# Multiple scattering modeling pipeline for spectroscopy, polarimetry, and photometry

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We are combining a set of numerical tools to analyze the reflectance spectra of granular materials, i.e., close-packed random media. Our motivation for this study comes from the present lack of such tools when it comes to intimate mixing of materials, including space-weathering effects with nano- or micron-sized inclusions in the host matrix. The current common practice is to apply a semi-physical approximate model such as some variation of the Hapke models (e.g., [1]) or the Shkuratov model [2]. These models are expressed in a closed form so that they are relatively fast to apply. They are based on simplifications to the radiative transfer theory. The problem is that the validity of a model is not always guaranteed, and the derived physical properties related to particle scattering properties can be unrealistic [3]. The Hapke space-weathering model does not include a correct size dependence for the nanophase iron inclusions [4].

Our numerical tool consists of individual scattering simulation codes and a main program that chains them together, calling the codes and converting the output of one code into the input for the next code. The chain for analyzing a macroscopic target with space-weathered mineral would go as follows: (1) Exact methods such as FaSTMM [5] solving the Maxwell equations of the small inclusions in the system. (2) Scattering by a single regolith grain is solved using a geometrical optics method SIRIS4 [6] accounting for surface reflections, internal absorption, and possibly the internal diffuse scattering. (3) The radiative transfer simulation $R^2T^2$ ([7] and Markkanen, Väisänen, and Muinonen, this meeting) is executed inputting the regolith grains from the previous step as the basic scatterers in a macroscopic planar volume element.

The tools in the proposed chain already exist, and the practical task for us is to tie these together into an easy-to-use public toolchain, i.e., a pipeline for spectroscopy, polarimetry, and photometry.

## References

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