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Abstracts of Papers to Appear

Variational Problems and Partial Differential Equations on Implicit Surfaces. Marcelo Bertalmío,* Li-Tien Cheng,† Stanley Osher,† and Guillermo Sapiro.* *Electrical and Computer Engineering, University of Minnesota, Minneapolis, Minnesota 55455; and †Mathematics Department, University of California, Los Angeles, California 90095.

A novel framework for solving variational problems and partial differential equations for scalar and vector-valued data defined on surfaces is introduced in this paper. The key idea is to implicitly represent the surface as the level set of a higher dimensional function and to solve the surface equations in a fixed Cartesian coordinate system using this new embedding function. The equations are then both intrinsic to the surface and defined in the embedding space. This approach thereby eliminates the need for performing complicated and inaccurate computations on triangulated surfaces, as is commonly done in the literature. We describe the framework and present examples in computer graphics and image processing applications, including texture synthesis, flow field visualization, and image and vector field intrinsic regularization for data defined on 3D surfaces.

High-Order Monotonicity-Preserving Compact Schemes for Linear Scalar Advection on 2-D Irregular Meshes. Quang Huy Tran* and Bruno Scheurer.† *Institut Français du Pétrole, Division Informatique Scientifique et Mathématiques Appliquées, 1 et 4 avenue de Bois Préau, 92852 Rueil-Malmaison Cedex, France; and †Commissariat à l'Energie Atomique, DIF, B.P. 12, 91680 Bruyères-le-Châtel, France.

This paper is concerned with the numerical solution for linear scalar advection problems, the velocity field of which may be uniform or a given function of the space variable. We would like to propose the following: (1) a new family of 1-D compact explicit schemes, which preserve monotonicity while maintaining high-order accuracy in smooth regions; and (2) an extension to the 2-D case of this family of schemes, which ensures good accuracy and isotropy of the computed solution even for very distorted meshes. A few theoretical results are proven, while abundant numerical tests are shown in order to illustrate the quality of the schemes at issue.

Numerical Methods for Multiple Inviscid Interfaces in Creeping Flows. M. C. A. Kropinski. Department of Mathematics and Statistics, Simon Fraser University, Burnaby, British Columbia, Canada V5A 1S6.

We present new, highly accurate, and efficient methods for computing the motion of a large number of two-dimensional closed interfaces in a slow viscous flow. The interfacial velocity is found through the solution to an integral equation whose analytic formulation is based on complex-variable theory for the biharmonic equation. The numerical methods for solving the integral equations are spectrally accurate and employ a fast multipole-based iterative solution procedure, which requires only $O(N)$ operations where N is the number of nodes in the discretization of the interface. The interface is described spectrally, and we use evolution equations that preserve equal arclength spacing of the marker points. We assume that the fluid on one side of the interface is inviscid and we discuss two different physical phenomena: bubble dynamics and interfacial motion driven by surface tension (viscous sintering). Applications from buoyancy-driven bubble interactions, the motion of polydispersed bubbles in an extensional flow, and the removal of void spaces through viscous sintering are considered and we present large-scale, fully resolved simulations involving $O(100)$ closed interfaces.

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Flux Correction Tools for Finite Elements. D. Kuzmin and S. Turek. Institute of Applied Mathematics, LS III University of Dortmund, Vogelpothsweg 87 D-44227, Dortmund, Germany.

Flux correction in the finite element context is addressed. Criteria for positivity of the numerical solution are formulated, and the low-order transport operator is constructed from the discrete high-order operator by adding modulated dissipation so as to eliminate negative off-diagonal entries. The corresponding antidiffusive terms can be decomposed into a sum of genuine fluxes (rather than element contributions) which represent bilateral mass exchange between individual nodes. Thereby, essentially one-dimensional flux correction tools can be readily applied to multidimensional problems involving unstructured meshes. The proposed methodology guarantees mass conservation and makes it possible to design both explicit and implicit FCT schemes based on a unified limiting strategy. Numerical results for a number of benchmark problems illustrate the performance of the algorithm.

On Time-Splitting Spectral Approximations for the Schrödinger Equation in the Semiclassical Regime. Weizhu Bao,* Shi Jin,† and Peter A. Markowich.‡ *Department of Computational Science, National University of Singapore, Singapore 117543; †Department of Mathematics, University of Wisconsin-Madison, Madison, Wisconsin 53706; and ‡Institute of Mathematics, University of Vienna Boltzmanngasse 9, A-1090 Vienna, Austria.

In this paper we study time-splitting spectral approximations for the linear Schrödinger equation in the semiclassical regime, where the Planck constant ε is small. In this regime, the equation propagates oscillations with a wavelength of $O(\varepsilon)$, and finite difference approximations require the spatial mesh size $h = o(\varepsilon)$ and the time step $k = o(\varepsilon)$ in order to obtain physically correct observables. Much sharper mesh-size constraints are necessary for a uniform L^2-approximation of the wave function. The spectral time-splitting approximation under study will be proved to be unconditionally stable, time reversible, and gauge invariant. It conserves the position density and gives uniform L^2-approximation of the wave function for $k = o(\varepsilon)$ and $h = O(\varepsilon)$. Extensive numerical examples in both one and two space dimensions and analytical considerations based on the Wigner transform even show that weaker constraints (e.g., k independent of ε, and $h = O(\varepsilon)$) are admissible for obtaining “correct” observables. Finally, we address the application to nonlinear Schrödinger equations and conduct some numerical experiments to predict the corresponding admissible meshing strategies.