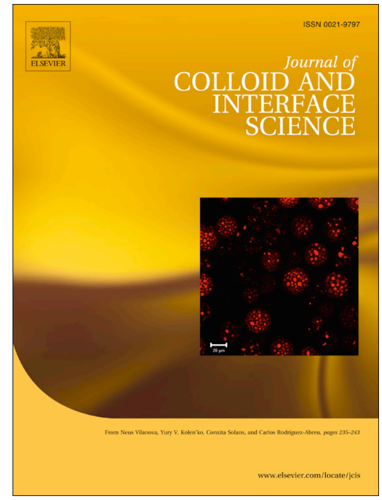


The flow of thin liquid layers on circular cylinders

Leonard W. Schwartz, Thomas A. Cender

PII: S0021-9797(18)30910-X
DOI: https://doi.org/10.1016/j.jcis.2018.08.004
Reference: YJCIS 23937

To appear in: *Journal of Colloid and Interface Science*

Received Date: 1 June 2018
Accepted Date: 3 August 2018

Please cite this article as: L.W. Schwartz, T.A. Cender, The flow of thin liquid layers on circular cylinders, *Journal of Colloid and Interface Science* (2018), doi: https://doi.org/10.1016/j.jcis.2018.08.004

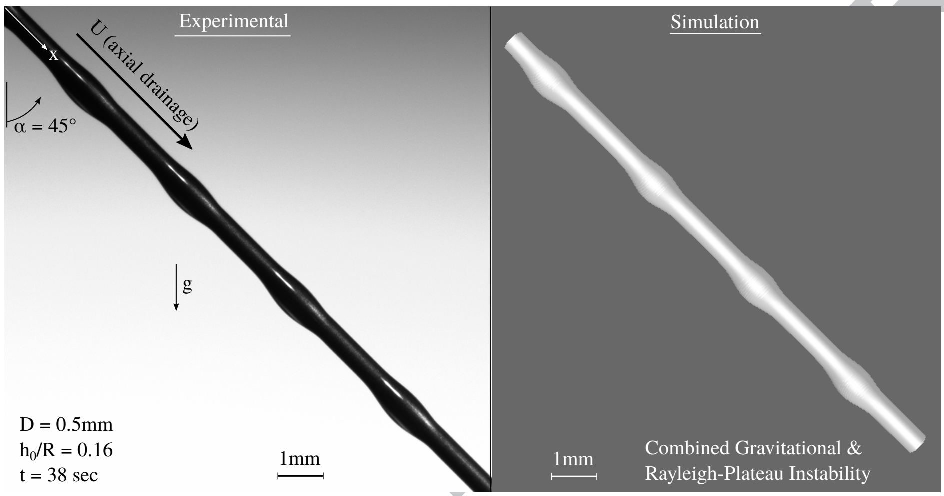
The flow of thin liquid layers on circular cylinders

Leonard W. Schwartz*and Thomas A. Cender

Department of Mechanical Engineering, University of Delaware, 130 Academy St. Newark, DE 19716

Resubmitted: August 2018

Graphical Abstract



Abstract

The time evolution of a coating layer of liquid on an inclined circular cylindrical substrate is studied experimentally and theoretically. For small-diameter cylinders, the motion of Newtonian liquids, driven by the combined influences of surface tension and gravity, is analyzed using the long-wave or "lubrication" approximation. Computed time-dependent solutions of the lubrication model are in general agreement with our experimental observations. Starting from a slightly-perturbed uniform coating, the full family of evolving flows is shown to depend only on three dimensionless parameters: the inclination angle of the cylinder from the vertical direction, the Bond number representing the ratio of gravity to surface tension effects, and a nondimensional measure of the initial coating thickness. Typically flow is initiated by the well-known Rayleigh-Plateau instability followed by drainage, and also wave propagation if the cylinder is not horizontal. Steady propagation of ring-like structures can occur as well as eventual overtaking, merging and reformation of the rings. We demonstrate that volumetric transport is maximized if the cylinder axis is inclined to, rather than aligned with, the direction of gravity. Results are relevant to the understanding, and potential optimization, of small-scale liquid transport. Such problems arise in the natural and industrial worlds.

Keywords: Thin Film Liquid Flow, Capillary Instability, Gravity Drainage, Lubrication Theory, Numerical Modeling, Experimental Visualization, Image Analysis

*Author to whom correspondence should be addressed. schwartz@udel.edu