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trices corresponding to univariate Hermite interpolation problems. We also consider the case of generalized polynomials, such as Cauchy-Vandermonde systems.

Key Words.
Hermite interpolation, bivariate interpolation, generalized Kronecker product

AMS Subject Classifications.
41A05, 41A63, 65D05

31 Numerical bifurcation of separable parameterized equations. *Yun-Qiu Shen and Tjalling J. Ypma*.

Abstract.
Many applications give rise to separable parameterized equations, which have the form $A(y, \mu)z + b(y, \mu) = 0$, where $z \in \mathbb{R}^N$, $y \in \mathbb{R}^n$, $\mu \in \mathbb{R}^s$, and the $(N + n) \times N$ matrix $A(y, \mu)$ and $(N + n)$ vector $b(y, \mu)$ are C^2-Lipschitzian in $(y, \mu) \in \Omega \subset \mathbb{R}^n \times \mathbb{R}^s$. We present a technique which reduces the original equation to the form $f(y, \mu) = 0$, where $f : \Omega \to \mathbb{R}^n$ is C^2-Lipschitzian in (y, μ). This reduces the dimension of the space within which the bifurcation relation occurs. We derive expressions required to implement methods to solve the reduced equation. Numerical examples illustrate the use of the technique.

Key Words.
separable parameterized equations, singular value decomposition, static bifurcation points, extended systems, Newton's method, LU factorization, curve switching and tracking

AMS Subject Classifications.
65P30, 65H10, 37G10, 34C23

44 Random coefficient differential models of growth of anaerobic photosynthetic bacteria. *Dan Stanescu, Benito Chen-Charpentier, Brandi J. Jensen, and Patricia J. S. Colberg*.

Abstract.
In many fields of science and engineering there are mathematical models given in terms of differential equations with random coefficients. The randomness is due to errors or uncertainty. Closed solutions are few, and usually numerical approximations need to be calculated. Polynomial chaos is a powerful method in this regard. Here we apply this method to several modeling approaches for the time evolution of photosynthetic bacterial populations. Usual methods used in microbiology are contrasted with approaches based on differential equations with random coefficients. Numerical results based on laboratory data for two different species of bacteria are presented.

Key Words.
bacterial growth models, random differential equations, curve fitting

AMS Subject Classifications.
60H25, 65C20, 92D25

59 Elliptic grids with nearly uniform cell area and line spacing. *Vianey Villamizar and Sebastian Acosta*.

Abstract.
Two new quasi-linear elliptic systems of partial differential equations to automatically generate two-dimensional boundary conforming structured grids are formulated. One of the new systems generates grids with near-uniform cell areas. The other produces meshes with near-uniform coordinate line spacings. In both cases, the resulting grids conform to complex boundaries with severe singularities without self-overlapping. In contrast with other elliptic generators, the control functions are held as dependent variables. They obey Poisson-type equations with appropriate forcing. Grid quality analysis reveals the advantage in terms of smoothness and cell area uniformity of the new grids compared with other structured grids. An efficient procedure to combine the novel elliptic grids with algebraic grids for large domains is devised.

Key Words.
elliptic grids, control functions, smoothness, complex geometries, nearly uniform cell area, nearly uniform grid line spacing, mixed grids

AMS Subject Classifications.
65N50, 65D10, 35J60

76 Generating quality structured convex grids on irregular regions. *P. Barrera-Sánchez, F. J. Domínguez-Mota, G. González-Flores, and J. G. Tinoco-Ruiz.*

Abstract.
In this paper, we address the problem of generating good quality grids on very irregular regions, and propose a measure for both the quality of the generated grids and the difficulty of the problem, as well as an efficient algorithm based on the minimization of area functionals to solve it. Using the proposed measure, a preliminary classification of some standard test regions is presented.

Key Words.
numerical grid generation, variational grid generation, area functionals, direct optimization method

AMS Subject Classifications.
65L50, 65M50, 65N50, 78M50, 80M30

90 Impact of gravity on thin-layer cell electrochemical deposition. *E. Mocskos and G. Marshall.*

Abstract.
Electrochemical deposition (ECD) in thin cells with different orientations relative to gravity leads to complex stable and unstable physicochemical hydrodynamic flows. Here we study the impact of gravity on these flows through a theoretical macroscopic 3D model and its numerical simulation. The model describes the diffusive, migratory, and convective motion of ions in a fluid subject to an electric field through the Nernst-Planck, Poisson, and Navier-Stokes equations, respectively. The equations are written in terms of dimensionless quantities, in particular, the gravity Grashof number, revealing the importance of gravitoconvection. The nonlinear system of partial differential equations is solved on a uniform grid using finite differences and

a strongly implicit iterative scheme. In ECD in a cell in a horizontal position, our model predicts the evolution of two gravity-driven convective rolls and concentration shells attached to each electrode. We predict their birth, growth, expansion towards one another, collision, and merger into a single roll that invades the whole cell. In ECD in a cell in a vertical position, cathode above anode, our model predicts that gravity-induced rolls and concentration shells remain locally attached to fingers that grow downwards; thus, global invasion of the cell by gravity-induced rolls is suppressed, leading to a stable stratified flow. In ECD in a cell in a vertical position, cathode below anode, our model predicts the detachment of rolls and concentration shells from each electrode in the form of plumes that expand towards one another, mix, invade the whole cell, and lead to an unstable stratified flow. For ECD, whether in horizontal or vertical position, in the presence of growth, our model predicts the existence of an electrically driven vortex ring at the dendrite tip that interacts with concentration shells and rolls, leading to complex helicoidal flows. Such structures are experimentally observed, suggesting that ion transport underlying dendrite growth is remarkably well captured by our model.

Key Words.
electrochemical deposition, computational modeling, finite differences, stable physicochemical hydrodynamic flows, unstable physicochemical hydrodynamic flows

AMS Subject Classifications.
76W05, 76U05, 65Z05, 65C20, 68U20, 65M06, 76D05

102 Hybrid compact-WENO scheme for solving relativistic flows. *Ricard Garrido, Pedro González-Casanova, and Elvira Torondel.*

Abstract.
In this paper the method hybrid compact-WENO proposed by Yu-Xin Ren, Miao'er Liu and Hanxin Zhang has been modified to be used for relativistic fluid dynamics instead of Euler equations. The behavior of this new fifth-order conservative hybrid method is analyzed.

Key Words.
hybrid compact-WENO, compact schemes, relativistic fluid dynamics, relativistic flows

AMS Subject Classifications.
15A15, 15A09, 15A23

119 Numerical study of a descending sphere in a low Reynolds number strongly stratified fluid. *Carlos R. Torres, Dany De Cecchis, Germán Larrazábal, and José Castillo.*

Abstract.
The flow generated by a sphere descending uniformly in a linearly stratified diffusive fluid is investigated numerically for different Reynolds (Re) and Froude (F) numbers. The parameters used for the simulations were $10^{-1} \leq Re \leq 10$ and $10^{-2} \leq F \leq 10^{2}$, keeping the Schmidt number, Sc ($= 700$, typical of sea water) fixed. The results demonstrate drag dependence on viscosity and stratification,

suggesting that changes in these parameters would be intimately related to the phenomena of zooplankton vertical movement in the ocean.

Key Words.
stratified fluid, flow past sphere, low Reynolds number, MAC method, preconditioning, Krylov methods

AMS Subject Classifications.
35Q30, 35Q35, 35K15, 35K20

125 Chebyshev semi-iteration in preconditioning for problems including the mass matrix. *Andy Wathen and Tyrone Rees*.

Abstract.
It is widely believed that Krylov subspace iterative methods are better than Chebyshev semi-iterative methods. When the solution of a linear system with a symmetric and positive definite coefficient matrix is required, the Conjugate Gradient method will compute the optimal approximate solution from the appropriate Krylov subspace, that is, it will implicitly compute the optimal polynomial. Hence a semi-iterative method, which requires eigenvalue bounds and computes an explicit polynomial, must, for just a little less computational work, give an inferior result. In this manuscript, we identify a specific situation in the context of preconditioning where finite element mass matrices arise as certain blocks in a larger matrix problem when the Chebyshev semi-iterative method is the method of choice, since it has properties which make it superior to the Conjugate Gradient method. In particular, the Chebyshev method gives preconditioners which are linear operators, whereas corresponding use of conjugate gradients would be nonlinear. We give numerical results for two example problems, the Stokes problem and a PDE control problem, where such nonlinearity causes poor convergence.

Key Words.
iteration, linear systems, preconditioning, finite elements, mass matrix

AMS Subject Classifications.
6F10, 65N20

136 Implicitly preconditioned and globalized residual method for solving steady fluid flows. *Jean-Paul Chehab and Marcos Raydan*.

Abstract.
We develop a derivative-free preconditioned residual method for solving nonlinear steady fluid flows. The new scheme is based on a variable implicit preconditioning technique associated with the globalized spectral residual method. The new scheme is robust and allows numerical computation of the steady state of the two-dimensional incompressible Navier-Stokes equations (NSE), which we consider here in both primary variables and streamfunction-vorticity formulations. The results are encouraging and agree with those reported in the literature.

Key Words.
nonlinear systems of equations, residual methods, globalization strategies, preconditioning, Navier-Stokes equations

AMS Subject Classifications.
76D05, 65H10, 76M20, 90C30

152 Mimetic schemes on non-uniform structured meshes. *E. D. Batista and J. E. Castillo*.

Abstract.
Mimetic operators are approximations that satisfy discrete versions of continuum conservation laws. We propose a technique for constructing mimetic divergence and gradient operators over non-uniform structured meshes based on the application of local transformations and the use of a reference set of cells (RSC). The RSC is not a mesh, but a set of two uniform elements that are used while the operators are being built. The method has been applied to construct second and fourth order gradient and divergence operators over non-uniform 1D meshes. Our approach leaves invariant the boundary operator expressions for uniform and non-uniform meshes, which is a new result and an advantage of our formulation. Finally, a numerical convergence analysis is presented by solving a boundary layer like problem with Robin boundary conditions; this shows that we can obtain the highest order of accuracy when implementing adapted meshes.

Key Words.
mimetic schemes, summation-by-part operators, non-uniform meshes, partial differential equations, high order, divergence operator, gradient operator, boundary operator

AMS Subject Classifications.
65D25, 65M06, 65G99

163 Boosting the inverse interpolation problem by a sum of decaying exponentials using an algebraic approach. *Marco Paluszny, Miguel Martín–Landrove, Giovanni Figueroa, and Wuilian Torres*.

Abstract.
An algebraic method is proposed to solve the inverse interpolation problem for data fitting by a linear combination of decaying exponentials. The method transforms the interpolation question into a problem of finding the roots of a single polynomial. The method is validated by numerical simulations using noiseless synthetic data with excellent results. The method is applied to medical data coming from magnetic resonance images of tumoral lesions in brain to obtain relaxation rate distribution functions, with results that are trustworthy and fast when compared with inverse Laplace methods.

Key Words.
de Prony's method, continuation methods, Gröbner bases, exponential equations, polynomial equations, nonlinear algebraic equations

AMS Subject Classifications.
15A15, 15A09, 15A23

170 On the discrete solution of the generalized Stokes problem in one time-step for two phase flow. *Wilfredo Angulo and Hilda López.*

Abstract.
In this paper, we demonstrate the existence, uniqueness, and uniform stability of the discrete solution obtained with the nonconforming Crouzeix-Raviart/P_0 finite element for a generalized Stokes problem of a two-phase flow in one time-step.

Key Words.
two-phase flow, Stokes problem, discrete solution, finite element

AMS Subject Classifications.
15A15, 15A09, 15A23

187 Comparison between different numerical discretizations for a Darcy-Forchheimer model. *Hilda López, Brígida Molina, and José J. Salas.*

Abstract.
This paper is a numerical study of different discretizations for a mixed formulation of the Darcy-Forchheimer equation. Different finite elements are used: constant functions, conformal linear functions and Crouzeix-Raviart non-conformal finite elements. The behavior of the discretizations is analyzed through a comparative study of some test problems. The numerical results suggest that one of the proposed discretizations has better convergence properties for the velocity.

Key Words.
Darcy-Forchheimer's model, mixed formulation, numerical discretizations, finite elements, algorithm of alternating directions

AMS Subject Classifications.
35Q35, 74S05, 58C15, 65F10