What's new about single-scattering from dust particles?

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Single-scattering theory is nowadays underrated due to the profusion of efficient multiple-scattering numerical codes. However, we should not forget that the single-scattering theory has many unique features, such as deep analytical results and immediate physical interpretations. In this presentation, the problem of electromagnetic-wave single-scattering patterns from dust particles made of aggregated small grains will be reassessed in the context of the modern light-scattering framework.

Actually, single-scattering theory is of prime importance for particles of vanishing optical cross sections, such as loose aggregates of very small grains or particles illuminated with very small wavelength photons. The latter case deals with *any* dust particle in X-ray beam, thus synchrotron facilities are commonly used on Earth to characterize aerosol dust particles or colloidal aggregates through scattered intensity measured at various phase angles. Natural cosmic X-ray sources exist too, but phase angles cannot be varied. Instead, one can use a remarkable characteristic of the single-scattering theory: the normalized scattered intensity, I, at the wavelength λ and phase angle α, depends on the ratio: $\lambda/\sin(\pi-\alpha)/2$. Then, the data needed for getting the two-points mass correlation function can be obtained either through: "phase-angle variation at a given wavelength" (convenient for experiments) or through: "wavelength variation at a given phase angle" (convenient for observations). Moreover, this theory predicts simple behaviors such as: $I(\lambda) \propto \lambda^{D_\mathrm{f}}$ for scattering from particles of fractal dimension D_f at any given phase angle. This robust formula results from scan of the particle morphology by probes (photons) of "extension" λ. Therefore, fractal structure of particles in a dust cloud can, in principle, be deduced from the X-ray background originated from the cloud. These results hold as well for particles "loose enough", such as grain-aggregates of fractal dimension $D_\mathrm{f} < 2$, or for grains with refractive index $n \approx 1$. Moreover, other essential characteristics - such as the particle size distribution - are obtained through mathematical manipulation of the single-scattering data.

All these results push to the idea that, to conclude about the morphology of dust particles, we should first search for physical conditions of observation where the single-scattering theory be usable. Along this line, we will present known cases where the single-scattering theory does apply, as well as some yet unexplored cases.

Beyond this approach, we will discuss deviations from the single-scattering results when this theory is no more expected to hold true. In particular, we will see how robust is the λ^{D_f} -law, when second-scattering, …, multiple scattering, is taken into account. Actually, the old single-scattering theory appears to be a pretty good approximation in the cases far from resonance, though under limited conditions. At last, well, in the case where multiple-scattering codes must really be used, we have to leave behind us the clear analytical formulas. It is more precise, but is it better than a robust approximation?