About a new nanoparticle mass measurement method in the transition regime

B.A. Heiden[1]

[1]Dr. Heiden, Ghegagasse 1, 8160 Weiz, Austria, office@dr-heiden.com

Keywords: Mass Measurement, DMA, Millikan Experiment, Mass Size Distribution, Nanoparticle Measurement.

This paper presents a method usable for particle mass measurement in the transition regime. The complete method is applied for an Austrian Patent (Heiden & Sturm, 2012).

The Millikan experiment is based on a set of equations including the Stokes resistance and the mass and velocity of small particles. Although the experimental setup of the Millikan experiment is different, describing oil droplets and finally determining the electron mass, in this case the Einstein method of taking the equation and interpretating it in another field of application is useful. The equations can be written with the three forces: the gravitational force F_g, the electric force F_e and the Stokes Resistance Force F_w:

(1) $$F_g = m_P \cdot g = \frac{4}{3} r_P^3 \pi \rho_P \cdot g$$

(2) $$F_e = q \cdot \vec{E} \wedge \vec{E} = \frac{U}{d}$$

(3) $$F_w = 6 \pi \eta r_P \cdot v$$

Those forces around particles in the fluid flow must be balanced left and right in Figure 1,

(4) $$F_w = F_e + F_g \text{ and}$$

(5) $$F_w = F_e - F_g$$

especially when they are connected through the fluid flow as the arrows are indicating.

The substitution of (1)-(3) in (4)-(5) and resolution for the unknown mass m_P and particle radius r_P results in:

(6) $$m_p = \frac{(\vec{E}_2 - \vec{E}_1) \cdot q}{2 \cdot g} \wedge q = n \cdot e_0$$

(7) $$r_p = \frac{q \cdot (\vec{E}_1 + \vec{E}_2)}{12 \pi \eta \cdot v}$$

Here is g the gravitational vector, E the electric field caused by Voltage U and distance d of electrodes. ρ_P denotes the particle density, n the number of charges with e_0, the elementary electron charge, η is the viscosity of the fluid and v is the velocity of the particle(s).

So when the fluid flows through the first DMA the size or the mobility diameter can be classified. When it flows through the second the mass and hence the density of the particle can be determined. The equation gives the dynamic balance of one particle size and one particle mass with one electric field strength. In varying the voltage, the parameters of the measurement can be tuned to get a number and a mass size distribution in the flight. With this method it should be possible to solve the most difficult question (compare e.g. Heiden et al., 2005), whether particles are liquid or solid in the transition regime, as particle mass density distribution function can be measured. Another advantage is that particles are measured in the flow, meaning a follow up of a variety of measurements and comparisons is possible.

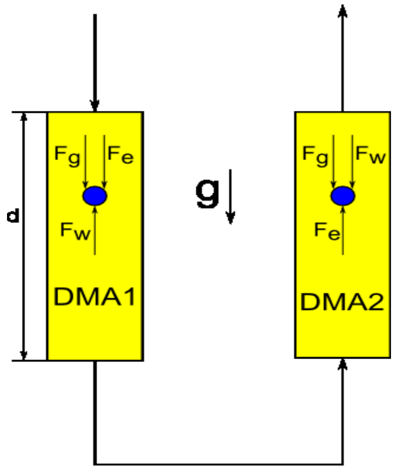

Figure 1. Two Differential Mobility Analyzer (DMA's) in opposite direction with respect to the gravitation vector g and forces for balance.

Heiden, B. A. & Sturm, P.-J. (2012). *In Situ Nanoparticle Mass Measurement Device* in German, Austrian Patent Office Application: A1252-2012

Heiden, B. A., Sturm, P.-J., Pretterhofer, G., Le An Tuan & Ivanisin M. (2005). *Exhaust Gas Dispersion Effects under Controlled Environmental Conditions*: in 10th EAEC, p. 1-12, Beograd, Yugoslavia