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Extinction and scattering by aggregates composed of submicron particles

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The optical properties of dust are central to a wide class of astrophysical objects and the interpretation and modeling of observations, the study of protoplanetary disks being just one example. The development of infrared (IR) astronomy, including observations from Antarctica, will produce a huge amount of data from micron-sized dust, with important implications for radiative transfer processes, which rely on accurate knowledge of the scattering and extinction cross-sections. As is the case in other fields of study, such as atmospheric optics, dust can hardly be described as composed of ideal spheres: the inhomogeneous internal structure affects its radiative properties significantly and hampers the applicability of common approximations. Here we report an analytical, numerical, and experimental study aimed at validating a novel approach to calculate scattering and extinction cross-sections from the two-point density-density correlation function inside the scatterer. Deviations from the commonly used mean-field approximation of up to a factor of 3 are found. The model is closely compared with cross-section measurements and spectrophotometry for the ideal case of well-known colloidal aggregates, which we studied in the visible range, and then extended to the IR range relevant for more general astronomical observations.

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