Measurement of the charge distributions of 4-70 nm aerosols

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The charge distributions of aerosols in an 8 m^3 stainless steel reaction chamber were measured using a scanning mobility particle sizer measuring aerosols from about 4 to 70 nm. A Kr-85 source in the instrument forced the aerosols into a known equilibrium charge distribution, which could then be used to infer the size distribution of the aerosols. By replacing the Kr-85 source with a dummy we were able to measure only the aerosols that were charged inside our reaction chamber, which we then compared with the measurements using the Kr-85 source, thus revealing if the aerosols were under- or overcharged relative to the equilibrium. Charge distributions were measured for both positively and negatively charged aerosols and for different levels of radiation in the chamber.

We found that the negative aerosols were overcharged by a factor of up to about 5 below 10 nm and at about 15% from 10 to 70 nm. At higher levels of radiation on the chamber the small aerosols were less overcharged while the large aerosols were more overcharged. For the positive aerosols only those under 10 nm were overcharged while those over 10 nm were undercharged by about 20%.

Method

Aerosols were generated by nucleation of sulphuric acid, started by photolysis of ozone by UV lamps, resulting in hydroxyl radicals that oxidised SO_2 into sulphuric acid. The chamber was kept in a steady state where areosols were continuously being generated and lost to the walls and dilution. The aerosols were charged by the natural abundance of cosmic rays and the charging could be increased by exposing the chamber to two 30 MBq Cs-137 gamma sources.

The size distributions of the aerosols were measured by a TSI model 3080 electrostatic classifier, with a model 3085 nano DMA and model 3075 condensation particle counter. The Kr-85 neutralizer in the classifier was TSI model 3077A, with an activity of about 270 MBq. To measure only the aerosols that were ionised in the reaction chamber the neutralizer was replaced with a dummy made from an old neutralizer where the remaining Kr-85 had been removed.

The system was attached directly to the reaction chamber with a sampling line that was varied in size from 2.4 m to 1.3 m.

Results

Figure 1 shows the relative charge distributions (compared to the equilibrium charge distribution) for positive ions at different levels of ionisation and sampling tube lengths. As ionisation increased the charging on the positive aerosols went down while the opposite happened for the negative aerosols – the difference in relative charging between positive and negative aerosols at high ionisation is shown in Figure 2.

That the negative aerosols were overcharged at larger sizes and that this overcharging even increased as the radiation level went up could mean that the negative ions played a significant role in the growth of the aerosols at larger sizes.

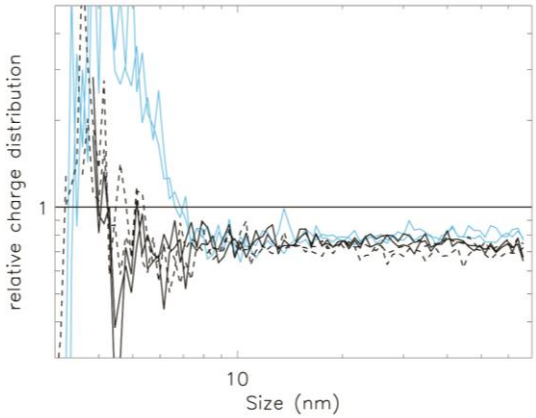

Figure 1. Relative charge distributions of positive aerosols for low (blue) and high (black) levels of ionisation. The dashed line is a measurement with the shorter sampling tube.

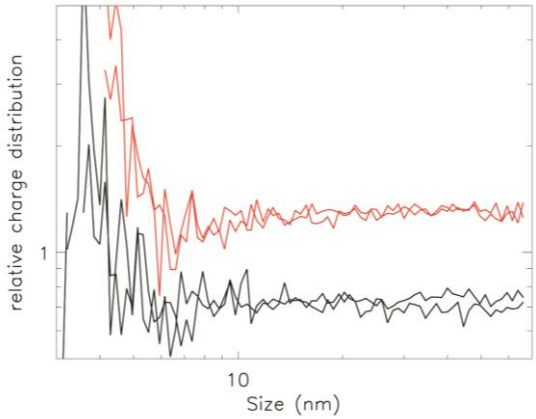

Figure 2. Relative charge distributions of negatively (red) and positively (black) charged aerosols with high ionisation using the Cs-137 gamma sources.