Accepted Manuscript

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PII: S0997-7546(16)30300-4
DOI: http://dx.doi.org/10.1016/j.euromechflu.2017.03.007
Reference: EJMFLU 3152

To appear in: *European Journal of Mechanics B/Fluids*

Received date: 27 July 2016
Revised date: 7 March 2017
Accepted date: 16 March 2017

Please cite this article as: L. Xie, L.-j. Yang, L.-z. Qin, Q.-f. Fu, Temporal instability of charged viscoelastic liquid jets under an axial electric field, *European Journal of Mechanics B/Fluids* (2017), http://dx.doi.org/10.1016/j.euromechflu.2017.03.007

Temporal Instability of Charged Viscoelastic Liquid Jets Under an Axial Electric Field

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ABSTRACT

A three-dimensional temporal linear instability analysis is performed for charged viscoelastic liquid jets moving in an inviscid gas under an axial electric field; the analytical dimensionless dispersion relation is derived in this paper. The viscoelastic fluid described by the Oldroyd-B model is intended to be a Taylor-Melcher leaky dielectric, while the ambient gas is treated as perfectly dielectric. Results show that two local growth rate maxima exist in the axisymmetric mode, and the instability domain can be simply connected or can consist of two separate regions separated by a stable area, depending mainly upon the axial electric field intensity and two viscoelastic parameters considered here, i.e. the time constant ratio and residual stress tension. It is found that the radial electric field has dual effects on the axisymmetric instability and it enhances the asymmetric instability, while the axial electric field affects the asymmetric mode non-monotonically versus different surface charge, and inhibits the axisymmetric mode. The competition between the axisymmetric and asymmetric instabilities reveals that the axial electric field will promote the predominance of asymmetric instability over the axisymmetric mode, which causes the bending motion in most experimental observations. An energy budget is also applied to explain the variation trend in the temporal growth rate versus different radial and axial

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