Poster

Manipulation of nanoparticles by arrays of electrodes: a theoretical analysis

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Electric fields are commonly used for the manipulation and control of nano/bioparticles [1]. Microelectrode structures represent an opportunity for direct actuation either on the liquid or suspended particles [2] and, when integrated in microchannels, electrodes make possible some standard processes in the "Lab-on-a-Chip" technology (i.e. pumping liquids [3], mixing analytes [4], sorting of cells [5],...)

In this work we analyze the motion of particles suspended in saline solutions on top of coplanar microelectrodes subjected to AC potentials. On one hand, the particles can undergo direct forces, as dielectrophoresis (DEP) or gravity. On the other hand, the particles can be dragged by the fluid flow. Upon application of an electric field, fluid flow in an electrolyte can be generated by either of the following mechanisms: electrothermal effect, AC electroosmosis and/or buoyancy. We also include in the analysis the random displacement of particles caused by Brownian motion.

As a model system, we consider an array of electrodes subjected to a travelling-wave potential (see Fig.1). We derive simple expressions for the magnitude of the forces on the particles and for obtaining estimates of the fluid velocity. From these expressions, we produce diagrams like those in Fig. 2, where we indicate which mechanism is dominating the motion of a particle (250 nm dia.) depending on the amplitude and frequency of an ac signal applied to an array of wavelength 100 μm.

References:

[1] H. Morgan and N.G. Green. *AC Electrokinetics: Colloids and Nanoparticles*. Research Studies Press Ltd. **2003**.
[2] A. Ramos, H. Morgan, N.G. Green and A Castellanos. *J. Phys. D: Appl. Phys.* 31, 2338, **1998**.
[3] A. Ramos. In *Microfluidics technologies for miniaturized analysis Systems.* Springer, **2007**.
[4] N. Nguyen and Z. Wu. *J. Micromech. Microeng.* 15, R1-R16, **2005**.
[5] S. Fiedler, S.G. Shirley, T. Schnelle, and G. Fuhr. *Analytical Chemistry.* 70, 1909, **1998**.

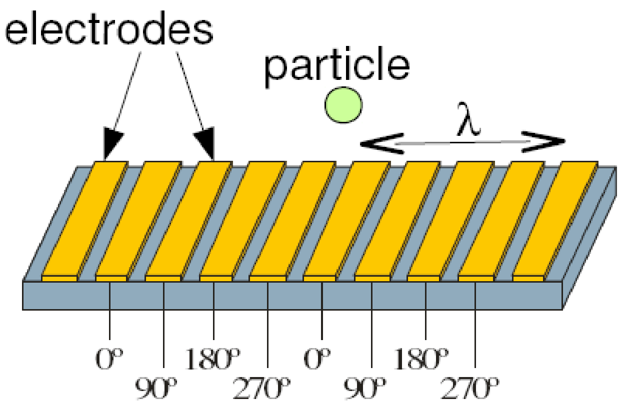

Fig. 1. Particle on top of an array of microelectrodes. AC signals of a given amplitude and frequency are applied to each electrode. The voltage on consecutive electrodes is phase shifted by 90°, generating a travelling-wave potential of wavelength λ.

(a) Low conductivity $\sigma = 10^{-3}$ S/m   (b) High conductivity $\sigma = 10^{-1}$ S/m

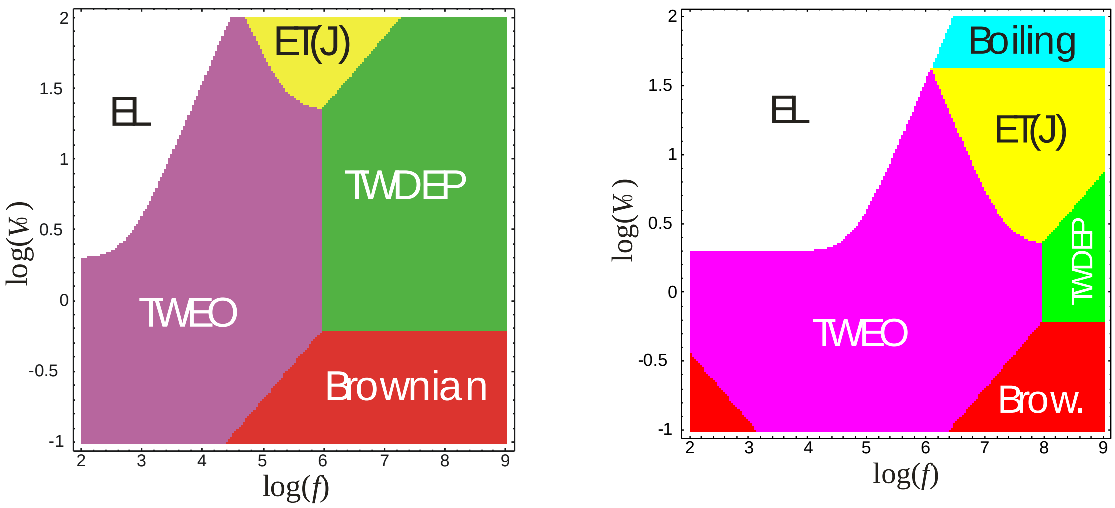

Fig. 2. The different regions indicate the mechanism dominating the motion of the particle (250nm dia.) as a function of the amplitude (V_0) and frequency (f) of the signal applied to a travelling wave array of λ=100μm. Two different conductivities are considered (a) 10^{-3} S/m, and (b) 10^{-1} S/m. The different mechanisms are: travelling-wave dielectrophoresis (TWDEP), travelling-wave electroosmosis (TWEO), electrothermal effect (ET) and Brownian motion. Water electrolysis (EL) can also be observed when the voltage drop at the electrodes is sufficiently high.