The MIT International Conference on the Physics of Very Low Temperatures, September 6–10, 1949

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LOW TEMPERATURE PHYSICS is a field which has been slow and deliberate in its growth. During the last century a group of brilliant experimenters succeeded in liquefying one after another of the "permanent" gases, until finally helium succumbed, and there were no more left to conquer. This early work was international: England, Holland, France, a number of countries took part in the progress. Then during the first years of the present century a great laboratory devoted entirely to very low temperatures was set up at Leiden, by Kamerlingh Onnes. A succession of brilliant discoveries came from this great installation, and established it as the foremost laboratory of the world in the field. It was not long to stand unchallenged, however. In England, Kapitza pioneered in the modern school of low temperature work, at Cambridge; there the Royal Society Mond Laboratory was founded, carrying on in the field after Kapitza's departure for Russia, and today, is one of the leading English low temperature laboratories. The Clarendon Laboratory at Oxford, profiting from the departure from Germany of some of the leading low temperature workers of that country as a result of Hitler's policies, has built up a low temperature laboratory of the first magnitude. The Russian school of low temperature physics, established by Kapitza on his return to that country, forms one of the leading groups in the field. In Canada the laboratory at Toronto, in the United States those at the University of California and the National Bureau of Standards, were working before the war. A few other institutions have been active, but before the war it was a branch of physics confined to a few places, largely because of the magnitude of the installations required, and the difficulty of the experimental techniques encountered.

Since the war, the interest in low temperature physics has greatly increased, particularly in the United States. There are probably two quite different reasons for this. One is a practical, experimental one. The development of new techniques of liquefaction, as a result of work undertaken for military purposes, has made the production of liquid helium (at least in this country, where the helium itself is plentiful) no longer a major undertaking, but a relatively easy task. This has led a considerable number of laboratories to move into the fascinating field of low temperature research, perhaps partly unaware of the fact that the production of liquid helium is only a small part of the experimental problem encountered in getting significant new scientific results. The other reason for the increasing interest in very low temperatures is probably the attraction of a field where major problems still stubbornly refuse to yield to theoretical explanation.

There are probably three principal lines of low temperature research at present: superconductivity, the properties of liquid helium, and low temperature paramagnetism, with its related technique of adiabatic demagnetization. The first two of these still defy all attempts at the construction of theories. It is true that partial theories exist; but they are very far from being complete or satisfactory. This is the only point at which the study of matter in bulk still shows the qualities of a challenging puzzle, qualities which are so characteristic of nuclear physics. Until the physicist can explain these strange facts, he will not rest content.

The other active field, low temperature paramagnetism and adiabatic demagnetization, shows no such mysteries, but it nevertheless has its particular reasons for being interesting just now. It relates to the energy levels of electronic spins in crystals. These energy levels are associated with absorption frequencies in the microwave part of the spectrum; and the greatly expanded interest in microwaves as a result of wartime developments has turned physicists in this direction. Not only the electronic, but also the nuclear resonance is concerned in these properties; very shortly after the war, it was found that nuclear absorptions occur in the radiofrequency part of the spectrum. These studies lead to an exciting possibility: just as the adiabatic demagnetization using electron spins has led to the lowest temperatures so far attained, a few thousandths of a degree, so there is the possibility that use of nuclear resonance may make it possible to reach temperatures of the order of millionths of a degree.

Before the war, there were relatively few low temperature physicists. They had meetings, among others, every four years in connection with the Refrigeration Congresses of the International Institute

of Refrigeration, an organization largely devoted to the practical side of refrigeration, but having a very active committee, largely stimulated by the group at Leiden, concerned with the fundamental side of very low temperature research. This organization became dormant during the war, but in July 1948, at the Amsterdam meeting of the International Union of Pure and Applied Physics, a group of low temperature workers was called together, at the initiative of Gorter of Leiden, to consider reviving the international meetings of low temperature physics. Two suggestions were made: either to encourage the International Institute of Refrigeration to resume its activities, or to organize a Commission on the Physics of Very Low Temperatures under the auspices of the International Union of Pure and Applied Physics, an organization which has been much more active since the war than before. Even better than either of these suggestions was the possibility of following both of them. This is essentially what is being done.

The International Union of Pure and Applied Physics was already in active existence, it was known to be favorable toward a suggestion for forming a low temperature commission, and Gorter and Slater, both of whom were at the Amsterdam meeting, were vice presidents. Accordingly it was felt that a meeting could be arranged more expeditiously through this union than through the International Institute of Refrigeration. The suggestion was made that a conference be called for 1949, associated with the Union of Physics, preferably in America, and an invitation was at once issued by the Massachusetts Institute of Technology. It is this conference which has just occurred. On the other hand, the other approach was not neglected. The scientific committee of the International Institute of Refrigeration has been reestablished, under the joint presidency of F. E. Simon of Oxford and C. J. Gorter of Leiden, and it is actively working on plans for a future conference on the physics of very low temperatures, under the joint auspices of the Institute of Refrigeration and the Union of Physics, to meet probably in England in 1951. Meanwhile, the low temperature commission of the Union of Physics has been constituted, under the presidency of Simon, with Gorter acting as secretary, and it held its first meetings in connection with the MIT conference.

The planning of the MIT conference was carried out by Simon, Gorter, and Slater, with much use of the airmail, as well as personal discussions on the occasion of the Amsterdam meeting, and at more recent opportunities. It was realized from the first that, in order to have a truly international meeting in the United States, most of the leading workers in the field would have to be present, and this would involve securing of funds, in dollars, enough to make possible the journey of a considerable number of scientists across the ocean. The preliminary estimate was sixteen, and this proved to be remarkably accurate: just this number had the major part of their traveling expenses paid, as well as several to whom partial payments were made, and several others who found other sources of funds, so that some twenty-five European workers were present.

Application for funds was of course made to the International Union of Pure and Applied Physics, which has at its disposal small grants which come from Unesco. Largely through the friendly interest and efforts of Professor Fleury, secretary of the union, funds to the amount of $2,500 were secured, intended principally for the traveling expenses of the members of the Commission of the Union. It was obvious from the first that the major part of the support would have to be raised from American sources, in dollars, and it was an interesting experiment in the financing and arranging of international conferences in this country to see how difficult this would be. Fortunately, we appealed to President Killian, of MIT, for suggestions, and he personally agreed to help with the securing of funds. Through his efforts, successful appeals for support were made to the Research Corporation, which made a contribution of $5,000, and Arthur D. Little, Inc., which contributed $2,500. In addition, MIT itself agreed to make a substantial contribution. Without these sources of funds, the conference could not have been held.

Announcements were sent to a fairly large mailing list, with requests for suggestions of additional persons who should be invited, and it was possible to invite all those who were thus suggested. This procedure was one which had been used for other MIT conferences on various subjects, and it seemed to be a good compromise between a very small, exclusive conference, and a very large one, announced publicly, with no semblance of an invitation list, which plan we at no time considered for the present conference. The result of this procedure was an attendance of about 200.

Two other conferences were in a way combined with this one. In the first place, the Office of Naval Research arranges small, closed conferences at periodic intervals for its contractors who are working in the low temperature field, a group which includes almost all the principal low temperature laboratories in the United States. They agreed to omit the conference which they would have scheduled at approximately the time of the MIT conference, feeling that that would adequately take its place. In addition, a group in the United States had scheduled conferences on low

temperature calorimetry at periodic intervals, often in conjunction with the ONR conferences. Members of that group were also invited and held their conference on one of the days of the larger conference, in parallel with it (see *Science,* 1949, **109**, 348). Thus a considerable number of industrial representatives were present, a fact which should prove to be a stimulus to low temperature work in industry in this country.

In arranging the program, as in choosing the membership of the conference, there were two possibilities: to have only invited papers, suggested by the committee, or to throw the meeting open to a wider group of speakers. Here again the choice was for the wider invitation, since we felt that there were many cases where speakers whose work was not well known to the committee might have important and interesting contributions to make. Accordingly the possibility was opened for any one attending the conference to suggest topics on which he would like to talk. This resulted in a rather full program; the only restriction which the committee placed on the suggested papers was that they should represent rather new work. The consensus of those attending the conference was that, though the meetings were strenuous, there was great value in getting a more complete view of the field.

The papers on the program fell naturally into a few main divisions, based on the current fields of interest in low temperature research. There was liquid helium, with numerous speculations about the theory of the superfluid phase, new results on the liquid helium film, and much new information on the behavior of the isotope He^3, which appears not to show the superfluid behavior, lending support to the hypothesis that it is the Bose-Einstein statistics (which govern the behavior of He^4 but not of He^3) which are responsible for some of the peculiar properties of liquid helium. Paramagnetic resonance, nuclear resonance, and adiabatic demagnetization came in for a good deal of discussion. There were a number of papers on superconductivity, both theoretical and experimental. Interesting low temperature effects on electrical conduction, semiconductors, diamagnetism, and various other topics were discussed; and there was a session on helium liquefiers, including a treatment of the Collins cryostat, developed at MIT during the war, and perfected by Arthur D. Little, Inc., which has furnished much of the recent impetus to the development of low temperature work in this country.

All of the topics of present interest in low temperature research were covered; and, more important, all the important laboratories were represented by their principal workers, so that discussion was lively and authoritative. Nearly everyone whose earlier work was mentioned was in the room, ready to comment on the papers. The only important group missing was that from Russia. They were invited, but sent their regrets, the term in Moscow starting too early to permit their attendance. Unfortunately, their letter of regret, enclosing numerous reprints, reached Cambridge too late to be reported at the conference, but their work was of course well known to the other research groups, and was thoroughly considered at the conference.

The members of the conference lived together at a new dormitory on the MIT campus. In many ways the most useful feature was the way in which all the workers in the field became acquainted. Many of the European visitors had opportunity not only to visit Cambridge for a longer period than the actual week of the conference, but to visit numerous other American low temperature laboratories. Such an interchange of acquaintance and ideas can well be invaluable in advancing the field of low temperature research. A number of the European workers spoke of the stimulus which they received as a result of the opportunity to hear in a connected way the whole present status of the low temperature field. Much greater than this, however, was the benefit to the American scientists, many of whom were new to the field, and who had the opportunity to come to know the masters of the subject personally and to learn at first hand of the difficulties and intricacies of research in this difficult field. The conference may well have had the effect of speeding up by a number of years the time when the many new American groups in low temperature research will get through the process of learning techniques, and will be able to start making significant contributions.

Based on the introduction to the Proceedings of the Conference on Low Temperatures, to be published shortly by the Research Laboratory of Electronics of the Massachusetts Institute of Technology.