Static structure of a pointed charged drop

JUAN FERNANDEZ DE LA MORA, Yale University, USA — The static equilibrium structure of an equipotential drop with two symmetric Taylor cones is computed by assigning a charge distribution along the z axis $q(z) = \sum B_n (L^2 - z^2)^{n+1/2}$. Taylor's local equilibrium at the poles $z = L, -L$ fixes two of the $B_n$ coefficients as a function of the other, determined by minimizing stress imbalance. Just two optimally chosen terms in the $B_n$ expansion yield imperceptible errors. Prior work has argued that an exploding drop initially carrying Rayleigh's charge $q_R$ is quasi static. Paradoxically, quasi-static predictions on the size of the progeny drops emitted during a Coulombic explosion disagree with observations. The static drop structure found here also models poorly a Coulomb explosion having an equatorial over polar length ratio (0.42) and the drop charge exceeding those observed (0.28-0.36 and $q_R/2$). Our explanation for this paradox is that, while the duration $t_c$ of a Coulomb explosion is much larger than the charge relaxation time, the dynamic time scale for drop elongation is typically far longer than $t_c$. Therefore, the pressure distribution within the exploding drop is not uniform. A similar analysis for a drop in an external field fits well the experimental shape.

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