XVI. ELECTROMAGNETIC WAVE THEORY AND REMOTE SENSING

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1. ELECTROMAGNETIC WAVES

Joint Services Electronics Program (Contracts DAAG29-78-C-0020 and DAAG29-80-C-0104)

Jin Au Kong, Weng C. Chew

Electromagnetic waves are studied with application to microstrip antenna and microwave integrated-circuit problems, geophysical subsurface probing, microwave remote sensing, and optical-beam diffraction by periodic structures. Microstrip antenna and microwave integrated-circuit problems have been carried out with rigorous analytical approaches. The resonant-frequency characteristics of a circular microstrip disk are studied regorously using a numerical technique, perturbation analysis, and matched asymptotic analysis.[1-4] The input impedance of a microstrip disk is calculated using the perturbative argument of single-mode approximation for thin dielectric substrates and Galerkin's method with singularity subtraction for thick dielectric substrates.[5,6] In addition, the capacitance of a circular disk and a microstrip line have also been investigated using numerical, isoperimetric, and matched asymptotic analysis.[7-10] Seminumerical analysis provides a simple formula for the capacitance usable on a desk calculator. The dispersion characteristics of a microstrip line have also been studied with asymptotic analysis, providing a simple eigenequation from which the effective permittivity as a function of frequency can be readily calculated.[11] Radiation characteristics of a microstrip antenna and the use of the equivalence principle in solving such

problems have also been studied.[12,13] The use of electromagnetic waves in geophysical exploration has been studied.[14-16] Extensive work has been accomplished on theoretical modeling and data interpretation for active and passive microwave remote sensing with radars and radiometers.[17-26] Second-order coupled-mode equations have been used to study the diffraction of optical beams by a periodically modulated layer.[27] Multiple-scattering effects of acoustic waves by random distribution of discrete scatterers have been studied.[28]

2. REMOTE SENSING WITH ELECTROMAGNETIC WAVES

National Science Foundation (Grant ENG78-23145)

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Active remote sensing with dipole antennas has been studied for monochromatic and pulse excitations.[15,16] Extensive work has been accomplished on theoretical modeling and data interpretation for active and passive microwave remote sensing of earth terrain with radars and radiometers.[19-26,29-34] Scattering of electromagnetic waves from periodic and random rough surfaces has been investigated.[17,18,36] Multiple-scattering effects of electromagnetic waves by random distribution of discrete scatterers have been studied using coherent potential and quantum-mechanical formulism.[37] A theory for vector electromagnetic wave propagation in a random medium with strong permittivity fluctuation is derived and used to study the scattering of electromagnetic waves from a vegetationlike half-space and from a half-space dielectric mixture.[38-40]

3. ACTIVE AND PASSIVE MICROWAVE REMOTE SENSING

National Aeronautics and Space Administration (Contract NAS5-24139)

Jin Au Kong, Shun-Lien Chuang

In the active and passive microwave remote sensing of earth terrain, the scattering effects due to medium inhomogeneities and surface roughness play a dominant role. The volume scattering effect has been treated with two theoretical models

for the terrain media: (1) the random medium model where scattering can be accounted for by introducing a randomly fluctuating part in the permittivities; and (2) the discrete scatterer model where discrete scatterers are imbedded in a homogeneous background medium. With the earth terrain modelled as layers of such scattering media, the radar backscattering cross sections and the radiometric brightness temperatures are calculated with the radiative transfer theory and the wave approach.[19-25,29] The theoretical results have been used to interpret the experimental data collected from vegetation and snow-ice fields. Energy conservation and asymptotic solution for the reflectivity of a very rough surface have also been studied.[17,18]

4. ACOUSTIC-WAVE PROPAGATION STUDIES

Schlumberger Doll Research Center

Jin Au Kong, Leung Tsang, Weng C. Chew

Electromagnetic fields of a dipole submerged in a two-layer conducting medium in the ELF regime have been studied.[14] Transient fields of a vertical electric dipole over a two-layer dielectric medium have been studied by reducing the double-integral expressions for the time response of the fields into series of single integrals by asymptotic methods and explicit inversion approaches.[16] Multiple-scattering effects of acoustic and electromagnetic waves by random distribution of discrete scatters have been studied using coherent potential and quantum-mechanical formulism.[28,37] Microstrip antenna and microwave integrated-circuit problems, relating to the study of resonance phenomena, electric capacitance, input impedance, and radiation fields have been carried out with rigorous analytical approaches.[1-11]

5. EFFECT OF EARTH TERRAIN ON MILLIMETER WAVE PROPAGATION

U.S. Air Force — Hanscom (Contract F19628-80-C-0052)

Jin Au Kong, Robert T. Shin

Extensive work has been accomplished in the development of theoretical models that account for absorption, scattering, layering, and rough surface effects of

earth terrain.[19-26,30-36,41,42] The radar backscattering cross sections and the radiometric brightness temperatures have been calculated with the radiative transfer theory and the wave approach, and these results have been used to interpret the experimental data. Strong fluctuation theory for electromagnetic wave propagation in a random medium with large variance of permittivity function is derived,[38-40] and the results are shown to be consistent with those derived from discrete-scatterer theory[37] under the common regime of validity.

6. THEORIES FOR MICROWAVE REMOTE SENSING OF SNOW

National Aeronautics and Space Administration (Contract NAG 5-16)

Jin Au Kong

In the microwave remote sensing of snow, the scattering effects due to medium inhomogeneities and surface roughness play a dominant role in the determination of radar backscattering cross sections and radiometric brightness temperatures. Radiative transfer theory has been used to develop theoretical models applicable to the active and passive remote sensing of snow.[22-25,30-34] The Born approximation has been applied to the active remote sensing of an anisotropic two-layer random medium.[20] The modified radiative transfer equations appropriate for electromagnetic wave propagation in bounded random media are derived from the Bethe-Salpeter equation with the ladder approximation and the Dyson equation with the nonlinear approximations.[21,26,35] Vector electromagnetic wave scattering from a random medium with strong permittivity fluctuation is studied by taking into proper account the singularity of the dyadic Green's function in the renormalization method.[38]

7. SAR IMAGE PREDICTION, SIMULATION, AND ANALYSIS

Draper Laboratory (Contract DL-H-182642)

Jin Au Kong, Francesco J. Vallese

In both active and passive remote sensing of earth terrain, it has been found very useful to model terrain media such as snow and ice with a random medium model. The correlation function which describes the random permittivity fluctuations with its associated mean, variance, and correlation lengths has been shown to characterize the physical ground-truth parameters of density, composition, structure, etc. Several snow and ice samples have been studied, and the correlation functions have been shown to be exponential in character with correlation lengths which correspond to the actual size of the ice particles in snow or air bubbles in ice.[43]

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