14. Electromagnetic Wave Theory and Remote Sensing

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14.1 Electromagnetic Waves

Joint Services Electronics Program (Contract DAAG29-80-C-0104)
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Electromagnetic waves are studied with applications to microstrip antennas,[1-5] microwave integrated circuit problems[6-10], and geophysical subsurface probing and communications.[10-16] Significant advancements have been made in the understanding of the radiation and resonance characteristics of the microstrip disks with thick substrates, annular-ring structures, and coupled excitations. Theoretical techniques including asymptotic approaches, numerical techniques, Galerkin's method, and newly developed Hankel transform analysis are utilized to explore the new dimensions and applications of the microstrip integrated structures. The same theoretical approaches are used to study the classical subject of dipole antenna radiation in the presence of stratified earth as applied to geophysical probing and submarine communications problems. A new double-deformation technique has also been developed to analyze transient electromagnetic phenomena.

14.2 Remote Sensing with Electromagnetic Waves

National Science Foundation (Grant ENG78-23145)
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Remote sensing with electromagnetic waves[17-35,11-14] has been studied with the theoretical models of random media, discrete scatterers, and random distribution of discrete scatterers. These models

simulated earth terrain media such as snow-ice, forest, and vegetation. Scattering and emission of electromagnetic waves by such media bounded by rough interfaces are investigated. The development of the strong fluctuation theory and the random discrete scatterer model with the quasi-crystalline approximation and the Percus-Yevick equation are the most significant contributions in advancing the understanding of wave scattering by earth terrain media.

14.3 Acoustic Wave Propagation Studies

Schlumberger-Doll Research Center
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Multiple scattering of acoustic waves by random distributions of discrete scatterers has been studied with the use of quasi-crystalline-coherent potential approximation and the Percus-Yevick equation.[15,25] Such an approach represents a significant step towards understanding of the scattering process by dense distribution of volume scatterers. The technique is also used to study electromagnetic wave scattering.[26] In addition, the radiation and resonance of microstrip line structures[1-10] and geophysical subsurface probing by dipole antennas[11-14] are being studied under the support of this contract.

14.4 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.[1,18-20,23-24,27-34,36-37] Radar-backscattering cross sections and radiometric brightness temperatures have been calculated with radiative transfer theory and the wave approach. The results have been used to interpret the experimental data.

14.5 Theories for Microwave Remote Sensing of Snow

National Aeronautics and Space Administration (Grant NAG5-16)
Jin Au Kong, Robert T. Shin

Theories for microwave remote sensing of snow have been developed with the snow modelled both as a random medium[18,24,27-28] and as a homogeneous layer containing spherical scatterers.[20] The radar-backscattering coefficients and the radiometric brightness temperatures are calculated and

used to interpret experimental data obtained from snow fields.

14.6 SAR Image Prediction, Simulation, and Analysis

Draper Laboratory (Contract DL-H-182642)
Jin Au Kong, Francesco J. Vallese

Several snow and Ice samples have been studied and their correlation functions have been shown to be exponential in character with correlation lengths corresponding to the actual sizes of ice crystals in snow and air bubbles in ice.[32,36] Such correlation functional characterization is very essential in describing earth terrain media with the theoretical random medium model.[28,34]

14.7 Remote Sensing of Vegetation and Soil Moisture

National Aeornautics and Space Administration (Contract NAG5-141)
Jin Au Kong, Robert T. Shin

Two important contributions have been made in the remote sensing of vegetation and soil moisture studies.[18-23,27-34] The strong fluctuation theory has been developed for the random medium model, which is particularly pertinent for vegetation canopy as the contrast of vegetation permittivity, which is essentially water droplets, and the air is very large. For row structures in plowed vegetation fields, we have developed the modal theory with the extended boundary condition approach to calculate for the radar-backscattering coefficients and the radiometric brightness temperatures.

References

1. W.C. Chew and J.A. Kong, "Analysis of a Circular Microstrip Disk Antenna with a Thick Dielectric Substrate," IEEE Transactions on Antennas and Propagation, AP-29, 1, 68-76, January 1981.
2. S.M. Ali, W.C. Chew, and J.A. Kong, "Vector Hankel Transform Analysis of Annular-Ring Microstrip Antenna," IEEE Transactions on Antennas and Propagation, AP-30, 4, 637-644, July 1982.
3. W.C. Chew and J.A. Kong, "Asymptotic Formula for the Resonant Frequencies of a Circular Microstrip Antenna," Journal of Applied Physics, 52, 8, 5365-5369, August 1981.
4. W.C. Chew, "A Broadband Annular-Ring Microstrip Antenna," submitted for publication.
5. S.M. Ali, W.C. Chew, and J.A. Kong, "Radiation from Printed Conducting Patches on Thin Films with a Ground Plane," Optical Society of America Annual Meeting, Kissimmee, Florida, October 26-30, 1981.
6. S.Y. Poh, W.C. Chew, and J.A. Kong, "Approximate Formulas for Line Capacitance and Characteristic Impedance of Microstrip Line," IEEE Transactions on Microwave Theory and Techniques, MTT-29, 2, 135-142, Feb. 1981.
7. S.M. Ali, T.M. Habashy, and J.A. Kong, "Resonance of Two Coupled Circular Microstrip Disk Resonators," Journal of Applied Physics, 53, 9, 6418-6429, September 1982.
8. W.C. Chew and J.A. Kong, "Asymptotic Eigenequations and Analytic Formulas for the Dispersion Characteristics of Open Wide Microstrip Lines," IEEE Transactions on Microwave Theory and Techniques, MTT-29, 9, 933-941, September 1981.

9. W.C. Chew and J.A. Kong, "Asymptotic Formula for the Capacitance of Two Oppositely Charged Discs," Math. Proc. Camb. Phil. Soc., 89, 373-384, 1981.
10. W.C. Chew and J.A. Kong, "Microstrip Capacitance for a Circular Disk through Matched Asymptotic Expansions," SIAM Journal of Applied Mathematics, 42, 2, 302-317, April 1982.
11. A. Ezzeddine, J.A. Kong, and L. Tsang, "Transient Fields of a Vertical Electric Dipole over a Two-Layer Nondispersive Dielectric," Journal of Applied Physics, 52, 3, 1202-1208, March 1981.
12. A. Ezzeddine, J.A. Kong, L. Tsang, "Time Response of a Vertical Electric Dipole over a Two-Layer Medium by the Double Deformation Technique," Journal of Applied Physics, 53, 2, 813-822, February 1982.
13. W.C. Chew and J.A. Kong, "Asymptotic Approximation of Dipole Fields in the Geophysical Probing of a Two-Layer Earth," IEEE Geoscience and Remote Sensing Symposium, Washington, DC, June 8-10, 1981.
14. W.C. Chew and J.A. Kong, "Electromagnetic Fields of a Dipole on Two-Layer Earth," Geophysics, 46, 3, 309-315, March 1981.
15. L. Tsang and J.A. Kong, "Multiple Scattering of Acoustic Waves by Random Distributions of Discrete Scatterers with the Use of Quasicrystalline-Coherent Potential Approximation," Journal of Applied Physics, 52, 9, 5448-5458, September 1981.
16. J.A. Kong, W.C. Chew, and T.H. Habashy, "Electromagnetic Fields of Dipole Antennas in the Presence of Layered Media," Symposium on Medium, Long and Very Long Wave Propagation (at Frequencies Less than 3000 kHz), AGARD/NATO Meeting, Brussels, Belgium, September 21-25, 1981.
17. L. Tsang and J.A. Kong, "Application of Strong Fluctuation Random Medium Theory to Scattering from Vegetation-like Half Space," IEEE Transactions on Geoscience and Remote Sensing, GE-19, 1, 62-69, January 1981.
18. L. Tsang and J.A. Kong, "Scattering of Electromagnetic Waves from Random Media with Strong Permittivity Fluctuations," Radio Science, 16, 3, 303-320, May-June 1981.
19. L. Tsang, M.C. Kubacsi, and J.A. Kong, "Radiative Transfer Theory for Active Remote Sensing of a Layer of Small Ellipsoidal Scatterers," Radio Science, 16, 3, 321-330, May-June 1981.
20. R.T. Shin and J.A. Kong, "Radiative Transfer Theory for Active Remote Sensing of a Homogeneous Layer Containing Spherical Scatterers," Journal of Applied Physics, 52, 6, 4221-4230, June 1981.
21. S.L. Chuang and J.A. Kong, "Scattering of Waves from Periodic Surfaces," Proceedings of the IEEE, 69, 9, 1132-1144, September 1981.
22. S.L. Chuang and J.A. Kong, "Scattering of Waves from Periodic Dielectric Surface for a General Angle of Incidence," Radio Science, 17, 3, 545-557, May-June 1982.
23. L. Tsang, J.A. Kong, and R.W. Newton, "Application of Strong Fluctuation Random Medium Theory to Scattering of Electromagnetic Waves from a Half-Space of Dielectric Mixture," IEEE Transactions on Antennas and Propagation, AP-30, 2, 292-302, March 1982.
24. M.A. Zuniga and J.A. Kong, "Mean Dyadic Green's Function for a Two-Layer Random Medium," Radio Science, 16, 6, 1255-1270, November-December 1981.
25. L. Tsang, J.A. Kong, and T. Habashy, "Multiple Scattering of Acoustic Waves by Random Distribution of Discrete Spherical Scatterers with the Quasicrystalline Approximation and Percus-Yevick Equation," J. Acoust. Soc. Am. 71, 3, 552-55, March 1982.
26. L. Tsang and J.A. Kong, "Effective Propagation Constants for Coherent Electromagnetic Wave Propagation in Media Embedded with Dielectric Scatters," J. Appl. Phys. 53, 1, 7162-7173, Nov. November 1982.
27. R.T. Shin, S.L. Chuang, and J.A. Kong, "Radiative Transfer Theory for Thermal Microwave Emission from an Inhomogeneous Medium with Rough Surfaces," National Radio Science Meeting, Boulder, Colorado, January 12-16, 1981.

27. J.A. Kong, R.T. Shin, F.J. Vallese, S.L. Chuang, and L. Tsang, "Theory and Application for Microwave Remote Sensing of Earth," National Radio Science Meeting, Boulder, Colorado, January 12-16, 1981.
29. J.A. Kong, R.T. Shin, and S.L. Chuang, "Active and Passive Microwave Remote Sensing of Earth Terrain," IEEE Antennas and Propagation Conference, University of York, England, IEEE Conference Publication No. 195, pp. 89-92, April 13-16, 1981.
30. S.L. Chuang and J.A. Kong, "Remote Sensing of Dielectric Media with Periodic Rough Surfaces," IEEE Geoscience and Remote Sensing Symposium, Washington, DC, June 8-10, 1981.
31. M.A. Zuniga and J.A. Kong, "Mean Dyadic Green's Function for Remote Sensing of a Two-Layer Random Medium," IEEE Geoscience and Remote Sensing Symposium, Washington, DC, June 8-10, 1981.
32. F. Vallese and J.A. Kong, "Correlation Function Studies for Microwave Remote Sensing of Snow and Ice," IEEE Geoscience and Remote Sensing Symposium, Washington, DC, June 8-10, 1981.
33. R.T. Shin, S.L. Chuang, and J.A. Kong, "Radiative Transfer Theory for Microwave Remote Sensing of an Inhomogeneous Medium with Rough Surfaces," URSI Meeting, Los Angeles, CA, June 16-19, 1981.
34. J.A. Kong, R.T. shin, F.J. Vallese, S.L. Chuang, and J.K. Lee, "Random Medium Model for Microwave Remote Sensing of Earth Terrain," URSI Meeting, Los Angeles, CA, June 16-19, 1981.
35. S.L. Chuang and J.A. Kong, "Diffraction from Optical Gratings and Surface Plasmon Excitations," Optical Society of America Annual Meeting, Kissimmee, Florida, October 26-30, 1981.
36. F. Vallese and J.A. Kong, "Correlation Function Studies for Snow and Ice," Journal of Applied Physics, 52, 8, 4921-4925, August 1981.
37. R.T. Shin and J.A. Kong, "Theory for Thermal Microwave Emission from a Homogeneous Layer with Rough Surfaces Containing Spherical Scatterers," Journal of Geophysical Research 87, B7, 5566-5576, July 1982.