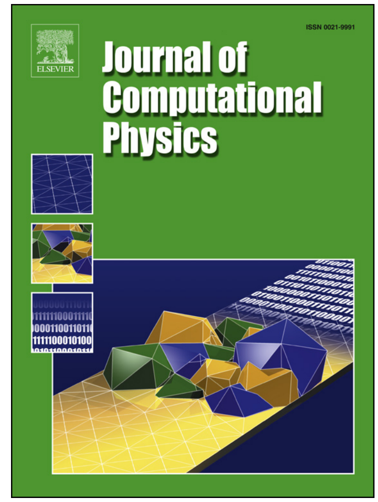
Accepted Manuscript



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PII: S0021-9991(17)30194-8
DOI: http://dx.doi.org/10.1016/j.jcp.2017.03.007
Reference: YJCPH 7211

To appear in: *Journal of Computational Physics*

Received date: 15 July 2016
Revised date: 1 March 2017
Accepted date: 5 March 2017

Please cite this article in press as: D.P. Garrick et al., A finite-volume HLLC-based scheme for compressible interfacial flows with surface tension, *J. Comput. Phys.* (2017), http://dx.doi.org/10.1016/j.jcp.2017.03.007

A finite-volume HLLC-based scheme for compressible interfacial flows with surface tension

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Abstract

Shock waves are often used in experiments to create a shear flow across liquid droplets to study secondary atomization. Similar behavior occurs inside of supersonic combustors (scramjets) under startup conditions, but it is challenging to study these conditions experimentally. In order to investigate this phenomenon further, a numerical approach is developed to simulate compressible multiphase flows under the effects of surface tension forces. The flow field is solved via the compressible multicomponent Euler equations (i.e., the five equation model) discretized with the finite volume method on a uniform Cartesian grid. The solver utilizes a total variation diminishing (TVD) third-order Runge-Kutta method for time-marching and second order TVD spatial reconstruction. Surface tension is incorporated using the Continuum Surface Force (CSF) model. Fluxes are upwinded with a modified Harten-Lax-van Leer Contact (HLLC) approximate Riemann solver. An interface compression scheme is employed to counter numerical diffusion of the interface. The present work includes modifications to both the HLLC solver and the interface compression scheme to account for capillary force terms and the associated pressure jump across the gas-liquid interface. A simple method for numerically computing the interface curvature is developed and an acoustic scaling of the surface tension coefficient is proposed for the non-dimensionalization of the model. The model captures the surface tension induced pressure jump exactly if the exact curvature is known and is further verified with an oscillating elliptical droplet and Mach 1.47 and 3 shock-droplet interaction problems. The general characteristics of secondary atomization at a range of Weber numbers are also captured in a series of simulations.

Keywords: Compressible multiphase, HLLC, surface tension, capillary forces, conservative level set, interface capturing, interface compression

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