Wake pairing of dust particles

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In the sheath region, the ion flow to the electrode provides a distinctive direction, with the plasma properties different in the direction parallel or perpendicular to the flow. The ion flow is responsible for the generation of the wake potential for a test dust particle, which in the linear approximation is within the Mach cone for supersonic ion velocities. The bottom dust particle appearing in the wake of the test particle is strongly coupled to the top particle by the Cooper-like pairing. The ion wake also influences the charge of the downstream particle which is different from the charge of the top one even in the case of identical particles. The latter has been shown by molecular dynamic simulations [1] as well as by experimental measurements of the charges on two vertically aligned particles in ICP argon plasma [2]. Thus the force that couples dust particles in the ion flow is a complex function of the dust and plasma parameters.

Here, we present experimental results on the pairing and motion of two dust particles coupled in the ion flow. It is shown that in the case of a sufficiently strong ion flow, the vertical separation of dust particles can be significantly less than the plasma electron Debye length. Possible mechanisms for the experimentally observed "closed pairing" of dust particles are discussed. On the basis of the particle pairing, the wake parameters are determined, including estimation of the influence of the bottom particle on the wake parameters. Comparison of the experimental data is made with the theoretically obtained combined interparticle potential (see Fig.1) including the molecular dynamics wake simulation data, the plasma Debye interaction, the external sheath potential, and taking into account the change of the charge of the downstream particle.

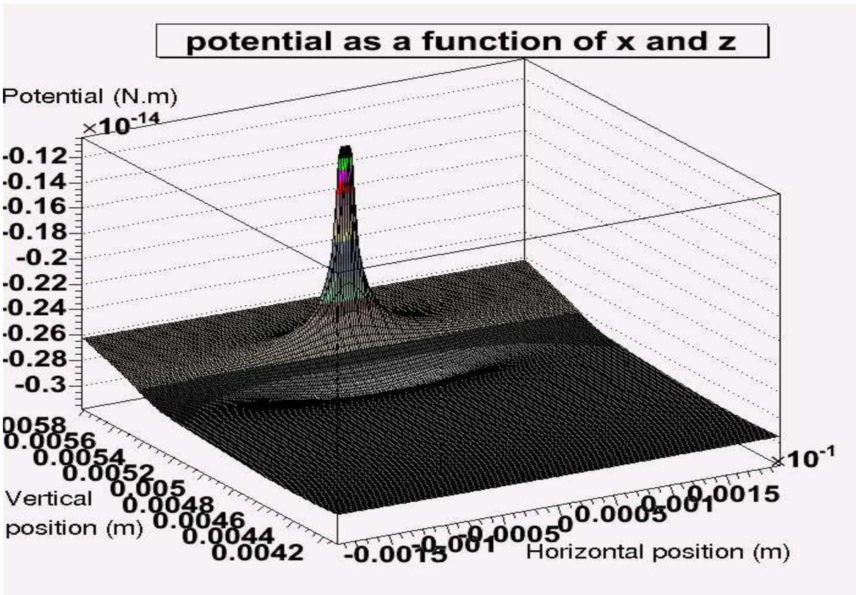

Fig. 1. *Interparticle potential between two vertically align particles in ion flow. The charge on top particle is assumed to be constant. The charge on bottom particle is* $Q(x,z) = 1 - 0.651\frac{\Delta X}{\Delta Z}\exp(-\frac{\Delta Z}{1.2\Lambda_D})\exp(-\frac{9\arctan^2(\Delta X/\Delta Z)}{2\arctan^2(\sqrt{M^2/(M^2-1)})}$ *[3]. A wake potential from [4] was incorporated.*

[1] S.V. Vladimirov, S.A. Maiorov, and N. F. Cramer, Phys. Rev. **67**, 016407 (2003).
[2] N. J. Prior, L.W. Mitchell, and A.A. Samarian, J. Phys. D: Appl. Phys. **36**, 1249 (2003).
[3] L. Cuedele, A.A. Samarian, B.W. James (to be published).
[4] S.Oshihara and S.V. Vladimirov, Phys. of Plasma, **4**, 467(1997).