Light Scattering Properties of Higher Order Chebyshev Particles and Implications for Aerosols with a Weak Surface Roughness

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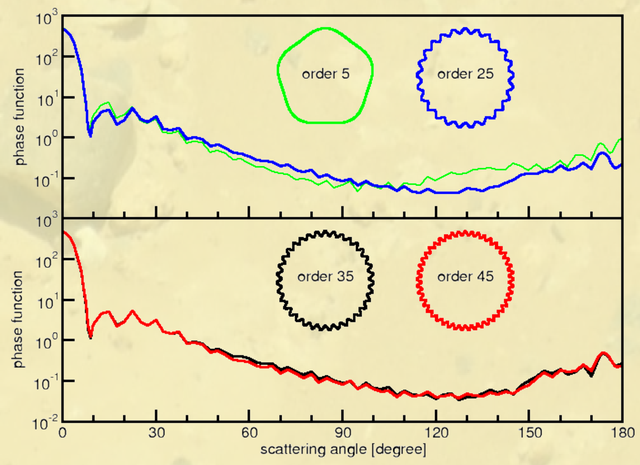
1. Introduction

Chebyshev particles the form of which is given by

$$R(\theta) = R_0(\theta) * [\, 1 + \varepsilon * cos(n\theta) \,]$$

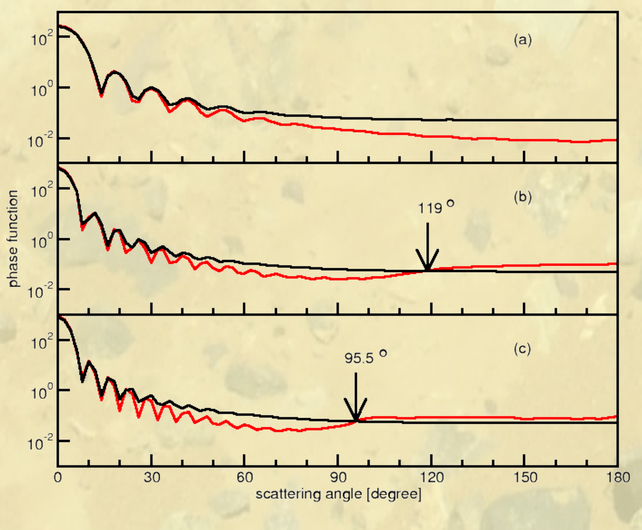
($R_0(\theta)$ – underlying smooth boundary surface, ε – deformation parameter, n – order) are used in the past to study the scattering behaviour of nonspherical geometries. Increasing the order *n* leads to effects that corresponds to expectations for particles with a weak surface roughness. If the commonly considered spherical boundary surface $R_0(\theta)$ = constant is replaced by a nonspherical one then nonspherical and weakly rough particles can be simulated (Ref. 1).

2. Convergence with respect to the order

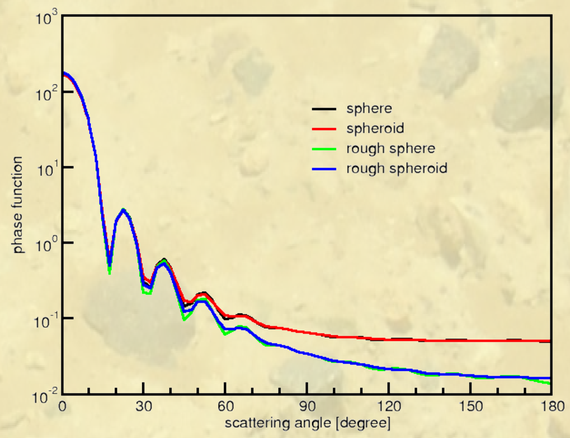


Normalized phase functions of randomly oriented Chebyshev particles at a size parameter of 27.5, a refractive index of 1.31(ice), and a deformation parameter of 0.05 for increasing orders *n*. $R_0(\theta)$ = constant (sphere)

3. Strongly absorbing particles

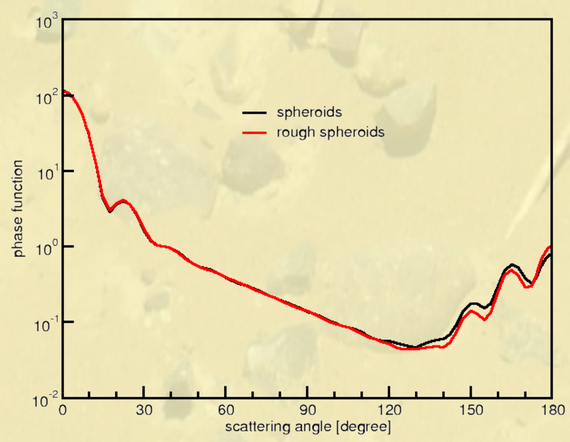


Normalized phase functions of randomly oriented Chebyshev particles ($R_0(\theta)$ = constant) of the order 45, a deformation parameter of 0.05, and a refractive index of (1.4717,0.389) (red curves) and of the corresponding spheres (black curves) at size parameters of (a) 15, (b) 24, and (c) 27.5.

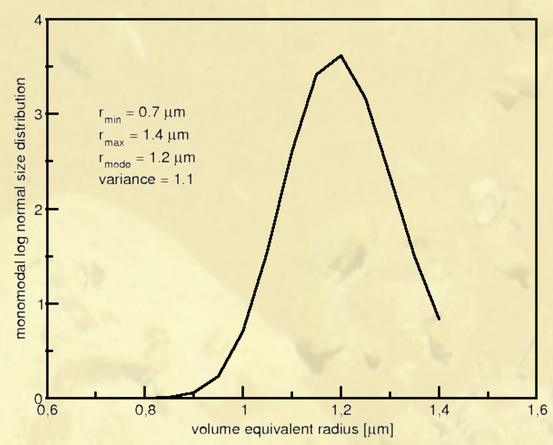


Normalized phase functions of a sphere, a randomly oriented spheroid and the same particles the boundary surfaces of which are modified by a Chebyshev polynomial of the order 45 and a deformation parameter of 0.05 (rough sphere and rough spheroid). The refractive index is (1.4717,0.389), the surface equivalent size parameter is 12.0 and the corresponding aspect ratio is 1.15 (prolate).

4. Size and shape mixture of volcanic ash particles



Normalized phase functions of a mixture of randomly oriented spheroids (black curve) and a mixture of randomly oriented spheroids with boundary surfaces modified by a Chebyshev polynomial of the order 45 and the deformation parameter 0.05 (rough spheroids, red curve). Each mixture contains an equal number of particles with aspect ratios of 0.87 (oblate), 1.0 (spherical), and 1.15 (prolate). The hypothetical monomodal log normal size distribution function used is shown on the right hand side. Note that the maximum volume equivalent size parameter is 13.9. The refractive index of (1.5,0.01) at a wavelength of 632.8 nm is typical for volcanic ash particles (Ref. 2).



5. Conclusions and references

Weakly rough particles the surface of which is modelled by higher order Chebyshev polynomials show a different side and back scattering bahaviour compared to their smooth counterparts. These differences can become important, e.g., in Lidar data analysis to retrieve aerosol properties and in aerosol radiative forcing estimations.

1. Rother, T., Schmidt, K., Wauer, J., Shcherbakov, V., and Gayet, J.F., Light Scattering on Chebyshev Particles of Higher Order, Appl. Opt., 45, 6030-6037, 2006.
2. Volten, H., Munoz, O., Hovenier, J., and Waters, R., The Amsterdam Light Scattering Database (www.astro.uva.nl), 2006.