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# Transition of light-scattering properties of complex medium as the medium volume increases

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## Abstract

We develop a radiative-transfer coherent-back-scattering (RT–CB) model that provides the possibility of calculating light-scattering properties from a dense medium composed of arbitrary particles. We use this algorithm to investigate the transition of the light-scattering curves from what would traditionally be considered to be single particles to that of extended media. What results is not a monotonic change in the light-scattering properties. For many of the light-scattering properties, we see a change to some maximum value occurring at approximate size parameters $kR \sim 100$. Then the properties tend to decrease, often to approximately half this original value.

## 1. Introduction

Over the past few decades, significant progress has been made in producing algorithms capable of calculating light-scattering properties of single particles. The Discrete Dipole Approximation (DDA) [1]-[3] and the Finite-Difference Time-Domain (FDTD) techniques [4]-[6] are each capable of calculating the light scattered by arbitrarily shaped particles. Unfortunately, the number of calculations, and resulting computation time, greatly increase with particle size, making calculations of extended media a pipedream. To consider such media, radiative-transfer techniques have been employed. We recently have developed a method that incorporates coherent backscattering that is efficient at calculating the light scattering from dense media [7] and have verified its results with those of exact calculations of a medium composed of spheres [8].

## 2. Results

In Figure 1, we present sample calculations of various light-scattering properties of a spherical volume containing spheres as a function of phase angle α. As the volume increases, we can see the curves evolve toward the bold line ($kR$ = 3000), which is representative of a large particle.

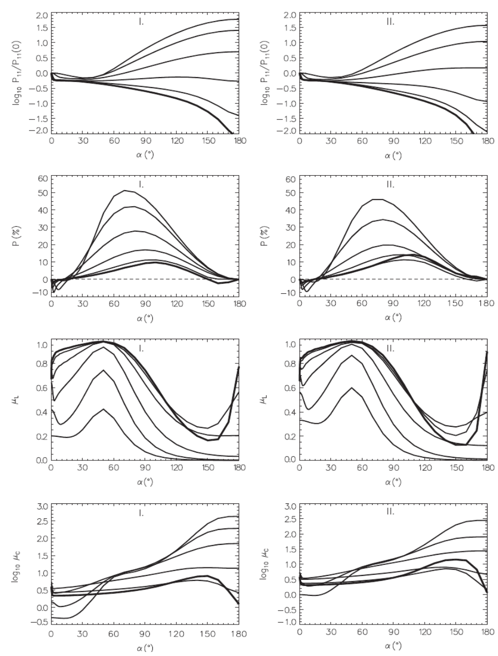

Figure 1: Light scattering by a spherical volume of particulate medium with a size parameter $kR$ = 10, 30, 100, 300, 1000, 3000 ($kR$ = 3000 is shown bold) populated with spherical particles of size $kr$ = 1.76 and refractive index $m$ = 1.50. The first column is for agglomerates having densities ν = 3% (I) and the second is for ν = 6% (II). The separate rows show, from top to bottom, the phase-function intensity, degree of linear polarization, linear polarization ratio, and circular polarization ratio.

Figure 2 shows light-scattering properties as a function of the volume of the medium on a semi-log plot. Note that these properties do not change linearly or even monotonically. Some properties, like the minimum of polarization, and the linear and circular polarization rations in panels 2a, 2e, and 2f, respectively have maxima/minima at approximately $kR \sim 100$.

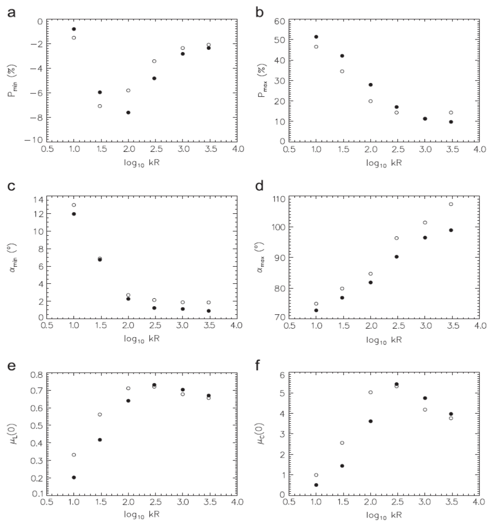


Figure 2: Plots of various scattering parameters as a function of agglomerate size *kR*. Plots show magnitudes of (a) $P_{min}$, (b) $P_{max}$, phase angle positions of (c) $P_{min}$, (d) $P_{max}$, (e) linear polarization ratio $\mu_L$ and (f) circular polarization ratio $\mu_C$ at $\alpha = 0^O$. Closed circles are for $\nu = 3.0\%$, and open circles are for $\nu = 6.0\%$.

## 3. Conclusion

We have used the RT-CB method to examine the transition of light-scattering characteristics of a volume of scatterers as the volume increases. We see that for many properties, there is not a monotonic increase as the final value is reached asymptotically. We have made calculations at different densities and do see differences in this transition value as the density changes. At present, we are making calculations of material having much greater densities than are shown here.

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