A new data inversion algorithm for Scanning Mobility Particle Sizers

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Particle number size distribution is an essential parameter for the physical characterization of aerosols. It is required for calculations of the effects of aerosols on climate and human health (Wiedensohler *et al.*, 2012), and nowadays also emissions regulations for vehicles rely on the measurement of particle size and number concentration.

The Scanning Mobility Particle Sizer (SMPS) consisting of a differential mobility analyzer (DMA) and a condensation particle counter (CPC) is a widely used instrument concept to determine aerosol size distributions, as it combines the advantages of high resolution and relatively short measurement duration. However, it requires a very involved data inversion algorithm which is in general not transparent for commercial SMPS and hence does not allow for an estimation of the uncertainties associated with particle sizing. The need to compare and harmonize SMPS inversion algorithms has been recognized, and various institutes have started developing individual inversion algorithms (see Coquelin *et al.*, 2013, Wiedensohler *et al*., 2012, and references therein).

We have developed a new SMPS inversion algorithm based on a stochastic approach which uses the raw CPC counts/ unit time as input data. The algorithm is based on the analytical computation of particle trajectories within the time-dependent electrical field of the DMA, in order to relate the time of detection of a particle in the CPC with its electrical mobility. Hereby the electrical mobility is treated as a random variable owing to the fact that particles are uniformly distributed over the surface area of the DMA inlet. This approach allows us to take into account the effect of Brownian diffusion (only in radial direction at this point) on the particle trajectories. Hence, Brownian diffusion is not only taken into account in terms of diffusion losses within the DMA and the plumbing lines, but also with respect to random motions affecting the trajectories inside the DMA. Details on the inversion algorithm along with a comparison to the commercial Aerosol Instrument Manager (AIM) software provided by the instrument manufacturer TSI will be presented.

Figure 1 and table 1 show a preliminary comparison of our new inversion algorithm with the AIM software. Combustion aerosol was generated with a CAST generator (Jing Ltd.), thermally treated, diluted, and measured with an SMPS consisting of a TSI DMA 3085 (for nominal 40 nm particles) or 3081 (for nominal 180 nm), respectively, and a TSI 3776 CPC. The increased level of scatter in the data obtained with the new inversion algorithm stems from the fact that CPC counts were recorded at a high rate of 10 Hz. To facilitate comparability the size distributions have been normalized with respect to the total number concentration.

Whereas our new inversion algorithm is in good agreement with the AIM algorithm for large particles (nominal diameter 180 nm), the resulting size distribution is shifted towards larger diameters for smaller particles (nominal 40 nm) as compared to AIM. This might be due to a more advanced treatment of Brownian motion in our algorithm. The associated geometric mean diameters are displayed in table 1.

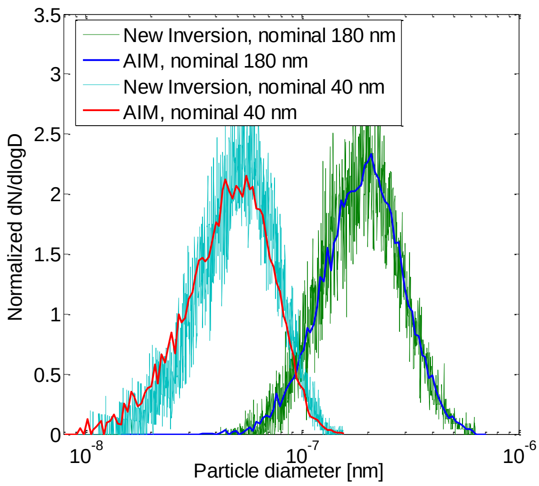

Figure 1. Comparison between the new data inversion algorithm and the AIM data inversion obtained with CAST particles of nominal diameters 40 nm and 180 nm.

Table 1: Geometric mean diameters associated with the number size distributions displayed in Fig. 1.

Algorithm	Nominal 40nm	Nominal 180 nm
METAS	49.3 nm	187.4 nm
AIM (TSI)	45.4 nm	188.8 nm

The new inversion algorithm will also open the possibility to take more advanced effects into account, such as Brownian diffusion in axial direction within the DMA and the effect of laminar flow profiles in the plumbing lines. Moreover, the multi-charge (MC) problem could theoretically be dealt with directly in the inversion and thus render a MC correction unnecessary.

Coquelin, L. *et al*. (2013). *Journal of Physics: Conference Series* **429**, 012018.

Wiedensohler, A., Birmili, W., Nowak, A., *et al.* (2012). *Atmos. Meas. Tech.* **5**, 657 – 685.