

Reduction of iterations for the linear equation solution in DDA - application for the orientation variation of irregularly shaped particles -

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ABSTRACT Reduction of iterations in DDA (Discrete Dipole Approximation) by incorporating interpolation of initial dipole polarizability for orientation variation.

Research Goal

Efficient DDA calculation for various shapes, sizes, materials, orientations.

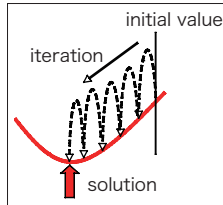
Method

a) Original DDA calculation

Linear equations in DDA calculation are iteratively solved. The initial value is rather arbitrarily given. (e.g. 0 in DDSCAT).

$$\sum_{k=1}^N A_{jk} P_k = E_{inc, j}$$

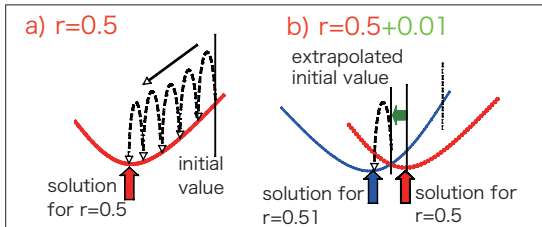
A : complex matrix
P : dipole polarization
E : Electric field incident on jth dipole



b) Reduction of iterations

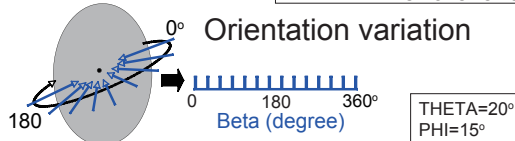
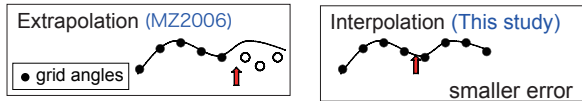
Muononen and Zubko (2006; hereafter MZ2006) proposed to use initial value of E by dipoles, which is extrapolated from the calculation for similar particle parameter

- variation in refractive index (m) or in radius (r)



c) This study

- application for orientation variation
- calculation of initial value of P with interpolation



Shape models

a) BCCA64 b) OMMT c) GSP



BCCA64 : Ballistic Cluster-Cluster Aggregate composed of 64 monomers (Mukai et al., 1992)

OMMT : Overlapping mixture of multiple tetrahedra (This study)

GSP : Gaussian random sphere (Muinonen et al. 1996)

refractive index: $m=1.60 + 0.01i$

volume-equivalent sphere size parameter: xv

DDA code: **DDSCAT6.1**

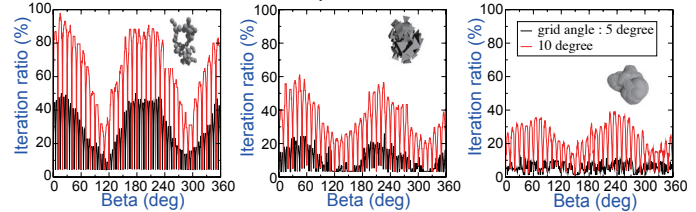
Results

Calculation for Beta(deg) of 0, 0.5, 1.0,360 with grid angle 0, 5, 10, ... (5 degree step) and 0, 10, 20, (10 degree step)

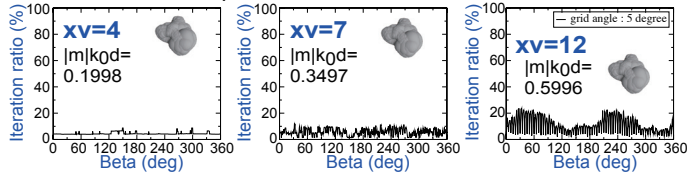
a) Reduction of iterations

$$\text{Iteration ratio (\%)} = \frac{\text{Iteration with reduction method}}{\text{Iteration by original DDA}} \times 100$$

xv=7 and different shapes

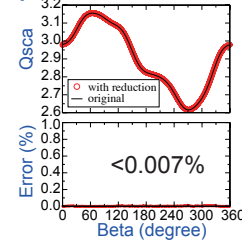


different size parameters

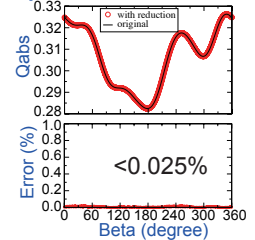


b) Comparison of results with original DDA

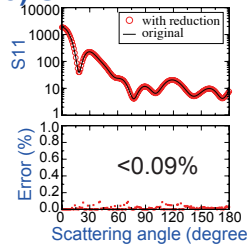
1) Qsca



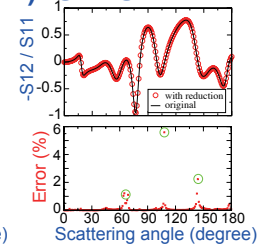
2) Qabs



3) S11



4) -S12/S11



$$\text{Error (\%)} = \frac{|A_{red} - A_{org}|}{A_{org}} \times 100$$

A: Qabs, Qsca, S11, -S12/S11
red: w/ reduction
org: original DDA

Summary

- In the case of grid angle of 5 degree, iteration ratio is less than 50%, 30%, 10% for BCCA64, OMMT, GSP. The ratio becomes larger for larger grid angles.
- The iteration ratio also depends on the dipole separation d. For larger dipole separation, the reduction is less efficient.
- Errors caused by reduction method for Qabs, Qsca, S11 is less than 0.1% while there is some large error in -S12/S11.

Acknowledgment and References

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DDSCAT6.1 was provided from Dr. Draine and Dr. Flatau.

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