Introduction of the new Differential Aerodynamic Particle Sizer (DAPS)

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Motivation

The Differential Aerodynamic Particle Sizer (DAPS) is designed to separate particles according to their relaxation time τ with a high resolution differential transfer characteristic (Kiesler and Kruis, 2012). The particle relaxation time and the linked Stokes-diameter d_S play an important role in the description of accelerated particle motion. It is used to describe sedimentation processes as well as particle loss due to impaction. In combination with complementary measurement methods (e.g. mass, mobility) the Stokes-diameter can be used for structure determination (Stein *et al*, 2013). The online measurement capability of the DAPS is well suited for this task.

Theory

The DAPS uses the principle of aerodynamic focusing. (Liu *et al*, 1995). Figure 1 shows the effect, that particles having a well-defined starting point can be separated according to their Stokes-number, when passing a single orifice of an aerodynamic lens. Only a single size is focused onto the axis at x=0. The focused Stokes-diameter depends on the pressure in front of the orifice, the particle density, the mass flow rate of the gas and the orifice diameter (Wang *et al*, 2005).

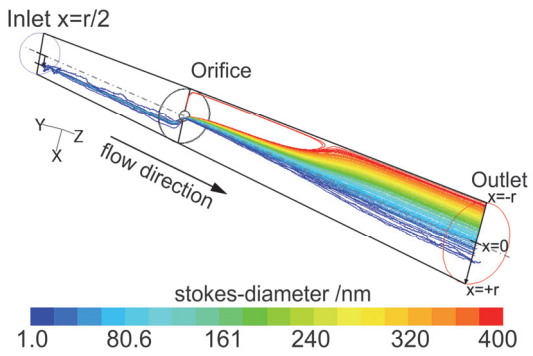

Figure 1. Separation of particles from the same starting point according to their Stokes-number inside an aerodynamic lens. (CFD modelled)

Experimental Setup

In the DAPS the aerodynamic lens is combined with a central sheath gas inlet in front of the orifice to keep the axis particle free before focusing. After the focusing, particles on the axis are sampled and counted in an electrometer. The selected diameter can be changed by scanning the pressure in the system, allowing the online measurement of a full particle number-size-distribution.

Results

The system has been calibrated using spherical metal particles with different densities. The measurement range for aerodynamic diameters is 80 nm to 3µm.

Figure 2 shows the comparison of the Stokes-number based measurement devices DAPS to the ELPI+ cascade impactor for spherical size selected silver particles. The differential transfer characteristic of the DAPS in combination with the scanning mode allows to obtain high resolution size distribution data. The attainable resolution is comparable to the reference SMPS system measuring electrical mobility.

To show the DAPS' capability to determine particle structures, the morphology change of silver nanoparticles during sintering is measured by a combination of a Differential Mobility Analyser (DMA) and DAPS.

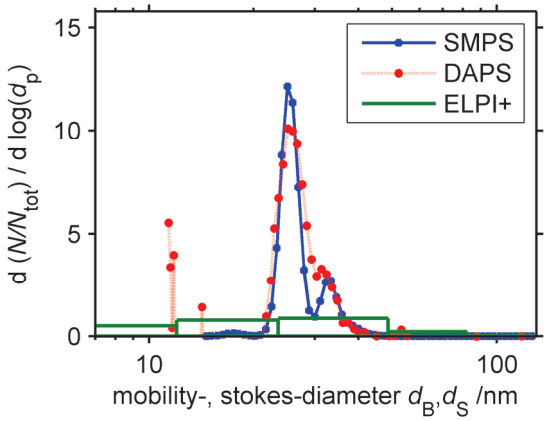

Figure 2. Normalized size-distribution of size selected spherical Ag-Particles. Comparison of Mobility based SMPS measurement to Stokes-number based measurements by DAPS and ELPI+.

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