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Abstracts of Papers to Appear

THE LATTICE SOLID MODEL TO SIMULATE THE PHYSICS OF ROCKS AND EARTHQUAKES: INCORPORATION OF FRICTION. David Place and Peter Mora. *Q.U.A.K.E.S., University of Queensland, 4072 QLD Brisbane, Australia.* E-mail: place@earthsciences.uq.edu.au, mora@earthsciences.uq.edu.au.

The particle-based lattice solid model developed to study the physics of rocks and the nonlinear dynamics of earthquakes is refined by incorporating intrinsic friction between particles. The model provides a means to study the causes of seismic wave attenuation, as well as frictional heat generation, fault zone evolution, and localisation phenomena. A modified velocity-Verlat scheme is developed that allows friction to be precisely modelled. This is a difficult computational problem given that a discontinuity must be accurately simulated by the numerical approach (i.e., the transition from static to dynamical frictional behaviour). This is achieved using a half time step integration scheme. At each half time step, a nonlinear system is resolved to compute the static frictional forces and states of touching particle pairs. An improved efficiency is achieved by adaptively adjusting the time step increment depending on the particle velocities in the system. The total energy is calculated and verified to remain constant to a high precision during simulations. Numerical experiments show that the model can be applied to the study of earthquake dynamics, the stick-slip instability, heat generation, and fault zone evolution. Such experiments may lead to a conclusive resolution of the heat flow paradox and an improved understanding of earthquake precursory phenomena and dynamics.

VOLUME-OF-FLUID INTERFACE TRACKING WITH SMOOTHED SURFACE STRESS METHODS FOR THREE-DIMENSIONAL FLOWS. Denis Gueyffier, Jie Li, Ali Nadim, Ruben Scardovelli, and Stéphane Zaleski. *Modélisation en Mecanique, CNRS URA 229, Université Pierre et Marie Curie, 4 place Jussieu 75005 Paris, France.* E-mail: zaleski@lmm.jussieu.fr.

Motivated by the need for three-dimensional methods for interface calculations that can deal with topology changes, we describe a numerical scheme, built from a volume-of-fluid (VOF) interface tracking technique that uses a piecewise-linear interface calculation (PLIC) in each cell. Momentum balance is computed using explicit finite volume/finite differences on a regular cubic grid. Surface tension is implemented by the continuous surface stress (CSS) or continuous surface force method (CSF). Examples and verifications of the method are given by comparing simulations to analytical results and experiments, for sedimenting droplet arrays and capillary waves at finite Reynolds number. In the case of a pinching pendant drop, both three-dimensional and axisymmetric simulations are compared to experiments. Agreement is found both before and after the reconnections.

AN INVESTIGATION INTO THE VALIDATION OF NUMERICAL SOLUTIONS OF COMPLEX FLOWFIELDS. Z. Jiang and K. Takayama. *Shock Wave Research Center, Institute of Fluid Science, Tohoku University, 2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan.* E-mail: jiang@ifs.tohoku.ac.jp, takayama@ifs.tohoku.ac.jp.

Three cases, including a two-dimensional, an axisymmetric, and a three-dimensional flowfield, were studied to demonstrate the effectiveness and reliability of a method proposed for validation of numerical solutions of complex flowfields. Images of these flowfields were first constructed from numerical solutions based on the principle of experimental flow visualization, and then compared directly with experimental interferograms. Because both experimental and numerical results are of identical physical representation, agreement between them can be evaluated effectively by examining characteristic flow structures of the flowfields as well as comparing differences in density. An efficient algorithm for three-dimensional density integration was also proposed to replace the

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conventional one that is computationally expensive. The study shows that reliable validation can be achieved in this way because it allows a direct comparison between numerical and experiment results without any loss of accuracy in either of them. The validation method is highly recommended for three-dimensional flowfields where quantification of images from experimental flow visualization is very difficult or impossible.

A MULTIPHASE GODUNOV METHOD FOR COMPRESSIBLE MULTIFLUID AND MULTIPHASE FLOWS. Richard Saurel* and Rémi Abgrali.† **IUSTI, CNRS UMR 6595, 5 rue Enrico Fermi, 13453 Marseille Cedex 13, France; and †Université de Bordeaux I, 351 cours de la Libération, 33405 Talence, France.* E-mail: richard@iusti.univ-mrs.fr, abgrall@math.u-bordeaux.fr.

We propose a new model and a resolution method for two-phase compressible flows. The model involves six equations obtained from conservation principles applied to each phase, completed by a seventh equation for the evolution of the volume fraction. This equation is necessary to the close the overall system. The model is valid for fluid mixtures, as well as for pure fluids. The system of partial differential equations is hyperbolic. Hyperbolicity is obtained because each phase is considered compressible. Two difficulties arise for the resolution: one of the equations is written in nonconservative form; nonconservative terms exist in the momentum and energy equations. We propose robust and accurate discretisation of these terms. The method solves the same system at each mesh point with the same algorithm. It allows the simulation of interface problems between pure fluid and multiphase mixtures. Several test cases where fluids have compressible behavior are shown, as well as some other test problems where one of the phases is incompressible. The method provides reliable results, is able to compute strong shock waves, and deals with complex equations of state.

AN EFFICIENT FINITE ELEMENT METHOD FOR COMPUTING SPECTRA OF PHOTONIC AND ACOUSTIC BAND-GAP MATERIALS. I. SCALAR CASE. Waldemar Axmann and Peter Kuchment. *Mathematics and Statistics Department, Wichita State University, Wichita, Kansas 67260-0033.* E-mail: kuchment@twsuvm.us.twsu.edu, axmann@twsuvm.uc.twsu.edu.

The paper describes an efficient finite element method for computing spectra of photonic and acoustic band-gap materials. In the photonic case only the scalar models are treated. The full vector model will be considered in the next publication.