UV-VIS depolarization of mineral dust particles at exact backscattering angle: laboratory experiment and comparison with T-matrix numerical simulations

A. Miffre, T. Mehri and P. Rairoux

Institute of Light and Matter, Department of Physics, Lyon 1 University, Villeurbanne, 69622, France
Keywords: Backscattering, depolarization, mineral dust, T-matrix
Presenting author email: alain.miffre@univ-lyon1.fr

Mineral dust particles contribute to the Earth's radiative budget directly through light scattering and absorption. Since most mineral dust particles are highly irregularly-shaped, no analytical solution of the Maxwell's equations exists for light-scattering by these particles, which are difficult to represent mathematically in climate models. To help developing more accurate light-scattering models, existing numerical simulations should be validated by controlled-laboratory experiments.

In this context, in the continuity of former presentations at EAC conferences (Manchester, Granada), we here present a controlled-laboratory experiment that accurately evaluates the UV-VIS depolarization from mineral dust particles at exact backscattering angle ($\theta = 180.0 \pm 0.2°$), an important scattering direction for aerosol remote sensing and climatology. Moreover, as our set-up fulfils the far-field single scattering approximation, the measured depolarization can be used to discuss on the applicability of the T-matrix method in the exact backward scattering direction and at two wavelengths, as we recently published in JQSRT (Miffre et al., 2016).

Figure 1 presents our experimental set-up that addresses laser light exact backscattering by mineral dust particles at both UV and VIS-wavelengths. Details on the experimental set-up can be found in Figure 1's caption as well as in the corresponding publications (David et al., 2013; Miffre et al., 2016).

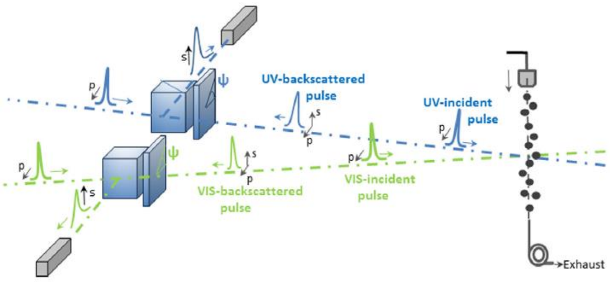

Figure 1. UV-VIS laboratory experiment at exact backscattering angle ($\theta = 180.0 \pm 0.2°$). A well-aligned polarizing beam-splitter cube is used to achieve the backscattering geometry and the particles backscattering radiation is discriminated from background stray light (time-resolved experiment at 2.5 GHz sampling rate). A quarter-wave plate is used to modulate the incident linear polarization of the UV ($\lambda = 355$ nm) and VIS ($\lambda = 532$ nm) laser pulses.

At exact backscattering angle, the depolarization is determined only by the ratio F_{22}/F_{11} of the scattering matrix elements, which depend on the particles size, shape and chemical composition (Mishchenko et al., 2002). This depolarization can be accurately evaluated with our experimental set-up by adjusting the detected backscattering signal S_p with the Ψ-modulation angle (see Figure 1) which can be expressed in the framework of the scattering matrix formalism (Miffre et al., 2016):

$$S_p(\Psi) \propto [F_{11} - F_{22} + (F_{11} - 3F_{22})\cos(4\Psi)] \quad (1)$$

Hence, the UV-VIS backscattering signals displayed in Figure 2 can be adjusted with Equation (1) to accurately evaluate the depolarization from mineral dust particles. The depolarization reaches 37.5 % (resp. 35.5 %) at λ = 355 nm (resp. at λ = 532 nm) and depends on the size distribution of the generated dust samples.

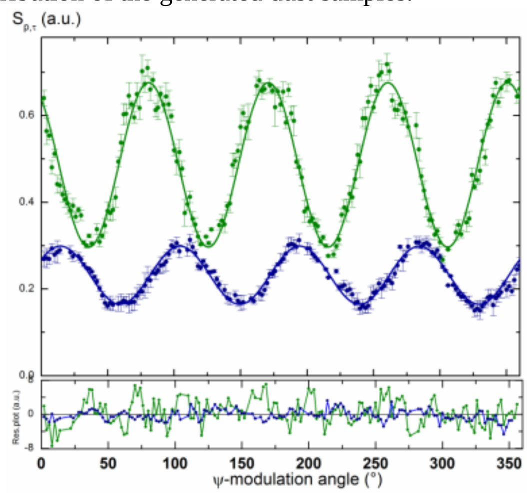

Figure 2. UV, VIS backscattering radiation as a function of the Ψ-modulation angle for Arizona Test Dust particles adjusted with Equation (1) and residue plot.

Interestingly, we found out that the measured depolarization agreed with T-matrix numerical simulations, at least for a determined particle size distribution and at a determined wavelength. However, the spectral dependence of the depolarization could not be reproduced with the spheroidal model, even for not evenly distributed aspect ratios. The oral presentation will detail these results, recently published in JQSRT (Miffre et al., 2016), as well as outlooks of this work.

Miffre, A., Mehri, T., Francis, M. and Rairoux, P. (2016) *J. Quant. Spec. Rad. Transf.*, 169, 69-90.

Mishchenko, M.I. et al., Scattering, absorption and emission of light scattering by small particles, (2002), 3rd Ed., U.K., *Cambridge University Press*.

David, D. Miffre, A., Thomas, B., Coillet, E. and Rairoux, P. (2013) *Opt. Exp.*, 21, 16, 18624-181639.