

IX. ELECTRODYNAMICS OF MEDIA

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RESEARCH OBJECTIVES AND SUMMARY OF RESEARCH

1. Subsurface Probing and Communication with a Dipole Antenna

Joint Services Electronics Program (Contract DAAB07-71-C-0300)

J. A. Kong

We are studying the radiation of dipole antennas in a stratified medium with reference to geophysical subsurface probing and underground communication. During the past year we have formulated the problem and obtained solutions to many aspects of it. The general formulation is applied to anisotropic stratified media. The conventional use of potential functions has been bypassed in order to express the field vectors directly in terms of integrals that are in form for numerical and analytical evaluation. Extensive studies have been made of the case of a horizontal electric dipole on the surface of a two-layer medium. Two physical interpretations that reinforce each other have emerged. An interpretation from geometrical optics suggests the use of an infinite series of images. A modal interpretation expresses the results in terms of normal modes of a two-layer medium. Other dipole sources, such as current loops and horizontal magnetic dipoles, are also being studied and anisotropic layers are being examined. The fast Fourier transform (FFT) method and stratification factors have been used to investigate cases of more than two layers. Comparison of the results with the results of laboratory model tank experiments shows them to be very accurate. Our results have been used to interpret field data collected in trips to glaciers with considerable success.

2. Optics of Bianisotropic Media and Optical Systems

Joint Services Electronics Program (Contract DAAB07-71-C-0300)

J. A. Kong

In this project, we are concerned with guided waves in layered media and electromagnetic waves in bianisotropic media. Several theorems applicable to bianisotropic media have been studied, and these results have aroused considerable interest in the United States and abroad. We have used the kDB system to study wave behavior inside linear media. Solutions of the dispersion relations are programmed with the symbolic computer language MACSYMA. The normal modes can be obtained in analytical form and easily interpreted. The model of a biaxial multilayer medium is being investigated in view of applications to integrated optics and thin-film optics. We have also studied the modulation of an optical waveguide with an anisotropic substrate. Numerical results are being examined to show its feasibility. Mode conversion attributable to the rough surface in optical waveguides has been investigated for the TE modes and is being extended to the TM modes. At present, we are investigating the coupling of waves in circular and rectangular waveguides.

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3. Microwave Remote Sensing of the Earth

California Institute of Technology (Contract 953524)

J. A. Kong, D. H. Staelin

We are undertaking the development of theoretical models for microwave remote sensing of the resources of the Earth. We have developed a multilayer model. The theory applies to any number of layers, layer properties, and thicknesses. The anisotropic behavior of Earth media has also been considered. In particular, we have investigated the probing depth of ice-covered water as a function of frequency, viewing angle, and physical properties of ice and water. The theoretical result has also been compared with controlled model tank experiments.

A scattering model, which considers various scattering effects from terrestrial material, such as snow and ice, has been developed. The surface effect is considered by taking into account backscattering from the submerged centers to the boundary for angles less than the critical angle of the subsurface medium. The treatment is a first-order approximation. Under the same assumptions, scattering centers in multilayer media have also been considered. In order to check the assumptions and the accuracy of the theoretical model, we have carried out an experiment, using a model tank sensed by two radiometers. We are now engaged in finding out whether the scattering centers are of cylindrical structure in order to simulate brine inclusions in ice. We are also considering surface roughness. Using a modal approach, we have obtained results for one-dimensional roughness. We shall also use geometrical and physical optics, as well as the Green's function method. We hope eventually to compare the effects of surface roughness, scattering centers, and multilayers.