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Application of spheroidal T-matrix model to account laboratory measurements of linear and circular depolarization ratios of ice crystals and atmospherically relevant aerosol particles

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Lidar and radar remote sensing use the linear and circular depolarization ratio to describe the light backscattering properties of atmospheric particles. The magnitude of the depolarization ratio of non-spherical particles depends on the size, shape and the refractive index of the material and thus is considered as a potential measure of particle microphysics in lidar retrievals. Therefore, accurate information about the light scattering properties of non-spherical particles is important. Many numerical studies using T-matrix approach have been conducted to explain rather complicated dependence between the depolarization ratio and particle properties. However, we lack laboratory studies to validate these models.

In this study linear and circular depolarization ratios of growing and sublimating ice particles and of atmospherically relevant aerosol particles, specifically from dust particles and secondary organic aerosol, were measured. The experiments were conducted at the AIDA cloud simulation chamber in Karlsruhe and in CERN CLOUD chamber. In the aerosol experiments a relatively narrow size distribution of single aerosol type was generated and led to the chamber volume, where the linear and/or circular depolarization was measured with the laser scattering and depolarization instrument SIMONE (Schnaiter et al., 2012). Simultaneously to this, aerosol size distribution was measured. In the ice experiments, ice particles were nucleated inside the chamber at temperatures ranging from -40°C to -70°C, after which they were let to grow or sublimate by controlling the ice saturation conditions.

We observed that both linear and circular depolarization ratio had strong size dependence. This size dependence was modeled with the spheroidal T-matrix model in the case of the dust and secondary organic aerosol particles. We found a good agreement between the measurements and the model, further showing that spheroidal model is a good approximation in the case of atmospheric dust particles. In some of the experiments we measured the linear and circular depolarization ratio alternately. We found that the circular depolarization can be related to the linear depolarization as expressed in the Mishchenko and Hovenier (1995). This expression was valid for all the aerosol types that we studied and in addition for ice particles over the whole size range measured, although normally too large to be modeled with T-matrix model. In addition, we show a case study of the light scattering properties of growing SOA, where oscillation in the depolarization signal was observed. Again, we were able to model the observed oscillation by using the spheroidal model.