Liquid micro-droplet effects in a plasma

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Ionized gases, usually referred to as plasmas, are present in a wide range of naturally-occurring and industrial cases. These plasmas often contain micrometre-scale droplets, particularly in technologically-important applications such as plasma spraying and vapour decomposition for materials processing, condensation of droplets in semiconductor fabrication plasmas, and droplet blowoff in plasma arc cutting and welding devices. Additionally, droplets are found in ionospheric and fusion reactor plasmas. The primary purpose of my PhD project is to investigate the stability and dynamics of these droplets.

Over the past year I have continued to study the processes which lead to an accumulation of charge on a dust grain or droplet in a plasma. This work has been published in two peer-reviewed journals [1,2] with a third currently at the second stage of review. I am now moving on to study the breakup of droplets due to this charge and a combination of other effects such as external electric fields, plasma flows and droplet rotation. This involves comparing simple analytic theories with numerical simulations of droplet breakup; these simulations will be facilitated by a code I have developed over the past six months for modelling electrohydrodynamic flows using the level-set method. This code includes electric, viscous, surface tension and rotational forces and some examples are shown below. Figure 1 shows the Rayleigh mechanism for breakup of overcharged droplets, characterized by elongation of the drop and emission of fine jets, while Figure 2 shows the formation of a Taylor cone and resulting emission of droplets from a liquid surface in an electric field. These preliminary results are in good quantitative agreement with the corresponding instability theories and provide a good foundation for detailed simulations of liquid-plasma interactions.

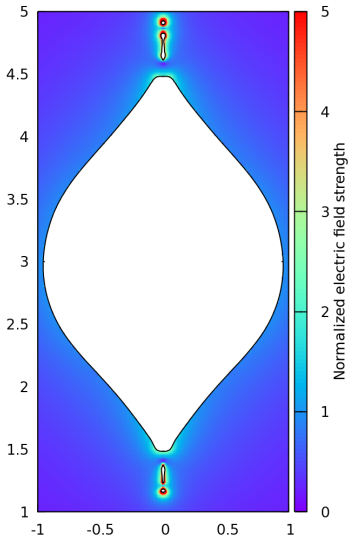

Figure 1: Disruption of an overcharged droplet.

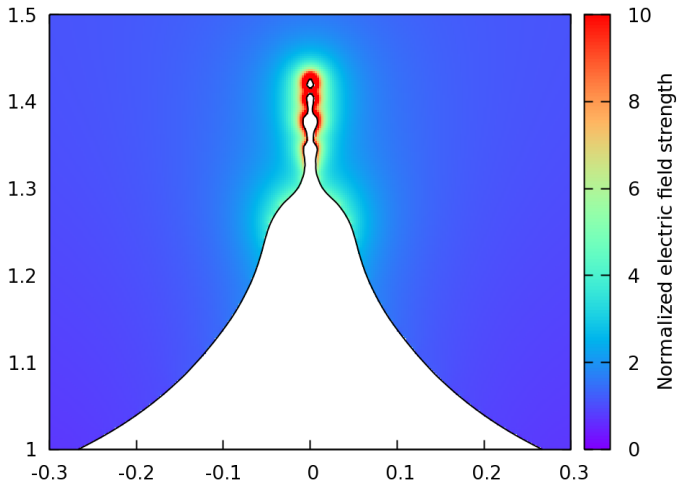

Figure 2: Cone formation and spraying of droplets from an initially flat liquid surface in an electric field.

1. J. T. Holgate and M. Coppins, Charging of nonspherical macroparticles in a plasma, *Physical Review E*, 93 (2016) 033208.

2. D. M. Thomas and J. T. Holgate, A treecode to simulate dust-plasma interactions, *Plasma Physics and Controlled Fusion* 59 (2017) 025002.