Fluid dynamics of complex multiphase systems through pyro-electrohydrodynamic effect (pyro-EHD) for microfluidic applications

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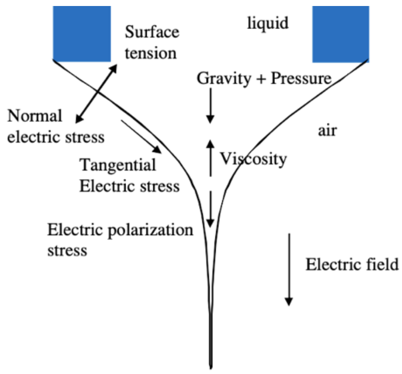
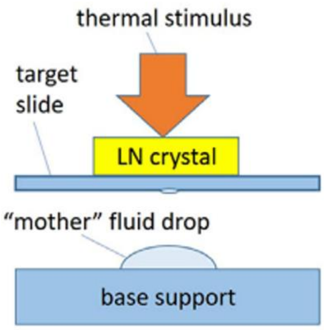
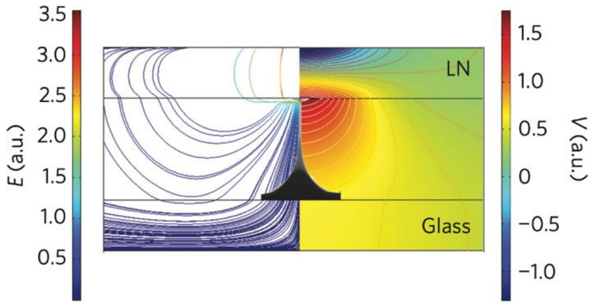
The manipulation and dispensing of liquids at the micro- and nano-metric scale is important for microfluidics and biotechnology, including jet printing. For jet printing, the most promising techniques appear to be based on electrohydrodynamics (EHD), i.e., the application of an electric field to a multiphase system generates electrohydrodynamic forces at the interface between the fluid phases. Appropriate electrodes and high-voltage circuits are typically used to regulate the electric field, hence the EHD forces. In addition, electrode devices require complicated manufacturing procedures and impose limits on operating conditions. An interesting technological solution is to generate the electric field through the 'pyro-electrohydrodynamic' (pyro-EHD) effect, i.e. by heating a substrate of lithium niobate (LN).



The characteristics of the electric field generated by the pyro-EHD technique, however, are not yet understood. This makes such a process far from being general (e.g., changing the fluid properties or operating conditions require a re-calibration of the thermal history of the lithium niobate substrate). Furthermore, EHD problems are usually simplified by assuming that the fluids involved are purely dielectric (insulating) or purely conducting. The modelling of an EHD system requires not only incorporating electrical forces into the Navier-Stokes equations, but also considering charge migration due to both conduction and convection in the electric charge conservation equation. We will develop a numerical simulation code that solves the fluid and electric equations governing the dynamics of a multiphase system without simplifications, so that it can be applied to any fluid-fluid system subjected to an external electric field.





The aim of this research is to carry out a detailed analysis of the fluid dynamics for sessile/pending droplets deformation induced by the pyro-EHD effect for microfluidic applications. The study will be conducted by accurate numerical simulations accounting for all the relevant parameters of the system, such as rheological properties and operating conditions.

The project is part of a collaboration between the University of Naples Federico II, the ISASI-CNR institute and the Agenzia Spaziale Italiana.

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