Light-scattering properties of forsterite particles modeled with four different types of irregularly shaped particles

Evgenij Zubko[a,*]

[a]*Planetary Atmospheres Group, Institute for Basic Science (IBS), 55 Expo-ro, Yuseong-gu, Daejeon 34126, South Korea*

[*]*Presenting author (evgenij.s.zubko@gmail.com)*

Scattering of light by small, irregular particles plays key role in remote sensing that is aimed at measurements and a follow-up interpretation of changes in the spectrum and state of polarization that the incident light acquires upon its scattering from target particles. It is affected by shape and internal morphology of particles, their chemical composition, and size distribution. These imply dozens of microphysical parameters, which are expected to be inferred from only a few characteristics of the scattered light. Such incommensurability typically makes remote sensing an ill-posed problem. Such a formal approach assumes that all microphysical characteristics have an equally important impact on the light-scattering response, which appears to be not the case.

Light scattering by four different types of irregularly shaped particles introduced in previous works (e.g., [1], [2]) with refractive index $m = 1.6 + 0.0005i$ is studied by means of the discrete dipole approximation (DDA) over a wide range of size parameter $x = 2\pi r/\lambda = 1 – 48$. The packing density of the constituent materials ρ varies by a factor of ~4.6 between the *pocked spheres* having ρ = 0.336, the *agglomerated debris particles* with ρ = 0.236, the *sparse agglomerates* with ρ = 0.169, and the *loose clusters* with ρ = 0.073. The DDA modeling reveals a great deal of similarity in the light-scattering response in these particles, despite their dramatically different morphology. The resemblance is further enhanced when the light-scattering response is averaged over all available sizes of particles.

All four types of particles are exploited to modeling the experimental optical measurements of the forsterite particles at wavelength λ = 0.633 μm reported by Volten et al. [3]. It is worth noting that the experimental data are available online via the *Amsterdam–Granada light scattering database* [4]. The modeling reveals that all four types of particles are capable of reasonably good fits to the experimental optical measurements of the forsterite particles with a simple power-law size distribution r^{-n}. It is significant that the power index providing these best fits appears to be squeezed to a very narrow range of values $n = 3.075 \pm 075$. Such similarity has a great impact on remote sensing as it raises confidence in the retrievals obtained with any model of irregularly shaped particles whose shape attains a high level of disorder. However, when the size distribution of laboratory-measured forsterite particles is considered, only the *agglomerated debris particles* (ρ = 0.236) immediately yield a reasonably good fit to the optical measurements. This suggests their morphology may more closely resemble that of the forsterite particles.

References

[1] Zubko, E., Shkuratov, Yu., Videen, G., 2015: Effect of morphology on light scattering by agglomerates. *J. Quant. Spectrosc. Radiat. Transfer* **150**, 42–54.

[2] Zubko, E., Weinberger, A.J., Zubko, N., Shkuratov, Yu., Videen, G., 2017: Umov effect in single-scattering dust particles: Effect of irregular shape. *Opt. Lett.* **42**, 1962–1965.

[3] Volten, H., Muñoz, O., Brucato, J.R., *et al.*, 2006: Scattering matrices and reflectance spectra of forsterite particles with different size distributions. *J. Quant. Spectrosc. Radiat. Transfer* **100**, 429–436.
[4] Muñoz, O., Moreno, F., Guirado, D., *et al.*, 2012: The Amsterdam–Granada light scattering database. *J. Quant. Spectrosc. Radiat. Transfer* **113**, 565–574.

Preferred mode of presentation: Oral