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Measuring spontaneous charging of single aerosol particles

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Charge accumulation on aerosol particles (including water droplets) plays a critical role in a variety of natural and industrial processes. It gives rise to lightning in thunder- and sandstorms, influences particle transport and interactions in the atmosphere and can lead to dangerous dust explosions during industrial processing [1]. Shavlov et al. [2] suggest that the hydroxide ions and protons formed by the dissociation of water molecules are sufficient to cause charging during evaporation and condensation of droplets or surface-adsorbed water on solid particles. This hypothesis is backed up by Moreira et al. [3] who find that liquid evaporation leads to charge buildup on dielectric surfaces.

By levitating individual aerosol particles in an optical trap we can characterize and manipulate the particle without losing information to ensemble averages or external interference from other particles or substrates [4, 5]. Our setup allows for trapping of various types of solid and liquid particles in the micrometer size range, like silica spheres, water droplets or droplets with solid nuclei inside. Figure 1 shows an illustration of the measurement principle. The particle's charge is measured by applying a sinusoidal electric field and observing the resulting particle motion. The Mie scattering pattern of the particle furthermore gives information about the particle's size and refractive index, both at equilibrium and during evaporation and condensation. The experiment allows us to control the relative humidity and air ion concentration around as well as air flow across the particle.

Ultimately we hope to contribute to a better understanding of the microphysical processes involved in thundercloud electrification and adjacent electrical phenomena in the atmosphere.

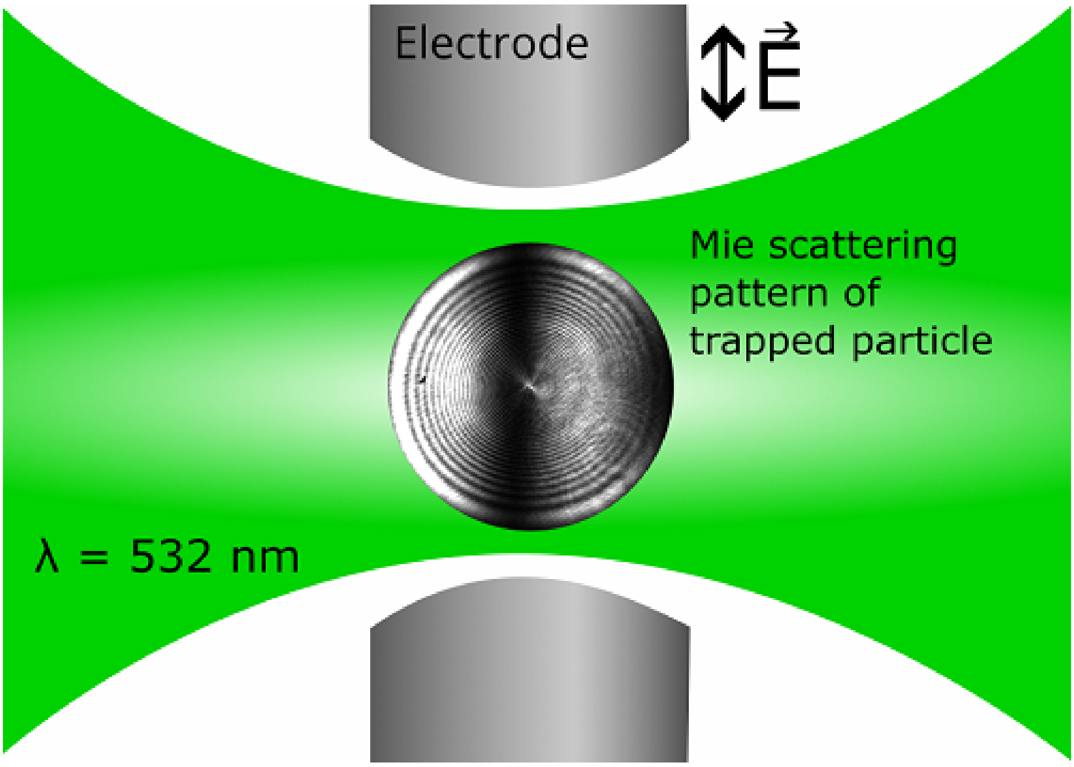

FIGURE 1. Optical tweezers (λ = 532 nm) holding a solid or liquid aerosol particle. A sinusoidal electric field is applied between the two electrodes and the resulting particle motion as well as the particle's Mie scattering pattern are recorded.

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