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CONFERENCE ON THE PHYSICS OF THE CONDENSED STATE

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A conference on the physics of the condensed state was held in Khark'kov on 11-15 May 1965 and was devoted to two topics: 1. Electronic spectra of solids. 2. Physical properties of liquefied and solidified gases.

The conference was organized by the Council on Solid State Problems and by the Physico-technical Institute of Low Temperatures, both of the Ukrainian Academy of Sciences. A total of 40 papers was delivered. Approximately 300 representatives of 32 organizations of the country participated in the conference.

The conference opened with a very interesting communication by **I. M. Lifshitz** "Quantum Diffusion in Solids." The author has investigated the thermodynamic and diffusion properties of impurities and vacancies in crystals, in which the potential barrier with respect to jumping over into a neighboring position of equilibrium is not too much higher than the zero-point oscillation. Such a situation apparently obtains in liquid helium. With decrease in temperature, the ordinary activation diffusion $D \sim \exp(-V_0/T)$ goes over into a temperature-independent quantum tunnel diffusion. However, with further lowering of the temperature, nonlocalized quasiparticles ("impuritons" or "vacancions" respectively) arise in place of localized impurity atoms or vacancies, and their dispersion law (or effective mass) is determined by the tunneling probability. The "vacancions" always obey Fermi statistics, while the statistics of the "impuriton" is connected with the statistics and arrangement of the impurity atoms to which they are due. A description of this kind is valid so long as the mean free path l of the "impuriton" is large compared with the lattice constant a; when the opposite inequality $a \gg l$ holds, the usual diffusion situation (classical or quantum) of localized impurities arises. Since the mean free path increases with decreasing temperature, ($l \to \infty$ as $T \to 0$), the mobility of the impurities or vacancies should increase at sufficiently low temperatures. Accordingly, the thermodynamics of a weak solution of impurities likewise changes with going over from the "impuriton" temperature region into the ordinary classical situation of localized impurities.

A large number of the papers delivered to the conference were devoted to superconductivity.

The topics considered were the influence of pressure, impurities, and crystal-lattices distortion on the temperature of the superconducting transition (and the critical magnetic field); the reconstruction on the anisotropy of the energy gap of superconductors with the aid of investigation of ultrasound absorption; experimental observation of the constant and alternating superconducting Josephson currents in tunnel emission in superconductors, etc.

The papers reported offer evidence that the contemporary developments in superconductivity are characterized both by a deeper insight in the concepts of the existing microscopic theory of superconductivity and a determination on its basis of the details of the superconductor energy-spectrum structure, and by investigations of qualitative new effects (one of which is the effect of superconducting tunneling—the Josephson effect).

The paper by **V. G. Bar'yakhtar, N. B. Brandt, N. I. Ginzburg, T. A. Ignat'eva, B. G. Lazarev, L. S. Lazareva, V. I. Makarov** and **I. I. Fal'ko** "On Change in the Topology of the Fermi Surface of Thallium under the Influence of Pressure and Impurities" is devoted to the effect of pressure (0—28,000 atm) and impurities (Bi, Sb, Hg) on the temperature of the superconducting transition of Tl. The anomalies of dT_c/dP of thallium (the presence of a nonlinear positive component which changes strongly when relatively small amounts of impurity are added) are attributed to singularities in the electronic structure of Tl. They can be explained theoretically if it is assumed that Tl has small regions of Fermi surface whose limiting energy is smaller than or of the order of $k\theta_D$ (θ_D is the Debye temperature), and in the indicated pressure interval there occurs the electronic transition predicted a few years ago by I. M. Lifshitz and connected with the jump-like variation of the Fermi-surface topology.

In the discussion, notice was taken of the great significance of this paper, connected with the fact that the superconductivity phenomenon has served as a method for investigating the band structure of a metal. **I. M. Lifshitz** expressed the desire that the electronic transition, "probed" by investigating the influence of pressure on the transition temperature of Tl, be investigated also by other methods which are used to interpret the energy spectra of metals. **N. E. Alekseevskiĭ** noted that if the explanation proposed by the authors is correct, such anomalies should not be peculiar to Tl only, and could occur also in other metals having small electron groups (for example, Sn).

In a paper by **I. M. Dmitrenko, I. K. Yanson** and **V. M. Svistunov** "Experimental Observations of Tunneling Effects of Cooper Pairs'' the authors report the results of investigation of a superconducting Josephson tunnel current (direct and alternating). The results of the paper reduce to the following: 1) the dependence of the Josephson direct current on the temperature and on the magnetic field was obtained and found to coincide with the theoretical value; 2) the generation of electromagnetic radiation with wavelength 3 cm by an $Sn-SnO_2-Sn$ tunnel junction was observed with the aid of a direct experiment; 3) the causes for the appearance of steps on the voltage-current characteristics of the tunnel junction were investigated. The authors propose to explain the appearance of such steps as being due to resonant interaction of the alternating Josephson current with the field of the decelerated electromagnetic waves propagating between the superconductors.

The great interest that attaches to a study of this new interesting effect was pointed out in the discussions. It was noted simultaneously that on the basis of the experiment performed on generation of electromagnetic waves by a tunnel junction one cannot establish uniquely whether this radiation is coherent or whether it constitutes a resonant "noise." Some unclear points remain in this question from the theoretical point of view, and consequently, further experimental as well as theoretical investigations are necessary.

A. G. Shepelev and **G. D. Filimonov**, in a paper "Anisotropy of the Energy Gap of Superconducting Tin from Data of Ultrasound Absorption," reported the results of a study of the energy spectrum of Sn by an ultrasonic technique. The experiment performed is characterized by the use of high frequencies (up to 300 Mc), pure single-crystal samples, and low temperatures (to 1°K). The results of the measurements are presented in the form of a "map" of the anisotropy of the energy gap of tin. Tin displays the maximum gap anisotropy (compared with other investigated metals) which reaches 70%.

In a paper "Criterion of Superconductivity," **I. I. Kulik** obtained by theoretical calculation a new criterion for superconductivity, in the form (in the isotropic model) $\rho s^2 < \frac{1}{3} N m v_F^2$, where ρ is the density of the metal, s the velocity of the longitudinal sound, N the electron density, and m and v_F the mass and the Fermi velocity of electrons. Such a criterion agrees with the experimental data for non-transition metals. The advantage of this criterion is that it: 1) is obtained theoretically (albeit approximately); 2) it apparently agrees well with experimental data.

It turns out that this criterion is similar in form to that proposed a few years ago by Bardeen, which can be regarded as empirical (since its derivation, in which no account was taken of the Coulomb interaction of electrons, is incorrect). In the discussions, **I. M. Lifshitz** noted that, on the one hand, the derivation of a rigorous superconductivity criterion is apparently impossible and, on the other hand, the approximate calculation and the criterion obtained with its aid is of undisputed interest, since the weak-coupling approximation used in modern theory of superconductivity does not hold, strictly speaking, (ρ is not a small quantity in the formula $T_c \sim \theta_D^{-1/\rho}$). Therefore a successful choice of the "zeroth approximation" is important; the zeroth approximation used in the paper by I. O. Kulik differs from that used in the Frohlich model.

A paper by **B. G. Lazarev, E. E. Semenenko, A. I. Sudovtsev** and **V. M. Kuz'menko** "On the Influence of Degree of Disorder in Lattices on the Superconducting Properties of Indium" is devoted to the superconductivity of metals in a strong nonequilibrium state, obtained by condensation on a substrate cooled with liquid helium. The critical magnetic field and the transition temperature increased with increasing degree of distortion, reaching values $H_c \approx 25{,}000$ G (corresponding to $T_c \sim 4.3$°K). This paper is of interest for the theory of disordered superconducting systems and also for modern theory of superconductors of kind II.

The last paper in the superconductivity section was that of **Ya. S. Berkovich, Ya. S. Kan** and **L. B. Rabukhin** "On the Destruction of Superconductivity by Direct Current in a Pure Cylindrical Sample of Tin," in which they report observation of an effect predicted by Cooper, that the resistance of the metal increases in the intermediate state as a result of scattering of the conduction electrons by the boundaries of the superconducting domains. The effect takes place in very pure samples with residual resistivity $\rho \sim 10^{-9}$–10^{-10} ohm-cm.

One of the sessions was devoted to investigations of transport phenomena in solids.

Undoubtedly the greatest interest was evoked by the communication by **R. N. Gurzhi** "The Role of Normal Collisions in Kinetic Properties of a Solid at Low Temperatures." In this paper the author developed several simple qualitative ideas which, in spite of their simplicity, turn out to be exceedingly fruitful and lead to a large number of quite untrivial consequences. One of these ideas consists in the following: normal collisions of quasiparticles (collisions without umklapp) can in themselves, as is well known, not lead to a finite resistance in the case of electrons or to thermal resistance in the case of phonons or magnons. However, they are indirectly capable of greatly modifying the resistance at low temperatures and in samples of sufficiently small size. This general idea is applied to phonons in dielectrics, to spin waves in ferrites, to electrons in metals in a constant electric field, and finally, to the problem of the skin effect in metals. In this region, which seemingly has already become classical, R. N. Gurzhi succeeded in obtaining a whole series of important physical results and to discover a new phenomenon—hydrodynamic transport mechanism.

In the past year, S. S. Shalyt and his co-workers observed experimentally quantum oscillations of the resistance of semiconductors (InAs), which were theoretically predicted by V. L. Gurevich and Yu. A. Firsov. At this conference **S. S. Shalyt** reported the results of further investigations of quantum oscillations and of the thermo-electric power in InAs from which certain information can be obtained concerning the energy spectrum of the electrons, which now are already of quantitative character. ("Investigation of Quantum Oscillations of Kinetic Effects in Indium Antimonide.")

In a paper "Galvanomagnetic Properties of Aluminum," **E. S. Borovik** and **V. G. Volotskaya** reported results of an experimental investigation of the behavior of the resistance and of the Hall field in aluminum in the presence of a strong magnetic field. The appreciable deviation from the Matthiesen rule for bulky aluminum samples in the absence of a magnetic field leads to a unique variation of the resistance in a strong magnetic field. For very pure samples of aluminum, E. S. Borovik and V. G. Volotskaya observed that the resistance increases following a small "plateau" in strong magnetic fields. Such a situation can be understood by assuming that aluminum has a narrow layer of open flat Fermi-surface sections, or else that favorable conditions exist for magnetic breakdown.

Recently much attention has been attracted by investigations of the galvanomagnetic properties of metals in the regions of strong magnetic fields, but there are very few papers devoted to a study of the galvanomagnetic characteristics of metals in weak magnetic fields.

In the paper "Contribution to the Theory of Galvanomagnetic Phenomena in Metals" by **M. I. Kaganov** and **V. G. Peschanskiĭ**, principal attention was paid to investigation of the behavior of the resistance and the Hall field in weak magnetic fields. The characteristics of a metal in a weak field are much less sensitive to the structure of the electronic spectrum than in the case of a strong field. In particular, the angular dependence of the specific resistivity and of the Hall "constant" in weak fields is determined only by the symmetry class of the given crystal.

Under most general assumptions concerning the dispersion and the character of the scattering of electrons, and using only the hermiticity properties of the scattering operator, they succeeded in establishing two universal relations, which are well known from experiment. First, the resistance of the metal always increases when a weak magnetic field is turned on and, second, the saturation of the resistance in a strong magnetic field is larger than the resistance in the absence of a magnetic field. The effects connected with energy quantization were disregarded in this case.

In the papers "Contribution to the Theory of Transport Phenomena in Metals in Strong Magnetic Fields" by **A. I. Akhiezer**, **V. G. Bar'yakhtar** and **S. V. Peletminskiĭ** and "Nondiagonal Kinetic Coefficients of Conductors in a Magnetic Field" by **S. V. Peletminskiĭ**, the authors developed the quantum theory of transport phenomena in conductors in the presence of temperature and chemical-potential gradients. In the quadratic dispersion law approximation for the conduction electrons, the authors investigated the role of different mechanisms of collisions between electrons and phonons, and the role of the phonon drag mechanism. Quantum oscillations of the kinetic coefficients are considered and it is shown that with variation of the magnetic field, oscillations set in not only in the kinetic coefficients, connected with the transport of charge and energy by the electrons, but also in the thermal conductivity coefficient which is due to the transport of energy by the phonons. It is shown that the total fluxes of heat and charge through the cross section of the conductor satisfy the Einstein relations in any approximation in the scattering.

Several investigations of the energy spectra of crystals in which phase transitions are observed were reported at the conference.

A report by **A. S. Borovik-Romanov**, **N. M. Kreĭnes**, **L. A. Prozorova**, **E. G. Rudashevskiĭ** and **V. A. Tulin** was devoted to an experimental study of antiferromagnetic resonance in rhombohedral antiferromagnets possessing weak ferromagnetism.

The phenomenological theory of spin waves in the case of such antiferromagnets predicts the existence of two resonance frequencies. If the external magnetic field H lies in the plane of "easy" magnetization, then the lower resonance frequency vanishes together with the field H, and is very convenient for an experimental study. The authors have established that the theoretically predicted formula for the lower resonance frequency is confirmed by experiment only in the case of $CoCO_3$, but in the case of the compounds $MnCO_3$ and α-Fe_2O_3 a systematic deviation of the experimental relaxation $\omega(H)$ from the theoretical one is observed. The authors relate this deviation with the presence of magneto-elastic interaction in the crystal, as well as interaction between the electronic and nuclear spins (hyperfine interaction). The resonance frequencies calculated with these interactions taken into account agree with experiments on crystals of $MnCO_3$ and α-Fe_2O_3.

The paper by **B. I. Verkin**, **V. V. Chekin**, **V. P. Romanov** and **V. A. Bokov** "Temperature Dependence of the Mössbauer Effect in Ferroelectric Solid Solutions of the System $Ba(Ti_{0.8}Sn_{0.2})O_3$" is devoted to investigation of resonant absorption of 23.8-keV γ quanta by Sn^{119} in nuclei of the solid solution of the system $Ba(Ti_{0.8}Sn_{0.2})O_3$. The measurements were made in the temperature interval 77–300°K. In the ferroelectric region the spectrum is a resolved doublet, while in the paraelectric region it is a broadened single line. In the region of the phase transition, the probability of the effect exhibits an anomalous behavior, attributed by the authors to the vanishing of some of the oscillations of the low-lying optical branch. **A. F. Prikhot'ko** and **M. I. Kaganov** have noted that research in this direction is promising because of the sensitivity of the effect to the phase transition.

In a paper "Spectroscopy and Magnetooptics in

Antiferromagnetic Crystals," V. V. **Eremenko, A. I.** Belyaeva, A. I. Zvyagin, and **Yu. A. Popkov** attempted to generalize the results of an experimental investigation of optical and infrared absorption spectra of dielectric crystals of certain compounds of transition metals (essentially fluorides and carbons of manganese and cobalt). The anomalies of the temperature dependence of the absorption bands and their widths, together with the influence exerted on the structure of the optical spectrum of the antiferromagnet by a strong external magnetic field which realigns the magnetic structure (in the case of manganese fluoride $H_C \geq 9 \times 10^4$ Oe) enable the authors to conclude that an appreciable role is played by the magnon influence on the formation of optical (and infrared) spectra of magnetically ordered crystals. In the discussion of the paper, **M. I. Kaganov** and **V. G. Bar'yakhtar** noted that to explain the experimental results it is apparently necessary to regard optical transitions in an antiferromagnetic crystal as combined transitions that lead to excitation of an exciton, phonon, and a spin wave simultaneously. **A. S. Borovik-Romanov** noted such a possibility of an optical transition, causing excitation of an ion (Mn^{2+}, Co^{2+}) with simultaneous production of two spin waves with oppositely directed momenta. Such a model can explain in principle also the large frequency shifts of the optical bands in the case of magnetic ordering, and the intervals between the main bands and the satellite lines.

Related to the last paper were several others reported to the conference and devoted to the study of optical absorption spectra of low-temperature modifications of solid oxygen: "Absorption of Light by the Antiferromagnetic Modification of Solid Oxygen" by **A. F. Prikhot'ko, O. S. Pakhomova, T. P. Ptukha** and **L. I. Shanskiĭ**, and "Temperature Dependence of Double Optical Transitions in Solid Oxygen" by **V. V. Eremenko, Yu. G. Litvinenko** and **É. M. Ogneva.**

In the first of these papers it is noted that the frequencies of double optical transitions that lead to simultaneous excitation of a pair of molecules differ noticeably from the values obtained by simple summation of frequencies of ordinary single transitions. This circumstance offers evidence of the appreciable coupling between the O_2 molecules, which apparently induces the double transitions. In the second paper it is reported that the absorption bands connected with double transitions become noticeably weaker when a sample consisting of the α-modification of oxygen is heated. This fact offers evidence that an increase in the temperature weakens the interaction between the molecules of O_2 inducing the double transitions.

One group of papers was devoted to spectral investigations of nonmetallic crystals.

A. S. Davydov and **E. F. Sheka** proposed in "The Structure of Exciton Bands of Molecular Crystals" a method for calculating the exciton dispersion law, and investigated the analytic properties of $E(\mathbf{k})$ in the vicinity of $\mathbf{k} = 0$. A numerical calculation of the exciton band corresponding to intramolecular excitation 27,570 cm^{-1} was made for the anthracene crystal. It turned out that for this system the minimum of the exciton band is shifted somewhat relative to the point $\mathbf{k} = 0$, which in the authors' opinion may explain the high quantum yield of luminescence of this crystal from the exciton state. In the course of discussion, **M. I. Kaganov** noted that the fact that a minimum exists at $\mathbf{k} \neq 0$ can in itself not lead to an increase in the lifetime of the exciton and the luminescence quantum yield.

M. S. Brodin and **M. V. Kurik** reported in "Optical Investigations of the Energy Structure of CdS–CdSe Crystals" an experimental investigation of low-temperature absorption and reflection spectra of crystals of solid solutions of the type CdS_xSe_{1-x}. On the basis of the data obtained, they calculated, using the **Rp** method, the parameters of certain energy bands of the electronic spectrum in these crystals.

V. A. Lisovenko and **M. T. Shpak**, in a paper "Influence of Ultraviolet Radiation on the Intrinsic Luminescence of Anthracene," reported the appearance (under the influence of irradiation) in the luminescence spectrum of anthracene of two new series of bands, which are related to the occurrence of two sorts of glow centers.

The papers "Energy Structure of the Active Laser Media and the Possibility of Changing the Generation Frequency" by V. L. **Broude** and **M. S. Soskin** and "Dependence of the Luminescence Spectrum of Anthracene on the Intensity of the Exciting Light" by V. L. **Broude** and **E. F. Sheka** dealt with problems of lasers. The first paper considers methods, proposed by the authors, of tuning the laser generator frequency and experimental realization of such a tuning (using a ruby laser as an example) is reported using a prism placed inside the interferometer. In the second paper the authors report results of investigation of the luminescence spectra of single-crystal anthracene films with the intensity of the exciting light varied over a wide range (up to 10^{22} qu/cm^2 sec). They succeeded in showing that in the spectrum of the luminescence obtained from the "end face" of a thin sample the dependence of the intensity of certain bands on the intensity of the exciting light is steeper than linear. A thorough analysis of the experimental results has enabled the authors to state that the lasing mode was realized in thin anthracene samples.

Related to the spectral papers is the communication by **Yu. A. Bratashevskiĭ, N. N. Dykhanov**, V. A. Moiseev, V. N. **Topchiya** and V. R. **Shilov** "Investigation of EPR in the Halidarylsulfamide Ammonia Complex." The paper contains a determination of the valence state of copper in the complex and the symmetry of its environment. Based on the obtained temperature dependence of the absorption line width, the authors advance certain considerations concerning the character of the interaction of the copper ions. The frequency of the exchange interaction and the Curie temperature are determined.

The conference heard a very interesting paper, also one somewhat remote from the main subject of the conference, by **I. Ya. Fugol'**, **P. L. Pakhomov**, **G. P. Reznikov** and **Yu. F. Shevchenko**, "Spectral Investigation of the Afterglow of a Helium Plasma at Low Temperatures." In this paper they investigated thoroughly the elementary processes of collisions in a decaying low-temperature helium plasma at 77 and 20°K. They measured the rates of the pair-recombination process and the diffusion coefficients of the metastable state $2\ ^3S$ of He. They investigated the kinetics of the de-excitation of atomic lines of helium and proposed a mechanism for the intense afterglow of helium plasma, on the basis of processes

$$\mathrm{He}\,(2^3S) + \mathrm{He}\,(2^3S) + \mathrm{He}\,(1^1S) \rightarrow \mathrm{He}_2^+ + \mathrm{He}\,(1^1S) + e,$$

$$H_2^+ + e \rightarrow \mathrm{He}^1 + \mathrm{He}\,(1^1S) \rightarrow 2\mathrm{He}\,(1^1S) + h\nu.$$

In the discussions, **A. S. Davydov** and **M. I. Kaganov** noted that the diffusion process investigated by the authors is unusual, and that allowance must be made for the resonance exchange of the interaction.

Several communications reported to the conference pertained to the investigation of the electronic spectra of metals.

Great interest was evoked by the paper by **R. T. Mina** and **M. S. Khaĭkin** "Investigation of Electromagnetic Microwave in the Skin Layer of Indium." These authors, investigating the Doppler broadening and the decrease in the amplitude of the cyclotron-resonance peaks on non-central sections of the Fermi surface at small angles of inclination of the magnetic field to the surface of the sample, measured the rate of propagation and the depth of penetration of an electromagnetic wave in indium. At frequencies 9.6 and 18.6 Gcs and $T = 1.8$°K the velocity of the wave, averaged over the depth of the skin layer, amounts to 1.4×10^6 and 2×10^6 cm/sec, while the active depth of penetration is estimated at 5.3×10^{-5} and 3.9×10^{-5} cm, respectively.

The oscillations of the coefficient of absorption of longitudinal ultrasound in bismuth was the subject of two papers by **A. N. Korolyuk.** At a frequency of 500 Mcs the author observed a large number of oscillations of geometrical resonance, and in strong magnetic fields, he observed "giant" oscillations. A study of these phenomena using the same sample of bismuth has made it possible to explain several features of the electronic spectrum of bismuth.

P. A. Bezuglyĭ, **A. A. Galkin**, and **S. E. Zhevago** reported results of measurement of anisotropy of the periods of oscillation of the geometrical resonance in single-crystal samples of gallium in transverse and longitudinal magnetic fields (relative to the direction of the wave vector of the sound). A qualitative agreement was established between the results of the experiment and individual regions of the Fermi surface of the seventh and eighth electron zones, constructed by the method of orthogonalized first-approximation plane waves. In regard to the ninth electron zone, its dimensions in the $\mathbf{k}_a$ direction turn out to be 20 times smaller than the dimensions that follow from the aforementioned model. Evidence of the sharp deviation of the electron dispersion law in gallium from quadratic was the observation of oscillations of the resonant type in a magnetic field that was longitudinal with respect to the wave vector.

In the paper "On the Absorption of Sound in Graphite" **M. I. Kaganov** and **A. I. Semenenko** considered the absorption of a high frequency ($\omega\tau \gg 1$) sound in graphite, due to interaction between the phonons and the conduction electrons. It is shown that the absorption coefficients have strong anisotropy, and that the part of the coefficient connected with the interband transitions increases like ω^3 in the most important region of frequencies. In addition, it is shown in the paper that the character of the singularity produced by the phonon-electron interaction in the phonon spectrum is determined by the local characteristics of the Fermi surface.

Investigation of the electronic structure of indium and its alloys with the aid of the magnetic properties was the subject of a communication by **B. I. Verkin**, **I. V. Svechkarev** and **L. B. Kuz'micheva** "Magnetic Susceptibility of Metals and Alloys." An analysis of the experimental data has led to the conclusion that the magnetism of non-transition polyvalent metals is due essentially to the interband interactions of the electrons. A new interpretation is proposed for the temperature dependence of the susceptibility of polyvalent metals.

I. Ya. Dekhtyar and **R. G. Fedchenko** investigated the influence of thermocyclic treatment on the paramagnetic susceptibility of alloys of palladium with iron and palladium with aluminum and iron. A deviation of the temperature dependence of the susceptibility from the Curie-Weiss law was observed. A dependence of the susceptibility on the field was observed, and an influence of alloying palladium with iron on the annihilation spectrum of the ions and positrons was noted, as well as a change in this dependence after numerous quenchings of the alloy. The results obtained are attributed by the authors to the interaction between the iron atoms and the defects arising during heat treatment.

Yu. N. Tsiovkin advanced the hypothesis that the change in the susceptibility can be attributed to the change in concentration of the hydrogen during heat treatment. **B. I. Verkin** noted that there are no grounds as yet for preferring one of the proposed explanations for the effect.

N. V. Volkenshteĭn and **Yu. N. Tsiovkin** investigated the temperature dependence of the electric resistivity and the susceptibility of 0.5% atomic solutions of 3d metals and certain 4d metals in platinum in the interval 2—400°K. They have shown that the resistance of the solutions in the 6—30°K interval is described by a formula of the type $R = R_{res} + R_{id}(T) + R_{imp} + A \log T$. The anomalous term in the resistance, of the form $A \log T$, is connected with the scattering of conduction electrons by the localized magnetic moments of the impurities.

Data on magnetic susceptibility confirmed the presence of magnetic moments on the impurity atoms.

Reports of investigations devoted to the physical properties of liquefied gases have become traditional for cryogenic conferences.

Yu. P. Blagoĭ, A. E. Butko, S. A. Mikhaĭlenko, I. L. Nizkovolos, N. A. Orobinskiĭ, A. I. Savina and **V. V. Yakuba** investigated the thermodynamic properties of several liquefied gases and their solutions. The phase equilibria and the density were investigated of the systems helium-hydrogen, nitrogen-propylene, argon-propylene, methane-propylene, and others. Large deviations from ideal behavior were observed in addition to a limited solubility in the investigated solutions. A thermodynamic analysis of the data was made and conclusions are drawn concerning the connection between the form of the equilibrium diagram of the solution and the energy of the intermolecular interaction or the structure of the solution.

Investigations of the speed of sound, carried out by the same authors for argon, oxygen, nitrogen, methane, propylene and krypton, have made it possible to determine several important thermodynamic properties of these substances, the adiabatic and isothermal compressibilities, and the specific heat at constant volume and along the saturation line in a broad temperature interval.

N. S. Rudenko and **V. G. Konareva** reported results of investigations of the viscosity of D_2, HD, and H_2 and their solutions from the triple point up to the boiling temperature and in the entire range of concentrations. A linear relation was observed between the relative difference of the viscosity coefficients of the hydrogen isotopes and the relative difference of the isotope masses. The maximum deviation of the viscosity coefficients of the solutions from additive values reaches 11.5, −7 and −5% for the solutions D_2–H_2, HD–H_2, and D_2–HD, respectively.

A feature of this conference was the appreciable number of communications devoted to the study of solidified gases. By virtue of many distinguishing features—simplicity of the molecules, high symmetry of the lattices, and the presence as a rule of one type of intermolecular interaction forces—solidified gases can serve as a convenient research object in the solution of several fundamental problems of solid-state physics.

L. P. Mezhov-Deglin carried out measurements of the thermal conductivity of crystalline He^4 in the region 0.5—2.5°K and pressures up to 185 atm. The temperature dependence and also the maximum values of the thermal conductivity of such single crystals differ greatly from those usually observed, and are in close correspondence with the results of Gurzhi, who investigated theoretically transport processes in ideal crystals.

V. G. Manzheliĭ, A. M. Tolkachev, V. G. Gavrilko and **E. I. Voĭtovich** reported results of an investigation aimed at determining the density and thermal expansion of solidified gases. They measured by a pycnometric method the densities of solid methane, ammonia, nitrogen, oxygen, and xenon. The authors produced for the first time an experimental setup for direct study of thermal expansion of solidified gases. They determined the coefficients of linear expansion of crystalline ammonia (25—175°K), methane (21—60°K), and oxygen (20—47°K). Part of the thermal expansion of these solidified gases is connected with the molecular degree of freedom. For ammonia, a method is proposed for separating the lattice and molecular contributions to the thermal expansion.

P. A. Bezuglyĭ, N. G. Burma and **R. Kh. Minyafaev**, using a pulse procedure, determined the rate of propagation of longitudinal and transverse ultrasonic waves of 1 Mc frequency in polycrystalline ammonia (77—170°K) and polycrystalline methane (14.4—77°K). On the basis of the measurement results and the literature data on the density in the indicated temperature intervals, they determined the "adiabatic" elastic constants of solidified ammonia and methane and estimated their Debye temperature.

D. N. Bol'shutkin, L. I. Borisova, A. V. Leont'eva, A. I. Prokhvatilov, T. V. Sil'vestrova, V. G. Snigirev, V. I. Startsev and **Yu. E. Stetsenko** made an exhaustive investigation of the mechanical properties of solidified methane and ammonia. They developed original procedures for determining the mechanical properties of polycrystalline ammonia (under tension, compression, impact bending, indentor impression, and creep) and methane (under tension and indentor impression). The temperature dependences of the properties of ammonia ($T \geq 77°K$) and methane ($T \geq 20°K$) were established. The temperature dependence of the static modulus of normalized elasticity under compression and the Poisson coefficient of ammonia were determined.

The temperature dependence of the hardness of methane was discussed on the basis of notions concerning the negotiation of obstacles by dislocations via diffusion during creep, observed upon penetration of the indentor. An analytic dependence of the hardness on the temperature was obtained.

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