

MODELED AEROSOL OPTICAL PROPERTIES FROM MEASUREMENT-BASED MIXTURES OF CHEMICAL SPECIES—ASSESSING THE IMPACTS OF PARTICLE MORPHOLOGY AND ABSORPTION

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FY 2000 PROGRESS REPORT

This past year, the Applied *microparticle* Optics and Radiometry program, to be known as $A\mu$ OR, got underway at the National Space Science and Technology Center. The $A\mu$ OR program incorporates research supported by the GACP with the PI's other work in the area of interactions of electromagnetic radiation with matter, and involves scientists in physics, atmospheric science and chemistry at UAH and NASA's MSFC. An important component of this program is the construction of a web site, <http://vortex.nsstc.uah.edu/amuor/> for the distribution of $A\mu$ OR's resources and research results.

A multichannel rotating shadowband radiometer, provided by Prof. Jack Fix of UAH and originally the Iowa component of the SIRN network, was put in operation at Stephen F. Austin State University (SFASU), in Nacogdoches TX. (It will later be relocated to the NSSTC in Huntsville, AL.)

Work on the retrieval of nighttime aerosol and trace gas loadings was begun at SFASU's observatory (see <http://vortex.nsstc.uah.edu/amuor/toads.html> for an outline). This will form the basis for future effort to assemble smaller observatories in AL into a network of nighttime atmospheric measurement stations. (The collocation of the shadowband radiometer at the observatory should provide full diurnal coverage for AOD and trace gas measurements.)

Work has continued on calculations of optical properties of aerosol particles. This includes the refinement and documentation of computer programs for scattering and absorption by spheres and coated spheres (to be made available as an $A\mu$ OR resource <http://vortex.nsstc.uah.edu/amuor/codes.html>), and studies of the sensitivity of aerosol albedo to uncertainties in measurements on light absorbing carbon.

Work was also begun on the development of an aerosol optical properties data base that is independent of existing models that assume homogeneous internal mixing of virtually all species. The infrared complex refractive index of ammonium nitrate (previously not widely available) is being incorporated into NSSTC's tunable multichannel lidar retrievals for improved analyses of in situ sulfate/nitrate/dust loadings.

A formulation, based on effective-medium theory, has been developed to approximate the T matrix for large-scale clusters of spheres that are not amenable to direct solution. A limited set of numerical calculations have been performed which test the effective medium model against exact calculations for densely-packed aggregates containing up to 300 spheres. Results at this point are very encouraging: they show that the effective medium model can predict random-orientation cross sections and asymmetry parameters to $\approx 1-5\%$ of the exact result, in a small fraction of the time required for the exact result. Predictions of the random-orientation scattering matrix elements, via the exact and the effective-medium model, are also in close agreement.

A fast cluster–cluster aggregation simulation algorithm has been developed which provides monomer coordinates for specified fractal structure characteristics. These coordinates are then used in an electrostatics model to predict the polarizability of the aggregate as a function of the monomer refractive index and the number of spheres in the aggregate.

Twelve manuscripts have been reviewed by the principals for *Optics Letters*, *JOSA*, *Applied Optics*, *JGR–Atmos.*, and *J. Climate*.

FY 2001 STATEMENT OF WORK

During the concluding phase of this work, we will

- Course development: PHY 680/ATS 790: Special Topics in the Interaction of Electromagnetic Radiation with Matter, <http://vortex.nsstc.uah.edu/amuor/spring01.html>.
- Employ the effective medium T matrix in the modeling of the optical properties of mineral dust.
- Identification of a simple power–law empirical formula for the aggregate polarizability as a function of the monomer polarizability in the electrostatics limit.
- Postings to $A\mu$ OR web site :
 - optical constants database
 - nighttime optical depth retrivals
 - column forcing trends

GACP BIBLIOGRAPHY

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BIBLIOGRAPHY:

Papers, reports, and presentations

- a. List of publications (including books, book chapters, and refereed papers).
 - ‘Electromagnetic Scattering by Compounded Spherical Particles,’ in *Light Scattering by Nonspherical Particles: Theory, Measurements and Applications*, M. I. Mishchenko and L. D. Travis, Eds., Academic Press, New York, 1999.
 - ‘Effects of mixing on extinction by carbonaceous particles: II possible artifacts associated with particles packed on a filter,’ K. A. Fuller, S. M. Kreidenweis, and W. C. Malm, *in preparation* for submittal to *J. Geophys. Res.*
 - ‘Issues in Radiometry and Absorption by Filter Samples,’ K. A. Fuller, S. M. Kreidenweis, and W. C. Malm, *in preparation* for submittal to *Appl. Opt.*
 - ‘An effective medium model for the T matrix of aggregated spheres,’ D. W. Mackowski, *J. Quant. Spec. Rad. Trans.*, submitted for publication (10/2000).

- ‘The infrared optical properties of a concentrated solution of ammonium nitrate aerosol,’ K. A. Fuller, H. D. Downing, and R. S. Coffman, in preparation for *Appl. Opt.*
- ‘Boundary layer aerosol composition over mid California derived from multi-wavelength CW lidar backscatter and modeled backscatter using aerosol microphysics data,’ D. R. Cutten, M. Jarzembski, V. Srivastava, R. Pueschel, E. McCaul, S. D. Howard, and K. A. Fuller, in preparation for submittal to *J. Geophys. Res.*
- CSU-Auburn atmospheric aerosol model. *planned.*

c. Presentations

- ‘Calculation of scattering by sphere clusters,’ invited presentation, Applied Physics Department, Yale University, April 1999.
- ‘Regge, Clebsch-Gordan, and Mie: Theory and Applications of Light Scattering by Compounded Spherical Particles,’ invited presentation to the Department of Physics and Astronomy, Vanderbilt University, July 1999.
- ‘Applied Microparticle Optics and Radiometry,’ presented to the Global Hydrology and Climate Center, University of Alabama in Huntsville, July 1999
- ‘A Hazy Picture of Global Warming,’ seminar presented to the National Space Science and Technology Center, UAH, March 2000.
- ‘Microparticle Optics and Radiometry in Environmental Science: Some Current Issues in Global Warming and Air Quality,’ presented by K. A. Fuller to the Stephen F. Austin State University chapter of Sigma Xi, April, 2000.
- ‘Effective medium T matrix approach to scattering by aggregated particles,’ Fifth International Conference on Light Scattering by Nonspherical Particles, Halifax, NS, Canada, August 2000.
- ‘An Optical Model for US Aerosol Consistent With Observations of Chemical Speciation,’ Kirk A. Fuller, S. M. Kreidenweis and D. W. Mackowski, to be presented to the Millennium Symposium on Atmospheric Chemistry at the 81st Annual Meeting of the American Meteorological Society, January, 2001.