Light scattering by particles: the view from q-space

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We take an empirical approach to study the angular dependence of light scattering by particles. As the independent variable, the dimensionless quantity qR is used, where q is the magnitude of the scattering wave vector, $q = (4\pi/\lambda)\sin(\theta/2)$, λ is the wavelength of light, θ the scattering angle, and R is an effective radius of the particle. Moreover, and importantly, plots of intensity vs qR are double logarithmic. This "Q-space analysis" reveals functionalities of the scattering with q that are not apparent with conventional plotting, i.e. intensity vs linear θ. Often in Q-space analysis, the differential scattering cross section is normalized by the Rayleigh cross section of the particle, which we have generalized for any particle shape. For spheres we find the scattering evolves from the 3d Fraunhofer diffraction limit for weak refractivity to a combined 2d Fraunhofer diffraction with a remnant 3d diffraction regime for large, strongly refractive particles. These regimes are identified by, and connected with, power laws. This evolution is governed universally by an internal coupling parameter which also governs the forward scattering. The effects of the imaginary part of the refractive index are described by a second, universal parameter. Q-space analysis applied to particles with other shapes, including dust and fractal aggregate data from our lab and others, and computational data for Gaussian random and perturbed spheres, dense agglomerates and ice crystals, show similar evolution from the 3d diffraction limit and power law functionalities.

Preferred mode of presentation: Invited