Experimental light scattering by small particles: first results with a novel Mueller matrix scatterometer

Antti Penttilä (1), Göran Maconi (1), Ivan Kassamakov (1), Maria Gritsevich (1), Edward Hæggström (1), Karri Muinonen (1,2)

(1) Department of Physics, University of Helsinki, Finland (antti.i.penttila@helsinki.fi), (2) Finnish Geospatial Research Institute FGI, Kirkkonummi, Finland

We describe a setup for measuring the full angular Mueller matrix profile of a single mm- to μm-size sample, and verify the experimental results against a theoretical model. The scatterometer has a fixed or levitating sample, illuminated with a laser beam whose full polarization state is controlled. The scattered light is detected with a wave retarder-linear polarizer-photomultiplier tube combination that is attached to a rotational stage, to allow measuring the full angular profile, with the exception of the backscattering direction.

By controlling the angle of the linear polarizers and the angle of the axis of the wave retarders before and after the scatterer we record such a combination of intensities that reconstructing the full Mueller matrix of the scatterer is possible. We have performed the first measurements of our calibration sample, a 5 mm sphere (N-BK7 glass, Edmund Optics).

We verify the first measurement results by comparing the angular scattering profile against the theoretical results computed using Mie theory. The profiles recorded using the linear polarizers only agree with the theoretical predictions in all scattering angles. With the linear polarizers, we are able to construct the upper left 2×2 submatrix of the full Mueller matrix. The constructed (1,1) and (2,2) elements of the matrix are almost identical, as they should for a sphere, as well as the (1,2) and (2,1) elements. There are some discrepancies, as expected since calibration spheres are never perfect spherical shapes with completely homogeneous internal structure.