

## XIV. ELECTRODYNAMICS OF MEDIA

### Academic and Research Staff

Prof. Hermann A. Haus  
Prof. Jin Au Kong

Prof. David H. Staelin  
Dr. Leung Tsang

### Graduate Students

Weng C. Chew  
Boucar Djermakoye

Donald L. Lee  
Algis S. Leveckis

Roger S. Putnam  
James T. Walton

## 1. ELECTROMAGNETIC WAVES

Joint Services Electronics Program (Contract DAAB07-76-C-1400)

Jin Au Kong

We have the following objectives in our studies of electromagnetic waves: examination of subsurface probing and communication with a dipole antenna, study of remote sensing of the Earth, and investigation of integrated optics and fiber optics as applied to optical communication systems.

Papers on research supported in 1976 by the Joint Services Electronics Program which have been published, accepted for publication, submitted for publication, or presented at meetings are listed in the references.<sup>1-17</sup> The advantages of using horizontal magnetic dipole antennas were explored in detail for both isotropic and anisotropic layered earth.<sup>1-3</sup> We compared field calculations and experimental results for a horizontal electric dipole submerged in lake water.<sup>4</sup> In remote sensing we studied thermal microwave emission from random media and from media containing spherical scatterers.<sup>5-13</sup> In applied optics we investigated electro-optical modulators and developed theories for spatially modulated periodic media.

In the study of geophysical subsurface probing and communication with dipole antennas, the theory for surface waves and subsurface waves arising from dipole images has been developed. The surface waves are proportional to inverse distance squared and the subsurface waves to inverse distance. We shall evaluate the image contributions to second order in inverse distance and hope to attain a compatible, rigorous theory. In remote sensing we are now incorporating the surface roughness and subsurface inhomogeneous temperature distributions. In integrated optics and fiber optics we are studying the diffraction and guidance of a Gaussian beam by a spatially modulated periodic medium. Mode coupling and conversion mechanisms in guided optical systems will be applied to both optical communication and solar energy collection studies.

(XIV. ELECTRODYNAMICS OF MEDIA)

References

1. J. A. Kong, D. Cheng, and L. Tsang, "Geophysical Subsurface Probing with Horizontal Electric and Magnetic Dipole Antennas," 1976 International IEEE USNC/URSI Meeting, University of Massachusetts, Amherst, Massachusetts, October 10-15, 1976.
2. W. C. Chan, J. A. Kong, and L. Tsang, "Geophysical Subsurface Probing with a Horizontal Magnetic Dipole," IEEE Trans. (AP) Vol. AP-24, No. 6, pp. 877-879. November 1976.
3. D. Cheng, J. A. Kong, and L. Tsang, "Geophysical Subsurface Probing of a Two-Layer Uniaxial Medium with a Horizontal Magnetic Dipole" (submitted to IEEE Trans. on Antennas and Propagation).
4. J. A. Kong, L. C. Shen, and L. Tsang, "Field of an Antenna Submerged in a Dissipative Dielectric Medium" (submitted to IEEE Trans. on Antennas and Propagation).
5. J. A. Kong and L. Tsang, "Passive Microwave Remote Sensing of Layered Media," Spring Annual Meeting, American Geophysical Union, Washington, D. C., April 12-15, 1976.
6. L. Tsang and J. A. Kong, "Microwave Remote Sensing of a Two-Layer Random Medium," IEEE Trans. on Antennas and Propagation, Vol. AP-24, No. 3, pp. 283-287, May 1976.
7. L. Tsang and J. A. Kong, "Emissivity of Half-Space Random Media," Radio Sci. 11, 593-598 (1976).
8. L. Tsang and J. A. Kong, "Thermal Microwave Emission from Half-Space Random Media," Radio Sci. 11, 599-610 (1976).
9. L. Tsang and J. A. Kong, "Thermal Microwave Emission from a Random Inhomogeneous Layer over a Homogeneous Medium Using the Method of Invariant Imbedding" (to appear in Radio Sci.).
10. L. Tsang, J. A. Kong, E. Njoku, D. H. Staelin, and J. W. Waters, "Theory for Microwave Passive Remote Sensing of Cloud and Rainfall" (submitted to IEEE Trans. on Antennas and Propagation).
11. L. Tsang and J. A. Kong, "Theory for Thermal Microwave Emission from a Bounded Medium Containing Spherical Scatterers" (submitted to J. Appl. Phys.).
12. L. Tsang, J. A. Kong, D. H. Staelin, E. Njoku, and J. W. Waters, "Passive Remote Sensing of Cloud and Rainfall," 1976 International IEEE USNC/URSI Meeting, University of Massachusetts, Amherst, Massachusetts, October 10-15, 1976.
13. L. Tsang and J. A. Kong, "Radiative Transfer Theory for Microwave Remote Sensing of Two-Layer Media," 1976 International IEEE AP-S Symposium, University of Massachusetts, Amherst, Massachusetts, October 10-15, 1976.
14. R. S. Chu, J. A. Kong, and D. Lee, "Theory for Electro-optical Grating Modulators," Proceedings of the IEEE MTT-S International Microwave Symposium, Cherry Hill, New Jersey, June 14, 1976, pp. 24-26.
15. R. S. Chu and J. A. Kong, "Modal Theory of Spatially Periodic Media" (to appear in IEEE Trans. on Microwave Theory and Techniques).
16. J. A. Kong, "Coupled Mode Approaches to Spatially Periodic Media in Integrated Optics," 1976 International IEEE USNC/URSI Meeting, University of Massachusetts, Amherst, Massachusetts, October 10-15, 1976.
17. J. A. Kong, "Second-Order Coupled Mode Equations for Spatially Periodic Media" (to appear in J. Opt. Soc. Am.).

## 2. PASSIVE REMOTE SENSING OF THE EARTH WITH MICROWAVES

California Institute of Technology (Contract 953524)

Jin Au Kong, David H. Staelin

In passive remote sensing of the earth we have studied microwave thermal emission from a layered random medium.<sup>1-5</sup> The model of a medium containing spherical scatterers has also been developed.<sup>6-10</sup> These theoretical models have been applied to the solid earth, as well as to clouds and rainfall.<sup>9-10</sup>

### References

1. J. A. Kong and L. Tsang, "Passive Microwave Remote Sensing of Layered Media," Spring Annual Meeting, American Geophysical Union, Washington, D. C., April 12-15, 1976.
2. L. Tsang and J. A. Kong, "Microwave Remote Sensing of a Two-Layer Random Medium," IEEE Trans. on Antennas and Propagation, Vol. AP-24, No. 3, pp. 283-287, May 1976.
3. L. Tsang and J. A. Kong, "Emissivity of Half-Space Random Media," Radio Sci. 11, 593-598 (1976).
4. L. Tsang and J. A. Kong, "Thermal Microwave Emission from Half-Space Random Media," Radio Sci. 11, 599-610 (1976).
5. L. Tsang and J. A. Kong, "Radiative Transfer Theory for Microwave Remote Sensing of Two-Layer Media," 1976 International IEEE AP-S Symposium, University of Massachusetts, Amherst, Massachusetts, October 10-15, 1976.
6. L. Tsang and J. A. Kong, "Thermal Microwave Emission from a Random Inhomogeneous Layer over a Homogeneous Medium Using the Method of Invariant Imbedding" (to appear in Radio Sci.).
7. L. Tsang and J. A. Kong, "Theory for Thermal Microwave Emission from a Bounded Medium Containing Spherical Scatterers" (submitted to J. Appl. Phys.).
8. E. G. Njoku and J. A. Kong, "Theory for Passive Microwave Remote Sensing of Near-Surface Soil Moisture" (submitted to J. Geophys. Res.).
9. L. Tsang, J. A. Kong, D. H. Staelin, E. Njoku, and J. W. Waters, "Passive Remote Sensing of Cloud and Rainfall," 1976 International IEEE USNC/URSI Meeting, University of Massachusetts, Amherst, Massachusetts, October 10-15, 1976.
10. L. Tsang, J. A. Kong, E. Njoku, D. H. Staelin, and J. W. Waters, "Theory for Microwave Remote Sensing of Cloud and Rainfall" (submitted to IEEE Trans. on Antennas and Propagation).

(XIV. ELECTRODYNAMICS OF MEDIA)

3. REMOTE SENSING WITH ELECTROMAGNETIC WAVES

National Science Foundation (Grant ENG76-01654)

Jin Au Kong

Active sensing with dipole antennas has been studied with a horizontal magnetic dipole<sup>1</sup> and with a horizontal electric dipole.<sup>2</sup> Passive remote sensing of near-surface soil moistures and ice-covered land or water by using a model of a layered medium has been investigated.<sup>3,4</sup> The theory for thermal microwave emission from a bounded medium containing spherical scatterers has also been developed.<sup>5</sup>

References

1. D. Cheng, J. A. Kong, and L. Tsang, "Geophysical Subsurface Probing of a Two-Layer Uniaxial Medium with a Horizontal Magnetic Dipole" (submitted to IEEE Trans. on Antennas and Propagation).
2. J. A. Kong, L. C. Shen, and L. Tsang, "Field of an Antenna Submerged in a Dissipative Dielectric Medium" (submitted to IEEE Trans. on Antennas and Propagation).
3. E. G. Njoku and J. A. Kong, "Theory for Passive Microwave Remote Sensing of Near-Surface Soil Moisture" (submitted to J. Geophys. Res.).
4. L. Tsang and J. A. Kong, "Thermal Microwave Emission from a Random Inhomogeneous Layer over a Homogeneous Medium Using the Method of Invariant Imbedding" (to appear in Radio Sci.).
5. L. Tsang and J. A. Kong, "Theory for Thermal Microwave Emission from a Bounded Medium Containing Spherical Scatterers" (submitted to J. Appl. Phys.).