Comment on "Enhanced Stability of Electrohydrodynamic Jets through Gas Ionization"

The Letter by Korkut, Saville, and Aksay [1] argues that the partial neutralization of an electrohydrodynamic (EHD) jet by a gas discharge reduces nonaxisymmetric instabilities. This can be used to optimize printing by micro- and nanojets. The practical importance of this finding is significant. Conversely, claims are made about cone-jet electrosprays which require clarification. We also think that the analysis is insufficient to prove the general stabilizing nature of gas discharges.

The Letter starts with a reference to two families of EHD jets: cone jets (a well-known phenomenon with a universal behavior decoupled from the electrostatics of electrodes) [2,3] and jets used for electrospinning [4]. The following statement regarding both families is made: "experimental conditions leading to the disappearance of the whipping instability are not understood." This is erroneous, at least for cone jets. It is well known that cone jets display both axisymmetric and nonaxisymmetric instabilities depending on the Taylor number (the ratio between electric stress and capillary pressure on the jet surface). Gañán-Calvo [3] has shown that the Taylor number for a given liquid increases with its flow rate Q: At low Q's, the Taylor number is small and the breakup is axisymmetric, generating droplets with narrow size distributions. As Q is increased and a critical Taylor number reached, the breakup becomes nonaxisymmetric, the jet oscillates, and the quality of the sprays worsens [5]. We know that Taylor numbers between 0.3 and 0.4 trigger nonaxisymmetric breakups [6,7]. If a cone jet were used for printing, one would need only to reduce Q to eliminate the whipping or lateral oscillations.

The mention in the introductory paragraph of a general error in the measurement of electrospray currents is unfortunate, because it raises doubts about the extensive body of work associated with atmospheric electrosprays. The authors should have made this statement specific to their experiments. The last two sentences in the first paragraph are erroneous: Taylor does not observe that "EHD jets travel a much longer length than what is expected by the theoretical predictions before the whipping instability sets in." Furthermore, we are unaware of any publication demonstrating that EHD jets with nonaxisymmetric breakups are more stable than expected. Thus, the mentioned "discrepancy" apparently does not exist in the literature. The authors should provide a valid reference supporting the existence of an acknowledged discrepancy.

The authors do not provide enough data to estimate the Taylor numbers of these jets, nor do they provide their estimates of the Taylor numbers. Information about the charging level of the jet is key for a comparison between experimental and theoretical instability results. The authors describe experiments governed by different charge transport mechanisms in the jet: In the experiments of Fig. 1, bulk conduction is significant, while it is apparently negligible in the experiments associated with Fig. 2. Despite the different physics, the results derived from Fig. 2 are used to explain the phenomenology described in Fig. 1. The comparison of the measured growth rates of lateral oscillations with Saville's theory is questionable: Saville's prediction is for a linearized model based on a small perturbation, while the Letter's data are for large disturbances; and there is not enough information to estimate the charging level of the jets. In conclusion, although the experimental evidence associated with Fig. 3 is compelling, the quantitative analysis provided by the Letter is insufficient to prove a general stabilizing nature of gas discharges: The accuracy of the unreported Taylor numbers is poor; comparison with the linear theory is inappropriate; the authors do not prove that Taylor numbers accounting for the gas discharge prevent a nonaxisymmetric breakup (i.e., does a reduction in the charging level of these jets by, for example, a factor of 2 lower the theoretical growth rate of lateral oscillations by a factor of 1000?); and the complexities of the gas discharge, including the nonlinearities and high sensitiveness between electrodes' potentials and discharge current, are ignored.

Manuel Gamero-Castaño
Department of Mechanical and Aerospace Engineering
University of California
Irvine, California 92717, USA

Received 11 February 2008; published 30 July 2008
DOI: 10.1103/PhysRevLett.101.059401
PACS numbers: 47.65.−d, 47.85.Dh, 52.80.−s, 68.03.−g

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