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17 December 1979

USSR Report

PHYSICS AND MATHEMATICS

(FOUO 7/79)

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JPRS L/8820

17 December 1979

USSR REPORT

PHYSICS AND MATHEMATICS

(FOUO 7/79)

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LASERS AND MASERS

UDC 621.375.826

EXPERIMENTAL INVESTIGATION OF A MIXING-TYPE GAS DYNAMIC CO_2 LASER

Moscow DOKLADY AKADEMII NAUK SSSR in Russian Vol 248, No 1, 1979, pp 81-83

[Article by B. A. Vyskubenko, Ye. T. Demenyuk, G. A. Kirillov, Yu. V. Kolobyanin, S. B. Kormer, N. A. Nitochkin, received 10 June 1979; presented by academician Yu. B. Khariton on 17 February 1979)]

[Text] It is possible to increase the efficiency of a gas-dynamic laser [1] if vibrationally excited nitrogen is mixed rapidly with cold carbon dioxide in a supersonic nozzle [2] inasmuch as the relaxation time determining the losses of vibrational energy, and together with this efficiency of the nozzle, is appreciably greater for pure nitrogen than for mixtures containing CO_2, He, or H_2O. However, it has not yet been possible to realize the advantages of the mixing type gas-dynamic laser, judging by the published data [3, 4], for the achievement of high radiation power is prevented by a decrease in the specific energy pickup with an increase in the braking pressure of the nitrogen at the entrance to the nozzle. Thus, for the version of the mixing gas-dynamic laser presented in reference [4], the specific energy pickup and radiation power are reduced, beginning with the pressures of 5-6 atmospheres, which explains the low value of the reduced power obtained (12.5 watts/cm^2)*. In reference [3], a specific energy pickup of 20 joules/g and a reduced power of 33 watts/cm^2 were achieved at a pressure of 9 atmospheres.

The purpose of this experiment was to investigate the electrical characteristics of a mixing gas-dynamic laser with a flat nozzle at pressures to 50 atmospheres and temperatures to 3 kK. The schematic of the experimental setup is presented in Figure 1. For heating nitrogen, just as in reference [5], an electric explosion in the chamber 1, 5 meters in volume, was used. After rupture of the diaphragm 2, the nitrogen, which was expanded in the flat, supersonic nozzle 3, reached the resonator 4. The height of the critical cross section of the nozzle h* = 0.16 cm, the width was 17 cm. The geometric degree of expansion of the nozzle is 15.5.

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* By reduced power we mean the ratio of the radiation power to the area of the exit cross section of the nozzle.

In the initial version the injector was analogous to the one used in reference [3]. The mixture of CO_2 and He was mixed in advance in the "mixer" 5 and was released to the injector through the high speed valve 6. In order to obtain generation, two single-passage resonators were used arranged in series one after the other. The resonators were in the form of flat dielectric mirrors 7 with a backing made of BaF_2 and a transmission coefficient on a wave length of 10.6 microns of 12-32 percent for the first and 7-10 percent for the second. The blind copper mirrors 8 were made of three rectangular 4 x 4 cm spherical mirrors 10 m [sic] in radius fastened to a common backing so that their axes were parallel. The edge of the mirror of the first resonator was at a distance of 5 cm from the critical cross section of the nozzle; the total length of the active part of the resonator along the flow was 24 cm. The radiation energy was measured by calorimeters 9 located at the focal point of the spherical mirror 10. Part of the radiation scattered by the calorimeters was collected by the spherical mirror 11 and was directed at the opening in the germanium photo resistance 12 for recording the shape of the radiation pulse in time.

In the basic and the mixing chambers the gas pressure was measured during the escape process by inductive sensors 13. The temperature and flow rate of the nitrogen and also the mixture of CO_2 and He were found from the pressure by the procedure described in [5]. The specific energy pickup was obtained by dividing the instantaneous radiation power by the instantaneous flow rate of the nitrogen--the carrier of the thermal energy--as was done in [3, 4]. The experimental setup made it possible to obtain the radiation power as a function of the braking parameters and composition of the operating mixture in one experiment.

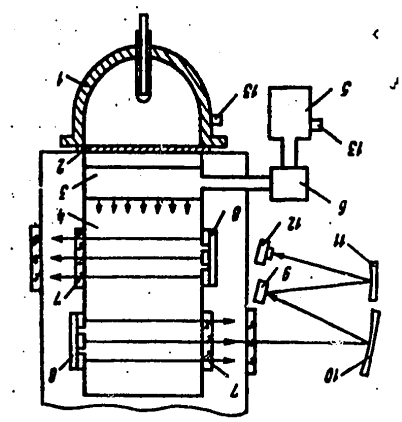

Figure 1. Diagram of the Experimental Setup

The optimal mixture with respect to specific energy pickup, with which the series of experiments was performed with different initial pressures and discharge energy in the chamber and the relations for the energy characteristics as a function of the braking parameters were defined (Figure 2, the light dots), was found by multifactor optimization. It is obvious that the reduced power increases with an increase in pressure to 30-40 atmospheres, and then it begins to decrease. The maximum reduced power was ~ 90 watts/cm^2. The value of the maximum specific energy pickup of 18 joules/g agrees well with the data in reference [3].

The decrease in energy characteristics with an increase in pressure indicates the strong influence of the relaxation processes in the mixing zone. The basic factors determining the relaxation losses in the mixing gas-dynamic laser are the extent along the flow of the mixing zone and the gas-dynamic disturbances connected with the structural elements of the injector and interaction of the injected jets with the basic flow. Here the three-dimensional nozzle lattice described in reference [6] is of interest. The uniform distribution on the injection points with respect to transverse cross section, and the small pitch of the lattice insure short extent of the mixing zone along the flow, and injection almost in the wakes makes it possible to reduce the level of gas dynamic disturbances to a minimum. The indicated advantages made it possible to obtain a specific energy pickup of 26 joules/g in [6] at high pressure (50 atmospheres). The basic deficiency of this system is the high degree of expansion of the nozzles, which limits the reduced power (100-110 watts/cm^2) in spite of the high gas pressure at the entrance to the nozzle unit and it leads to high losses of total pressure in the flow.

We have improved the flat mixing nozzle with CO_2 and He injection in the vicinity of the critical cross section aimed at decreasing the mixing length and reducing the level of gas dynamic disturbances. The results of the experiments with the improved nozzle are presented in Figure 2 (the dark points). points).

As is obvious from Figure 2, the energy characteristics of the mixing gas-dynamic laser increased significantly. The maximum reduced power was 275 watts/cm^2 with a specific energy pickup of 26 joules/g. The maximum specific energy pickup reached 54 joules/g (32.3 joules/g with respect to the flow rate of the entire mixture). With an increase in pressure from 6 to 30 atmospheres the value of the specific energy pickup is approximately cut in half, which corresponds to an increase in the relaxation losses connected with an increase in pressure. The specific energy pickup of the investigated mixing gas dynamic laser at high pressure can obviously be increased by using a nozzle with large geometric degree of expansion. This is confirmed by the results of the experiments performed with an increase in the helium concentration in the mixture (CO_2: He = 1 : 6). At a pressure of 8 atmospheres and a temperature of 2.48 °K, the maximum specific energy pickup of 55.6 joules/g was obtained (37.8 joules/g with respect to the flow rate of the entire mixture.

A comparison of the mixing gas-dynamic laser presented in this paper with the best homogeneous gas-dynamic lasers presented in the literature [5, 7] indicates that in the investigated range of parameters, the mixing gas-dynamic laser is superior with respect to the specific energy characteristics to the homogeneous one. The maximum values of the specific energy pickup and the reduced radiation power are record values for the gas-dynamic CO_2 lasers.

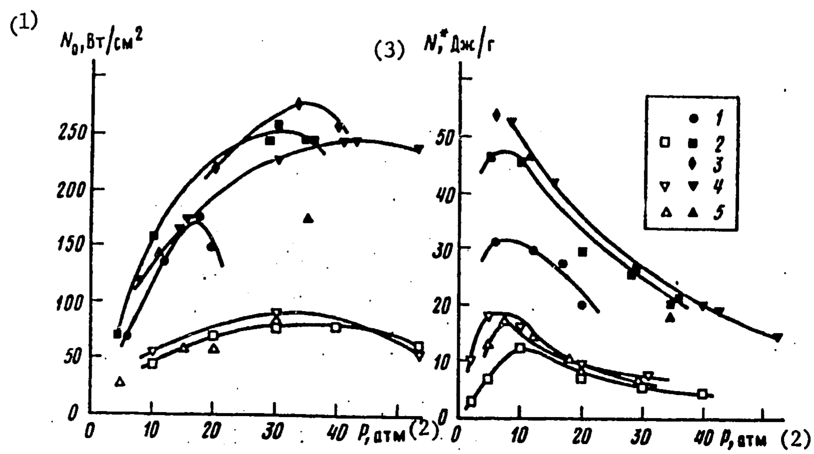

Figure 2. Energy characteristics of the mixing gas-dynamic laser as a function of the braking parameters. Mixture composition: 7.5-14.5 percent CO_2; CO_2 : He = 1 : 4, N_2 -- the rest. The area of the exit cross section of the nozzle is 55.2 cm^2. T = 1.5 (1); 2.0 (2); 2.2 (3); 2.5 (4) and 3.0 kK (5).

Key: (1) N_0 Watts/cm^2
(2) P, atmospheres
(3) N*, joules/g

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10845
CSO: 8144/0318

PUBLICATIONS

UDC 536.25:538.4

MAGNETIC FLUIDS-NATURAL CONVECTION AND HEAT EXCHANGE

Minsk MAGNITNYYE ZHIDKOSTI--YESTESTVENNAYA KONVEKTSIYA I TEPLOOBMEN in Russian 1978 signed to press 6 Jul 78 pp 2,3,4, 205-206

[Annotation, Foreword, Table of Contents of book by V. Ye. Fertman, Izdatel'stvo "Nanka i tekhnika," 206 pages, 100 copies]

[Text] The principal methods of synthesizing magnetic fluids and the physical properties of these fluids are examined in this book. Original results of research on convective heat exchange in the layers of a magnetic fluid of distinct configuration, which are found in nonuniform magnetic fields, are presented. The vigorous development of the thermomechanics of magnetic fluids, which arose at the junction of the fields of mechanics and the electrodynamics of continuous media, is characterized by the widespread introduction into industry of a new material--the magnetic fluid. Publication of these results will familiarize a large group of specialists with the properties of magnetic fluids and possibly extend their use.

The book is intended for scientific workers and engineers working in the fields of thermophysics, fluid mechanics and heat engineering; it may be useful to students in institutions of higher learning.

three tables; 51 illustrations; 187 titles in the Bibliography.

FOREWORD

The growth of contemporary technology is accompanied by attempts to create new working media which permit effective use of power equipment and to rework the original technological processes and the designs of technological equipment. On the other hand, scientific investigations in the area of the transfer of energy (heat) and mass of material are directed at establishing the interdependence of comparatively independent processes.

A. V. Lykov noted this tendency already at the beginning of the 1960's. In particular, the study of the interaction between electromagnetic fields and fluids and gaseous media has been especially productive.

In the last decade the attention of a large group of researchers has been drawn to a new technological material--the magnetic fluid, whose interaction with the outer magnetic field is conditioned by its strong magnetic properties. Ferro-hydrodynamics, as it is known, is occupied with the study of this interaction. Extending the traditional domain of magnetohydrodynamics, it is located at the junction of mechanics and the electrodynamics of continuous media.

Taking into account the interdependence of the temperature conditions of the medium and the electrodynamic interaction of the magnetic fluid with the field, questions which we relate to the thermomechanics of magnetic fluids are examined in the book. Major attention is focused on elucidation of the peculiarities of convective heat exchange in magnetic fluids, but along with this is given a great deal of information about the physical properties of such fluids and an attempt is also made to systematize the theoretical models.

In the present work, of course, since it is of an introductory nature, attention is not given to a discussion of many important problems. The author hopes, however, that the book will help the reader to form a sufficiently complete picture of the development of this comparatively new problem in fluid mechanics.

Materials prepared by the following colleagues were used in writing the sections indicated: V. K. Rakhuba and N. P. Matusevich, paragraph 1.2 of Chapter 1; V. G. Bashtovyy and M. I. Pavlinovyy, paragraph 3.2 of Chapter 3; A. N. Vislovich, Appendix 1; V. K. Polevikovyy, Appendix 2. B. E. Kashevskiy participated in the writing of Chapter 2.

The author expresses his gratitude to all the colleagues mentioned above.

The author is deeply indebted to Doctor of Physical and Mathematical Sciences B. M. Berkovskiy, who proposed the idea of writing the book, for his constant attention and scientific assistance.

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CSO: 1862

PUBLICATIONS

THEORY OF JETS IN IDEAL FLUIDS

Moscow TEORIYA STRUY IDEAL'NOY ZHIDKOSTI (Theory of an Ideal Fluid Jet) in Russian 1979 signed to press 1 Feb 79 pp 2, 3-4, 5-9

[Annotation, foreword and table of contents from book by Maksim Isidorovich Gurevich, revised, supplemented second edition, Nauka, 3,700 copies, 536 pages]

[Text] The book has been written by a prominent scientist who has made a substantial contribution to the development of the theory of an inviscid fluid jet and cavity flows. It contains an exposition of the basic ideas and results of this theory, as well as a solution to numerous problems which are of practical use. The second, posthumous edition of the book has been supplemented by new materials of the author's colleagues included at his request and concerned with the jet flow around various obstacles, unsteady currents, consideration of the forces of gravity and surface tension and other questions. The bibliography has been significantly augmented.

The book is of interest for scientific workers, engineers and graduate students working in the area of fluid and gas mechanics and its applications.

The book has 42 tables, 300 illustrations, and a bibliography of 661 entries.

Contents

Foreword to the Second Edition

The first edition of the book by M. I. Gurevich was published in 1961. The book was highly praised by specialists, and became widely known. In 1964, it was awarded the Prize imeni S. A. Chaplygin; in 1965, it was published abroad in an English translation.

The book contained new positings of problems and fundamental theoretical conclusions obtained in the theory of jets in ideal fluids over the 100 years since its founding. Along with the well known book by G. Birkhoff and E. Sarantonello [36], it provided an exhaustive exposition of jet theory up to the time of its publication, however in a more accessible form and with a detailed examination of the achievements of the Soviet school of hydrodynamics. It is not surprising that this book became a desk reference not only for specialists in the area of hydrodynamics, but also for engineers concerned with numerous applications of jet theory. Since the time of the first edition, a number of new interesting works have appeared on the theory of jets in ideal fluids, including those by the author himself as well as his students and colleagues. These works relate to the cavity theory of a hydrofoil, to calculating the forces of gravity and surface tension, to unsteady flows and to various general and applied questions of fluid and gas mechanics. The designated questions have been reflected in the subjects of special conferences, and in particular, they were examined at the International Symposium on the Application of Functions Theory in Flow Mechanics (Tbilisi, 17-23 September 1963), at the All-Union Conference on Boundary Problems and Their Applications in Fluid and Gas Mechanics (Kazan', 28-31 May 1969), at the International Symposium on Unsteady Flows of Water at High Velocities (Leningrad, 22-26 June 1971), and at the all-Union congresses and international congresses on theoretical and applied mechanics. We must note the very informative reviews of new works on jet theory, and above all those of the author himself [92, 94], as well as G. Birkhoff [35a] and Wu Yao-tsu [54]. The questions of the theory and technical applications of jet and cavity flows are taken up in special books [117, 164, 244, 263, 265 and others], as well as in various periodicals and series.

The urgent need for republishing the book of M. I. Gurevich has long existed. The author had previously begun collecting new materials and working on the book, however the completion of it was prevented by his severe illness and untimely death.

The overall structure and style of the book have been kept as much as possible according to the author's plans; at the same time it has undergone substantial reworking. Upon the request of M. I. Gurevich, some of his students and colleagues kindly agreed to participate in this work, and they provided their own materials and reworked a number of sections of the book for its second edition.

The second edition (like the first) consists of 12 chapters. The first four chapters were prepared for publishing by the author himself.

Chapter 1, from the example of the classic problem, gives a comparative exposition of the methods of G. Kirchhoff, N. Ye. Zhukovskiy and S. A. Chaplygin. It describes the general particular features of the theoretical methods of S. A. Chaplygin and reestablishes his primacy in working out a new method of jet theory.

Chapter 2 solves a group of very simple problems on the flow of streams from vessels with rectilinear sides. The given group of problems historically was the first to obtain practical application in science and technology. The value of solving the problems of a jet flow around obstacles was discovered significantly later. Chapter 3 is devoted to these problems, and it examines the flow around polygonal obstacles, and above all a wedge. In a number of examples, the possibility is analyzed of constructing various systems of a jet flow around the same obstacle, and this was discovered for the first time by S. A. Chaplygin. In line with the solving of the Chaplygin problem, the use of the theta function device is shown, and this is used predominantly in the second edition of the book. There is a special discussion of the familiar erroneous critique of jet theory which for a long time reduced the theory to the level of a mathematical theory without the possibility of practical application.

Chapter 4 studies a jet flow around curvalinear obstacles using the Kirchhoff system; the Levi-Chivita method is described; the integrodifferential equations of Villat and Nekrasov are derived; the well known method [290] of finding the flow around of an arbitrary number of curvalinear obstacles is described.

The questions of the existence and uniqueness of solving jet problems are examined in the description by L. M. Kotlyar in a new and somewhat more detailed manner than in the first edition, and the classic device of functional analysis is employed.

Chapter 5 deals with the cavity flow of bodies. On the basis of a brief description of the cavitation phenomenon, the reasons are brought out why the theory of jets in ideal fluids for a long time was subjected to unmerited criticism, and it is pointed out for what conditions and flow-around modes jet theory provides solutions which conform satisfactorily to experience. The positing of a problem is given for a cavity flow with a pressure in the cavity that differs from the pressure in the incident flow (with a cavitation number not equal to zero), and a comparison of various cavitation systems is given. M. I. Gurevich was responsible for detailed research on these systems, including the system of D. A. Efros which has recently been given a new interpretation and application. The author also restored the primacy of N. Ye. Zhukovskiy for the system which significantly later was developed by A. Roshko. For the second edition, Chapter 5 was completely reworked by A. G. Terent'yev; it includes a comparative review of certain new systems, and in particular, the system with a cavity terminating in two infinite spiral coils.

The chapter ends with a brief exposition of a linear theory of cavity flow-around of a thin profile at a low angle of incidence and this in recent years has undergone significant development and practical application.

Chapters 6 and 7 which have also been significantly supplemented and prepared for republication by A. G. Terent'yev examine various problems of the cavitation flow around obstacles in limited flows (channels and jets with a finite expenditure), gliding theory and hydrofoil theory. It must be emphasized that M. I. Gurevich was one of the first to begin to be concerned with gliding theory and made a significant contribution to its development.

In the substantially supplemented Chapter 8, various particular problems of jet theory are described and which have basically gained practical application. First of all the problems are examined of the colliding of jets and on currents with an internal line of failure; these problems are used in the theory of armor piercing and in the hydrodynamic theory of jet automation (pheumonics). These problems have been described for the second edition by P. M. Belotserkovskiy. The new section prepared by G. Yu. Stepanov with the participation of Ya. R. Berman involves the calculating of the jet currents under an air cushion device and across steps on the bottom of a channel. In this section various systems of cavity currents for the first time are discussed comparatively.

This ends the exposition of the first, classic part of the theory of flat steady jet currents of an ideal weightless uncompressable fluid.

Chapter 9 is devoted to the theory of unsteady flows. The problems are examined of a flat plate in an accelerated flow, on the hitting of a contour flowed around with a break in the jet, on slightly disturbed jet flows and the submerging of a wedge. The exposition of the last two questions has been improved by A. V. Kuznetsov who wrote §42 and by A. G. Terent'yev who supplemented §43. A more detailed exposition of certain new results in the theory of nonstationary disturbed flows of a fluid with free boundaries is given in the book [195].

Chapter 10 describes the theory of subsonic gas jets the founder of which was S. A. Chaplygin. This chapter has been supplemented with certain new references by L. M. Kotlyar and G. A. Dombrovskiy.

Chapter 11 which deals with the theory of axial-symmetric currents gives the approximation solutions and certain general theoretical results, including belonging to the author; of the latter the most important is the law of the asymptotic expansion of the jet. Chapter 11 has been the least altered since the development of this theory has basically occurred in the areas of numerical analysis and semiimperical systems which do not conform to the overall style of the book.

The last, 12th chapter describes the jet flows of a heavy fluid, and provides a calculation for the influence of the forces of surface tension. This chapter has been completely reworked by O. M. Kiselev. Due to the large number of new articles and results in the designated area, the chapter has assumed largely a review nature. The additional references and the detailed exposition of the questions of the theory of jet flows of a heavy fluid can be found in the monograph [161].

Supersonic jets and stalled flows of a viscous fluid as before are not specially examined in the second edition of the book. In line with this it must be pointed out that the hydrodynamics of an ideal fluid does not lose its significance, but on the contrary, becomes a necessary component element in the modern theory of the jet and stalled currents of a viscous fluid with high Reynolds numbers. For a general familiarization with the state of this question, it is possible to recommend the reviews [65] and [322] as well as the book [396].

The list of literature has been substantially enlarged, and the bibliography of the first edition has been completely kept. As regards the additions made, it must be pointed out that the literature on jet theory over the last two decades has attained such a volume that it was virtually impossible to reflect not only all the new works but even all the essential areas of research. Naturally, preference was given to the works close to the book in terms of its specific concern, as well as to the works of the students and co-workers of the author.

The book ends with a brief bibliographical sketch and a complete list of the works of M. I. Gurevich.

The general layout and scientific editing of the book were carried out by G. Yu. Stepanov. He also was responsible for a number of supplements, the most substantial ones being in §13, 25 and 38. Ya. R. Berman systematized the author's materials prepared by him for the republishing of the book, and also read the manuscript and made many useful comments and corrections.

Special thanks should be paid to the publishing house editor G. M. Il'ichev in whose able hands the text of the book assumed its final form. She was not only concerned with improving the text, but also delved profoundly into its essence and made a number of corrections.

Because of the circumstances of publication, the book obviously is not devoid of shortcomings; some of them are clear from the given foreword, while others will not escape careful readers. All comments and requests on the content and format of the book will be received with gratitude.

L. I. Sedov and G. Yu. Stepanov

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PUBLICATIONS UDC 532.526

EXPERIMENTAL INVESTIGATIONS OF THE BOUNDARY LAYER

Kiev EKSPERIMENTAL'NYYE ISSLEDOVANIYA POGRANICHNOGO SLOYA in Russian 1978 signed to press 27 Mar 78 pp 2, 3-4, 183-184

[Annotation, Foreword and Table of Contents of book by L. F. Kozlov and V. V. Babenko, 184 pages, 1650 copies]

[Text] In this monograph the results of experimental studies of hydrodynamic stability and artificial perturbation of the boundary layer are systematized. Peculiarities in the transition of a laminar boundary layer to a turbulent one in two-dimensional and three-dimensional streamline flow and, likewise, methods of modelling in experimental studies of hydrodynamic resistance in a model basin are examined. The effect of suction and the shape of the bow tip of the models on the characteristics of the boundary layer and on hydroaerodynamic resistance is studied. The procedure, apparatus and results of the hydrodynamic experiment are described.

The book is intended for scientific and engineering and technical personnel, and also for teachers, graduate and undergraduate students in institutions of higher learning in the appropriate specialties.

Foreword

Experience in the study of the history of science testifies to the fact that progress in the field of fluid and gas mechanics at the various stages of its development has always been stimulated and to a significant degree been dependent upon accomplishments in experimental studies. In this connection it is sufficient to recall the emergence and development of boundary layer and turbulence theory. The qualitative and quantitative experimental data obtained were essential in shaping fluid and gas mechanics, first of all in the creation of mathematical models of the phenomenon under investigation. Such models permitted formulation of the principal quantitative relationships, including differential and integral equations, which describe the phenomenon with sufficient accuracy and which it would be possible to integrate in the final analytical form desired. At the same time, experimental data always served as the fundamental criterion in verifying the theories being developed. It is appropriate to take special note of the decisive role of the hydrodynamic experiment in the creation and working out of various engineering structures and designs and likewise of their individual components.

In the present monograph are presented results of experimental studies of certain characteristics of the boundary layer and hydroaerodynamic resistance which were carried out by the authors in collaboration with their colleagues. Great attention in these investigations was devoted to study of the phenomenon of the transition of a laminar boundary layer to a turbulent one and especially the first stage of this--the onset of hydrodynamic instability. The above-mentioned direction of the studies was not accidental since, in the opinion of the authors, it is namely this problem that until recently has been the least researched in the field of boundary layer studies. Also included in the monograph are the results of experimental studies of hydrodynamic stability in rigid and flexible-damping surfaces and the means of having an effect on the boundary layer. In particular, certain questions have been examined that are related to the use of passive flexible-damping surfaces, of boundary layer suction, and to the study of the shape of the bow tip of the body and the preheating of the plate surface in towing tests in an aquatic medium.

The methodological arrangement of the book was devised by L. F. Kozlov. He also wrote Sections 7 and 8 of Chapter II, Sections 1 and 3-6 of Chapter IV, Chapter V, and Section 1 of Chapter VI. He wrote Section 2 of Chapter II with V. V. Babenko. V. V. Babenko wrote Chapters I, II, III, Section 2 of Chapter IV and Section 2 of Chapter VI.

The authors are deeply indebted to the science editor of the book Corresponding Member of the Academy of Sciences of the Ukrainian SSR I. L. Povokh, the reviewers Doctors of Technical Sciences Yu. I. Shvets and I. K. Nikitin and Candidate of Technical Sciences M. M. Nazarchuk, and also to our younger colleague N. F. Yurchenko for familiarizing themselves with the manuscript and making many useful comments. The authors are likewise deeply indebted to Candidates of Technical Sciences A. I. Tsyganyuk, Engineers N. A. Gnitetskiy and V. I. Korobov for placing certain materials at our disposal and also for their part in setting up and processing the experiments.

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PUBLICATIONS

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MHD-WAVES IN THE NEAR-EARTH PLASMA

Moscow MGD-VOLNY V OKOLOZEMNOY PLAZME in Russian 1979 signed to press 21 Mar 79 pp 2, 3-4, 138-139

[Annotation, Foreword, Table of Contents of book by A. V. Gul'el'miy, "Nauka" Publishers, 139 pages, 900 copies]

[Text] In the monograph are examined questions regarding the theory of the generation and diffusion of magnetohydrodynamic waves in various regions of near-earth outer space (in the radiation belt, at the leading edge of the magnetosphere, in solar wind). Fundamental consideration is given to comparison of the conclusions of theory with data provided by surface and satellite observations.

The book is intended for geophysicists involved in the study of near-earth space and also for physicists interested in geophysical applications of the electrodynamics of plasma.

58 illustrations; 288 titles in the Bibliography

FOREWORD

This book is devoted to the theory of the generation and diffusion of magnetohydrodynamic (MHD) waves in various regions of near-earth space: in the radiation belt, at the leading edge of a near-earth shock wave, in the tail of the magnetosphere and in solar wind. The general principles of the theory of waves in a plasma have been set out in detail in many surveys and monographs published in recent years. In the present work fundamental consideration is given to elucidation of the relationships between the theories and observations by means of analysis of specific types of low-frequency electromagnetic emissions.

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000200030034-9

The order of presentation is as follows. After a short introduction, the most significant particular instances of longitudinal (Chapter 2) and lateral (Chapter 3) diffusion of Alfven and magnetoacoustical waves are examined. In longitudinal diffusion waves are generated as a result of cyclotron instability in the first harmonics of the hydrofrequency of ions. In lateral diffusion instability occurs at high cyclotron harmonics. Instability at zero harmonic (Cherenkov instability) is possible in diffusion at an angle to the magnetic field. The case of diagonal diffusion is examined in Chapter 4. With this is completed the analysis of ionic instabilities of a uniform plasma leading to the generation of MHD-waves and connected with nonequilibrium character of diffusion of particles according to velocities (anisotropy of temperatures, cluster, nonmonotonic dependence of diffusion on energy). The nonuniformity of the near-earth medium in these instances does not have fundamental importance; one can disregard it or allow for appropriate modifications of the theory, for example, through the use of Wenzel-Kramers-Brillouin approximations.

On the other hand, a large class of drift instabilities related to nonuniformity of the plasma is known. One example of this type of instability is subjected to qualitative analysis in Section 3 of Chapter 4.

Instability is an important mechanism, but not the sole one in the generation of MHD-waves. To complete the picture, we examine in Chapter 5 generation produced by outside sources.

A chapter in which various nonlinear effects are discussed completes the book.

In the selection of material, consideration was given to those theoretical results which were easiest to compare with the observations. Complex or cumbersome calculations have been omitted as far as possible.

I wish to express my sincere gratitude to Professor V. A. Troitska for her interest in this work. It is my pleasant duty to thank my colleagues at the Borok Geophysical Observatory, Institute of Physics of the Earth Imeni Shmidt, Academy of Sciences of the USSR: N. M. Bondarenko, V. K. Veretennikova, B. V. Dovben', A. L. Kalisher, B. I. Klayn and V. N. Repin, A. M. D'Kosta, N. A. Zolotukhina and A. S. Potapov. A portion of the results set forth in the book was obtained together with these colleagues. I want to express my gratitude to N. A. Kokareva, G. A. Mironova and A. K. Selezneva for their assistance in preparation of the manuscript.

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PUBLICATIONS

ELECTRONIC PROPERTIES OF DOPED SEMICONDUCTORS

Moscow ELEKTRONNYYE SVOYSTVA LEGIROVANNYKH POLUPROVODNIKOV (Electronic Properties of Doped Semiconductors) in Russian 1979 signed to press 31 Jan 79 pp 2, 3-6, 414-416

[Annotation, foreword and table of contents from the book by Boris Ionovich Shklovskiy and Aleksey L'vovich Efros, Nauka, 4,500 copies, 416 pages]

[Text] The book examines the physical phenomena in doped semiconductors, and for a description of these it is essential to consider that the electrons are in the chaotic field of the donors and acceptors. Among these phenomena are the Anderson localization of electrons, hopping conductivity, the transition from metallic conductivity to activation with a change in the degree of doping and compensation, and the optical phenomena related to the density-of-states tails. A modern approach to the designated problems to a significant degree is based upon percolation theory. The book provides the first review in monographic literature of this new mathematical discipline. There is a detailed discussion of the method of calculating electroconductivity of heavily homogeneous media based on percolation theory. A theory of hopping conductivity constructed using this method has been described systematically. Great attention has been given to comparing its results with experimentation. Unsolved problems of the theory are also discussed.

The book has 13 tables, bibliography with 358 entries, and 85 graphics.

Foreword

The first generation semiconductors could not be termed doped. They were simply very impure. The uncontrollable inpurities did not make it possible to ascertain the physical regularities, and this misled the researchers and caused ridicule and pessimism in the proud representatives of the "pure" physical disciplines which were rapidly developing at that time. When they succeeded in overcoming this "impurity," a new age began in the development of semiconductor physics. This age has occurred under the motto of "purity." It brought the outstanding successes of the 1950's, and as a result of these a new area of technology arose which was called "semiconductor electronics."

Experiments with pure crystals provided a powerful impetus for the development of semiconductor theory. At this time the method of the effective mass for complex zones, the theory of impure states, and the theory of kinetic phenomena were developed and tested out.

In essence, these achievements also comprise what has presently come to be called semiconductor physics. However, in the last 15 years, a tangible shift has occurred in the direction of impure semiconductors. The fact is that precisely the impure properties are responsible for the work of a whole series of major semiconductor devices, and for this reason technology requires impure semiconductors. In contrast to the first generation semiconductors, they are termed not impure but rather doped, emphasizing by this that the engineers within certain limits are able to control the impurity composition.

New problems have arisen in the theory of the electron states of doped semiconductors. These examine the electron located not in the periodic field of the crystal atoms, but rather in the chaotic field of the impurities, and the potential energy of this field cannot be considered slight. With low temperatures, the doped crystal semiconductor is a disordered system which in terms of its general properties is reminiscent of amorphous systems. This applies not only to the heavily doped but also to the light doped semiconductors. The lighter the doping, the lower the temperatures at which these properties are manifested.

The aim of the present book is to provide a consistent exposition of the theory of electron states and conductivity of doped semiconductors at low temperatures, that is, in that range where the properties of the electron states differ sharply from the properties of Bloch waves.

Depending upon the doping, the electronic properties of the conductor at a zero temperature can be localized or delocalized. An important merit of the theory of disordered systems is the so-called Anderson theorem which asserts that under certain conditions strictly localized states exist. The exposition of the properties of electron states actually starts with the detailed discussion of this question (Chapter 2). A specific feature of the theory which distinguishes it from the theory of the electron properties of an ideal crystal is the necessity of considering the electron-electron interaction even with very small electron concentrations. In this regard a theory of nonlinear electron screening has been worked out (Chapter 3, §13) based on the method of the self-consistent field. In the immediate proximity of the Fermi level, this method does not work and the density of states shows interesting features (Chapter 10).

If the Fermi level is among the localized states, then electroconductivity is carried out by electron hops and in an exponential manner depends on the temperature and concentration of impurities. The hopping conductivity phenomenon has long been known, however in the last decade definite advances have been made in this area. A theory was constructed which provides a good quantitative description of the temperature, concentration and magnetic field dependences. The young mathematical discipline termed percolation theory has been the basis for these advances. For studying low-temperature conductivity, the percolation method has come to play the same role as the kinetic equation method for zone conductivity. The term "percolation level" is employed in the corresponding literature just as frequently as "relaxation time." There are good reviews on percolation theory which we have quoted in Chapter 5. However, in the first place, these reviews were written comparatively long ago, and secondly, they are not "in the same key" as is required for describing hopping conductivity. For this reason we have considered it necessary to write a special chapter (Chapter 5) which would give the basic results of percolation theory and provide a bibliography of works on this subject.

In all the chapters concerned with hopping conductivity, a detailed comparison has been made between theory and experimentation. The results of this comparison seem, as a whole, good to us. We have endeavored to note particularly those instances in which discrepancies arise as well as the theoretical problems which seem unresolved to us.

The book is devoted to crystal semiconductors, however the ideas and methods given in it are so close to the theory of amorphous semiconductors that "amorphous motives" inevitably are woven into the exposition. Sometimes (see Chapter 9) we have used experimental material obtained for amorphous semiconductors to affirm various concepts.

The scope of the book did not allow us to incorporate in it such questions as the dependence of hopping conductivity upon the frequency and tension of the electric field. The reader can become acquainted with them from the reviews of Pollak [1] and Böttger and Bryksin [2], as well as from the reviews of Mott quoted in the book.

The given book has been conceived of not only as a monograph for specialists, but also as a continuation of the regular course of semiconductor theory which takes up a new range of questions. Chapter 1, §14 as well as §35 should serve as the connecting links between this book and the canonical courses on the theory of "pure" semiconductors. The book is designed for a broad range of readers including theoretical and experimental physicists, graduate students and engineers who know the principles of solid state physics. It can be read in a simplified version by omitting §§3, 7-9, 19, 20, 28, 33, 34, 37, 40 and 46. It is also important to bear in mind that all the basic questions, as a rule, are given twice, initially on a qualitative level and then on a quantitative one. The reader who is not interested in the mathematics can continue reading the book in limiting himself to the qualitative explanation. The places which can be omitted are usually indicated in the text.

As a majority of the scientists working in this area, we are under the influence of the ideas of Prof N. F. Mott, and pay tribute to him by this book. His remarkable books and reviews awakened our interest in the theory of disordered systems.

Constant contact with the experimenting physicists at the semiconductor laboratories of the FTI [Physics Engineering Institute] imeni A. F. Ioffe and the MGPI [Moscow State Pedagogical Institute] imeni V. I. Lenin played an important stimulating role in our work. We are also grateful to all the participants at the theoretical seminars of the FTI imeni A. F. Ioffe and the IFP [Institute of Physics Problems] imeni S. I. Vavilov which regularly discussed our work. We are grateful to all Soviet and foreign colleagues who worked with us and sent their works for discussion prior to publication. We are grateful to S. D. Baranovskiy, A. G. Zabrodskiy, M. A. Krivoglaz, Nguyen Wan Lien, G. Ye. Pikus and I. I. Fel'dman who assumed the work of reading the manuscript partially or completely and who made a number of valuable comments. With particular affection we would thank our relations M. M. Margolina, D. Ye. Shklovskaya and N. I. Efros for support and unstinting aid in preparing the manuscript for publication.

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NUCLEAR PHYSICS

ROLE OF DUBNA NUCLEAR RESEARCH INSTITUTE IN HUNGARIAN SCIENCE

Budapest MAGYAR TUDOMANY in Hungarian Nos 8-9, 1979 pp 585-597

[Article by Dezso Kiss, Academician, vice director of Dubna Joint Nuclear Research Institute: "The Role of the Dubna United Nuclear Research Institute in Hungarian Science"]

[Text] Within the fascinating pace of development of the natural sciences in the past few decades an especially outstanding place is occupied by a few areas of physics which we might sum up--with some imprecision--under the name of "nuclear physics" research. The ultimate goal of this research is to discover and understand the most elementary, most basic building blocks of the material world around us and the laws holding them together. Looking more closely at this part of science we find three fields of science:

1. Particle physics (or high-energy physics),

2. Nuclear physics, and

3. The cultivation of solid state physics with nuclear phyaics methods (a part of neutraon physics).

Although these three fields differ from one another in many respects in regard to their themes and methods of work they have many common aspects which tie them together. In what follows let us look more closely at these common aspects.[1]

a. It is a common characteristic of all three fields that they belong to the sphere of basic research or "big science," they are fundamental. Their primary goal is to discover the laws or phenomena of nature, to develop the world picture of man; possible practical applications appear only secondarily as a by-product.

Although in my opinion it is not superfluous to clarify the place, necessity and importance of basic research in Hungary, I think that this is not the task of this article. Still, let me note--as an illustration of the fact, for example, of what stormy progress human awareness has lived through in the area of particle physics in recent years--that a unified theory has been found for two different interactions, the weak and electromagnetic interactions. This scientific discovery is comparable in its significance to that milestone in the history of science when Maxwell created the unified electromagnetic theory out of two similarly independent theories (the theories for electric and for magnetic phenomena). This theory made possible those technical inventions (e.g., the electric motor, the dynamo, telephone, radio and television) which fundamentally changed the life of mankind and cut through our everyday lives, without which life would be difficult to imagine for modern man. It appears that this is only a first step; we are obviously progressing on the best road toward the creation of a universal theory which will incorporate all the interactions, the practical result of which is as yet immeasurable.

Another line of development is the strengthening of our faith in the existence of the most elementary building blocks of matter, the quarks. What is involved is that after the elementary nature of atoms we have become aware of an elementary particle layer lying even deeper--the nucleons and electrons making up the atoms. We are now storming the structure of the nucleons and it appears that the nucleons themselves are composite particles built up from a few quarks. We are digging deeper and deeper in discovering the structure of matter and it is difficult to say today whether we have arrived at the deepest level or whether the number of these is inexhaustible. Whether the one or the other such investigations can revolutionize our world picture. The goal and significance of experimental research being done in this direction can be compared to the alpha scattering measurements performed by Rutherford at the beginning of our century, now considered a classic, as a result of which we learned that the atom was not uniform, learning for the first time of the existence of the atomic nucleus. It can be imagined that our new information today represents the threshold of a similarly new, as yet unimaginable technical age.

A recognition of the significance of the new achievements, which can be called revolutionary without any exaggeration, is reflected in the fact that a large number of the leading countries of the world are turning a significant proportion of their scientific budgets to studies of this character. The importance of it can be read from the fact, for example, that a recognition of the importance of basic research received a place at the congress of the CPSU too. ("The river of the scientific and technological revolution would dry up if it were not constantly fed by fundamental research." "There is nothing more important for practice than good theory.")

It is an interesting index of the swift speed of development that in these areas there is no sense in writing lexicons; as soon as they appear most of the information is obsolete and the newest and most exciting discoveries, understandably, could not have a place in them.

b. Another common aspect of the three fields is that research is extraordinarily expensive. The energy of accelerators has developed swiftly in recent years and, naturally, together with this their size and cost. The cost of seeting up the super-accelerator to be built in the Soviet Union in the near future will not be much less than half a billion rubles. Similar sums are spent in the western countries too. Although the accelerators represent the biggest investment of modern nuclear research setting up modern detector systems (e.g., large bubble chambers, counter equipment complexes, multiple level computer systems, etc.) which require a much smaller investment can cost nearly 10 million rubles (or dollars) each. Dozens of these are set up for each accelerator. Despite the extraordinary expense most countries of the world consider it necessary and important to support this research which promises so much.

c. It follows directly from what has been said above that for a small country like ours (and the number of these is large) building accelerators of the necessary energy (or even a modern detector or computer system) is an unachievable dream for material reasons and because of the industrial background for the cost of setting up an accelerator would take an excessively large proportion of the national income. In this situation the only realistic solution is to join forces, that is to create an international research center. This is the point where science must necessarily step beyond national frameworks. International collaboration is extraordinarily important and most productive in any area of science but here it is simply vital. So the third essential characteristic is internationality. This was the guide when the socialist countries, at the proposal of the Soviet Union, established the United Nuclear Research Institute (EAI) in Dubna, a little town of about 20,000 inhabitants 130 kilometers north of Moscow. The goal--which follows from the foregoing--was to make it possible for the scientists of those socialist countries which did not have the necessary material resources to participate in experimental work in the area of nuclear research. In addition, the tasks of the EAI included handing on the experience and results acquired here as a contribution to the development of domestic physics in the member countries. Without the existence of the EAI the researchers of the socialist countries (with the obvious exception of the Soviet Union) would be deprived of research giving such basic new information. So the creation of the EAI was an extraordinarily significant step from the viewpoint of the scientific life of the socialist countries. At the same time it is necessary to throw a proper light on another side of the question--the existence of the EAI is a political question of great import also. The EAI is the first and largest joint institute of the socialist camp. In accordance with this questions connected with the EAI must be treated with an awareness of their political importance, as well as their scientific significance.

At present the EAI has 11 member countries. In addition to the European socialist countries these are Korea, Cuba, Mongolia and Vietnam. The individual countries contribute to the costs of maintenance or development in proportion to their national incomes. To give an idea of the magnitudes involved, 200 million rubles are at the disposal of the EAI in a single five-year plan (investment, budget and wages) of which the Soviet Union provides 74 percent and Hungary provides 2.6 percent. It should not be forgotten that in addition to covering three quarters of the maintenance costs the Soviet Union made available to the institute, without recompense, the two large accelerators which constitute the basic equipment of the Dubna institute and it supports the institute through many other channels also. For example, the EAI uses about one third of the time of the Soviet accelerator in Serpukhov, which has an energy 7 times greater than those in Dubna, and does so free of charge. In the near future the Soviet Union will build a 3,000 GeV accelerator complex, the only one of its kind in the world, out of its own resources, but the EAI will have access to it. In addition it is practically alone responsible for the infrastructure of Dubna as a town, from housing through the clinic to the sport facilities. It would appear that a larger than justified part of the development of basic research rests on the shoulders of the Soviet Union--in addition to the other problems of the socialist camp. In many respects the situation is analogous in space research (Interkozmos).

At practically the same time as Dubna the western European countries also established an international institute, CERN (Conseil Europeen pour la Recherche Nucleaire), which works in Geneva and involves 12 western European countries. Actually expensive particle physics research can be done now in five places in the world--in the United States, in West Europe, in the Soviet Union, at Dubna and in Japan. Thus the world is divided into five "regions" and a few years ago an international organization, the ICFA (International Committee for Future Accelerators), was formed with representatives of the five regions to work on ideas for the distant future. It seems clear that despite the respectable efforts of individual countries (our homeland excluded) new steps, that is, for example, the construction of an accelerator offering possibilities greater by one order of magnitude, exceed not only the possibilities of individual countries (even if they are large industrial powers) but also the possibilities of the individual regions. So it can be imagined that the only realistic solution is the construction of one large, joint, international accelerator the costs of which would be divided up among the states of the participating regions. This would certainly be a great step forward for science but its political significance might be even more important. It also seems clear that the creation of such a new accelerator will require the solution of innumerable problems, not primarily scientific and technical ones but rather political and financial ones, and for the time being it is uncertain when this might be done. In any case this is the area where it is possible to cooperate without essential conflicts of interest and it might be a model for international cooperation extending to the whole world. This would raise scientific integration to an even higher level, to the level of integration embracing the entire world. Although the new large accelerator and research center is still in the distant future it already has a name--the VBA (Very Big Accelerator).

Returning to the EAI in Dubna, which interests us more directly, it is worth noting the place of the EAI in the world. The research possibilities offered by the EAI exceed by several orders of magnitude the possibilities of the member countries. From this point of view the existence of Dubna is well established in every respect. As for international comparisons, Dubna will take first place in the world in the area of neutron physics thanks to the large capacity unique impulse reactor now being built. This is a wonderful possibility for domestic neutron physicists. Dubna is also in a good position in regard to nuclear physics in the stricter sense; it has achieved outstanding results in the synthesis of transuranic elements, in the search for super-heavy elements, in the study of special, very rare decays and in high energy heavy ion physics, which it is customary to call relativistic nuclear physics.

The situation is much more complex in the area of particle physics. When Dubna was established it stood in the first rank in the world in regard to acceleration energies. Later accelerators with higher energies were built elsewhere in the world and the role of Dubna declined. In the early 1970's, thanks to the putting into operation of the Serpukhov accelerator, Dubna again attained front rank in world science and held this position for about 5 years. Since then new large accelerators have been built in the west, which makes Dubna's present situation less favorable. Under such circumstances the way out for the Dubna institute in the area of particle physics is to participate as a collaborating partner in other accelerator centers, for example in the measurements being made in CERN or in the United States. The Dubna institute prepares some of the measuring equipment and sends it out to the accelerators and physicists from Dubna (including Hungarians) participate in the measurements. Naturally, a real solution can come from a new "wave"--the construction of the previously mentioned 3,000 GeV super-accelerator (UNK)[2] which will occupy a unique position in the world in regard to energy. Then the Dubna and Hungarian physicists will again be capable of studying questions in the front rank of science in this area also. It is probable that this new period will last for a long time and it can be well exploited by our domestic physicists.

Organizational Structure of the Dubna Institute

The chief guiding organ of the institute is the so-called "Committee of Plenipotentiary Government Delegates" which meets once a year and decides the most important questions (investment, budget, annual and five-year plans, long-range plans, etc.). Every member country is represented by a delegate at the deputy minister level; our country is now represented by Academician Istvan Lang, deputy first secretary of the Hungarian Academy of Sciences.

Financial activity is supervised by the Finance and Audit Committee. In questions connected with scientific research the highest level forum is the scientific council (which meets twice a year) which submits its proposals for final approval to the Committee of Plenipotentiary Government Delegates. Every member country is entitled to three seats in the scientific council. Hungary is now represented by Academician Denes Berenyi, Norbert Kroo, doctor of physical sciences, and Karoly Szego, candidate in physical sciences. The activity of the scientific council is aided by the high energy, low energy and theoretical sections. Various committees (a total of six) support the work of these. Representatives of the member countries, including our homeland, participate in the work of both the sections and the committess.

A three member international directorate takes care of operational guidance of the institute; it is responsible to the Committee of Plenipotentiary Government Delegates. At present the director of the institute is Academician N. N. Bogolyubov, who was recently elected to be an honorary member of the Hungarian Academy of Sciences. His two vice directors are the Polish professor M. Sowinski and the author of this article.

The vice directors always come from the member countries. In general the appointment is for 3 years and generally circulates among the member countries. According to the division of labor which has developed one of the vice directors guides high energy physics activity and international contacts (at present Dezso Kiss) and the other supervises low energy physics activity and personnel matters.

The research activity of the institute takes place in six scientific laboratories and one independent scientific department. Each of these corresponds to a separate institute with several hundred or even a thousand workers. The laboratory directors guide the work of the laboratories, generally with the help of three deputy directors. One of the deputy directors is not Soviet. So it can be seen that the representatives of the Hungarians (and, naturally, of every member country in general) are represented at every level of both operational guidance and corporate guidance in addition to the scientific work in the stricter sense.

The atmosphere of the institute is extraordinarily favorable. Among other things this can be attributed to the fact that the EAI can ensure very good, balanced working conditions. The structural system of the institute is much more stable than is customary in our homeland; there has been no substantial organizational change in the past 23 years. Compared to the domestic practice the number of administrative personnel is low; the bureaucratic burden is relatively not too great. One of the gratifying consequences of this (and, understandably, it is one of the attractions of Dubna for leading scientific researchers) is that physicists occupying various posts in the scientific leadership are able to do their own research work too--to a much greater degree and with greater intensity than in our homeland.

In what follows I will list the various laboratories, with special regard to the activity of the Hungarians.

1. Theoretical Physics Laboratory (LFT)

Academician D. I. Blohintsev, an honorary member of MTA, was director until his death in 1979. The approximately 170 workers of the laboratory study primarily the interactions of the symmetry properties of elementary particles within the framework of the theory of elementary particles and they study theoretical problems of the atomic nucleus in regard to both nuclear structure and nuclear reactions. A smaller group does research in connection with a quantum statistics model of condensed matter. Two internationally significant theoretical schools have developed in this laboratory over the decades, the schools of academicians Bogulyobov and Blohinstsev. Hungarian theoretical physicists have worked actively in this laboratory practically since the founding of the institute, in all three scientific fields. Many have defended their candidate dissertation here or on the basis of their work here and the number of publications by Hungarian researchers is around 100.[3]

It is very difficult to select only a few from among the many outstanding theoretical achievements. But it might not be unjustified to mention the work done with group theory questions and soliton solutions of non-linear interaction equations, which won the first degree of the EAI Institute Prize.

2. High Energy Laboratory (LVE)

The director is Academician A. M. Baldin. Its large piece of equipment is the 10 GeV synchrophasotron which in recent years was adapted to acceleration of heavy ions also. They can now create here relativistic heavy ions (all the way up to carbon) of the highest energies (5 GeV per nucleon). Some of the more than 1,000 workers of the laboratory deal with high energy particle physics problems. Some of this work is being done on the accelerators of other institutes, primarily in Serpukhov but to a smaller degree in the CERN and in the Fermi Laboratory (Batavia, USA). The research being done with the synchrophasotron is shifting more and more toward a new field of science which is a "no-man's land" between high energy physics and low energy or medium energy nuclear physics, the so-called relativistic nuclear physics or relativistic heavy ion physics.

The broad cooperation which has developed with the member countries is characteristic of the work of the laboratory. This cooperation is made necessary by the processing of the results of the high energy experiments (the evaluation of nuclear emulsions, bubble chamber photographs and results recorded on magnetic tape and the computer processing of data--"remote" physics).

From the beginning Hungarian experimental particle physicists have participated very intensively in the work of this laboratory.[4] The measurements are high energy particle physics measurements so they are not done on the accelerator of the Dubna laboratory but rather on the larger accelerators of other institutes. But the problematics of the measurement and the ideas originate in Dubna and the measuring equipment is made in Dubna.

Between 1967 and 1972 the Serpukhov accelerator was the highest energy particle accelerator in the world so it is understandable that all of the measurements made here then aroused broad international interests. The most significant achievement was establishing that in contrast to the theoretical predictions the entire effect cross-section of the interactions of particles increased with the increase in energy. The K^o regeneration experiment was important in clarifying this so-called "Serpukhov effect" and Hungarian experimental physicists played a significant role in carrying out this experiment (among other things with the aid of the CDC 3300 computer of the MTA).

The regeneration experiments performed on hydrogen, deuterium and carbon proved that the "Serpukhov effect" did not contradict the so-called Pomeranchuk thesis because the effect cross-sections increased in such a way that the difference between the particle and anti-particle effect cross-sections decreased. Our results evoked a very lively response at various large international conferences (Kiev in 1970, Amsterdam in 1971, Batavia in 1972, Aix-en-Provence in 1973 and London in 1974). The number of publications on the theme approaches 40. The members of the group received various institutional prizes in Dubna and in the KFKI for their work; in 1973 the Hungarian participants also shared in the Academy Prize. Thus far one Hungarian researcher has defended his candidate dissertation in the theme and a doctoral defense is being prepared. The cooperation is continuing on one of the most exciting themes of our day, research on the new so-called "difficult" particles.

Another area where outstanding successes were achieved is in the study of the mechanism giving rise to multiple particles, using a two meter bubble chamber filled with propane, again on the Serpukhov accelerator, its pion beam. They demonstrated for the first time a linear correlation between the multiplicities of the charged and neutral particles generated and gave a possible interpretation of this with the aid of a simple klaster model.

The above experimental results met with serious international interest and there were numerous references to them. Also among the first to appear in the literature was the study of two-particle correlations as functions of various kinematic charges, which is a very important contribution to understanding the mechanism giving rise to particles. We can regard as important the experimental results pertaining to scale invariance in the central and fragmentation domains. The multifold results pertaining to an inconclusive study of the interactions of the pion-carbon nucleus provide significant data. In this area there have been 25 publications jointly with the entire collaboration or with smaller units of it and five publications appeared in Budapest with only Hungarian authors. The work is referred to in 250 articles. In 1975 the work was awarded the KFKI Institute Prize. One researcher defended his candidate dissertation in Dubna using the results achieved and two won their university doctoral degrees in Budapest.

At present a series of experiments, extraordinarily interesting from the scientific point of view, is being conducted in connection with the inflexible scatter of muons. The essence of the experiment is that we are bombarding various atomic nuclei with high energy muons and we are deducing the structure of the nucleons from the scatter picture. The measurements are very similar to the classical Rutherford experiment to which we can attribute the formulation and experimental proof of the concept of the atomic nucleus. We know, as a result of similar experiments done with electrons in the SLAC laboratory (in America), that nucleons also have a structure. This experiment is intended to make more precise the study of this nucleon structure. The measurements are being done in collaboration with the CERN, using the 400 GeV muon beam of the CERN. The Dubna institute is bearing about one third of the cost of the experiment, about 12.5 million Swiss francs, by preparing the necessary large magnets and the special large and extraordinarily sensitive detectors, the so-called proportional chambers. The measurement equipment was prepared in record time (four years) and the first test measurements are now being conducted. The magnets and chambers prepared at Dubna meet every need and requirement and were prepared in time. In my opinion this joint experiment is now the most significant scientific experiment being conducted by the Dubna institute today in the area of particle physics. We can take pleasure in the fact that Hungarians have been participating in this work from the beginning--at the EAI and (as representatives of the EAI) at the CERN.

In regard to the distant future, this laboratory will probably deal primarily with high energy nuclear physics and relativistic heavy ion physics, and the ratio of expressly super-energy particle physics measurements will substantially decrease. According to the long-range ideas they intend to establish, in cooperation with the Kurchatov Institute in Moscow, a new, large heavy ion accelerator (the UKTI)[5] with this laboratory as a base; the new accelerator will be capable of accelerating ions in the entire mass domain from protons to uranium with energies ranging from 250 MeV per nucleon all the way to 10 GeV per nucleon. In the latter stage of the development of the UKTI they will probably use the present synchrophasotron either in its present form or modernized with supraconducting magnets. Thus far domestic physicists have not shown any special interest in such high energy relativistic nuclear physics so it can be expected that the participation of the Hungarians in the work of this laboratory will decrease to a minimum, if not to nothing.

3. Nuclear Problems Laboratory (LJAP)

The director is Academician V. P. Zhelepov. The institute's 680 MeV synchrocyclotron works here. The larger part of the work of the approximately 800 people working in the laboratory is linked to this equipment. The bulk of the work done with the accelerator deals with a study of conservation laws and interaction symetries and a study of the structure of the atomic nucleus with mesons and high energy protons. Significant effort is also turned to radiochemical and nuclear spectroscopic research within the framework of whichthey study the properties of isotopes produced with the synchrocyclotron. Meson chemistry research (in the development of which the laboratory has played a pioneering role) and oncological experiments performed with protons and pions complete the research themes. Some of the colleagues of the laboratory perform their measurements with the Serpukhov accelerator using large experimental equipment built here and take part in the joint CERN-Dubna measurements. So it can be seen that the profile of the laboratory is rather broad, ranging from low energy nuclear spectroscopy through medium energies to the high energy measurements done in Serpukhov or in the CERN.

A few years ago the Hungarians working in this laboratory joined in the high energy measurements at Serpukhov. Within the framework of international cooperation they built a 5 meter "streamer" chamber (RISK or special particle detector) with unique parameters and dimensions and with which one can study, under oustanding conditions, the interactions of hadrons and multi-particle processes. It is hoped that later it will be possible to determine ionization density by the particle tracks, which would be a substantial step forward in identifying particles. At present this is one of the chief areas of cooperation with Dubna. The measuring equipment has begun operation successfully and evaluation of the first photographs is under way. Later the photographs will be distributed and processed by the laboratories of the participating member countries, including Hungary. Hungary has begun to prepare for this purpose, in the KFKI, an entirely new type of evaluation equipment (RIMA) using the most modern computer technology elements.

In the 1960's the first more significant contact with the Dubna institute in the area of nuclear physics research developed in the Nuclear Problems Laboratory. With the aid of the synchrocyclotron colleagues from ATOMKI produced isotopes which were strongly neutron deficient and carried out complex nuclear spectroscopic studies of these.

They observed a number of new types of radioactivity and defined about 200 characteristics of gamma radiation not known before; on the basis of this--with the aid of suitable theoretical calculations--they were able to draw comprehensive conclusions pertaining to the structure of entire atom groups. The radiochemistry expertise of the laboratory, which is at the top world level, played a large role in the successful conduct of the research program which lasted several years.

Another nuclear physics research group--consisting of researchers from the KFKI--is now working in the Nuclear Problems Laboratory too and it has achieved results in the area of medium energy nuclear physics. Using methods of a new type they have studied reactions in the course of which deuterons with a very large impulse emerge from the atomic nucleus under the effect of high energy protons.

In the course of the past 5-6 years about 30 researchers have participated for briefer or longer times in nuclear physics research at Dubna. Five of these have won scientific degrees on the basis of research work done here (one doctoral and four candidates degrees) and a number have been awarded the Academy Prize. More than one researcher has co-authored works which were awarded various level prizes of the Dubna institute. The number of publications on nuclear physics is about 30.

In addition to the synchrocyclotron there has been the possibility for fundamental nuclear chemistry research which has significant traditions here at home. Making use of these possibilities a small group of nuclear chemists from the KFKI has joined intensively in and now actively participates in a study of the chemistry of Astatine, a helogen which does not have a stable isotope in nature but which can be produced in accelerators.

They succeeded in producing and identifying a number of new and previously unknown Asatine compounds and studied their properties. We are also interested in studying the chemistry of the hot Astatine atom. We have a way to study the chemical consequences in organic chemistry systems of the nuclear transformation of $^{211}Ru(EC)^{211}At$. About 60 scientific publications have appeared in chemical fields; one candidates thesis has been defended and two are being prepared.

Hungarian researchers recently achieved valuable results in one of the newest scientific fields, meso-chemistry research.

About 10 years ago the synchrocyclotron of the laboratory was in the front rank in the world and many pioneering achievements and research initiatives were linked to it. Today, however, the accelerator is quite obsolete and it has become necessary to reconstruct it. It is hoped that this will be done by the beginning of 1981. Unfortunately the tools are not available for a reconstruction of such magnitude as to give the accelerator parameters which would surpass other equipment of this type in the world, or make it comparable to them. For this reason the long-range idea is to have the reconstruction represent merely a "major overhaul" so that the parameters of the rebuilt accelerator will not be substantially better than the old ones. This will define the future profile of the laboratory; it is clear that under these conditions the ratio of medium energy and meson-physics experiments will be limited to a minimum and the accelerator will primarily satisfy the nuclear spectroscopy needs of the member countries. This is a relatively small part of the activity of the laboratory so in the near future the emphasis in the research field of the laboratory must be shifted to the field of high energy particle physics. In practice this process began years ago because, as I have mentioned already, the laboratory has participated for years in the Serpukhov measurements (with Hungarians participating also). This profile will now expand substantially and it has already been given an organizational form; they have established within the laboratory an independent main department, linked directly to the vice director, the chief of which serves as deputy director of the laboratory. This unit is now regarded as the future center for high energy particle physics at the institute. In the future high energy experiments must be concentrated here.

The largest scale scientific plan of this laboratory, or rather of the above mentioned high energy main department, is directed at the field of neutrino physics, a most attractive field which has been developing a revolutionary way in recent years. According to the ideas they will establish, in cooperation with the Serpukhov institute, a large scale neutrino detector (neutrino calorimeter) which will contain many large magnets and several hundred drift or proportional chambers, scintillation counters and photonulsion detectors. This will make possible the exploitation of the most recent achievements in detection technology. According to the ideas the gigantic neutrino detector should be ready by 1981-1982; it will then be set up at the Serpukhov accelerator, the intensity of which will be substantially increased by the use of a so-called "booster." Later, when they have built the Soviet super accelerator (the UNK), they will slightly increase the dimensions so that this same equipment can be used for measurements at extra large energies.

At present this measurement seems to be the largest scale project at Dubna. Since the beginning the Hungarian colleagues have had a role of initiative in starting this measurement program and in designing the neutrino detector. So, in regard to the future, domestic physicists continue to have prospects in the area of nuclear spectroscopy and neutrino physics and in the cultivation of high energy particle physics in general within the framework of this laboratory.

4. Nuclear Reactions Laboratory (LJAR)

The director is Academician G. N. Flyorov. Until recently its chief experimental device was a cyclotron of 310 centimeters diameter for the acceleration of heavy ions. They recently dedicated a new heavy ion accelerator (the U-400) with a diameter of about 400 centimeters. The laboratory has about 360 people, dealing most intensively with the production of or search for transuranic and super heavy elements. Applied research plays a limited role in the life of the laboratory (primarily the production of microfilters with the aid of the accelerator equipment).

Historically the interest of the Hungarian colleagues in the work of the laboratory has been quite small and researchers have gone out to participate in this work only individually and as an exception. It can be imagined that this situation will change in the near future; ATOMKI is planning to do heavy ion physics research in the laboratory.

5. Neutron Physics Laboratory (LNF)

The director is Academician and Nobel Prize Winner I. M. Frank. The world's only impulse reactor (the IBR-30) works here; construction is nearing completion of a similar device which is about 100 times larger, the 2MW IBR-2. Physical initiation has been done successfully and they are now struggling with the problems of the difficult technology of the liquid Sodium cooling system. The reactor will probably be ready for physical measurements by the end of the year or by early 1980. One of the chief work areas of the 520 workers of the laboratory is nuclear physics research using neutron spectroscopy methods (polarization effects, magnetic forces, alpha decay of excited state nuclei). The study of ultra cold neutrons represents a special but very interesting line of research. The other chief research area is the study of condensed materials within the framework of which they study the structure of biological targets. So it can be seen that the profile of the laboratory is uniform from the viewpoint of the large equipment and particles used; but in regard to the problematics of physics (the latter including the studies of a biological and chemical nature which do not yet represent too great a volume).

Hungarian cooperation with this laboratory is traditional. A more significant link developed in the area of nuclear physics research in the 1960's. At that time neutron spectroscopy research represented one of the most important branches of nuclear physics and a research group from the KFKI, making use of the unique possibilities of the unique impulse reactor just then being placed into operation, achieved noteworthy results with the study of the structure of isolated resonance levels. This work was especially significant from the viewpoint of domestic research because the results acquired here could be used very well in the nuclear physics measurements made with the KFKI research reactor.

In the past 10 years the interest of the Hungarians has shifted in the direction of solid state physics problems which can be done with neutrons and for many years there has been an almost complete complex Hungarian group working in the laboratory.

Within the framework of cooperation there has been a study, making use of the Mossbauer effect, of phase transformations in metal alloys. In the course of this they succeeded in clarifying the atomic level aspects of the dual Curie phenomenon exhibited by iron-aluminum alloys. Significant achievements included in the demonstration, with the aid of neutron scattering, of local magnetic excitement in magnetically contaminated insulators, such as $KNiF_3(Mn)$, and a determination of one of the characteristics of the Condo effect in Al(Mn)-dilute alloys, namely the electron which shields the magnetic momentum of the Mn. Two methodological achievements are worthy of note; they built a small angle neutron scatter studying device and a spectrometer which uses a pseudostatistical modulation principle for use with the IBR-30 reactor. Both inventions improved the experimental possibilities by an order of magnitude.

The putting into operation of the IBR-2 will give a great impetus to the scientific work being done here and the Hungarian researchers have the instrumentation "ready to jump" when the reactor is ready for measurements. It is probable that in the future also there will be substantial Hungarian cooperation with this laboratory in the area of solid state physics research.

6. Computer Technology and Automation Laboratory (LVTA)

The director is Academician M. G. Meshcheryakov. It now has two large capacity computers, a CDC-6500 and a BESM-6. In addition several medium and innumerable small computers aid the carrying out of computer technology tasks. The 570 workers of the laboratory develop the methods necessary for the processing of theoretical and experimental results and deal with the development of cybernetic systems, which are necessary in part for the automation of experimental equipment but which are also needed to process and evluate measurement data. The operation and development of the central computer park is an important task of the laboratory.

The Hungarian computer technology industry plays a basic role in the computer technology life of Dubna; the TPA small computers and the CAMAC units were developed and produced primarily in the KFKI. In addition to this essentially commercial--but extraordinarily important--link Hungarian colleagues have had an essential role in the development of computer technology culture at Dubna.

The computer technology possibilities of the Dubna institute far surpass those here at home. In the near future they will buy a large capacity, large memory, fast CYBER-174 computer. So it seems that over the long run the institute will double its computer technology capacity every 4-5 years. They have already built a system consisting of 15 terminals and this will be developed substantially in the future.

7. New Acceleration Methods Department (ONMU)

The chief is V. P. Sarantsev, doctor of mathematical and physical sciences. It was formed to develop acceleration equipment which works on a new acceleration principle, the so-called collective acceleration principle. About 400 people work in the department and their task is to create equipment capable of accelerating heavy ions.

Since Hungary does not have the necessary acceleration specialists the participation of the Hungarians in the work of the laboratory has been minimal thus far. This laboratory recently received the task of developing and producing proportional chambers of the size needed for the joint CERN-Dubna muon measurements and Hungarian experts have joined in this work. In regard to the more distant future one can expect further Hungarian cooperation in this area and since chambers of very similar technology and size will be needed for the neutrino detectors developmental work in this area will continue.

8. The UNK

The design of the Soviet accelerator to be built at Serpukhov is now in progress. Responsible experts of the member countries can participate in this planning work but they are primarily not physicists but rather engineers. At present four Hungarian engineers are helping develop plans for the accelerator to be built.

Hungary and the Link to Dubna

The plenipotentiary delegate directs Hungarian-EAI cooperation, supported in this work by the "Dubna Committee." Until the very recent past the system of links to Dubna belonged entirely in the sphere of authority of the National Atomic Energy Committee. On the basis of various considerations this has been transferred to the Hungarian Academy of Sciences. Certainly many arguments speak for this decision; in the first place the research being done here is essentially basic research the caretaker of which in our homeland must be the Hungarian Academy of Sciences. In the second place the great majority of those working here are from some Academy institute. The other side of the coin is that this system differs from that of the other countries; with the exception of Czechoslovakia the Atomic Energy Committee deals with Dubna questions in every country.

In regard to Hungary the chief cooperating partners are the KFKI, ATOMKI in Debrecen, the ELTE (Lorand Eotvos Science University) and the SzTAKI (Computer Technology and Automation Research Institute of the Hungarian Academy of Sciences). People sent out from other Hungarian institutions play a role sporadically.

In recent years the link between work done by Hungarian experts at Dubna and domestic research has improved significantly; there is an increasing volume of research which is linked more or less organically to themes at home. Despite this we are far from exploiting the possibilities which the EAI could offer domestic research. The modest domestic base for basic research of the type being done at Dubna (particle physics, nuclear physics and solid state physics are a few fields which are expressly of a basic research character) plays a determining role in this. From the scientific point of view this is unjustified for the revolutionary progress of the field can be observed around the world; new achievements are being born which are radically transforming our world picture. Both the Soviet Union and the western countries (even little countries!) are turning serious material assets to this field.

The inadequate support is unjustified from the political point of view too; the existence of the Dubna institute, its effective use and the successful work being done here are not only scientific but also political questions. We cannot accept the position that by paying the Dubna membership fee we have "gotten rid" of the problem of care for this area. Both logic and international experience confirm that an international institute can bring scientific profit to the participating countries only if there is a suitable domestic base for the research being done there. In principle there are many ways to provide this base.

In addition to providing a base thought should be given to the idea that the MTA should classify particle physics research as a stressed theme at the authority level. This is supported by the fact that today particle physics is the area of physical research of fundamental significance and it is here that more active participation in the work of the Dubna institute is most justified for particle physics is today the chief profile of the Dubna institute.

To sum up, we can say that the Dubna EAI, as the first and largest research institute of the socialist camp, is worthy of especially serious attention and support. The institute offers an outstanding possibility for the cultivation of certain domestic branches of science the conditions for which hardly exist in our homeland. The work of the Hungarian researchers in the EAI constitutes an integral part of domestic scientific research and we must strive in the future to see that this is increasingly so.

FOOTNOTES

1. In what follows in illustration of Dubna problems I will show partiality in taking examples from the field of experimental particle physics. This is partly justified by the fact that historically the Dubna institute started as a particle physics research institute and even today about half of the budget of the institute goes to this field. In the second place, of the three branches of science cultivated, experimental particle physics is located on the "most basic" end of the spectrum and thus it is most characteristic of the activity of the institute. Going beyond this, the most problems expressly arise in this field.

2. UNK stands for Uskorityelno Nakopitelnii Kompleks, Accelerator Storage Ring Complex.

3. In noting publications by Hungarian researchers I have considered only data from the past 5-6 years.

4. Permit me here, as in the case of the other laboratories, to disregard the requirement to be complete and to mention only a few of the measurements of recent years in which the participation of Hungarian researchers was significant.

5. UKTI stands for Uskorityelnii Kompleks Tyazhyelik Ionov.

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NUCLEAR PHYSICS

HUNGARIAN-SOVIET COOPERATION IN SOLID STATE PHYSICS

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[Article by Tivadar Siklos, Doctor of Physics, Secretary of the Hungarian-Soviet Mixed Committee for Solid State Physics: "Cooperation in Solid State Physics"]

[Text] While there was high level research in the area of solid state physics in our homeland even before the liberation, the possibilities for modern experimental solid state research were created in an organized and well thought out manner only after the liberation. For many years the Hungarian Academy of Sciences (MTA) has turned great attention to questions connected with the development of solid state research, with special regard to the immediate economic significance thereof. Thus a significant intellectual and material capacity has come into being in the several research institutes of the MTA, in university faculties, in industrial research and development institutions and laboratories which is capable of doing high level work in the area of applied and technological research bringing concrete economic profit, in addition to the basic research which had earlier achieved significant results even by international standards. This situation was a justification for the approval of the chief direction of solid state research by the Council of Ministers, in resolution 1012/1972 (IV 27), among the chief research themes at the national level.

Solid state research in the institutes of the Scientific Academy of the Soviet Union (SZUTA) is very broad and the activity in the areas of semiconductor research, laser research, magnetic materials, metals and alloys is especially important. In several areas good contact and cooperation developed even earlier between the research institutes of the MTA and SZUTA. But if our institutes were to work effectively on the national chief tasks for "Solid State Research" there was need for a strengthening of their international contacts, before all else with the Soviet partner institutes. Starting from this and taking into consideration the advantages deriving from the socialist international division of labor and from the coordination of research the idea arose that it would be advantageous to create the Hungarian-Soviet Mixed Committee for Solid State Physics. The presidium of the MTA adopted this proposal at the session of 10 September 1971. The MTA selected the Hungarian members of the committee so as to represent leaders responsible for the guidance of both basic and applied research.

The founding session of the committee was held in Budapest in July 1973; the final name of the committee was decided on then and the "Operational Rules" were adopted.

Since 1973 the Solid State Physics Committee of the MTA and the SZUTA has guided the cooperation of the scientific research institutes of the MTA and the SZUTA in the area of research on condensed systems. The "Operational Rules" define the chief tasks of the committee:

--"to designate those most important directions in the area of solid state physics in which it would be useful to conduct joint research,..."

--"to coordinate...the prescribed solid state physics research,"

--"...to make the necessary corrections in the plan,..." and

--"to supervise the realization of joint research...."

In accordance with its tasks the committee worked out in 1974 its proposals for a plan for scientific cooperation between its academies for the years 1976-1980 and at the 1979 session in Yerevan it worked out a scientific cooperation proposal for the years 1981-1985. It initiates the necessary corrections to the cooperation plans each year.

Supervision of the fulfillment of the joint research plans constitutes a significant part of the work of the committee. Each year the cooperating institutes prepare a written report about the results of cooperation and about problems which have arisen. Representatives of the cooperating institutes also give verbal reports at the session of the committee, on themes determined in advance. The organization of scientific sessions is an effective form of supervision.

The scientific sessions take place yearly at the same time as meetings of the committee. In 1978 the scientific session dealt with the results of semiconductor research; this year's session in Yerevan is devoted to laser research; and next year the scientific session will deal with problems of crystal physics and crystal growth technologies.

The Hungarian members of the committee turn great attention to providing the Soviet members with adequate information about the possibilities of scientific research work in our homeland. Thus, during the sessions held in Hungary, the delegations have visited several research institutes of the MTA and university faculties participating in the cooperation. We have made it possible for the Soviet members of the committee to become acquainted with several industrial research laboratories too and with the work of plants which use and exploit results achieved in the area of solid state research.

In what follows--without trying to be complete--I would like to illustrate the results of cooperation with a few examples.

1. Quantum Electronics. The joint research results achieved at the Solid State Research Institute of the Central Physics Research Institute (KFKI) and at the Physics Institute (FIAN) of the SZUTA are especially outstanding and have won international recognition. These deal with the observation and theoretical interpretation of multi-photon photoeffect phenomena taking place on the surface of metals as a result of ultra-short laser impulses and with a study of the Mandelstamm-Brillouin diffraction observed in liquid crystals. It is characteristic of the good cooperation that much of the experimental equipment was developed jointly or with close cooperation and coordination.

In regard to applications there were significant achievements in the area of technology for the production of high melting point doped crystals serving optical and quantum electronic purposes developed as a result of joint research. The joint efforts made possible the domestic development of a few new types of lasers and supplementary equipment.

2. Solid State Physics. The vibration magnetometer developed at the KFKI has for several years served without problems important research in large magnetic fields at the FIAN. The scientific cooperation of the Crystal Physics Research Laboratory and the Crystallographic Institute (IKAN) of the SZUTA has led to significant results in the area of crystal physics, crystal growth technology and the experimental investigation of dislocations. ATOMKI (the Nuclear Research Institute) and the Nuclear Physics Institute in Leningrad are working jointly on the development of technology for radiation detectors and they have jointly developed a spectrometer which can provide a resolution of 170 eV with an energy of 5.9 keV.

In 1978 the KFKI and the Solid State Physics Institute of the SZUTA conducted a study of the phonom dispersion curves of PAF single crystals and studied the structure and dynamic properties of PAA liquid crystals using neutronographic methods. As a result of the neutron physics studies they succeeded in developing a cluster model for the nematic phase which avoids the deficiencies of the generally used phenomenological Mayer-Saupe model. Cooperation has begun also in the area of studying amorphous metals and in the area of research on organic conducting materials.

The regular organization of Hungarian-Soviet Solid State Theory Seminars proved to be a very effective form of cooperation in the area of solid state theoretical research but the present level of cooperation has put on the agenda the necessity of developing a new form of cooperation--the creation of solid state theory creative partnerships.

3. Semiconductor Research. There have been significant achievements as a result of the cooperation of the Ioffe Institute in Leningrad and the Technical Physics Research Institute (MFKI) of the MTA in the area of studying $A^{III}B^{V}$ type compounds and solid solutions. The MFKI and the Semiconductor Institute

of the Ukrainian Academy of Sciences are doing successful joint research in the study of MIS structures. There is effective cooperation between the KFKI and several Soviet research institutes in research connected with ion implantation.

Naturally these few examples selected at random give only a very sketchy picture of the many-sided cooperation which has developed among research institutes of the MTA and the SZUTA as a result of the coordinating activity of the Solid State Physics Committee of the MTA and the SZUTA. In recent years the significance of research serving the practical application of scientific achievements has increased greatly. Naturally this also is reflected in the cooperation with Soviet institutes. Our committee is prepared to take care of these tasks also.

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