ELECTRODYNAMIC INTERACTIONS OF NANODROPLETS IN PLASMAS

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The interactions of nanosize droplet jets with a plasma beam are important in electrosprays and has similarities with dusty plasmas.

We developed a theoretical model for the electrodynamics of electrospray droplets injected in a plasma. The model accounts for the dynamics of plasma particles and the droplets, and includes the collisional absorption of plasma species by the droplets with the use of a multi-step Monte Carlo algorithm. Poisson's equation provides the self-consistent electric fields. The model has been implemented using an unstructured 3d particle-in-cell Monte Carlo methodology (UPIC-MC). The model is applied to a droplet cloud bounded by surfaces or to a droplet cloud embedded in an unbounded plasma.

Charging of isolated droplets is compared with estimates based on orbital motion limited current collection. The charge and potential structure of finite length droplet clouds embedded in a plasma are examined and the results are compared to one-dimensional solutions from dusty plasmas. The average droplet charge is found to decrease with increasing droplet density. Low density droplet clouds do not perturb the potential and their average charge approaches that of isolated particulates.

Charging of droplets jets injected in an electron beam is simulated with a parametric investigation. We examine the effects of droplet size, droplet drift energy, and the electron beam properties.

For comparison with experimental data, an electrospray operating with a mixture of an ionic liquid in tributyl phosphate is used to produce a spray of micron-sized droplets in vacuo. The spray of droplets is introduced into a chamber where it is subjected to electron bombardment. The electrons are produced with a thermionic cathode allowing control of the electron flux. Charge and size of the droplets is measured using an inductive charge detector which characterizes the droplet size distribution as a function of electron flux. The size distribution measured with and without electron bombardment provides evidence of charging beyond the Rayleigh limit and subsequent droplet breakup. The breakup of primary droplets is characterized by a broadening of the size distribution. The mean droplet charge as a function of electron flux and exposure time is compared with simulation results.

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