Single Particle Extinction and Scattering (SPES) allows the characterization of aerosol optical properties

F. Mariani[1], L. Cremonesi[1], T. Sanvito[2], B. Paroli[1], A. Pullia[1] and M.A.C. Potenza[1]

[1]Department of Physics, University of Milan, via Celoria 16 Milan, I-20133, Italy
[2] EOS s.r.l., viale Ortles 22/4, Milan, I-20139, Italy
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Presenting author email: marco.potenza@unimi.it

Aerosol is widely recognized as a fundamental component of the climate system, although the direct impact on the energy balance of the Earth system represents an issue mainly because of uncertainties in dust radiative properties. Although particle size (and size distribution) dominates by far the scattering properties of a collection of particles, other features like the composition, shape, orientation, internal structures, surface properties give rise to effects which are larger than the accuracy required by the radiative transfer computations in the Earth's atmosophere.

Here we show the results obtained by applying the Single Particle Extinction and Scattering (SPES) technique (Potenza, 2015) to provide direct, independent measurements of both the single particle optical thickness and size. The technique has been extensively validated in liquids. It is based upon the measurement of the interference between the intense transmitted beam illuminating one particle and the faint forward scattered wave, which is ultimately related to the complex scattered field amplitude and phase. The measurement of the complex forward scattered field delivers important information, being related to the optical thickness of the particle (Potenza 2014a, Potenza 2010). In such a way a detailed characterization becomes possible as it has been already proven for liquid suspensions, accessing minute details like, for example, the average refractive index (Potenza 2015a), particle shape and orientation effects on radiation, the presence of particles formed by aggregation of smaller constituents (Potenza 2015b). The attainment of these features largely improves the determination of the particle size distributions.

From the experimental point of view, the SPES technique takes unprecedented advantage from 1) being totally calibration-free; 2) relying on a rigorous validation method for recognizing the particles passed out of the focal region; 3) being experimentally simple and robust.

We present the first experimental results obtained operating this technique on airborne particles. Results of accurate characterization with known samples are reported, which show the accuracy of the method in determining the size distribution and refractive index of several kinds of aerosol generated in standard ways in laboratory. Measurements in the outdoor are also discussed.

For each particle we measure the real and imaginary parts of the complex forward scattered field amplitude S(0), from which we rigorously determine the extinction cross section and the optical thickness. These are parameters of paramount importance to be inserted in radiative transfer models. In particular, accessing the effect of shape and orientation of single non-spherical particles opens the possibility of unique assessments about the aerosol optical properties (Mishchenko, 1998).

Data interpretation is performed through a deterministic approach relying on fundamentals of light scattering (Bohren, 1993), and also through a numerical approach based on the results of more than 10^6 simulations performed with the established A-DDA code (Yurkin, 2011) for particles with different size, compositions, shape and orientations.

We propose this novel measurement method as a powerful candidate for improving the characterization of airborne dust, to be used both for a better knowledge of the aerosol itself and as an input into radiative transfer and climate model simulations.

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