Electrostatics of arrays of quasilinear electrospray plumes

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Compact arrays of multiple electrosprays are used to increase droplet production rates in nanoparticle production, thin film coatings, colloid thrusters, and mass spectrometry (Jaworek, 2007). Different design strategies have been adopted to achieve stable spraying from such arrays. For example, so called *extractor electrodes* are often placed in front of each Taylor cone in order to lower the voltage requirements to "reasonable" low levels, and to prevent uneven spraying in different zones of the array (assuming equal voltage is applied on all the emitters) (Bocanegra *et al*, 2005; Deng and Gomez, 2007; Agostinho *et al*, 2013).

However, our theoretical understanding on these arrays is limited. We lack models which can be used to predict the trends in the electrostatic field experienced by the spray clouds as a function of array factors like the emitter spacing or the total number of emitters. Simple questions such as "what impact does the number of sprays (size of the array) have on spray expansion" or "can an array be operated stably without extractor electrode" cannot be easily answered except for experimentally tested situations.

In this work, we gain insights into the electrostatics of scaled up electrospray sources by solving "simplified" analogues of these systems. By reducing the complexity of the system description, we are able to theoretically solve for an electrical field which resembles the real system reasonably, and to enquire how it changes as a function of the geometrical parameters describing the array.

For example, in figure 1 for a 1D array of emitters with extractor plate, each electrospray is modelled by a simple homogeneous line-of-charge (inspired in Deng and Gomez, 2007). The electrical field has analytical solution as the sum of an infinite series. In the figure we show the electrical field strength at the center of the line-of-charge which is located at edge of the array, as the number of sprays (lines of charge) is increased. The field strength approaches its asymptotic value already when the array width *W* attains one inter-plate separation *H* (*W*/*H* = 1 in the graph). A similar curve is obtained with much lower emitter lines densities, suggesting that the main effect from the spray density is to increase the asymptotic value of the field, but not its functional dependence with array width.

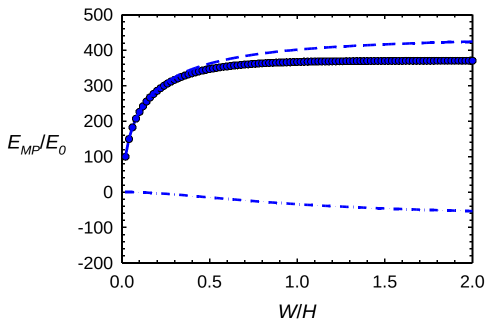

Figure 1. Dimensionless E-field at the edge of an array of lines-of-charge arranged between two parallel plates separated a distance *H*, as a function of the width of the array *W* (where the total number of lines-of-charge = 1+*W*/*P*). The plates are separated a distance of 50 times the interline separation (pitch, *P*). The dashed line is the direct contribution from the lines-of-charge, whereas the dot-dashed line is the contribution from their image charges in the plates.

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Agostinho, L.L.F., Yurteri, C.U., Wartena, J., Brouwer, S.P., Fuchs, E.C. and Marijnissen, J.C.M. (2013) *Appl. Phys. Lett.* **102**, 194103.

Bocanegra, R., Galán, D., Márquez, M., Loscertales, I.G. and Barrero, A. (2005) *J. Aerosol Sci.* **36,** 1387-1399.

Deng, W. and Gomez, A. (2007) *J. Aerosol Sci.* **38,** 1062-1078.

Jaworek, A. (2007) *Powder Technol.* **176,** 18-35.