Los Alamos NATIONAL LABORATORY

Application and Study of the KM and VKL Methods on Flows with Interfaces

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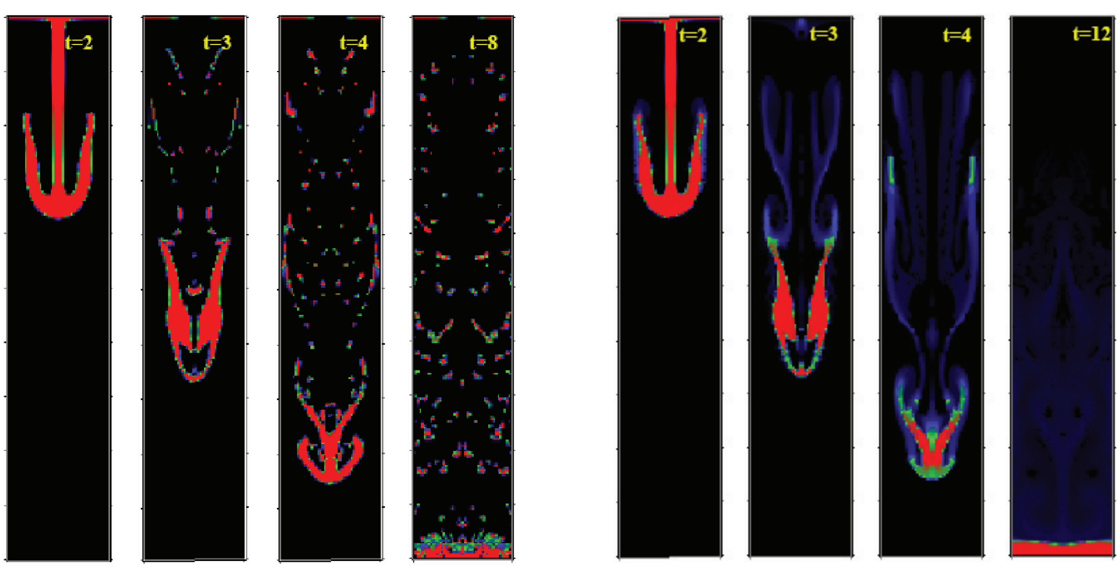
Project Description

A challenge in the computation of multidimensional, multimaterial gas dynamic flows is the simulation of severe material interface distortions. Highly distorted regions develop in many physical phenomena, including fluid instabilities leading to turbulent mixing. Engineering-scale flows presently cannot be simulated in a manner that is faithful to the fundamental physics at all length scales; consequently, interface or volume-tracking methods, in which computational cells contain several materials ("mixed cells"), must be employed. This topic is the focus of this project.

An initial study of these methods was completed under contract 377130133 in FY03, which covered the basic algorithms, simulations, and documentation of the methods in the VNIIEF LEGAK family of codes. That initial study described two techniques developed at VNIIEF: (1) the Concentration Method (KM) and (2) the Singled-Out Contact Lines (VKL) Method. The current project significantly extends these studies, providing understanding of the fundamental performance and characteristics of these algorithms on high-deformation fluid flow problems.

Technical Purpose and Benefits

This work supports the objectives of the NNSA and both research institutions (LANL and VNIIEF) by providing a critical, quantitative examination of multimaterial hydrodynamics algorithms used in VNIIEF simulation codes.



Comparison of late-time Rayleigh-Taylor simulation: left—using the method of concentrations (KM) without homogenization; right—using the homogenized three-fluid model.

Tasks to be completed during the first year of this project include (1) implementing high-resolution methods for the remap (advection) step of the algorithm and verifying this implementation in 1-D; (2) studying velocity smoothing on 2D test problems; and (3) computing, evaluating, and quantitatively assessing the accuracy of the KM and VKL methods on pure interface transport. Results have shown that (1) the particular advection method has a smaller effect than the interface treatment for hydrodynamic mixing; (2) velocity smoothing has a noticeable effect on small- and intermediate-scale structures in Rayleigh-Taylor flow; and (3) pure interface transport test problems clearly indicate that VNIIEF is using modern, high-resolution techniques.

Tasks to be completed in the second year of the project include work to (1) describe and implement algorithms for homogenization of disparate materials in the KM and VKL methods, providing evaluation of these approaches on specified test problems and (2) implement a tensor artificial viscosity in the Lagrangian step of the solution algorithm in LEGAK and quantitatively exercise these approaches on specified 2D problems. The outcome of this study included the following: (1) the so-called "three fluid" model used by VNIIEF is a unique method in multimaterial hydrodynamics that provides a novel approach to the homogenization problem with very good results and (2) edge- and projection-based tensor viscosities provide performance superior to the traditional Richtmyer-Neumann viscosity for both shock calculations and adiabatic flow problems.

ВНИИ
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