Theory of condensed matter the joint symposia

Conyers HerringDavid Pines

Citation: Physics Today **28**, 11, 46 (1975); doi: 10.1063/1.3069204
View online: http://dx.doi.org/10.1063/1.3069204
View Table of Contents: http://physicstoday.scitation.org/toc/pto/28/11
Published by the American Institute of Physics

Советская Physics
Soviet Физика

Theory of condense the joint symposia

Conyers Herring and David Pines

During the past seven years the National Academy of Sciences of the US and the Academy of Sciences of the USSR have jointly sponsored five symposia on current topics in the theory of condensed matter. These symposia have made possible a significant transfer of scientific information in both directions and have led to the establishment of many useful personal contacts between the scientists of the two countries. In this article we wish to describe briefly the history and organization of the symposia, and discuss in some detail the most recent symposium in the series, which was held in Moscow during the week of 14 October 1974.

Our aim is to convey a sense of the scientific accomplishments of these symposia, which have included not only the communication of many hitherto unpublished results in the formal papers and informal discussions at the regular symposium sessions, but also some very significant outside interactions among small groups of people. We shall consider some examples of the role that this continuing interaction between Soviet and American scientists is currently playing in the development of new ideas in the physics of condensed matter, and in other fields of physics as well. In our concluding remarks we examine some of the promising possibilities for further scientific interaction and collaboration.

Conyers Herring is a member of the technical staff of Bell Laboratories, Murray Hill, and David Pines is a professor of physics at the University of Illinois at Urbana-Champaign.

History and organization

The Agreement on Exchange of Scientists between the US and Soviet Academies provides for small joint symposia to be held on topics of current interest. The Joint US-USSR Symposium on the Electron Theory of Solids, which was held in Moscow and Leningrad from 2–12 July 1968, was the third symposia to be held under this agreement [the first two having been devoted to radio astronomy (1961) and partial differential equations (1963)]. It proved so successful that the authors who, together with I. M. Khalatnikov, director of the L. D. Landau Institute of Theoretical Physics, have served as co-chairmen of the series of symposia, were encouraged by both their Soviet and American colleagues to set up a return meeting of the solid-state theorists of the two countries, to be held in the United States. With the cooperation of the two Academies, a second symposium was then held at Rockefeller University in New York City, from 9–12 January 1970. This was followed by a third, in Leningrad, in November and December of 1971. A pattern was thereby established: joint symposia held at approximately eighteen-month intervals, with the site alternating between the USSR and the US. The fourth and fifth symposia, held at the University of California in Berkeley (1–5 May 1973) and in Moscow (October 1974) have conformed to this pattern, and a sixth symposium, tentatively scheduled to be held in the US in the fall of 1976, has now reached the planning stage.

A pattern has likewise developed in the organization of the symposia. Tentative lists of possible foreign participants are exchanged well in advance of the symposium, and every effort is made to arrive at a mutually acceptable list. Typically some ten visiting scientists and fifty domestic scientists take part in a given symposium. The sending country assumes responsibility for the international travel of its participants, while responsibility for the travel and living expenses of these scientists in the host country is assumed by the institutions of that country. In addition to attending the symposium itself, the guest scientists generally spend approximately one week visiting various scientific institutions. Thus US scientists have visited the Institute for Physical Problems, the Landau Institute of Theoretical Physics and the Lebedev Institute in Moscow, the Ioffe Institute and the Institute of Semiconductors in Leningrad, and the Institute of Physics of the Georgian Academy of Sciences in Tbilisi, while Soviet scientists have visited Bell Labs, the Universities of Chicago, Illinois, Maryland, Oregon, Pennsylvania, Southern California and

matter: A series of symposia alternating between the US and the USSR has made possible a significant transfer of information in such topics as superfluid helium, critical phenomena and one-dimensional systems.

Visiting theoreticians gather at the L. D. Landau Institute of Theoretical Physics. Shown are, from left to right, G. S. Bisnovati-Kogan, I. D. Novikov, Academicians V. L. Ginzburg and Ya. B. Zel'dovich, and David Pines. Informal discussions such as this enhance the quality and fruitfulness of scientific communication and lead to a greater willingness to listen to unfamiliar ideas. (Photo: G. Baym)

Spectroscopists

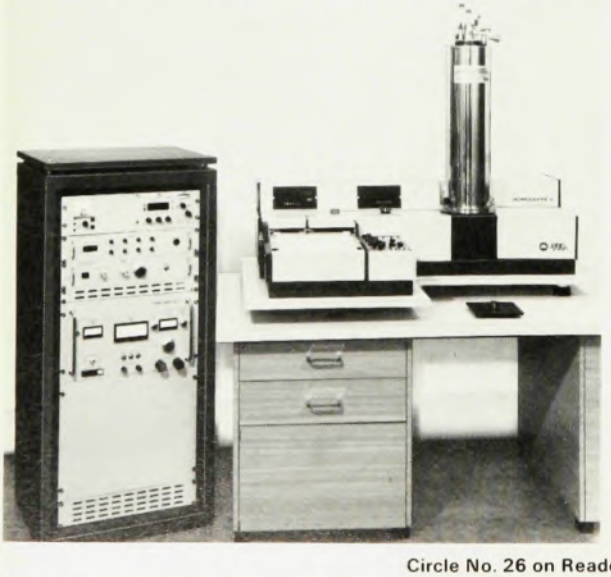
You get the all-round choice in cryogenics from Oxford Instruments

That's because Oxford Instruments are leading pioneers in the development of cryogenic equipment and are the world's major suppliers in this field – particularly for superconducting magnets and ancillary electronic equipment, as well as continuous flow, reservoir and open cycle liquid helium/nitrogen cooling units. Take a look at these two examples:—

SPECTRO MAG

A series of cryomagnetic systems providing intense magnetic fields and variable low temperature facilities for most areas of magneto-optical research including Mössbauer spectroscopy, magnetic circular dichroism, Faraday effect and spin-flip raman.

☐ Compact enough to fit most commercial and home-built spectrometers and spectropolarimeters.



☐ Features unique low-temperature, strain-free windows.

CONTINUOUS FLOW CRYOSTAT CF204 LIQUID HELIUM

Specifically designed for optical spectroscopy, CF 204 incorporates a central gas-filled sample space terminating at room temperature. Samples can be changed within 20 sec. without disrupting the cooling cycle.

☐ Sample tube 20mm internal dia.

☐ Synthetic sapphire gas cell windows – 12.5mm dia. aperture.

☐ Base temperature 2.7 – 3.5 K.

☐ Temperature range continuously variable up to 500 K.

☐ Liquid helium consumption 0.5 litre/hr.

For more details on these, or any others in the 'world-leading' range of cryogenic equipment from Oxford Instruments – write to

OXFORD INSTRUMENTS

Oxford Instruments Incorporated
222 Severn Avenue, Annapolis
MD 21403

The Oxford Instrument Co. Ltd., Osney Mead, Oxford, England.
Oxford Geraete, Neu Isenburg, West Germany.
Oxford Instruments Australia, Sydney, Australia.

See us at Physics 75, Moscow, British Pavilion.

Circle No. 26 on Reader Service Card

Washington, the Berkeley, Irvine, Los Angeles, San Diego and Santa Barbara campuses of the University of California as well as Cal Tech, Cornell, Harvard, MIT, Princeton, Stanford, Syracuse and Washington University (St. Louis). In both countries these visits have not only made for more extensive informal discussions with research leaders, but have provided opportunities for the visitors to meet junior scientists in a variety of institutions.

The philosophy that has been adopted in choosing participants for the joint symposia has been:

- to choose participants of breadth and intellectual stature, so that they can not only deliver papers of their own but comment intelligently on other developments as well;
- to choose primarily people who have important new work to report, with which scientists of the other country are likely to be insufficiently familiar through published channels, and
- to maintain a balance between the cumulative advantage of renewing old acquaintances and the desirability of acquainting scientists of the host country with new representatives of the visitor's community of theoreticians. That the "new faces" aspect has not been neglected is evidenced by the fact that in the three symposia that have been held on Soviet soil the participants have included 28 different US physicists. (This figure includes not only the official participants, but also several unofficial ones who were able to take part in 1968.) For the two symposia held in the United States, the number of different Soviet scientists participating has been eleven. The smallness of this figure is due not only to its being derived from only two symposia, but also to the fact that the 1970 symposium was attended by only seven participants. As for the domestic participants, we do not have precise figures: The number of US scientists participating in either or both of the 1970 and 1973 symposia was about 70; the number of Soviet participants in the 1974 symposium alone was about 70. Research in the Soviet Union is concentrated in a smaller number of centers than in the United States—the Soviet participants have included representatives of all the major institutions in the condensed-matter area not only in the cities the participants visited, but also from such other cities as Kiev, Kharkov and Sverdlovsk.

There seems to be fairly universal agreement amont those who had participated in the earlier joint symposia that the quality and fruitfulness of scientific communication has been improving and that the fifth symposium was the best so far. This improvement probably stems in part from the formation of personal acquaintanceships and friendships among individuals of the two countries and in part from improved familiarity with the literature of the other country. Personal friendships have made for better mutual understanding of thought patterns and a greater willingness to listen to unfamiliar ideas and iron out differences in discussion periods and out-of-hours activities. Soviet and American physicists now pay more careful attention to the literature of the other country, partly as a consequence of these personal contacts and partly because they realize the high esteem some of their colleagues have developed for certain scientists of the other country. Improved awareness of work in the other country has also made it possible for each side to select its participants and its contributions to the program so as more nearly to optimize contacts in areas of high mutual interest.

The fifth symposium

Three aspects of the extremely valuable scientific communication that was achieved at last year's symposium in Moscow can be distinguished: formal presentations, brief communications and extra-symposium contacts.

The majority of the formal papers, both American and Soviet, reported work of some importance, often with exciting new concepts. The program of talks is shown in the Box below. A check of the literature of the last year or so reveals that, of the ten formal papers presented by the Soviet physicists, the proportion containing extensive material already published prior to the middle of 1974 was no more than about half, and that for one or two of these the material was not yet available in translation. The papers presented by the Americans had about the same distribution in publication status.

I. M. Khalatnikov, the director of the L. D. Landau Institute of Theoretical Physics, served as a cochairman of the symposia.

As can be seen from the program, these papers covered a wide variety of topics, with clusters of talks in two or three areas and a number on special topics isolated from the rest. The clusters were on many-body theory for one-dimensional structures (four papers), superfluid He^3 and He^4 (five papers) and pion condensation in neutron stars and nuclei (two papers). Each of these

Program of the Moscow Symposium

The speakers at the 1974 Moscow Symposium on condensed-matter theory, and their topics, were:

A. A. Abrikosov Calculation of critical indices for gapless semiconductors
V. Ambegaokar Superfluid He^3: Microscopic theory and spin dynamics
A. F. Andreev, D. A. Kompaneets Surface phenomena in superfluid liquids
G. Baym Pion condensation in dense matter
V. L. Ginzburg Thermoelectric phenomena in superconductors
L. P. Gorkov, I. E. Dzialoshinsky Phase transitions in quasi-one-dimensional metals
K. B. Efetov, A. I. Larkin Spin pairing in quasi-one-dimensional and layered superconductors
B. I. Halperin Application of the renormalization group to dynamic critical phenomena
Yu. Kagan, M. I. Klinger Theory of quantum diffusion of atoms in crystals
W. Kohn Density-functional theory of metal surfaces
Yu. V. Kopaev, B. A. Volkov, A. I. Rusinov Theory of exciton ferromagnetism
A. Luther Recent exact theories of the one-dimensional electron gas
H. J. Maris Propagation of sound in superfluid He^4
N. D. Mermin Superfluid He^3: What is the structure of the equilibrium order parameter?
A. B. Migdal Pion condensation and properties of nuclei
D. Pines Polarization potentials and elementary excitations in liquid He^3 and He^4
V. L. Pokrovsky, A. Ya. Blank, G. V. Uimin Magnetic properties of two-dimensional and layered structures
D. J. Scalapino Ordering in pseudo-one-dimensional systems
E. A. Turov, A. N. Voloshinsky Electric resistance of transitional metals
K. Wilson A solution of the Kondo problem
V. E. Zakharov, V. S. Lvov Parametric excitations of spin waves in ferromagnets with magnetic impurities

Douglas Scalapino, A. B. Migdal and Gordon Baym during their discussions on pion condensation in Tbilisi, site of the physics institute of the Georgian Academy of Sciences.

clusters had contributions from both nations.

An approximately orthogonal way of classifying the papers is by their relative emphasis on mathematical formalism or on relationship to experiment. Both for the US and the Soviet papers the largest group consisted of studies formulated in physical terms and designed to interpret specific observed phenomena. In addition, some extremely interesting speculations were presented about effects that had not yet been observed. Both groups also reported impressive progress on some of the formal mathematical problems arising out of many-body physics. The four such areas discussed (one-dimensional conductors, the Kondo effect, gapless semiconductors and phenomena in the critical region near phase transitions) had all been worked on in the past by participants from both countries. The reports were therefore received with considerable interest and served to generate much subsequent informal discussion.

The reports relating to observations and experiments ranged all the way from studies addressing specific single effects to broad reviews of whole areas. Two examples of the latter are David Mermin's review of evidence on the order parameter in superfluid He^3 and Y. M. Kagan's survey of tunnelling effects on impurity diffusion and self-diffusion in a wide range of materials.

Two spots were allotted in the program for brief reports (of the order of ten minutes) of unpublished work involving particularly novel ideas. These spots made possible not only accounts of additional work by the participants, but also reports by the Americans of work by other US scientists who were not able to come to Moscow—advance approval having of course been obtained from the latter. Most of these brief communications were related to existing or hypothetical experiments, and some very novel ideas were aired.

Informal talks

An important feature of the symposia held in the USSR was the opportunity that they often presented us for informal discussions with our Soviet colleagues working on solid-state problems of mutual interest, as well as other fields of physics. We here present a brief summary of some of these discussions. As will be seen, these discussions covered several topics in condensed-matter physics as well as developments in elementary-particle theory and relativistic astrophysics. Many significant things were learned on both sides and it seems likely that at least one collaborative authorship will result.

Gordon Baym and Douglas Scalapino took part in a continuing series of discussions with Academician A. B. Migdal and his coworkers on pion condensation in nuclei, nuclear matter and neutron-star matter, discussions that were pursued extensively during some of the recreational excursions at Tbilisi and later continued in Moscow. As a result of these discussions, further calculations of the properties of, and existence arguments for, pion condensates were carried out, and Baym, Migdal and Scalapino expect to summarize their discussions and relevant calculations in a critical review.

It is worth noting that the idea of pion condensation in dense matter systems was proposed independently by Migdal and by Ray Sawyer and Scalapino in 1970 and 1971 respectively; Baym and his associates have made a number of important contributions to the resulting theory. The Moscow symposium provided the first opportunity for these representatives of three of the groups most concerned with this problem to compare and contrast their results and outlook.

Herring and Humphrey Maris explored a number of interesting points with Kagan. Those, touched on in Kagan's symposium talk, have to do with

A. A. Abrikosov (left) and Leo Falicov at a reception during the third symposium in Leningrad, 1971. Behind them are G. R. Khutsishvili (left) and C. J. Pethick (partly hidden).

PHOTOS ON PAGES 49–51: D. PINES

J. S. and his son S. J. Tsakadze with a model for exploring the behavior of liquid helium between spherical shells. In these experiments, which help to test theories that predict the response of a neutron star to a sudden acceleration, they have observed transient oscillations.

tunnelling between atomic sites in quantum crystals and other systems. Maris also had a number of discussions with A. Andreev concerning defects in quantum crystals as well as the description of the ground state in these systems. With Vinay Ambegaokar of Cornell, Maris visited V. P. Peshkov in his laboratory and had the privilege of describing some novel aspects of the theory of second sound to him.

Kenneth Wilson took part in a number of discussions with A. A. Migdal and A. M. Poliakov concerning scaling in condensed-matter theory and particle theory. They discussed recent work on the behavior of lattice gauge theories in weak coupling. He also met with members of the Institute of Theoretical and Experimental Physics (K. A. Ter-Martirosian, B. L. Ioffe, L. B. Okun and others) as well as V. L. Gribov for an afternoon of exchange of ideas on problems in strong interactions at high energies.

Pines, together with a number of other members of the group, heard a presentation by D. F. Tsakadze of the Institute of Physics in Tbilisi of work by his group on laboratory experiments in low-temperature astrophysics, experiments designed to test theories on the behavior of a neutron star following a sudden speed-up. In a previous visit to the Institute in 1970, Pines had described theoretical work on this problem and had suggested that experimenters at Tbilisi might be interested in carrying out just such experiments—by studying the behavior of a rotating solid spherical shell containing liquid helium immediately after a sudden speed-up of the outer shell. This is just what the Tsakadze's (father and son) have done; they have measured the relaxation times for the vortices in liquid helium to come to equilibrium with the shell. They have also observed a transient oscillatory behavior that may well be due to excitation of the Tkachenko mode (a shear wave in the vortex lattice). Further experiments on the temperature dependence of both phenomena are under way, and one may hope that these experiments will provide useful clues to the behavior of pulsars as well as information of considerable value in expanding our understanding of rotating liquid helium.

On two occasions Pines and Baym also met with astrophysicists from the Lebedev Institute, the Institute of Cosmic Physics and the Sternberg Astronomical Institute. Those taking part included Academicians Ya. B. Zel'dovich and V. L. Ginzburg, and I. D. Novikov, D. A. Kirshnitz, G. S. Bisnovati-Kogan, A. D. Linde and J. M. Bruk. Problems discussed included the physics of compact x-ray sources, the optical and x-ray appearance of binaries containing black holes, the cooling of neutron stars, phase transitions and broken symmetries in the early stage of the universe and models for the binary system HZ Herculis—Herculis X–1. The American scientists brought their Soviet colleagues news of the discovery of the binary pulsar PSR 1913 + 16 by Russell Hulse and Joseph Taylor. Subsequently, Zel'dovich and Novikov, in collaboration with their colleagues, V. A. Brumberg and N. I. Shakura, suggested a novel scheme for determining the mass of the pulsar and its companion from the variable part of second-order relativistic Doppler shift of the pulse period. Early in the morning of our departure Pines met for two hours with R. N. Sunyaev, Shakura and M. M. Basko, who had returned the previous evening from a meeting in the Crimea, in order to have the possibility of a meeting to discuss properties of compact x-ray sources. The problems discussed included x-ray-induced mass flow, stellar winds, disk behavior, the accretion column above a neutron star and models for various x-ray sources.

What of the future?

We have discussed a number of the benefits that have accrued to the scientists of both countries as a result of this series of symposia. At this point one might ask: Which group of scientists has gained more, the Soviet or the US? Our response would be that both groups have derived substantial benefits, both tangible and intangible.

It could easily be argued that the Soviets have gained more since, as a group, they have travelled far less to international meetings than their US counterparts. As a result, these symposia have represented an opportunity for a number of Soviet theorists to learn at first hand many important new results, both theoretical and experimental, in condensed-matter physics: here we would mention, *inter alia*, Kenneth Wilson's description of his work on critical phenomena at the third symposium, John Wheatley's summary of experimental work on superfluid He^3 at the fourth symposium and the summaries by Mermin and Ambegaokar of Western theoretical work on superfluid He^3 at the fifth symposium. Moreover, those Soviet scientists who have travelled to the US have had an opportunity to visit a large number of American institutions and hence to become acquainted at first hand with both theoretical and experimental American work on almost every kind of problem in condensed-matter physics.

But these agruments are reversible. It is generally agreed that both the US and the Soviet scientists are among world leaders in condensed-matter theory, and that the theoretical groups in the two countries are of roughly comparable strength. For example, among the US participants have been eight members of the National Academy of Sciences, including three Nobel laureates, while on the Soviet side nine members of the Soviet Academy of Sciences, including three Academicians, have played an active role in the symposia. Hence, since Soviet scientists do not often travel abroad, these symposia represent a special opportunity for their US counterparts to discuss with them, at some leisure, problems of mutual interest. Indeed, the brief summary we have given here scarcely does justice to the spirit of the symposia, which is that

Get it all with an ISIT*

***An Intensified Silicon Intensifier Target detector, the latest addition to the OMA family**

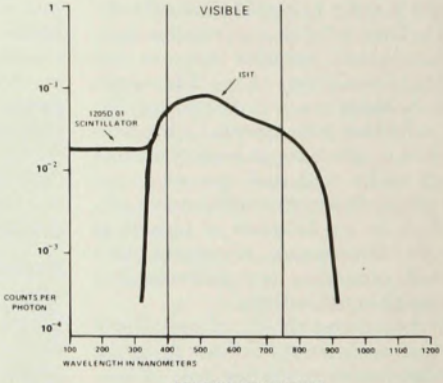
With a Princeton Applied Research Corp. ISIT (Model 1205I) you get

*Photon counting sensitivity **AND** parallel detection in 500 channels

*Response to 900 nm in near IR **AND** response to 200 nm and below with a scintillator

*Signal averaging with background subtraction **AND** time resolution to nanoseconds

*Real time monitoring **AND** single shot capability



SENSITIVITY OF ISIT

No longer must your experiment be limited by trade-offs. The ISIT offers a combination of features previously thought to be mutually exclusive. However elusive your optical signal, the ISIT can catch it.

Complete specifications on the Model 1205I ISIT are included in our OMA catalog. Write for your free copy to:

Princeton Applied Research Corporation
P. O. Box 2565, Princeton, New Jersey 08540
Phone: 609/452-2111 Telex: 84-3409

In Europe—contact Princeton Applied Research GmbH, D8034 Unterpfaffenhofen, Waldstrasse 2, West Germany.

319

Booth 315—Electro Optics '75
Circle No. 27 on Reader Service Card

of intensive—and at times, intense—communication between the scientists of our two countries.

What of the future? The symposia have already borne one "child": the Joint Symposium on Light Scattering in Solids, which was held in Moscow in May 1975. It may be expected to give birth to other children—joint symposia in specialized topics in solid-state physics.

Still further in the future, another possible offspring of the symposium might be the development of joint US-USSR research groups in solid-state theory. At its meeting on 24–25 October 1974, the US–USSR Joint Commission on Cooperation in Science and Technology endorsed the idea of joint research in theoretical physics and referred it to the respective Academies for implementation. Such cooperation necessarily requires continued personal interaction between the scientists of the two countries for a period of time. In fields in which our scientists are well known to each other, both through prior personal contact and knowledge of each other's scientific work, it may be expected that a joint workshop of two to three months' duration, focussing on a specialized topic, would provide opportunities for joint research leading to significant new scientific results. Given the success of the joint symposia in condensed-matter theory, this field would seem in many ways an ideal one for such a cooperative research venture. Indeed, following a recent meeting, experts designated by the two Academies to recommend directions for future collaboration in theoretical physics proposed that joint working groups be established in both solid-state theory and relativistic astrophysics. The proposal has already been endorsed by the National Academy of Sciences and is now under consideration by the Soviet Academy.

* * *

It has been a pleasure to work together with I. M. Khalatnikov in the organization of these symposia; his cooperation and assistance had been invaluable in every aspect of their planning and execution. In addition we have been greatly assisted by very able local hosts and by the respective national Organizing Committees. We should like to take this opportunity to thank, on the Soviet side, A. F. Andreev, E. L. Andronikashvili, V. A. Belinsky, I. A. Fomin, I. P. Ipatova, G. R. Khutsishvili, O. V. Konstantinov, Yu. G. Mamaladze and V. M. Tuchkevich, and on the US side, John Bardeen, Henry Ehrenreich, Leo Falicov, Albert Gold, Bert Halperin, Pierre Hohenberg, Paul Martin, J. Robert Schrieffer and Fred Seitz. Without their active cooperation and support, the symposia would not be nearly as successful as they have proven to be. We are pleased to acknowledge the support of these symposia by grants from the National Science Foundation. □