**Title:** Wave Propagation in Dense Geophysical Media

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**Keywords:** coherent and incoherent fields, radiative transfer, multiple scattering, pulse broadening, backscattering

**Abstract:**
This final report summarizes our study of the interactions between the wave characteristics and the dense geophysical media. We have clarified the propagation constant of the coherent wave in a dense medium, conducted a pulse-broadening study, observed an interesting backscattering phenomenon, and investigated vector radiative transfer theory.
WAVE PROPAGATION IN DENSE GEOPHYSICAL MEDIA

FINAL REPORT

Akira Ishimaru

June 12, 1984

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A. STATEMENT OF THE PROBLEM STUDIED

Theoretical and experimental studies have been conducted to clarify the interrelations between the wave characteristics and the dense geophysical scattering medium. Experimental studies have involved carefully controlled optical and ultrasound measurements. This basic information will be used to obtain useful numerical codes for the wave characteristics in the actual atmospheric and terrestrial environments.

B. SUMMARY OF THE MOST IMPORTANT RESULTS

The propagation constant of the coherent field in a dense scattering medium has been studied experimentally with controlled optical measurements. At a density higher than 1%, the attenuation constants show a marked departure from the low density Foldy approximation. This departure has been measured for different particle sizes and compared with theoretical predictions which include pair-correlations of scatterers. We have not, however, completed the study of the phase constant.

We have conducted pulse broadening experiments using pico-second optical pulse. We obtained some practical results, but our studies are still not complete, and we intend to continue this work using ultrasound.

We observed an interesting phenomenon showing a sharp peak in the backscattering direction with the small angular width corresponding to the lateral correlation distance of a mean free path. We have confirmed this experimentally and theoretically using the second-order multiple scattering theory.

We have also investigated the vector radiative transfer theory for nonspherical scatterers. It indicates two propagation constants for the
coherent field, and the radiative transfer equation includes a 4 x 4 extinction matrix. Further study on this and beam wave problems is continuing.

C. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP DURING THIS PERIOD


"Backscattering enhancement of random discrete scatterers," accepted Journal of the Optical Society of America; coauthor, L. Tsang.

"Retroreflectance from a dense distribution of spherical particles," accepted Journal of the Optical Society of America; coauthor, Y. Kuga.

C. PRESENTATIONS AT MEETINGS

A. Ishimaru, "Multiple scattering effects on optical propagation in turbulence and particles," NATO-AGARD Meeting, Monterey, California, April 1981.


A. Ishimaru, "Frequency spectra of ultrasound pulses reflected from scattering medium," 7th International Symposium on Ultrasound Imaging and Tissue Characterization, NBS, Gaithersburg, Maryland, June 1982.


C. PRESENTATIONS AT MEETINGS (Continued)


C. PRESENTATIONS AT MEETINGS (Continued)


D. PARTICIPATING SCIENTIFIC PERSONNEL

Akira Ishimaru, Principal Investigator
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