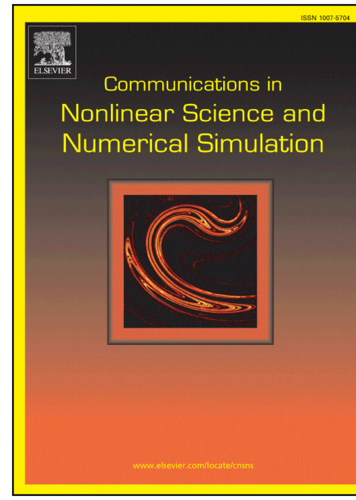

Simulation of a pending drop at a capillary tip

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Simulation of a pending drop at a capillary tip

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Abstract

We derive four different numerical schemes to compute the shape of axisymmetric drops at the tip of a capillary for a given drop volume and a given Bond number. Small drop volumes show a convex shape, however increasing the drop volume a point of inflection appears and at a critical drop volume (depending from the Bond number) the drop detaches from its capillary. One of the four schemes produces drop shapes completely different from the others. We show that these shapes are unstable by solving numerically the free boundary value problem for the transient Navier-Stokes equations.

Keywords: Pending drop, Numerical simulation, Free surface, Finite difference method, Finite element method
2000 MSC: code 76D45, 76E17, 65L60

1. Introduction

We are interested in the shape of a drop appearing at the tip of a fixed circular capillary under gravity. In a dimensionless setting the drop shape is influenced by the drop volume and the Bond number. The latter characterizes the ratio of gravitational forces to capillary forces. These shapes are used in the drop profile analysis tensiometry to determine the surface tension of a liquid experimentally [1, 2]. By means of a tailored image process the profile is fitted against the theoretical shape given as a solution of the Young-Laplace equation. This is often done by converting the Young-Laplace equation to three arc length-based first-order ordinary differential equations developed by Bashforth and Adams [3] in 1883. The set of equations is solved numerically by an initial value approach [4, 5, 6, 7]. The volume constraint is fitted by