The versatile Size Analyzing Nuclei Counter (vSANC)

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We present a newly developed expansion chamber condensation particle counter - the versatile Size Analyzing Nuclei Counter - suitable for studies on nanoparticles from diameters of 1-2nm upwards. The vSANC is applicable for both, laboratory as well as long-term field measurements at temperatures ranging from $-20°C$ to $+40°C$ and inlet gas pressures ranging from 0.2bar to 1.2bar.

The operation is based on heterogeneous nucleation of supersaturated vapor on aerosol particles and subsequent droplet growth, whereby well-defined uniform supersaturation inside the measuring chamber is achieved by adiabatic expansion. Thereby small particles grow to visible sizes where they can be detected by applying the multiple Constant Angle Mie Scattering method. The measuring principle was adopted from the Size Analyzing Nulcei Counter and can be found elsewhere (see Wagner *et al*, 2003). Here the droplets, growing in the expansion chamber are illuminated by a solid state laser beam ($\lambda = 488nm$). The resulting scattered light fluxes are then monitored simultaneously at 10 different scattering angles.

In order to enable an automatic establishment of a correspondence between experimental and theoretical (Mie-theory) light scattering extrema, a tailormade software was developed dividing scattering intensities for two specifically selected angles by each other. The resulting structure has strongly pronounced extrema, which make an automated data evaluation possible (Hollaender *et al*, 2002). By additionally measuring the transmitted light flux, absolute determination of particle number concentrations ranging from 50/cc to 10^7/cc is enabled without the need of external calibration. Moreover well-defined uniform conditions in the expansion chamber allow for an automated determination of droplet growth rates for precision verification of vapor supersaturation ranging from 5% up to the limit of homogeneous nucleation.

The design of the experimental setup, including expansion chamber, subpressure vessel, valves, tubing, pumps and critical orifices, enables constant and continuous aerosol flow during measurements. In addition the sampling flow through the chamber can be controlled either by means of critical orifices (active sampling mode) or externally (passive sampling mode). Particularly the latter is of advantage when performing measurements in combination with a uDMA. The redundant system layout allows the exchange of filters and dryers during experiment. Thus continuous long-term measurements are possible.

Furthermore the system pressure can be chosen independent from the ambient air pressure. The only limitation is given by the measuring range of pressure sensitive components, such as pressure gauges. Hence the input gas pressure can range from 0.2bar to 1.2bar.

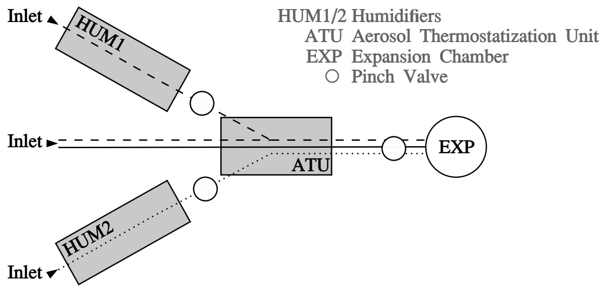

Figure 1: Schematic diagram of the aerosol inlet system. Either the aerosol is already humidified and is passed directly into the expansion chamber (solid line) or it first passes through one of the two humidifiers (dotted line) or it gets mixed with humidified air in the aerosol thermostatisation unit (dashed line).

To minimize particle losses along the sampling line the inlet system was designed as short and straight as possible using only stainless steel tubing and pinch valves with complete and true full bore, when open. The inlet system includes three alternative aerosol inlets, two humidifiers, and the aerosol thermostatization unit. Its design provides flexibility with respect to aerosol presampling conditions (see figure 1). In addition it is possible to alter two different condensing liquids, e.g. polar and non-polar, or use binary vapors.

In conclusion, the vSANC provides a powerful tool to investigate nanoparticles from diameters of 1-2nm upwards. It enables the determination of droplet growth rates and absolute number concentrations ranging from 50/cc to 10^7/cc. The vSANC was optimized to achieve high flexibility with respect to temperature, inlet gas pressure, and condensing liquid. Its mobility and the redundant system layout even enable long-term field measurements. We present first measurement results providing determinations of heterogeneous nucleation probabilities and allowing evaluations of sizes of molecular clusters.

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