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EXTINCTION BY DIELECTRIC PARTICLES AT OPTICAL AND
INFRARED WAVELENGTHS(U) CLARKSON COLL OF TECHNOLOGY
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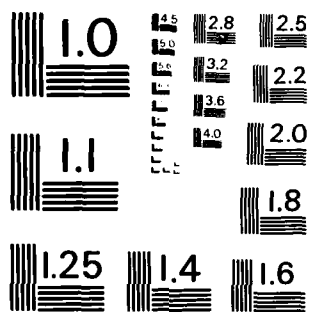
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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ARO 20121-2-65	2. GOVT ACCESSION NO. AD-A146 305 N/A	3. RECIPIENT'S CATALOG NUMBER N/A
4. TITLE (and Subtitle) Extinction by Dielectric Particles at Optical and Infrared Wavelengths		5. TYPE OF REPORT & PERIOD COVERED Final 1 Dec. 1982-31 May 1984
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Peter W. Barber		8. CONTRACT OR GRANT NUMBER(s) DAAG29-83-K-0011
9. PERFORMING ORGANIZATION NAME AND ADDRESS Dept. of Elect. and Comp. Engr. Clarkson University Potsdam, NY 13676		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Research Office Post Office Box 12211 Research Triangle Park, NC 27709		12. REPORT DATE 30 July 1984
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		13. NUMBER OF PAGES 2
		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
15. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) NA		
18. SUPPLEMENTARY NOTES The view, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) LIGHT SCATTERING DIELECTRIC PARTICLES METAL PARTICLES MUELLER MATRIX NONSPHERICAL PARTICLES EXTINCTION SCATTERING ABSORPTION RAYLEIGH SCATTERING MULTIPLE SCATTERING		
21. ABSTRACT (Continue on reverse side if necessary and identify by block number) Calculations for metal prolate spheroidal particles show that enhanced fields can occur even when the particles are a significant fraction of a wavelength in size. Analysis of the information content of the Mueller Matrix has shown that signal processing techniques can be used to extract the particle volume and axial ratio from the polarized angular scattering. The exact scattering solution for coupled parallel fibers has permitted an investigation of the onset of multiple scattering as a function of fiber spacing. Calculations for a size/shape spheroidal distribution of soil particles are shown to fit measured results better than a simple spherical distribution.		

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Problem Statement

The goal of this project is to quantify the optical and infrared extinction properties of dielectric particles. Tasks include the development of new numerical methods and the use of these methods to analyze the polarized scattering and absorption characteristics of nonspherical particles.

Summary of Results

Conducting Particle Studies

Internal, surface, and scattered fields have been calculated for prolate spheroidal metal particles. Electrodynamic calculations show that the use of the Rayleigh approximation is much more restricted for conducting particles than one would expect based on experience with nonabsorbing particles. However, a major finding was that metal particles which exhibit polariton resonances can scatter considerable energy even when the size of the particle is a significant fraction of a wavelength. Furthermore, enhanced scattering can occur over a relatively broad band of visible or infrared wavelengths, depending on the metal. Although earlier calculations had shown that Rayleigh-sized particles can be efficient scatterers over a narrow wavelength band, it had been assumed that larger particles would not be very effective scatterers.

Mueller Matrix Calculations

We have completed an extensive analysis of the Mueller Matrix for nonspherical particles. The overall goal is to develop a scheme for extracting particle size and shape information from the six unique matrix elements obtained for randomly oriented spheroidal particles. It has been shown that for particles with size parameters of five or less, Fourier analysis of the P_{11}

element (phase function) can be used to determine particle volume without knowledge of the axial ratio of the spheroids. Subsequent analysis of the spectral energy in the P_{22} element or of the angular variation of all six

elements compared to an equal volume sphere provides information about the axial ratio. The signal processing method currently being used provides two possible values of the axial ratio, one oblate and one prolate. Additional work is required to resolve this ambiguity.

Scattering by Coupled Fibers

The exact solution for the wavelength-dependent and angular scattering by two parallel coupled fibers has been solved using the method developed by G.O. Olaofe (Radio Science, 5, 1351-1360, 1970). Preliminary calculations show good correlation with experimental results provided by R.K. Chang of Yale University. Furthermore, calculations which ignore the coupling between the fibers, but which take into account the interference between the scattered fields, correlate well with both the coupled fiber and measured results when the fiber separation is large. These results should be useful in specifying the transition between single scattering and multiple scattering for other particle systems as well.

Soil Particle Scattering

A sample of soil particles have been modeled by a size/shape distribution of spheroids. The goal was to investigate how well the measured scattering is approximated by a similar distribution of spheroids and (assuming a similarity) to use the calculated results to estimate scattering properties (such as the forward scattering) that are too difficult to measure. Reasonably good agreement was found. In particular, it was found that the measured angular scattering patterns are better approximated by a distribution of spheroids than by a distribution of spheres of equal surface area or of equal volume.

List of Publications

P. W. Barber and H. Massoudi, "Recent Advances in Light Scattering Calculations for Nonspherical Particles", Aerosol Science and Technology, 1, 303, 1982.

K. N. Liou, Q. Cai, P. W. Barber and S. C. Hill, "Scattering Phase Matrix Comparison for Randomly Oriented Hexagonal Cylinders and Spheroids", Applied Optics, 22, 1684, 1983.

P. W. Barber and P. E. Geller, "Scattering and Absorption by Atmospheric Aerosol Models", Proceedings of the URSI Comm. F Symposium on Wave Propagation and Remote Sensing, 357, 1983.

M. A. Morgan, C. H. Chen, S. C. Hill and P. W. Barber, "Finite Element-Boundary Integral Formulation for Electromagnetic Scattering", Journal of Wave Motion, 6, 91, 1984.

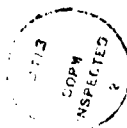
S. C. Hill, A. C. Hill and P. W. Barber, "Light Scattering by Size/Shape Distributions of Soil Particles and Spheroids", Applied Optics, 23, 1025, 1984.

Scientific Personnel

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Marshall Cline and Valerie Gundrum completed all requirements for the Master's degree in Electrical Engineering and received diplomas at commencement in May 1984.

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