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Abstracts of Papers to Appear

INTERFACIAL DYNAMICS FOR STOKES FLOW. C. Pozrikidis. *Department of Mechanical and Aerospace Engineering, University of California, San Diego, La Jolla, California 92093-0411.*

Theoretical and computational aspects of the method of interfacial dynamics for flow at vanishing Reynolds number are considered. The mathematical formulation relies on the boundary-integral representation, which expresses the flow in terms of distributions of Stokes-flow singularities over the interfaces. The densities of the distributions are identified with the jump in hydrodynamic traction due to interfacial in-plane and transverse tensions, the interfacial velocity, or the strength of a hydrodynamic potential. The numerical procedure involves describing the interfaces in terms of interfacial marker points that reproduce the evolving shapes of the interfaces by global or local interpolation; solving integral equations of the second kind for the interfacial velocity or for the density of a hydrodynamic potential; and computing the motion of the marker points while simultaneously updating interfacial fields relevant to the dynamics, including the concentration of a surfactant and the position of interfacial point particles at an equilibrium configuration. Interfaces exhibiting isotropic tension, elastic tensions, and viscous and incompressible behavior are considered. The mathematical modeling of the tensions and bending moments developing over interfaces with a membrane-like constitution is discussed in the context of the theory of thin shells. To facilitate the numerical implementation, the coupling of the interfacial mechanics to the hydrodynamics by means of interface force and torque balances is formulated in global Cartesian coordinates. Recent progress in the implementation of boundary-element methods is reviewed, and areas for further research are identified.

ESTIMATION OF LOCAL MODELING ERROR AND GOAL-ORIENTED ADAPTIVE MODELING OF HETEROGENEOUS MATERIALS. I. ERROR ESTIMATES AND ADAPTIVE ALGORITHMS. J. Tinsley Oden and Kumar S. Vemaganti. *Texas Institute for Computational and Applied Mathematics, The University of Texas at Austin, Austin, Texas.*

A theory of a posteriori estimation of modeling errors in local quantities of interest in the analysis of heterogeneous elastic solids is presented. These quantities may, for example, represent averaged stresses on the surfaces of inclusions or mollifications of pointwise stresses or displacements, or, in general, local features of the “fine-scale” solution characterized by continuous linear functionals. These estimators are used to construct goal-oriented adaptive procedures in which models of the microstructure are adapted so as to deliver local features to a preset level of accuracy. Algorithms for implementing these procedures are discussed and preliminary numerical results are given. The analysis is restricted to linear, static, heterogeneous, elastic materials.

A FLUX SPLITTING SCHEME FOR COMPRESSIBLE AND INCOMPRESSIBLE FLOWS. Cord-Christian Rossow. *DLR, Deutsches Zentrum für Luft- und Raumfahrt, Institut für Entwurfsaerodynamik, 38022 Braunschweig, Germany.*

A recently proposed flux-splitting scheme suitable for compressible flow is extended to incompressible flows. Appropriate dissipation terms for both incompressible and compressible flows are determined by expanding the Roe flux-difference splitting in terms of Mach number. Analysis of the dissipation terms in this form for both the Roe scheme and the basic (current) scheme leads to the incorporation of certain terms into the basic scheme to establish the transition from compressible flow toward the incompressible limit. When the proper terms are used in the dissipation formulation, convergence rates for airfoil flows became nearly independent of the freestream Mach number.

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A PSEUDO-SPECTRAL SCHEME FOR THE INCOMPRESSIBLE NAVIER–STOKES EQUATIONS USING UNSTRUCTURED NODAL ELEMENTS. T. Warburton,* L. F. Pavarino,† and J. S. Hesthaven.* *Division of Applied Mathematics, Brown University, Providence, Rhode Island 02912; and †Department of Mathematics, Università di Milano Via Saldini 50, 20133, Milan, Italy.

A pseudo-spectral scheme for solving the incompressible Navier–Stokes equations using unstructured nodal triangles is proposed. Efficient algorithms are developed with numerical evidence that indicates that optimal rates of convergence can be achieved. Navier–Stokes simulations of Kovasznay, shear layer roll-up, and flow past a cylinder are included to show comparisons between the different nodal sets considered and an alternative modal approach.

AN IMPLICIT SCHEME FOR SOLVING THE CONVECTION–DIFFUSION–REACTION EQUATION IN TWO DIMENSIONS. Tony W. H. Sheu, S. K. Wang, and R. K. Lin. *Department of Naval Architecture and Ocean Engineering, National Taiwan University, Taipei, Taiwan, Republic of China.*

We consider a passive scalar transported in a two-dimensional flow. The governing equation is the convection–diffusion–reaction equation. For purposes of computational efficiency, we apply an alternating direction implicit scheme akin to that proposed by Polezhaev. Use of this implicit operator splitting scheme allows the application of a tridiagonal Thomas solution solver to obtain the solution. Within each solution step, a semidiscretization scheme is applied to discretize the differential equation in one dimension. We approximate the time derivative term using a forward time-stepping scheme. The resulting inhomogeneous differential equation has only spatial derivative terms and is solved using a newly proposed nodally exact steady-state convection–diffusion–reaction scheme. Details on the development of the flux discretization scheme are provided. Modified equation analysis, Fourier stability analysis, and the study of scheme monotonicity are also performed to shed further light on the proposed transient scheme. To validate the proposed scheme, we first consider test problems which are amenable to analytic solutions. Good agreement is obtained with both one- and two-dimensional steady/unsteady problems, thus demonstrating the validity of the method.