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The Backscattering Linear Depolarization Ratio of Ice Clouds Composed of Small Ice Crystals

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The importance of small ice crystals (< 50 μm) for cirrus cloud radiative properties is a matter of controversial debate, mainly because some measurements seemed to clearly overestimate the number concentrations of small ice particles due to particle shattering on the instrument inlets. On the other hand, there is no doubt that small micrometer-sized ice crystals dominate the particle size distributions of contrails and cirrus clouds emerging from contrails.

Polarisation LIDAR is frequently used to investigate the microphysics of contrails and contrail cirrus remotely. These investigations reveal unusually high maximum linear depolarization ratios of 0.5 - 0.7. The knowledge of the link between ice crystal depolarization and their size and shape is a prerequisite for the interpretation of these LIDAR data. Since young contrails consist of relatively small ice crystals with sizes typically less than 10 μm, the scattering matrix of these non-spherical particles can be calculated by the T-matrix method.

In order to investigate the relation between the linear backscattering depolarization ratio and the microphysical properties of small ice particles that closely resemble those found in contrails and young cirrus, we started to run dedicated ice crystal nucleation and growth experiments at the large cloud simulation chamber AIDA of Forschungszentrum Karlsruhe. Such studies became feasible after the installation of the new in situ laser scattering and depolarization set up SIMONE at the chamber in 2006. The light scattering measurements are analyzed in the context of the microphysical properties of the ice clouds measured by optical cloud particle spectrometers, single particle imaging, and in situ infrared extinction spectroscopy. We compare our experimental results with theoretical results generated by the T-matrix method for finite cylinders.

The results give new insight into the scattering depolarisation properties of small ice crystals grown under simulated contrail and cirrus formation conditions.