# Numerical surface-scattering laws for asteroid applications

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We present a database of numerically computed surface-scattering laws for surfaces consisting of close-packed spherical volume elements of particles.

Simple analytical scattering laws, such as the Lommel-Seeliger law, are commonly used to model the scattering of sunlight by asteroid surfaces. In their simple form, however, they are only valid for smooth surfaces, while the surfaces of asteroids are roughened by a loose regolith. The particulate surface structure causes subtle photometric features [1], but taking them into account is difficult with a simple analytic scattering law. Our intention is to allow a user to efficiently simulate light scattering from this type of surfaces by using pre-computed values.

We use a ray-tracing technique [2] to compute the scattering of light from a surface medium composed of spherical volume elements of particles. The medium has a variable volume-element size distribution, packing density, and macroscale roughness. The scattering is discretized over the angles of incidence, emergence, and azimuth using an efficient and simple hemisphere discretization scheme.

The numerical scattering laws are provided as data files containing the sky hemisphere and descriptive metadata. In practice, the user will load the hemisphere array from the file and compute the scattering-law values in his/her software through interpolation between the array values, then multiplying by a desired phase function.

The first release of data contains scattering laws computed for media of low-to-moderate geometric albedo, with packing densities in the range of 0.15 to 0.55 and a uniform size distribution.

Documentation and example source code are also provided to help users integrate our scattering-law approach to their software.

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**References:** [1] Wilkman, O. and Muinonen, K. (2014) Asteroid lightcurve phase shift from rough-surface shadowing, Meteoritics and Planetary Science 49 1–7. [2] Parviainen, H. and Muinonen, K. (2009) Bidirectional reflectance of rough particulate media: Ray-tracing solution. Journal of Quantitative Spectroscopy & Radiative Transfer, 110(14–16):1418–1440.