Electrothermoplasmonic Flow In Gold Nanoparticle Suspensions

Emilio Ruiz-Reina[1], Carlos David Gónzalez-Gómez[2], Raúl A. Rica[2]

[1]University of Málaga, Málaga, Spain
[2]University of Granada, Granada, Spain

Abstract

Efficient mixing and pumping of liquids at the microscale is a technology that is still to be optimized. The combination of an AC electric field with a small temperature gradient leads to a strong electrothermal flow that can be used for multiple purposes. Combining simulations and experiments, an analysis of the performance of electrothermal flow is provided when the temperature gradient is generated by illuminating plasmonic nanoparticles in suspension with a near-resonance laser. Fluid flow is measured by tracking the velocity of fluorescent tracer microparticles in suspension as a function of the electric field, laser power, and concentration of plasmonic particles. Among other results, a non-linear relationship is found between the velocity of the fluid and particle concentration, which is justified in terms of multiple scattering-absorption events, involving aggregates of nanoparticles, that lead to enhanced absorption when the concentration is raised.
COMSOL Multiphysics simulations provide a description of the phenomenon that is compatible with experiments and constitute a way to understand and estimate the absorption and scattering cross-sections of both dispersed particles and/or aggregates. A comparison of experiments and simulations suggests that there is some aggregation of the gold nanoparticles by forming clusters of about 2-7 particles, but no information about their structure can be obtained without further theoretical and experimental developments. This nonlinear behavior could be useful to get very high ETP velocities by inducing some controlled aggregation of the particles.

Reference

C. D. González-Gómez, R. A. Rica, and E. Ruiz-Reina. Electrothermoplasmonic Flow in Gold Nanoparticles Suspensions: Nonlinear Dependence of Flow Velocity on Aggregate Concentration, Journal of Colloid and Interface Science, 648, 397-405 (2023).
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Figures used in the abstract

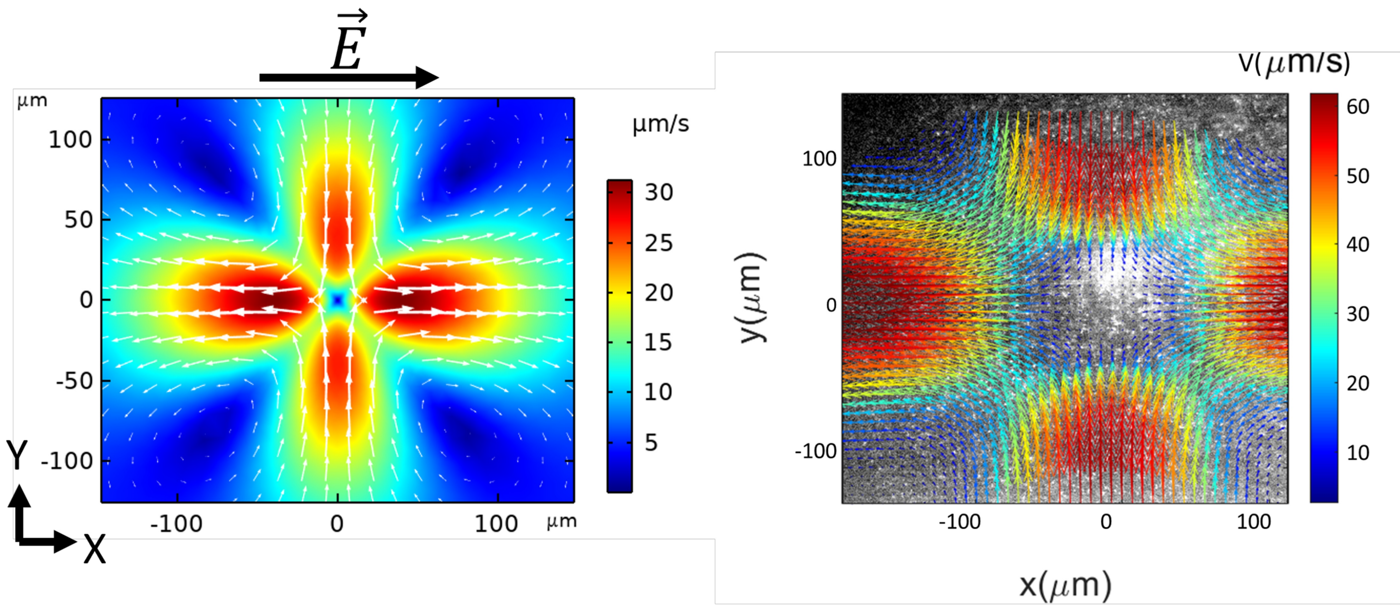

Figure 1 : Comparison between simulated (left) and experimental (right) flow fields.