Migration of a Rigid Disc in Couette Flow Subject to an External Electric Field Simulated Using ISPH

N. Tofighi[†], M. Ozbulut[†], A. Rahmat[†], J.J. Feng[‡] and M. Yildiz[†]

[†] Faculty of Engineering and Natural Sciences (FENS)
Sabanci University, Tuzla, 34956 Istanbul, Turkey
e-mail: nima@sabanciuniv.edu

[‡] Department of Mathematics and
Department of Chemical and Biological Engineering
University of British Columbia, Vancouver, BC V6T 1Z2, Canada

ABSTRACT

The interaction of a solid body with a fluid environment is one of the most common flow features in nature and industry. When exposed to an external electric field, the motion of the solid may undergo significant changes. Migration of rigid discs in Couette flow has been the subject of many studies [1]. On the other hand, the rotation of spherical bodies in electric field known as Quincke rotation [2], has attracted much attention [3]. It is known that a particle laden fluid may exhibit changing viscosity when exposed to an external electric field [4]. This behavior is attributed to changing motion of particles due to electric field. However, a fully resolved simulation of a disc migrating in electric field has not been conducted.

In this study, a two-dimensional Incompressible Smoothed Particle Hydrodynamics (ISPH) scheme is used to simulate the interaction between a rigid body and its surrounding fluid [5]. Solid and fluid phases are modeled as leaky dielectric material [6]. Numerical simulation of a single disc placed off-center in Couette flow is carried out and the results are validated against literature data in the absence of an electric field. Then the same case at different electric permittivity and conductivity ratios is simulated and compared to the case with no electric field. The results show that when the conditions for Quincke rotation are satisfied, the disc's migration toward the channel's center is hindered, in agreement with experiments [4].

REFERENCES

[1] Yan, Y., Morris, J.F. and Koplik, J. Hydrodynamic interaction of two particles in confined linear shear flow at finite Reynolds number. *Phys. Fluids* (2007) **19**:113305.

[2] Quincke, G. Ueber rotationen im constanten electrischen felde. *Annalen der Physik* (1896) **295**:417-486.

[3] Peters, F., Lobry, L., Khayari, A. and Lemaire, E. Size effect in Quincke rotation: A numerical study. *J. Chem. Phys.* (2009) **130**:194905.

[4] Huang, H.F., Zahn, M. and Lemaire, E. Continuum modeling of micro-particle electrorotation in Couette and Poiseuille flows-The zero spin viscosity limit. *J. Electrost.* (2010) **68**:345-359.

[5] Tofighi, N., Ozbulut, M., Rahmet, A., Yildiz, M. and Feng, J.J. Descent of a solid disk in quiescent fluid simulated using incompressible smoothed hydrodynamics. *Proceedings of WCCM XI* (2014) **5**:5310-5318.

[6] Saville, D. Electrohydrodynamics: The Taylor-Melcher leaky dielectric model. *Annu. Rev. Fluid Mech.* (1997) **29**:27-64.