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Abstracts of Papers to Appear

DIFFERENT MODES OF RAYLEIGH–BÉNARD INSTABILITY IN TWO- AND THREE-DIMENSIONAL RECTANGULAR ENCLOSURES. Alexander Yu. Gelfgat. *Computational Mechanics Laboratory, Faculty of Mechanical Engineering, Technion—Israel Institute of Technology, Haifa 32000, Israel.*

The article describes a complete numerical solution of a recently formulated benchmark problem devoted to the parametric study of Rayleigh–Bénard instability in rectangular two- and three-dimensional boxes. The solution is carried out by the spectral Galerkin method with globally defined, three-dimensional, divergent-free basis functions, which satisfy all boundary conditions. The general description of these three-dimensional basis functions, which can be used for a rather wide spectrum of problems, is presented. The results of the parametric calculations are presented as neutral curves showing the dependence of the critical Rayleigh number on the aspect ratio of the cavity. The neutral curves consist of several continuous branches, which belong to different modes of the most dangerous perturbation. The patterns of different perturbations are also reported. The results obtained lead to some new conclusions about the patterns of the most dangerous perturbations and about the similarities between two- and three-dimensional models. Some extensions of the considered benchmark problem are discussed.

NUMERICAL SOLUTION OF A GENERALIZED ELLIPTIC PARTIAL DIFFERENTIAL EIGENVALUE PROBLEM. S. R. Otto* and James P. Denier.† **School of Mathematics and Statistics, University of Birmingham, Edgbaston, Birmingham B15 2TT, United Kingdom; and †Department of Applied Mathematics, University of Adelaide, Adelaide 5005, Australia.* E-mail: S.R.Otto@bham.ac.uk, jdenier@maths.adelaide.edu.au.

In this article we discuss a method for the solution of nonseparable eigenvalue problems. These problems are taken to be elliptic and linear, and arise in a whole host of physically interesting problems. The approach exploits finite differences and a pseudo-spectral scheme. We elect to normalise at a single point, which is usually internal to the domain, and exploit the fact that the partial differential equation has not been satisfied at this point to determine whether we have an eigenvalue of the system. The eigenvalue solver is of a local nature and is consequently relatively inexpensive to run.

DIRECT SIMULATIONS OF 2D FLUID-PARTICLE FLOWS IN BIPERIODIC DOMAINS. B. Maury. *Laboratoire d'Analyse Numérique URA CNRS 189, tour 55-65, 5ème étage, Université Pierre et Marie Curie, 4, place jussieu 75 252 Paris Cedex 05, France.* E-mail: maury@ann.jussieu.fr.

We propose a method to simulate the motion of 2D rigid particles in a viscous, incompressible fluid. Within the Arbitrary Lagrangian Eulerian framework, momentum equations for both the fluid and the particles are discretized, and a coupled variational formulation is established. By introducing an appropriate finite element approximation, a symmetric linear system is obtained. This system is solved by an inexact Uzawa algorithm. The main interest of such simulations lies in the average behaviour of a high number of particles. We therefore introduced a biperiodic formulation of the problem, which makes it possible to represent many-body mixtures at a reasonable computational cost. In order to model realistic situations, an extra term must be added to the pressure. This extra term is shown to be the Lagrange multiplier associated with the vertical volume conservation constraint. We developed an appropriate unstructured mesh generator, so that the biperiodicity of the fields can be treated in a strong sense. The question of particle contact is addressed, and a simple technique to overcome numerical problems is proposed. The influence of periodic lengths is investigated through different simulations. The same case is simulated for different sizes of the window, and the behaviour of some space-averaged quantities is studied.

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A COMPUTATIONAL STUDY OF RISING PLANE TAYLOR BUBBLES. Prabir Daripa. *Department of Mathematics, Texas A&M University, College Station, Texas 77843.*

The problem of a plane bubble rising in a 2-D tube is revisited using Birkhoff's (1957) formulation. The equations in this formulation have a one-parameter (Froude number F) family of solutions which are divided into three regimes characterized by distinct topologies at the apex. These equations are solved numerically using a conventional series representation method and Newton's iterations. This numerical method fails for values of F in a range which contains the transition points. In this paper, it is demonstrated through careful numerical computations how and why this method fails. We also analyze the series and provide estimates of the transition points. This strategy of estimating the transition points can be used for some problems where the conventional series representation method fails because it does not adequately account for changes in the nature of the singularity that takes place as these transition points are approached in the parameter space. Furthermore, existence of two new critical Froude numbers is demonstrated numerically. We further show that the previous results on this problem have been incomplete by leaving out the characterization of the topology at the apex of the bubbles for values of F in the regime: $0.234 < F < 0.3578$. We also resolve this issue in this paper.

A COMPATIBLE, ENERGY AND SYMMETRY PRESERVING LAGRANGIAN HYDRODYNAMICS ALGORITHM IN THREE-DIMENSIONAL CARTESIAN GEOMETRY. E. J. Caramana, C. L. Rousculp, and D. E. Burton. *Applied Theoretical and Computational Physics Division, Los Alamos National Laboratory, Los Alamos, New Mexico 87545.*

This work presents a numerical algorithm for the solution of fluid dynamics problems with moderate to high-speed flow in three dimensions. Cartesian geometry is chosen owing to the fact that in this coordinate system no curvature terms or fictitious forces are present that break the conservation law structure of the fluid equations. Written in Lagrangian form, these equations are discretized utilizing compatible, control volume differencing with a staggered-grid placement of the spatial variables. The concept of "compatibility" means that the forces used in the momentum equation to advance velocity are also incorporated into the internal energy equation so that these equations together define the total energy as a quantity that is exactly conserved in time in discrete form. Multiple pressures are utilized in each zone; they produce forces that resist spurious vorticity generation. This difficulty can severely limit the utility of the Lagrangian formulation in two-dimensions, and make this representation otherwise virtually useless in three-dimensions. An edge-centered artificial viscosity whose magnitude is regulated by local velocity gradients is used to capture shocks. The particular difficulty of exactly preserving one-dimensional spherical symmetry in three-dimensional geometry is solved. This problem has both practical and pedagogical significance. The algorithm is suitable for both structured and unstructured grids. Limitations that symmetry preservation imposes on the latter type of grids are delineated.