Experimental Verification of Multisphere Light-Scattering Calculations: I) Rigorous Solution and II) the DDA

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Because much of the light throughout the solar system is due to sunlight scattered by dust particles and surfaces of larger structures, and because these are commonly believed to be aggregates of complex morphology, there is a need to develop practical solutions to the scattering problem. Currently, numerical techniques are most often used. Best known are the DDA (Discrete Dipole Approximation) originally developed by Purcell and Pennypacker in 1973 [1,2] and the T-matrix method developed by Waterman in 1971 [3]. As more computer power becomes available, the flexibility and conceptual simplicity of the DDA allow users to adapt it to an increasing range of problems encountered in astronomy and astrophysics. We therefore like to know if the DDA yields reliable solutions when applied to solar system problems and find out if a more suitable solution currently exists.

We present comparisons of calculations for the scattering by aggregates of spheres, using respectively the DDA method and our rigorous solution developed recently [4,5], to experimental data from our microwave analogue scattering laboratory [6]. While all tests of the rigorous theory made so far are satisfactory, the approximate solution works well only for the small volume structures that it has been applied to in the past. We show that the validity of the approximate solution is questionable, at least as it is currently implemented, when used on larger structures.

Besides the advantages of the exact solution in reliability and convergency, timing-test results also indicate its superior efficiency to the approximate DDA solution. Our calculations are all carried out on a DEC 600 5/333 AlphaStation. Practical examples show that the exact solution method is approximately ten times faster than the DDA method and that the scattering calculations can be extended to significantly larger aggregates using the exact method.

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