the energy-momentum conservation law, and (for $n \geq 6$) to the additional system of geometrical conditions connected with the four-dimensionality of space. It is shown what the choice of independent variables should be for the n-point function for arbitrary n; in particular a choice of independent variables (with adjacent subscripts) for which the geometrical conditions (generally speaking, a system of equations of fifth degree) reduce to a set of quadratic equations with respect to any of the variables is analyzed in detail. A graphical method for obtaining the necessary relations among the invariants is described.

Invariant Formulation of the Theory of the Gravitational Wave Field, Yu. B. Rumer, pp. 402–405.

The Einstein theory of gravitation is formulated in such a way that the fundamental quantity is the fourth-rank gravitational field-strength tensor F_{iklm}, which is linearly connected with the Reimann curvature tensor R_{iklm} and vanishes in a Euclidean space. The equations of gravitation, which enable us to calculate both F_{iklm} and g_{ik} for prescribed sources, are formally the same as the Bianchi identities. The main advantages of the new formulation is the possibility of constructing an invariant theory of weak gravitational waves.

Growth of Fluctuations in a Plasma with an Unstable Distribution Function, I. A. Akhiezer, pp. 406–410.

The growth of fluctuations is investigated in plasma characterized by an unstable distribution function (primarily systems consisting of a plasma and a beam of charged particles). The expectation values for the amplitudes of the growing oscillations excited by the beam passing through the plasma are determined, as are the correlation functions for various physical quantities (electric field, charge density of the plasma system, density and velocity of the beam). These correlation functions and the squares of the oscillation amplitudes contain terms that grow exponentially with time; the exponential is proportional to $N_B^{1/2}$ and is multiplied by a factor that is also proportional to $N_B^{1/2}$ (N_B is the beam density). If the beam velocity is high compared with the mean thermal velocity of the plasma electrons a resonance arises between the plasma oscillations excited by the beam and the Langmuir oscillations of the plasma. In this case the correlation functions grow with a factor proportional to $N_B^{1/3}$ but the exponential is multiplied by a factor that is independent of beam density.

Transition of Liquid He^3 into the Superfluid State, L. P. Gor'kov and L. P. Pitaevskii, pp. 417–421.

A study has been made of the Cooper effect in liquid He^3, showing that at sufficiently low temperatures He^3 undergoes a transition into the superfluid state. The problem of estimating the temperature of the transition is discussed. Various estimates yield transition temperatures from 2×10^{-4} to 8×10^{-3}° K.

Collapse of a Small Mass in the General Theory of Relativity, Ya. B. Zel'dovich, pp. 446–447.

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Shock Compression of Porous Tungsten, K. K. Krupnikov, M. I. Brazhnik, and V. P. Krupnikova, pp. 470–476.

Parameters of strong shock waves in tungsten samples of various initial densities were investigated experimentally. Shock adiabats were negative slopes in pressure-density coordinates were found for porous samples at pressures below 0.5×10^6 atm. Bending of the adiabats and a change in the sign of their derivatives were observed with increase of the shock-wave amplitude. This behavior of the adiabats is accounted for by changes in the dependence of the effective Grüneisen constant on the degree of compression and heating due principally to the increase in the electronic specific heat. Expressions are derived relating the partial derivatives $(\partial E/\partial P)_v$ and $(\partial E/\partial_v)_P$ with the slopes of two intersecting curves.

Dynamic Compression of Porous Metals and the Equation of State with Variable Specific Heat at High Temperatures, S. B. Kormer, A. I. Funtikov, V. D. Urlin, and A. N. Kolesnikova, pp. 477–488.

Results of an investigation of dynamic compression of Al, Cu, Pb, and Ni are presented for various initial densities and pressures between 0.7 and 9×10^{12} dyn/cm^2. The laws of shock compression of porous substances are studied. A new form of the equation of state is presented, which allows for the decrease of the specific heat and of the Grüneisen coefficient with increasing temperature. The parameters of the equation are determined for four of the investigated metals. Values of the "electron" analog of the Grüneisen coefficient are determined for Cu and Ni and its magnitude is estimated for Pb and Al.

Ionization of Gases by Fast Hydrogen Atoms and by Protons, E. S. Solov'ev, R. N. Il'in, V. A. Oparin, and N. V. Fedorenko, pp. 459–464.

Ionization of H_2, N_2, He, Ne, Ar, and Kr gases by 10–180 kev fast hydrogen atoms and protons was studied. The ionization cross section, "stripping" cross section for fast hydrogen atoms, and cross section for formation of slow ions with various e/m ratios were measured. The cross sections for "stripping" of hydrogen atoms and for ionization of atoms and molecules by protons are compared with theoretical data obtained using the Born approximation. Factors that influence the ratios of various ionization cross sections and the positions of the maxima in the energy dependences of the cross sections are discussed.

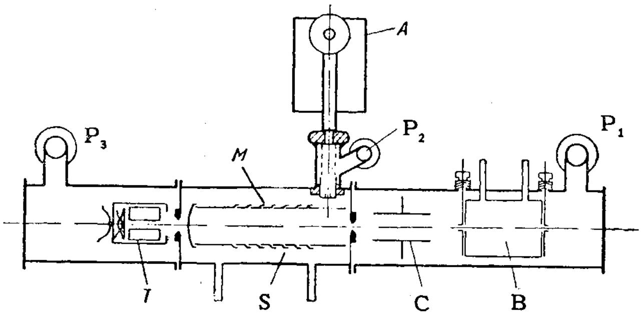

Fig. 1 Experimental setup: B is the chamber where an atomic beam is formed by charge exchange; C the capacitor where charged particles are removed from the atomic beam; *S* the scattering chamber; *M* the measuring capacitor; *T* the receiver of fast particles; *A* the analyzer of slow ions; and P_1, P_2, P_3, are pumps.

High-Energy Fragments Emitted during the Absorption of Slow π^- Mesons by O^{16} Nuclei, A. T. Varfolomeev, pp. 505–506.

The disintegration of a nucleus by a slow π meson is analyzed. The analysis indicates that the O^{16} nucleus is disintegrated into Li^8, Be^7, and n^1. The kinematic characteristics of the disintegration products are such that the Li^7 and Be^7 fragments could be produced only as a result of direct interaction between the π meson and two nucleon groups, the masses of which are approximately equal to the masses of the observed fragments.

Experimental Investigation of Stimulated Emission from a Gas Mixture, V. K. Ablekov, pp. 513–514.

The change in the spectrum of light passing through a medium with negative absorption coefficient is investigated. Narrowing of the 6362 Å line of Zn is observed.

Equilibrium Shape of Atomic Nuclei, V. G. Latysh, pp. 543–544.

Single-particle energy levels in an infinitely deep nonspherical rectangular well are calculated by diagonalizing the energy matrix with account of spin-orbit coupling. The dependence of the total energy on the nonsphericity parameters is determined for different nucleon configurations. The equilibrium shape of the nucleus in such a model is considered.

Spectral Representations of Matrix Elements, R. V. Tevikyan, pp. 545–546.

Spectral representations are obtained for the matrix elements of the product of n scalar Heisenberg operators.

Deceleration of Antiprotons in Matter, Yu. D. Fiveĭskiĭ, pp. 558–560.

Slowing down of antiprotons in matter from nonrelativistic energies to energies $\sim Z^2 \epsilon \mu / 2\hbar^2$ is considered. It is shown that in this energy interval the antiprotons are mainly absorbed by nuclei. It is also shown that the number of antiprotons changes only slightly during the slowing down. The behavior of the cross section for the capture of low-energy antiprotons in atomic shells is also considered.

Energy Losses of Charged Particles in a Plasma, V. N. Tsytovich, pp. 561–566.

The differential probabilities for radiation and absorption of longitudinal and transverse quanta by a charged particle in media with spatial dispersion are determined in the presence of radiation. It is shown that in a quantum analysis that allows for the recoil effect the energy losses depend on the radiation density. Energy losses of relativistic particles in a high-temperature media and particularly in an ultrarelativistic plasma are considered.

Single-Particle Excitations in a Nondegenerate Gas, E. K. Kudinov and S. T. Pavlov, pp. 585–588.

We evaluate the single-particle Green's function of a nondegenerate electron gas in the Born approximation. We show that when we take the Coulomb interaction into account the single-particle excitations (plane waves) are distorted because of damping and because of a time modulation of the unperturbed wave.

Effect of Viscous Transfer of Momentum on Diffusion in a Gas Mixture, V. Zhdanov, Yu. Kagan, and A. Sazykin, pp. 596–602.

The "13 momentum" approximation in Grad's method is used to derive a general set of equations of diffusion in a multicomponent gas mixture. The problem of diffusion in the presence of viscous transfer of momentum in a gas is studied in detail. An explicit expression is obtained for the barodiffusion constant α_p is a viscous flow of an arbitrary binary mixture. The magnitude of α_p depends significantly on the character of the interaction between the molecules and can have either sign. The nature of the difference between the derived value of α_p and the value of $(m_2 - m_1)/[m_1 y_1 + m_2(1 - y_1)]$, obtained by methods of irreversible thermodynamics, is analyzed.

Asymptotic Smoothing Out of a Discontinuity in a Monatomic Gas, R. G. Barantsev, pp. 615–618.

The structure of a shock wave in a monatomic gas is studied with the help of the integral kinetic equations derived by Wallander. Asymptotic laws for smoothing out of the density, velocity, and temperature profiles can be determined in a first approximation to the gasdynamic solution. The form of the asymptotic formulas depends appreciably on the behavior of the collision cross section at large values of the relative velocity of the colliding particles.

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Some Peculiarities in the Behavior of a Relativistic Plasma with an Anisotropic Distribution of Electron Velocities, G. M. Zaslavskiĭ and S. S. Moiseev, pp. 731–734.

The nature of cyclotron and aperiodic instabilities in a relativistic plasma is investigated. It is shown that the stability of a relativistic plasma against cyclotron resonance and aperiodic instability is greater than that of a nonrelativistic plasma.

Quantum Theory of Relaxation Process, V. M. Faĭn, pp. 743–748.

In the investigation of relaxation processes of various physical systems, we are concerned with the following characteristic situation. Relaxation occurs as a result of the interaction of some dynamic system with a dissipative one. That part of the system which has a finite number of degrees of freedom, discrete energy levels, and is described in principle by simple dynamic equations, will be called the dynamic system (or dynamic subsystem). This dynamic subsystem interacts with a dissipative system that has in the limit an infinite number of degrees of freedom and a continuous energy spectrum. The dissipative system represents the macroscopic body. A simple example of a relaxation process is the spontaneous emission of an atom in free space. Here the atom plays the role of the dynamic system, and the dissipative system is the radiation field in free space. The radiation field in free space has a continuous energy spectrum, whereas the atom has a discrete spectrum.

Relaxation processes are described by kinetic equations. Boltzmann was the first to derive kinetic equations from the equations of classical mechanics. Boltzmann's derivation was based on the assumption of molecular chaos (Stosszahlansatz). This assumption does not follow from the equations of mechanics; hence it is of interest to derive the kinetic equations without assuming molecular chaos. In the classical case this problem was considered by Bogolyubov and by Prigogine and his co-workers.

Quantum-mechanical derivatives of the kinetic equations were undertaken by Landau, Pauli, and Bloch. They deduced the transport equation (assuming molecular disorder):

$$dP_m/dt = \Sigma (W_{mn}P_n - W_{nm}P_m) \qquad (1)$$

Here P_m is the probability of finding the system in state m, and W_{mn} is the transition probability per unit time. The derivation of the transport equation without the assumption of molecular disorder was accomplished by Van Hove, and by Sher and Primakoff. Van Hove also considered the case when the perturbation causing the transitions is not small; in this case the relaxation process has a non-Markov character. Van Hove considered the case where the relaxing system has a continuous spectrum. Of interest would be the case in which the spectrum of the system is characterized by both discrete (dynamic part) and continuous indices (dissipative part). Just such a case was also considered in the forementioned works of Landau, Pauli, and Bloch.

Equation (1) contains only the diagonal elements of the density matrix of the system

$$\rho_{mm} = P_m$$

Hence this equation does not give the likelihood of determining all the average properties of the physical system. The latter, generally speaking, are determined by both the diagonal elements of the density matrix and the non-diagonal ones. Bloch and Wangsness obtained for a density matrix an equation that was nondiagonal in the discrete indices. In this case it is assumed that the dissipative part of the system, characterized by the continuous indices, is in a state of thermodynamic equilibrium. (On the other hand, Van Hove considers in essence the case of relaxation of a dissipative system.)

In a number of cases, the assumption that the dissipative subsystem is in a state of equilibrium is not fulfilled. In Secs. 2 and 3 of this paper a quantum kinetic equation is derived for a density matrix $\rho m\alpha;n\alpha$, nondiagonal in the discrete indices m, n and diagonal in the continuous indices α. As particular cases, the equations derived by Van Hove and by Bloch and Wangsness are obtained in Sec. 4. In Sec. 5 the question of the application of the various quantum kinetic equations in quantum radio physics is briefly discussed.

Volume 15, Number 5, November 1962

Application of Quantum Field Theory Methods to the Problem of Degeneration of Homogeneous Turbulence, V. I. Tatarskiĭ, pp. 961–967.

The problem of homogeneous turbulence in an incompressible viscous fluid is considered on the basis of the Hopf equation (in variational derivatives) for the characteristic functional. Owing to the analogy between this equation and the Schrödinger equation for a vector Bose field with a strong interaction, the mathematical theory of quantum field theory can be applied to the problem. The solution is obtained in the form of a continual integral. An analysis of the solution shows that for infinite Reynolds numbers of the initial state the law of turbulence degeneration is independent of the form of the initial-state probability distribution.

Volume 15, Number 6, December 1962

Lateral Distribution of the Intensity of Cerenkov Radiation from Extensive Air Showers, V. I. Zatsepin and A. E. Chudakov, pp. 1126–1130.

Blackett first drew attention to the fact that it should be possible to observe Cerenkov radiation emitted by fast particles not only in dense media but in air as well. Jelley and Galbraith detected short light pulses accompanying the passage of extensive air showers (EAS) of cosmic radiation, superimposed on the night sky background. Later experiments have shown that this light is in fact the Cerenkov radiation from EAS electrons.

Cerenkov radiation of EAS has since been used to obtain information on the features of the shower development (mainly through an analysis of the lateral distribution of the light) and to search for the sources of cosmic radiation.

Calculations of the lateral light distribution, based on definite models of EAS, are necessary for the interpretation of these experiments, and for understanding the variation of the lateral distribution with any shower characteristics. The first serious attempt of a theoretical treatment was made by Gol'danskiĭ and Zhdanov. Independently, Galbraith carried out calculations in which, however, the transverse dimensions of EAS and the angular distribution of particles were neglected.

In 1957 we began a calculation of the lateral distribution of Cerenkov light in EAS. The results, referring to an altitude of 3860 m above sea level, were partially published. The purpose of the present paper is to present quantitative results of the calculations for two observation levels, under the same basic assumptions. The angular and energy distributions of electrons in EAS were taken from the cascade theory of electron-photon showers. Numerical results were obtained for showers produced by primary protons and photons of different energies.

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Rotation of the Plane of a Circular Satellite Orbit, V. F. Illarionov and L. M. Shkadov, pp. 17–25.

Variational Problems of Optimization of Control Processes, V. A. Troitskii, pp. 35–49.

The problems of optimization of control processes in recent years attract considerable attention of researchers. The classical apparatus of the calculus of variations, as well as newer methods, are employed for their solution. Certain results, important for the theory of optimum systems, have been obtained with the use of the maximum principle of Pontryagin, the methods of functional analysis, and the method of dynamic programming.

Numerous questions of optimization of control processes can be formulated in the form of the Lagrange problem, the Mayer problem, and the Mayer-Bolza problem of the calculus of variations. Here, the most general of them, the Mayer-Bolza problem, is discussed, with the modifications introduced by the questions of optimization, and with the limitations imposed on the controls being taken into account. For this case the necessary conditions of minimum are established.

Features of Introducing a Small Parameter in the Investigation of Nonlinear Oscillations in Automatic Systems, E. P. Popov, pp. 82–92.

The objective of the present article is to call the attention of mathematicians interested in applied problems to an unusual formulation of the problem of a small parameter in the equations of the dynamics of nonlinear automatic systems, which seemingly can be fruitfully used for the development of a mathematically rigorous basis (to which the author makes no pretense) for widely used approximate methods in the study of nonlinear automatic systems.

Resolution of an Arbitrary Discontinuity in Magnetohydrodynamics, V. V. Gogosov, pp. 127–129.

The problem of the resolution of a discontinuity in magnetohydrodynamics with a magnetic field perpendicular to the plane of the discontinuity is considered. The parameters of the medium on both sides of the discontinuity are arbitrary. Altogether twenty different cases of resolution are possible. This paper shows which of the possible cases of resolution can be realized as a function of the values of the initial parameters of the medium.

Variational Problems for Supersonic Bodies of Revolution and Nozzles, Iu. D. Shmyglevskii, pp. 150–171.

Variational problems in the gasdynamics of axisymmetric irrotational flows have been treated in a large number of papers up to the present time. The idea of considering a control contour, which appreciably simplifies the solution of the problems, was proposed by Nikol'skii in 1950. The method of solution of degenerate variational problems was worked out in 1946 by Okhotsimskii. Guderley and Hantsche in 1955 formulated the problem of the optimal supersonic nozzle and reduced it to a boundary problem for ordinary differential equations. In 1957 the author of the present paper published the solution of a number of variational problems of gasdynamics of a perfect gas. The results of these papers, relating to axisymmetric nozzles, were