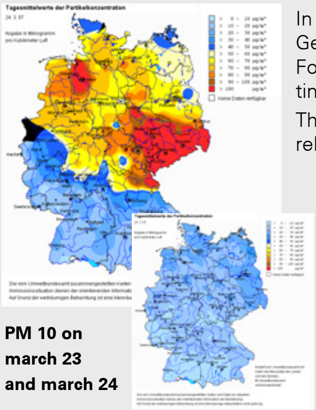
TECHNISCHE UNIVERSITÄT DRESDEN

Faculty of Mechanical Engineering   Institute of Process Engineering and Environmental Technology   Research Group Mechanical Process Engineering

Aerosol mobility spectrometry based on diffusion charging

L. Hillemann, A. Zschoppe and R. Caldow

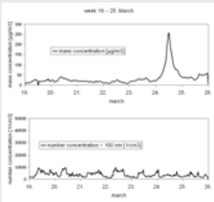
Motivation



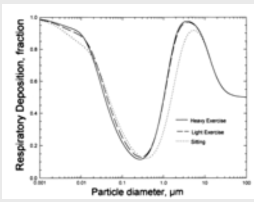
PM 10 on march 23 and march 24

In March 2007 high PM-10-concentrations were observed in Germany, caused by long range transport of coarse dust. Fortunately no impact on human health was registered during this time.

This illustrates the need for monitoring of ultrafine particles for the relation of health effects to dust concentrations.



number and mass conc. in march 2007



particle deposition in the respiratory system

Requirements

In a particle sample characterized by mass the particles contribute to this measure weighted by x^3. Hence a mass concentration is overemphasized by coarse particles whereas the critical fraction of ultrafine particles is underpredicted. This problem can be tackled by using number concentrations to quantify the particle concentration in the environment.

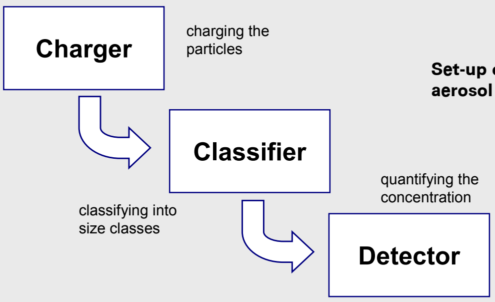
Several available systems for the number concentration measurement are designed for the lab and are not suitable for monitoring networks.

The demands for this purpose are:

- no radioactive source
- no butanol
- reduced data set
- easy operation
- low maintenance

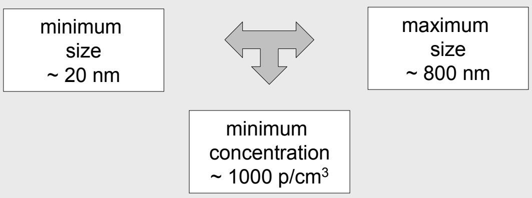
Spectrometer setup

Aerosol spectrometers combine an electrostatic classifier and an electrometer to measure the mobility distribution of an aerosol. This technique bases on the classification of charged particles in an electric field. Accurate particle size detection requires a well-defined charge status of the aerosol which is achieved by diffusion charging.



Set-up of an aerosol spectrometer

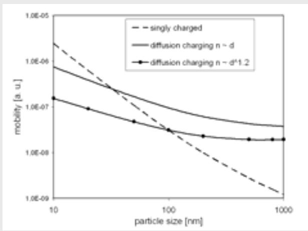
By combining the corona-jet-charger with a DMA and an electrometer, a new aerosol spectrometer similar to an EAA and DMPS was developed. The advantage of this device is its simple set-up and the stability and robustness of the components. More problematic is the superposition of the mobility spectra of different particle size fractions due to their broad charge distribution. This leads to a lower size resolution compared to the SMPS. However, it is sufficiently precise for environmental aerosol quantification in air pollution networks.



Working range of the developed spectrometer

[1] Whitby, K. T., Clark, W. E. (1966). Tellus , 18, 573.

Inversion



Relation between particle size and mobility for different charge states

Charging of particles by means of an electrical field or corona-generated ions has been known for many years. Whitby and Clark introduced the diffusion charging of an aerosol by preventing the particles from undergoing strong field charging. This mechanism was used to produce a monotonic decreasing relationship between size and electrical mobility of the aerosol particles [1].

A measurement cycle delivers the mobility distribution of the particle-bound electrical charge. The inversion problem to calculate the size distribution f(x) from the measured current distribution g(y) is described by the Fredholm-equation.

$$g(y) = \int_a^b K(x,y)\, f(x)\,\mathrm{d}x$$

The kernel data K(x,y) of the UFP-system is recorded by a parallel quantification of a monodisperse aerosol by SMPS, CPC and UFP.

The inversion algorithm employed in the UFP 330 uses constraints like the typical shape of an environmental particle size distribution and boundaries for the particle size.

Dipl.-Ing. Lars Hillemann,
TU Dresden, Inst. of Process Engineering and Environmental Technology
Research Group Mechanical Process Engineering, D-01062 Dresden
Phone: +49 351 463 32914 Fax: +49 351 463 37058
Email: lars.hillemann@tu-dresden.de
Web: http://www.mvt-tu-dresden.de

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