Meetings

Microwave Optics

Symposium at McGill University

Since the Second World War there has been a vast increase in the exploitation of ultra-high frequency or microwave electromagnetic radiation. To solve the problems which have arisen in this effort optical methods, both theoretical and experimental, have proved somewhat helpful. However, these methods are not quite adequate because the wave lengths are not very small compared to the physical bodies involved in the generation, reception, reflection, and scattering of microwaves. Electromagnetic wave theory proper, on the other hand, is equally limited. Insofar as the theoretical approach is concerned, Maxwell's equations can be solved exactly in rather few problems. On the experimental side the low frequency techniques either fail to work at the higher frequencies or they fail to operate satisfactorily. A large body of theoretical and experimental knowledge has therefore been created to treat this range of frequencies which lies between optics and the ordinary radio-frequency range.

It was, consequently, a happy thought on the part of several leaders in the microwave field to bring scientists together so that they might learn what has been accomplished and familiarize themselves with current research. Several agencies, the Eaton Electronics Research Laboratory of McGill University, the Electronics Research Directorate of the U. S. Air Force Cambridge Research Center, and Commission VI of the International Scientific Radio Union (U. S. and Canada) sponsored the Symposium on Microwave Optics which was held at McGill University, June 22–25, 1953. Leadership from these organizations was supplied by G. A. Woonton of McGill, Roy C. Spencer of the Air Force, and Samuel Silver and George Sinclair of URSI, Hans E. J. Neugebauer, George Bekefi, and Francis J. Zucker gave indispensable support to the leaders in planning and carrying out the program of the Symposium. Scientists from the United States, Canada, and Europe delivered 64 papers and about 100 others attended and joined in the discussions.

One of the major topics was the scattering of microwaves by obstacles. Many papers treated scattering by spheres, cylinders, cones, ellipsoids, perfectly and imperfectly conducting wedges, slots in spheres and cones, discs, and semi-infinite dielectric sheets of finite and infinitesimal thickness. The exact (!) solution of the field scattered by a perfectly conducting sawtooth surface with plane wave incident upon it was also treated. The theoretical papers used modal representations of the fields, perturbation procedures for the solution of integral equations, the Wiener-Hopf integral equation technique, and power series solutions in which the variable was the ratio of the dimension of the scattering body to the wave length. Some of these papers yielded as by-products results on diffraction through apertures, a problem which was also considered directly in the sessions on diffraction.

Two sessions were devoted to diffraction problems. A number of the papers in these sessions considered the now classical problem of diffraction by an aperture. The accuracy of the Kirchhoff method for acoustical and electromagnetic diffraction, experimental checks on the Kirchhoff method, improvement on the Kirchhoff method by the addition of a line source along the edge, conditions which must be imposed on approximate idealized formulations to solve the physical problem, diffraction by dielectric discs, and the effect of the directivity of the probe in experimental work were the chief topics under the aperture problem. The inverse problem of calculating the field in an aperture on the basis of the far field was also included. The sharpest discussion from the floor centered about the need for so many theoretical and experimental investigations of this problem. However, the consensus seemed to be that the exact solution for the circular aperture was not useful in calculation and that approximate methods developed for circular apertures might be useful for other shapes and for absorbing screens.

Other papers on diffraction treated acoustical diffraction through the aperture of a semi-infinite pipe of elliptical cross section and the related problem of the scattering of a plane wave by a semi-infinite rigid ribbon, the calculation of fields diffracted by cylinders and spheres by including the field radiated by surface waves which "creep" around the dark side, the use of asymptotic series to calculate diffraction by a cylinder, the effect of diffracting edges of bodies containing slots on the radiation field produced by the slot, and the reduction of undesirable edge diffraction effects by the use of auxiliary, compensating diffracting sources.

Noteworthy methodology utilized in the papers on diffraction included the Kirchhoff method and improvements on it, variational procedures, and integral equations. The Wiener-Hopf method was extended; the integral equation method for treating diffraction by a combination of scatterers (e.g., cylinders) was shown to be solvable by a convergent, recursive process. Formal expansions of the differential operator in the aperture problem were shown to yield information, and the technique of using a dyadic Green's function for diffraction by spherical obstacles was presented.

Another group of papers, devoted to microwave lenses, treated dielectrics as lenses, artificial dielectrics of several types, the Luneburg lens, variations on the Luneburg lens which reduce size by the introduction of reflecting surfaces and suffice for limited scanning angles, and arrays of metallic plates as lenses. The

optical interferometer was shown to be adaptable to the measurement of dielectric constant and wave length. The effect of dielectric radomes on beam shape was discussed, as was the Faraday effect in metals.

A series of papers discussed microwave antennas. Several of these papers presented types of antennas designed essentially by optical principles or showed what variations in purely optical methods would achieve the desired fields. Special feeds to produce shaped beams were described. Extensions of aberration theory useful for both optics and microwaves were made. The calculation of the caustic surfaces of a reflector fed by a family of parallel rays was explained. A method for calculating the electromagnetic field near optical foci and caustics, which includes explicitly the effect of wave length, was presented. The effect of the limited apertures of horns, wave guides, and paraboloids was calculated and measured and a simplification of the calculation of currents in large broadside arrays was introduced.

A promising new direction for research in microwave optical problems, presented in a conference as well as in special papers, centered about analogies between information theory and optics. The essential connection between the two fields is provided by their common and extensive use of Fourier transform theory. The present status of the theory was reviewed and several papers showed how the translation from information theory to optics could be made. Optical problems require that Fourier transform theory operates in a linear vector space of n-variables, but the extension of the theory to such a space is almost immediate. The utilization of this analogy, and therefore the carry-over of ideas in information theory to optical image formation, was strikingly demonstrated by some experiments which showed remarkable improvements in the optical images. The statistical methods of information theory, in particular the use of the autocorrelation function, and the Fourier transform idea were applied to calculate the effect of irregularities in a paraboloidal surface on the radiation pattern.

A number of special studies bearing directly on the theme of microwave optics added variety to the program. It was shown that a large class of electromagnetic fields can be represented by a single scalar function which satisfies the transport equation of optics, hence suggesting a generalization of optical laws to electromagnetic fields. One paper offered a mathematical criterion as to which radiation patterns can exist theoretically. Another paper demonstrated a method for obtaining an asymptotic solution of linear second order partial differential equations in terms of the zeroth and positive integral powers of the wave length, the first term of which provides the geometrical optics solution. A second paper on the same general theme showed that the ray theory of optics can be extended to diffracted fields by deducing the rays from an extension of Fermat's principle. Contributions of the diffracted field to the asymptotic representation of the total electromagnetic field problem then become possible. Approxi-

mate methods for the evaluation of contour integrals which arise in electromagnetic problems, e.g., the Sommerfeld problem, were presented. Finally, an existence and uniqueness theorem for two-dimensional vector problems in which an incident wave hits a bounded dielectric region was proved.

Participants in the Symposium are grateful for many boons. First of all, the leaders at McGill and the Air Force undertook the considerable task of compiling and duplicating a summary of each paper. Hence the participants knew beforehand just what each speaker was to discuss. This aid to understanding the talks was immeasurable and the record of the talks, which the participants were able to carry away with them, will prove invaluable for months to come. Second, the participants enjoyed the rare opportunity of meeting distinguished foreign scientists. E. Wolf, W. Culshaw, and P. M. Woodward of England, H. Bremmer of Holland, W. Franz and H. Severin of Germany, and A. Blanc-Lapierre of France gave talks and joined in the discussions. Those who have been involved in the administrative details required to bring visitors from abroad know how much labor must have been required to arrange for these visits. This undertaking is ample evidence that the leaders of the Symposium spared no personal efforts to make the meeting worth while. Thirdly, the Symposium brought together people who had common scientific interests and one therefore had the opportunity to learn much about one's own research field. It seems fair to say that every paper was, in substance at least, intelligible to all members. Such scientific returns for time spent are rare.

According to present plans the Proceedings of the Symposium will be published in the following manner. The Antenna Laboratory of the Electronics Research Directorate, Air Force Cambridge Research Center, will issue a series of three or four reports which will contain those papers presented at the Symposium not already published and which will give references to the published papers. These reports will be available on request from Dr. Roy C. Spencer, Chief of the Antenna Laboratory.

To the writer one aspect of the papers delivered at the Symposium was especially gratifying, namely, the preponderance of theoretical papers. This is as it should be. The science of electromagnetism is blessed with an excellent and comprehensive mathematical foundation. Though few boundary value problems can be solved exactly an enormous amount of information can nevertheless be extracted by mathematical analysis. It is a tribute to workers in the microwave field that they are willing to wrestle with the mathematics rather than resort immediately to experimentation which is fragmentary, expensive, and often difficult to evaluate because undesirable effects are present. (Indeed one discussion centered on just this difficulty with experimentation.) The temptation to pursue what seems to be the easier course is all too often yielded to where pencil and paper would accomplish far more. These remarks are not intended to imply that experimentation is unnecessary but rather to commend the wholly justifiable emphasis on theoretical investigations.

Morris Kline
New York University

Monte Carlo Methods

A Symposium on Monte Carlo Methods, sponsored by the Aeronautical Research Laboratory, Wright Air Development Center, will be conducted by the Statistical Laboratory, University of Florida, at Gainesville on March 16 and 17. Registration will be on Monday, March 15, for those who arrive early. An invitation is issued to those interested in the field to attend. Further information may be obtained by writing Professor H. A. Meyer, Building OE, University of Florida, Gainesville. Following the symposium, an eastern regional meeting of the Institute of Mathematical Statistics is being planned for Thursday, March 18, at Gainesville.

High-Polymer Physics

Nearing the completion of its tenth year, the Division of High-Polymer Physics of the American Physical Society will hold its twelfth meeting at Detroit and Ann Arbor, Michigan, March 18–20, marking the anniversary. The Division was inaugurated at a meeting at Rochester, N. Y., in June, 1944. The program, which will include a symposium on the properties of amorphous polymers in bulk, along with other invited and contributed papers, has been arranged by a committee headed by Dr. T. G. Fox.

Two British Conferences

The Institute of Physics, London, has organized a conference on the physics of particle size determination to be held April 6–9 in Nottingham. Sessions have been arranged on the motion of particles in fluids, the scattering of light by particles, the general phenomena encountered in particle size analysis, and the comparison of methods and the automatized methods of particle counting and sizing. The Institute has also announced that a conference on luminescence, with special reference to solid inorganic phosphors, will be held in the Cavendish Laboratory, Cambridge, April 7–10. Requests for further details concerning either conference should be directed to the Secretary, The Institute of Physics, 47 Belgrave Square, London, S.W. 1, England.

Network Theory

Information Networks is the topic of the third of a series of annual symposia to be held April 12, 13 and 14, 1954 at the Engineering Societies Building (33 West 39th Street) in New York City. The symposium will deal with network theory, particularly network synthesis as it is influenced by the newer concepts developed in information and general communication theory. The first part will concentrate upon the performance of net-