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Abstracts of Papers to Appear

A FAST, MATRIX-FREE IMPLICIT METHOD FOR COMPRESSIBLE FLOWS ON UNSTRUCTURED GRIDS. Hong Luo,* Joseph D. Baum,* and Rainald Löhner†. **Applied Physics Operations, Science Applications International Corporation, McLean, Virginia 22102; †Institute for Computational Sciences and Informatics, George Mason University, Fairfax, Virginia 22030.* E-mail: luo@mclapo.saic.com.

A fast, matrix-free implicit method has been developed to solve the three-dimensional compressible Euler and Navier–Stokes equations on unstructured meshes. An approximate system of linear equations arising from the Newton linearization is solved by the GMRES (generalized minimum residual) algorithm with a LU-SGS (lower–upper symmetric Gauss–Seidel) preconditioner. A remarkable feature of the present GMRES+LU-SGS method is that the storage of the Jacobian matrix can be completely eliminated by approximating the Jacobian with numerical fluxes, resulting in a matrix-free implicit method. The method developed has been used to compute the compressible flows around 3D complex aerodynamic configurations for a wide range of flow conditions, from subsonic to supersonic. The numerical results obtained indicate that the use of the GMRES+LU-SGS method leads to a significant increase in performance over the best current implicit methods, GMRES+ILU and LU-SGS, while maintaining memory requirements similar to its explicit counterpart. An overall speedup factor from eight to more than one order of magnitude for all test cases in comparison with the explicit method is demonstrated.

NUMERICAL SOLUTION OF THE HELMHOLTZ EQUATION IN 2D AND 3D USING A HIGH-ORDER NYSTRÖM DISCRETIZATION. Lawrence F. Canino, John J. Ottusch, Mark A. Stalzer, John L. Visher, and Stephen M. Wandzura. *Computational Physics Department of the Communications and Photonics Laboratory, HRL Laboratories, M/S RL65, 3011 Malibu Canyon Road, Malibu, CA 90265-4799.* E-mail: ottusch@hrl.com.

We show how to solve time-harmonic scattering problems by means of a high-order Nyström discretization of the boundary integral equations of wave scattering in 2D and 3D. The novel aspect of our new method is its use of local corrections to the discretized kernel in the vicinity of the kernel singularity. Enhanced by local corrections, the new algorithm has the simplicity and speed advantages of the traditional Nyström method, but also enjoys the advantages of high-order convergence for controlling solution error. We explain the practical details of implementing a scattering code based on a high-order Nyström discretization and demonstrate by numerical example that a scattering code based on this algorithm can achieve high-order convergence to the correct answer. We also demonstrate its performance advantages over a high-order Galerkin code.

A QUASI-TWO-DIMENSIONAL BENCHMARK PROBLEM FOR LOW MACH NUMBER COMPRESSIBLE CODES. Ananias G. Tomboulides* and Steven A. Orzag†. **Department of Aerospace and Mechanical Engineering, Boston University, 110 Cummington St., Boston, Massachusetts 02215; †Fluid Dynamics Research Center, James Forrestal Campus, Princeton University, Princeton, New Jersey 08544-0710.* E-mail: at@omega.bu.edu.

A quasi-two-dimensional model problem is presented, which can be used as a benchmark problem for verification of numerical methods for the solution of the low Mach number compressible reactive flow equations. A recently developed high order splitting method for this type of problem is presented and analyzed, and the behavior of the numerical errors is assessed and compared to asymptotic estimates. It is found that the behavior of splitting errors is predicted well by the asymptotic estimates and that these errors are always smaller than the formal truncation order of the integrating scheme.

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ON NUMERICAL APPROXIMATION OF ELECTROSTATIC ENERGY IN 3D. Daniele Finocchiaro,* Marco Pellegrini,† and Paolo Bientinesi‡. **Scuola Normale Superiore, Pisa, Italy; †Institute for Computational Mathematics of CNR, Pisa, Italy; ‡University of Pisa, Pisa, Italy.* E-mail: fino@cibs.sns.it, pellegrini@imc.pi.cnr.it, bientin@matcomp1.imc.pi.cnr.it.

Approximating the Coulomb self-energy of a charge distribution within a three-dimensional domain and the mutual Coulomb energy of two charge distributions often constitutes a computational bottleneck in the simulation of physical systems. The present article reports on a recently developed computational technique aimed at the numerical evaluation of the six-dimensional integrals arising from Coulomb interactions. Techniques from integral geometry are used to show a reduction of the domain from six-dimensional to two-dimensional. In the process analytic singularities due to Coulomb's law are eliminated. Experimental results on the self-energy of a charged cube show that the proposed method converges rapidly and is competitive with methods proposed in the literature for similar integration problems.

NUMERICAL SOLUTION OF FISHER'S EQUATION USING A MOVING MESH METHOD. Y. Qiu and D. M. Sloan. *Department of Mathematics, University of Strathclyde, Glasgow G1 1XH, Scotland.* E-mail: y.qiu@strath.ac.uk, d.sloan@strath.ac.uk.

The paper investigates the viability of using moving mesh methods to simulate travelling wave solutions of Fisher's equation. Results are presented that illustrate the weaknesses in moving mesh methods based on equidistribution of some popular monitor functions. It is shown that knowledge of the differential equation and the travelling wave solution may be used to construct a monitor function that yields accurate results with suitably chosen moving mesh methods. A comparison is made between a moving mesh partial differential equation and a moving mesh differential-algebraic equation for the evolution in time.