High Performance Computing of Light Scattering by Aggregate Dust Particles of Organic-rich Submicron Grains with Improvements to the MSTM Code

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Primitive dust particles in planetary systems and the interstellar medium are expected to contain organic matter as a major constituent, which might contribute to the origin of life in habitable planets. Collisional growth of primitive dust particles in molecular clouds and protoplanetary disks inevitably form fluffy aggregate particles of organic-rich submicrometer-sized grains. Organic matter plays a crucial role not only in sticking of the particles, owing to its highly cohesive nature, but also in light-scattering properties of the particles, owing to its highly absorbing nature. Astronomical data on dusty environments are often ascribed to electromagnetic waves that are scattered, absorbed, or emitted by fluffy aggregate particles of organic-rich submicrometer-sized grains. One the one hand, considerable knowledge of light scattering by fluffy aggregate particles of submicron constituent grains (monomers) is a requisite for the correct interpretation of astronomical data. On the other hand, our knowledge of light scattering by fluffy aggregate particles in the visible wavelength range is limited to a small number of monomers, due to the difficulty of numerically evaluating light-scattering properties of aggregate particles if their sizes are much larger than the wavelength and their monomers are absorptive.

The MSTM (Multi Sphere T-Matrix) Fortran 90 code developed by Daniel Mackowski (Auburn University, USA) is a powerful tool for computing light-scattering properties of aggregate particles. We have improved the publicly available MSTM code (version 3) to reduce computational resources such as CPU time and RAM size by rewriting its source programs with cache-efficient and memory-efficient optimized source programs. Since the computational speed is more than twofold and the memory requirement is reduced in our MSTM code at present, light-scattering properties of large aggregate particles are computed with the MSTM code on a multi-core personal computer as well as a supercomputer. We will present how light-scattering properties of aggregate particles consisting of organic-rich submirometer-sized monomers evolve with particle growth (i.e., the number of monomers). Our results will give new insights into interpretations of astronomical data on the angular profiles of intensity and polarization for dust particles in optically thin environments such as comets, debris disks, and the diffuse interstellar medium.