Radially forced liquid drops

A. Ebo Adou[1,2], L. S. Tuckerman[1], D. Juric[2], J. Chergui[2] & S. Shin[3]

[1] PMMH (UMR 7636 CNRS-ESPCI-UPMC Paris 6-UPD Paris7), 10 rue Vauquelin, 75005 Paris, France
[2] LIMSI (UPR 3251 CNRS Univ. Paris Sud Paris XI) BP133, Rue J. von Neumann, 91403 Orsay, France
[3] Department of Mechanical and System Design Engineering, Hongik University, Seoul, 121-791 Korea
eboadou@espci.fr

A spherical viscous liquid drop is subjected to a radial force $(g - a\cos\omega t)\mathbf{r}$, combining oscillating and constant terms which give rise to spherical versions of the Faraday and Rayleigh-Taylor instabilities [2], respectively. The resulting nonlinear behavior is of interest to researchers in pattern formation and dynamical systems as well as having practical application over a wide variety of scales from nanodroplets to astroseismology. For the Faraday problem, we generalize the Kumar & Tuckerman [1] Floquet solution for the appearance of standing waves on a spherical interface. The deformation of the interface is expanded in spherical harmonics $Y_\ell^m(\theta,\phi)$. The drop interface is destabilized in tongue-like zones in the $(a-\omega)$ plane where a and ω are the forcing amplitude and frequency, respectively. The spherical mode ℓ at onset predicted by the linear theory agrees with full three-dimensional nonlinear numerical simulations using a massively parallel 3D two-phase flow code [3]. This code uses a hybrid front-tracking/level-set algorithm for Lagrangian tracking of arbitrarily deformable phase interfaces to calculate the time-dependent shape of the drop and the velocity field in and around it. We interpret the shape in light of theoretical results by Busse [4], Matthews [5] and others concerning pattern formation in the presence of O(3) symmetry. When the radial force is constant and the density of the exterior exceeds that of the interior, the configuration is destabilized by the Rayleigh-Taylor instability, which we simulate for high forcing amplitude.

Références

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