Abstract Submitted
for the DFD08 Meeting of
The American Physical Society

Planar extensional motion of an inertially-driven liquid sheet[1]
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We examine the planar extensional motion of a liquid sheet driven by inertia and derive a time-dependent exact solution of the free surface problem for the Navier-Stokes equations. The linear stability of the exact solution to 1- and 2-D symmetric perturbations is examined in the inviscid and viscous limits within the framework of the slender body equations. Both transient growth and long-time asymptotic stability are considered. For 1-D perturbations in the axial direction, viscous and inviscid sheets are asymptotically marginally stable, though depending on the Reynolds and Weber numbers transient growth can have an important effect. For 1-D perturbations in the transverse direction, inviscid sheets are asymptotically unstable to perturbations of all wavelengths. For 2-D perturbations, inviscid sheets are unstable to perturbations of all wavelengths with the transient dynamics controlled by axial perturbations and the long-time dynamics controlled by transverse perturbations. The asymptotic stability of viscous sheets to 1-D transverse perturbations and to 2-D perturbations depends on the capillary number Ca; in both cases, the sheet is unstable to longwave transverse perturbations for any finite Ca.

[1]LS and TW acknowledge support from NSF Grants DMS-0707755 (LS), DMS-0239125 (TW) and DMS-0244498 FRG (TW).

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Date submitted: 04 Aug 2008 Electronic form version 1.4