Book of Abstracts of the
2^{nd} Annual Meeting of
Lebanese Society for Mathematical Sciences
LSMS-2011

April 1-2, 2011

Lebanese American University

Organized by the

Lebanese Society for Mathematical Sciences,
Lebanese American University,

and the

Lebanese University

in collaboration with the

Center for Advanced Mathematical Sciences
(AUB-CAMS)

and sponsored by the

National Center for Scientific Research

Foreword

The 2^{nd} annual meeting of the Lebanese Society for Mathematical Sciences (LSMS-2011) was held on the Beirut Campus of the Lebanese American University on April 1-2, 2011. LSMS-2011 was preceded by a two-day workshop on Stochastic Analysis and Partial Differential Equations on the Hadath Campus of the Lebanese University. The complete proceedings of the LSMS-2011 meeting will be published in a special edition of Elsevier's Procedia.

Rony Touma
Chairman, Organizing Committee

Acknowledgements

The organization of the second annual meeting of the Lebanese Society for Mathematical Sciences would not have been possible without the collaboration, help and contribution of a number of individuals and institutions.

First and foremost, we wish to thank the administration of the Lebanese American University for the unequivocal support to host this meeting. We acknowledge as well the help of the staff at LAU, the personnel of the Department of Computer Science and Mathematics, and the students and assistants for their efficiency and valuable collaboration.

We also acknowledge the support of our collaborators and sponsors who have greatly assisted in the organization of this meeting: The Center for Advanced Mathematical Sciences at AUB (CAMS) and the Lebanese National Center for Scientific Research (NCSR).

Many thanks are also owed to our plenary speakers (Prof. Mohamed Ayad, Prof. Thierry Coupez, Prof. Salah Doma, Prof. Amine El-Sahily, Dr. Ibrahim Hoteit, Prof. Christian Klingenberg, Prof. Gabriella Puppo, and Prof. Athanasios Tzavaras) for having accepted to share some of their most recent and innovative work with us.

We also thank all the members of the Scientific Committee who helped us in the selection, distribution, and reviewing of the abstracts that were delivered at this meeting.

Last but not least, we thank all the participants in the LSMS-2011 meeting as well as the contributed speakers.

On Behalf of the Organizing Committee
Rony Touma (Chair)

LSMS-2011 Organization

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Dr. Raafat Talhouk	Lebanese University

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Plenary Sessions

The LSMS-2011 Invited Speakers are:

Prof. Mohamed Ayad	France
Prof. Thierry Coupez	France
Prof. Salah Doma	Egypt
Prof. Amine El-Sahily	Lebanon
Dr. Ibrahim Hoteit	Saudi Arabia
Prof. Christian Klingenberg	Germany
Prof. Gabriella Puppo	Italy
Prof. Athanasios Tzavaras	Greece

Composition, Iteration and Irreducibility of Polynomials

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Abstract

I will review some known resuls on the functional decomposition of a given polynomial over a field. In a second part the composition of polynomials is related to the irreducibity of the resulting polynomial. I will focus on the problem of the stability of polynomials. More precisely let K be a field and $f(x) \in K[x]$ be a nonconstant polynomial. Define recursively the sequence of polynomials $f_n(x)$ by $f_1(x) = f(x)$ and for any $n > 1$, $f_n(x) = f_{n-1}(f(x))$. We say that $f(x)$ is stable over K if for any $n \geq 1$, $f_n(x)$ is irreducible over K. We exhibit some classes of stable polynomials like p-Eiseinstein polynomials, generic polynomials etc. Since the generic polynomial over any field is stable, we may expect that if we specialize the coefficients of that polynomial in the field, we get very often stable polynomials over K. Indeed, even over an hilbertian field, we cannot count the specializations which preserve the stability. Some questions remain open on the stability. For example we do not know of any polynomial of degree 3 which is stable over the rational field, not p-Eiseinstein on not of binomial type. I will mention a similar problem for multivarite polynomials.

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Anisotropic Finite Element For Fluid Dynamics

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Anisotropic finite elements can be been shown to be a powerful approach for applications with directional solutions. However a number of questions must be addressed in order to understand why and under which conditions Finite Element still perform well on unstructured anisotropic meshes and particularly how to build highly stretched elements in a robust and efficient way. In this work, we propose to show that adaptive anisotropic meshing based on a posteriori estimation can be used to solve a number of complex simulations. Different applications combining Stabilized Finite Element flow solver with the Convected Level Set approach [1] for multiphase flow calculation and fluid structure interaction within a monolithic approach are analyzed and presented. The theoretical basis of Anisotropic Finite Element in this work is the length distribution tensor approach and the associated edge based error analysis as recently proposed in [2]. An interpolation error analysis is performed on the projected approximate scalar field along the edges whatever the dimension is. It enables to calculate a stretching factor providing a new edge length distribution, its associated tensor and the corresponding metric. The stretching factors are obtained by considering an optimization problem. Moreover, the proposed framework en- ables quite easily to account for several vector or scalar fields in the a posteriori analysis while still producing a single metric field. For multiphase calculation with high contrast in the physical parameters, the proposed a posteriori estimation is applied to a modified Level Set scalar field, giving the anisotropic mesh refinement at the interface region. As for the incompressible Navier-Stokes at high Reynolds number [3], it will be shown that by using an adequate scaling, the boundary layers with highly stretched elements can be produced automatically.

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Ground and Excited States of the Helium Atom by Using Variational Monte Carlo Method

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Abstract

The Hamiltonian of the two-electron atom which takes into account the relativistic effect due to the kinetic energy, the spin-own orbit, the spin other orbit and the spin-spin interactions is constructed to solve the Schrödinger equation. Accordingly, the ground-state and the four lowest excited-states of the helium atom are obtained by using Variational Monte Carlo method. Trial wave functions depending on variational parameters are presented. The energies and the trial wave functions are plotted versus the variational parameters. The corresponding exact data are presented for comparison.

Keywords

Variation method, variational Monte Carlo method, Helium atom.

Title

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Particle Kalman Filtering: A Bayesian Framework for Large Dimensional State Estimation Problems

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Abstract

Bayesian filtering consists of determining the conditional probability distribution function (*pdf*) of the state given previous measurements. Once the state *pdf* is known, one can determine different estimates of the system state, as the minimum variance estimate. Particle filters (PF) are discrete nonlinear filters that use point-mass representation (Dirac mixture) of the state *pdf*. In practice, these filters suffer from the degeneracy of its particles that causes very often the divergence of the filter. Another discrete solution of the optimal nonlinear filters is based on Gaussian sum representation of the state *pdf*. This results in a hybrid particle-Kalman filter in which the standard weight-type PF correction is complemented by a KF-type correction for each particle using the associated covariance matrix in the Gaussian sum. We refer to this filter as the particle Kalman filter (PKF). The solution of the nonlinear filtering problem is then obtained as the weighted average of an ensemble of Kalman filters operating in parallel. The Kalman-type correction reduces the risk of ensemble collapse, which enables the filter to efficiently operate with fewer particles than the

PF. In this contribution, we present the PKF and discuss how this filter provides a nonlinear framework for ensemble Kalman filtering (EnKF) methods. We argue that the (deterministic) Square-Root EnKFs are Gaussian-based filters while the traditional (stochastic) EnKF propagates an approximation of the non-Gaussian pdf of the state. We also discuss approaches to reduce the computational burden of the PKF to make it suitable for high dimensional assimilation problems. We show numerical results from different applications dealing with ocean circulation estimation, storm surge forecasting, and tracking of underground contaminant transport.

Numerical simulations of ideal MHD and applications in astrophysics

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Abstract

We introduce a finite volume code for ideal MHD. The ingredients of the code are: a new approximate Riemann solver based on a relaxation approach, extension to multidimensions via a Powell source term, extension to higher order such that one preserves positivity. This gives rise to a very stable code which is usefull in astrophysical applications. We show extensive tests for our code and end with applications from astrophysics. This is joint work among others with Knut Waagan.

Entropy and the numerical integration of conservation laws

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Matteo Semplice
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Abstract

The entropy condition is an essential tool to select the unique weak solution of a conservation law. It contains information on the physics of the underlying phenomenon which is lost when the model is simplified disregarding, for instance, viscosity effects, to lead to a hyperbolic system of equations.
We expect therefore that the entropy condition is crucial also for the numerical integration of conservation laws. As a matter of fact, a few simple numerical schemes do satisfy a discrete version of the entropy inequality, and this is an essential ingredient to prove that their numerical solutions converge to the entropy-satisfying weak solution, under grid refinement.
Here, we are interested in the possibility of using a discrete version of the entropy inequality to assess the quality of the numerical solution even when we are not able to produce a convergence proof. In our approach, we compute an entropy residual which can be used as an a posteriori error indicator.
We propose an a-posteriori error/smoothness indicator for standard semi-discrete finite volume schemes for systems of conservation laws, based on the numerical production of entropy. We prove that the indicator converges to zero with the same rate of the error of the underlying numerical scheme on smooth flows under grid refinement. We construct and test an adaptive scheme for systems of equations in which the mesh is driven by the entropy indicator. The adaptive scheme uses a single nonuniform grid with a variable timestep. We show how to implement a second order scheme on such a space-time non uniform grid, preserving accuracy and conservation properties. We also give an example of a p-adaptive strategy.

Kinetic models for dilute suspensions of rigid rods

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Abstract

I will review some recent works on modeling and the mathematical theory for dilute suspensions of rigid rods. Such problems appear in modeling sedimentation of suspensions of particles. Similar in spirit models are also used for modeling swimming micro-organisms. Here, we focus on a class of models introduced by Doi and describing suspensions of rod-like molecules in a solvent fluid. They couple a microscopic Fokker-Planck type equation for the probability distribution of rod orientations to a macroscopic Stokes flow. (i) We show that steady states can have discontinuous solutions analogous to the ones studied in the context for macroscopic viscoelastic models (e.g. for Oldroyd-B models) and spurt phenomena or shear bands in that context. (ii) For the problem of sedimenting rods under the influence of gravity we discuss the instability of the quiescent flow and the derivation of the collective response in the diffusive regime described by variants of the Keller-Segel model. (joint work with F. Otto and Ch. Helzel)

Contributed Sessions

The LSMS-2011 Contributed Speakers are:

Dr. Abbas Alhakim	Lebanon
Dr. Hadeel Alkutubi	Iraq
Dr. Ghassan Antar	Lebanon
Prof. Mohammad Bagher Ghaemi	Iran
Miss. Nancy Chalhoub	France
Miss. Ghina El-Jannoun	Lebanon
Mr. Ali Ezz Edine	Iran
Dr. Ziad Francis	Lebanon
Dr. Rabih Ghostine	France
Dr. Elie Hashem	France
Prof. Anwar Jawad	Iraq
Miss. Widad Machmouhi	USA
Prof. Ebadollah Mahmoodian	Iran
Miss. Noura Morcos	Lebanon
Miss. Sophie Moufawad	Lebanon
Dr. Elie Nasr	Lebanon
Dr. Chadi Nour	Lebanon
Dr. Tofi Rahal	UAE
Dr. Guitta Sabiini Rishmany	Lebanon
Dr. Hassan Saoud	Lebanon
Miss. Dania Sheaib	Lebanon
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On Some Combinatorial Algorithms for de Bruijn Sequences

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Abstract

Binary de Bruijn sequences are sequences that are often used to model random binary sequences as they enjoy some properties which are expected for random sequences. In particular, in a de Bruijn sequence of order n, every possible binary string of length n occurs exactly once as a substring (therefore every string of size less than n occurs the same number of time, thus giving a balance property). We will present a combinatorial method of construction by appending one bit at a time. Throughout the construction, zeroes or ones are 'preferred' based on the value of only the previous, most recent bit. We will give a sketch of the proof that this simple algorithm results in all possible strings of a given size. We will also compare the resulting sequence with another popular one constructed using a similar mechanism. Time permitting, we will describe an attempt to generalize to non-binary alphabets and give some open problems.

Solution of Fractional Delay Linear Integro Differential Equation Using Variational Approach and Approximate Methods

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Abstract

In this paper we study fractional linear integro differential equation with and without delay and solving such equation by using the variational approach and singularity method.

On Experimental Design for Nursing Student

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Abstract

In this study we present five variables of lecturer's evaluation in department of community health nursing, college of Nursing, Kufa university in Iraq for this year. The data is analyzed using completely random design, LSD and factorial Experiment to explain the significant difference between all variables (scientific, personality, ability of evaluation and ability of communication) for each type of evaluation. SSPS program was used throughout this study to analyze the data and to generate various Tables.

Keywords

Analysis of variance, Experimental design, Completely random design and Factorial Experiment.

The Integer Lattice Points in the Newton Polyhedron and Applications

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Abstract

Let $I = (x_1^{a_1}, \ldots, x_n^{a_n}) \subset K[x_1, \ldots, x_n]$ be an ideal with $a_1, \ldots, a_n$ positive integers and K a field. The Newton polyhedron of I is the convex hull in $\mathbb{R}^n$ of the exponent set of I. The first main result of this paper is producing an algorithm for computing the set of all integer lattice points in the Newton polyhedron I. In particular, it produces the patterns of the minimal generators of the integral closure of the monomial ideals I. Then these patterns are used to give a generalization of the work of [1], namely, the integral closure of the monomial ideal I is normal if and only if the integral closure of the ideal $(x_1^{b_1}, \ldots, x_n^{b_n}, \ldots, x_m^{b_m}) \subset K[x_1, \ldots, x_n, \ldots, x_m]$ is normal, where $\{b_i \mid i = 1, \ldots, m\} \subseteq \{a_i \mid i = 1, \ldots, n\}$ and $n \leq m$. The last section of this paper uses the algorithm to give alternative proofs of previously known results on normal ideals; in particular, two special cases of results of [2].

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A posteriori error estimates for unsteady convection–diffusion–reaction problems and the finite volume method

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Abstract

We derive a posteriori error estimates for the discretization of the unsteady linear convection–diffusion–reaction equation approximated with the cell-centered finite volume method in space and the backward Euler scheme in time. The estimates are based on a locally postprocessed approximate solution preserving the conservative

fluxes and are established in the energy norm. We propose an adaptive algorithm which ensures the control of the total error with respect to a user-defined relative precision and refines the meshes adaptively while equilibrating the time and space contributions to the error. Numerical experiments illustrate the theory.

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Third derivative multistep methods for stiff systems

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Abstract

In this talk we present general form of third derivative multistep methods for the numerical solutions of ordinary differential equations (ODEs). In these methods, the first, second and third derivatives are used to improve the absolute stability regions and accuracy. Third derivative multistep methods is one stage method, its order is $k + 3$. The constructed methods are A-stable up to order 6 and A-alpha stable up to order 8. We compare our new methods with famous first derivative multistep methods (EBDF[1]) and second derivative multistep methods (Hojjati SDMM[2]) so that, as it is shown in the numerical experiments, they are superior for solving stiff systems with high accuracy and speed in computing results.

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Monte-Carlo method simulations in radiobiology and radio-induced DNA damage

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Abstract

Monte-Carlo track structure codes remain one powerful tool able to simulate the passage of ionizing particles through matter. The Geant4-DNA [1] package is presented as a set of processes developed for track structure simulation at the molecular level. It is based on the Geant4 general purpose Monte-Carlo toolkit [2]-[3]. Dedicated to sub-cellular studies, specific cross sections were calculated, for protons electrons and alpha particles, taking into account all possible interactions such as ionization, excitation, charge transfer and elastic scattering. Inelastic cross sections were calculated using the First Born Approximation. Low energy corrections were used for electrons and semi-empirical models for protons and alpha particles in liquid water. With the recently added extensions, the GEANT4-DNA package is now capable to track protons (100 eV - 100 MeV), relativistic electrons up to 1 MeV and sub-excitation electrons down till complete thermalization (0.025 eV). Alpha particles can be tracked using the Rudd Ionization model (10 keV-10 MeV) and the Miller & Green model for excitation.

In this work, the physics processes will be presented in details, describing the models used for cross-sections calculations as well as the corrections added for low incident energies. This Geant4-DNA package is the first free open source code that is able to generate ionizing tracks for microdosimetry applications. Users can download these processes along with the Geant4 toolkit from the official Geant4 webpage [4].

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Generalized System Of Additive, Quadratic And Cubic Functional Equations In Non-Archimedean Normed Spaces

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Abstract

In this paper, we prove the generalized Hyers-Ulam-Rassias stability for a system of functional equations, called system of linear and nonlinear functional equations, in non-Archimedean normed spaces and Menger probabilistic non-Archimedean normed spaces. By applying the method of this paper one can investigate the stability of many systems of various functional equations with n functional equations and n variables (n∈N).

Discontinuous finite element model for simulation of dam break flow through an idealized city

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Abstract

This study relates to sudden transient flow of the dam break wave type in an idealized city in order to investigate the effects of flow depth and velocity on such a city. Therefore, we are interested here in solving the nonlinear Saint-Venant equations governing free surface flows. These equations are derived from Navier-Stokes equations, using some simplifying assumptions. Particularly, the study aims at assessing the ability of a Runge-Kutta discontinuous finite element numerical model to reproduce fast transient flow including the multiple interactions with obstacles. The scheme is well suitable to handle complicated geometries and requires a simple treatment of boundary conditions and source terms to obtain high order accuracy. Experiments were conducted involving two different configurations: (1) a square city layout of 5 x 5 buildings aligned with the approach flow direction, and (2) a square city layout of 5 x 5 buildings not aligned with the approach flow direction. These experimental data are used to validate the numerical model at transient flow modeling in complex geometries. The results show excellent agreement between the model and the experimental data.

Keywords:

Saint-Venant equations, discontinuous finite element, dam break, fast transient flow.

Finite Element Method for Fluid-Structure Interaction at High Reynolds Number

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Abstract

In this paper, we propose a general new immersed stress method for solving rigid body motions in the incompressible Navier-Stokes flow. The proposed method is also developed in the context of the monolithic formulation. It consists of considering a single grid and solving one set of equations with different material properties. A fast anisotropic mesh adaptation [1] algorithm based on the variations of the distance function is then applied to ensure an accurate capture of the discontinuities at the fluid-solid interface. Such a strategy gives rise to an extra stress tensor in the Navier-Stokes equations coming from the presence of the structure in the fluid. With each immersed structure comes an appropriate law (rigid, elastic, viscoelastic). The proposed solver must be able then to welcome any behavior law and treat the full monolithic approach by a direct parallel finite element solver. The system is solved

using a finite element variational multiscale (VMS) method, which consists of decomposition for both the velocity and the pressure fields into coarse/resolved scales and fine/unresolved scales. The distinctive feature of the proposed approach resides in the possible efficient enrichment of the extra constraint. This choice of decomposition is shown to be favourable for simulating multiphase flows at high Reynolds number [2].
We assess the behaviour and accuracy of the proposed formulation coupled to the levelset method approximation in the simulation of 2D and 3D time-dependent numerical examples such as: vortex shedding behind an obstacle, turbulent and conjugate heat transfer inside industrial furnaces and the rigid bodies motion in incompressible flows. Results are compared with the literature and show that the present implementation is able to exhibit good stability and accuracy properties.

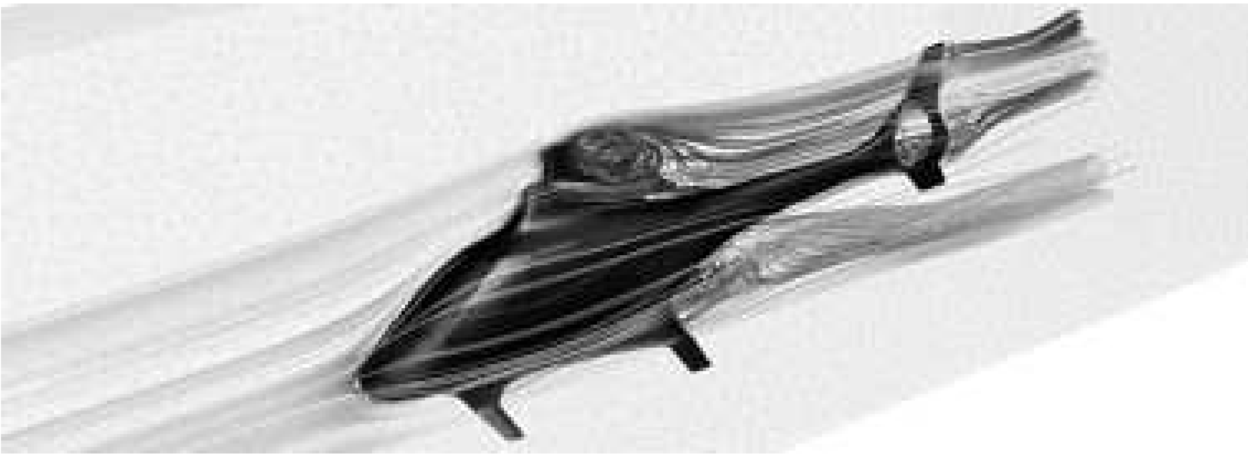

Figure 1: Numerical simulation of unsteady flow around helicopter in forward flight.

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Unstructured Central Finite Volume Schemes for Hyperbolic Conservation Laws

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Abstract

We propose a new class of central finite volume schemes on unstructured triangular grids to approximate the solution of general two-dimensional hyperbolic systems of conservation laws. The proposed methods are extensions of the first-order accurate Lax-Friedrichs scheme and the non-oscillatory second-order Nessyahu-Tadmor scheme, and evolve the numerical solution on an original unstructured triangular grid and on a staggered dual one.

Thanks to the staggering process, the time consuming resolution of the Riemann problems arising at the cell interfaces is bypassed, and the resulting scheme is numerically stable under an appropriate CFL condition. In contrast with the extension of the Lax-Friedrichs scheme that evolves a piecewise constant numerical solution, our extension of the Nessyahu-Tadmor scheme evolves a piecewise linear numerical solution defined at the cell centers and thus ensures second-order of accuracy in space; the flux integral is approximated using the midpoint quadrature rule and ensures the second-order accuracy in time. Furthermore, oscillations are avoided thanks to limited numerical gradients. We validate the developed scheme and solve classical two-dimensional problems arising in gas dynamics. The quality of the obtained numerical results confirms the efficiency and robustness of our proposed schemes.

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Solition Solutions to the Kadomtsev Petviashvili Equation by Tanh-Coth Method

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Abstract

Exact traveling wave solutions are obtained to the (3+1)-dimensional Kadomtsev-Petviashvili equation and (2+1)-dimensional equation by means of the tanh-coth method. New solitary wave solutions and trigonometric periodic wave solutions are got. The method is applicable to a large variety of nonlinear partial differential equations.

Simulating Bi-Dimensional Plasma Turbulence using the Hasegawa-Mima Equation

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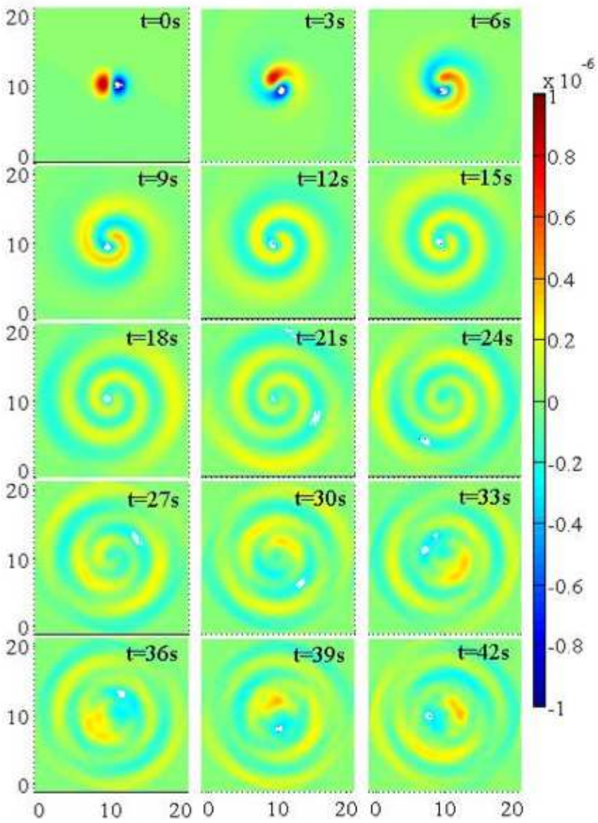
Abstract

Magnetic confinement is one of the most promising ways to produce energy in the future. Turbulence decreases the confinement of the plasma significantly making this option economically unattractive [1]. Understanding and controlling turbulence in fusion devices is the main motivation behind this work. We perform numerical simulation of a two-dimensional (2D) electrostatic fluid model called the Hasegawa-Mima model (HM) derived from the Navier-Stokes equations [2]. We briefly present the physics basics behind the HM equation [3]. Then, we focus on the finite difference scheme, called the Arakawa Jacobian, to simulate 2D plasma turbulence. The specific finite difference scheme is properly derived so that the interaction between grid points conserves quadratic quantities of physical that are the total energy and mean square vorticity. This prevents nonlinear computational instabilities and thereby permits long-term numerical integrations. Results are presented that demonstrate the

correctness of the code by simulating a modon, which is an exact non-linear solution for the HM equation. Then, we present a study of the inverse energy cascade as well as the turbulence spreading as it is appearing in the figure below.



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Well-Balanced Central Schemes for the Two-Dimensional Shallow Water Equations

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Abstract

We aim to develop a new class of well-balanced non-oscillatory second-order accurate central schemes for the approximating solution of general two-dimensional hyperbolic systems, and in particular to approximate the solution of shallow water equation systems (SWE) on Cartesian grids. The base scheme avoids the resolution of the Riemann problems arising at the cell interfaces thanks to a layer of ghost staggered cells implicitly used while updating the solution. The system of shallow water equations

$$\frac{\partial}{\partial t}\begin{pmatrix} h \\ hu \\ hv \end{pmatrix} + \frac{\partial}{\partial x}\begin{pmatrix} hu \\ hu^2 + \frac{1}{2}gh^2 \\ huv \end{pmatrix} + \frac{\partial}{\partial y}\begin{pmatrix} hv \\ huv \\ hv^2 + \frac{1}{2}gh^2 \end{pmatrix} = \begin{pmatrix} 0 \\ -gh\frac{\partial b}{\partial x} \\ -gh\frac{\partial b}{\partial y} \end{pmatrix}$$

represents a good mathematical model for the hydrodynamics of coastal oceans, simulation of flows in channels and rivers, study of large-scale waves and vertically averaged regimes in the atmosphere and ocean. Most numerical schemes fail to maintain the steady state constraint of shallow water equation problems and generate numerical (nonphysical) waves and storms. In this project, we shall investigate several approaches that could be coupled with our numerical base scheme in order to ensure, when necessary, the steady state condition of SWE systems.

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Making Branching Programs Oblivious Requires Superlogarithmic Overhead

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Abstract

We prove a time-space tradeoff lower bound of $T = \Omega(n \log(\frac{n}{S})) \log(\log(\frac{n}{S})$ for randomized oblivious branching programs to compute $1GAP$, also known as the pointer jumping problem, a problem for which there is a simple deterministic time n and space $O(\log n)$ RAM (random access machine) algorithm. We give a similar time-space tradeoff of $T = \Omega(n \log(\frac{n}{S})) \log(\log(\frac{n}{S})$ for Boolean randomized oblivious branching programs computing $GIP - MAP$, a variation of the generalized inner product problem that can be computed in time n and space $O(\log^2 n)$ by a deterministic Boolean branching program.

These are also the first lower bounds for randomized oblivious branching programs computing explicit functions that apply for $T = \omega(n \log n)$. They also show that any simulation of general branching programs by randomized oblivious ones requires either a superlogarithmic increase in time or an exponential increase in space.

Defining Sets in mathematics

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Abstract

We present as examples, some problems which motivate undergraduates, or even high school students, to do research in mathematics. These problems are related to the speaker's research activity. They have been presented in the past to recruit very bright students. In this talk we will go through the roots of some of these problems and elaborate the research topics behind them.

In a given class of mathematical structures there may be many distinct objects with the same parameters. Two questions arise naturally:

(i) How much of an individual object is needed to identify it uniquely?

(ii) Given two such objects, where and how do they differ?

These questions are obviously related, the first leading to the concept of a *defining set*, and the second to that of *trade*. There are examples of such sets in different mathematical topics. We will mention some in algebra, solutions of linear equations, infinite sequences, but our emphasis will be in combinatorics and graph theory, where these problems lead to an interesting theory and to many solved and unsolved problems with applications in the real life problems. The following references are some beginning journey to this theory.

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Communication-Avoiding General Minimum Residual Method (CA-GMRES)

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Abstract

Many important practical scientific problems require the solution of a system of linear equations formulated as the matrix equation $Ax = b$. Such systems of linear equations arise mainly from the discretisation of partial differential equations, for example discretising the Dirac operator in QCD. To solve such very large and sparse systems, Krylov subspace methods are used to take advantage of this sparsity.

Krylov subspace methods approximate the solution of the system at the k^{th} iteration by a vector $x_k \in \kappa_k(A, r_0) = span\{r_0, Ar_0, A^2r_0, \cdots, A^{i-1}r_0\}$ where r_0 is the initial residual and $\kappa_k(A, r_0)$ the Krylov subspace.

GMRES, a Krylov subspace method, finds the solution of the system by minimizing the residual $||r_(k)|| = ||b - Ax_k|| = min||b - Ax||, \forall x \in \kappa_k(A, r_0)$ at each

iteration and builds up an orthonormal basis for $\kappa_k(A, r_0)$ using the Arnoldi procedure. GMRES has the minimal residual at each iteration and converges to the solution in fewer iterations than other iterative methods. One disadvantage of this method is the increase of work performed per iteration and the memory requirements. One way to overcome this issue is to restart the GMRES after m iterations. This comes at the cost of slowing the convergence. Another approach is to parallelize GMRES. To do so efficiently the modified Gram Schmidt Arnoldi process has to be replaced by a parallelizable process.

Demmel and coworkers have proposed a generic strategy for communication avoiding General Minimum Residual Methods (CA-GMRES) where GMRES is reformulated mathematically. First, to obtain the basis, the one-step matrix vector multiplication at each iteration (Ax) was replaced by a k-step matrix vector multiplication ($Ax, A^2x, \cdots, A^k r_0$). Second, the modified Gram Schmidt Arnoldi process was replaced by a block Gram Schmidt kernel and a Tall Skinny QR (TSQR) factorization. The first orthogonalizes the k basis vectors obtained at each iteration against all previous basis vectors. The second makes those k basis vectors orthogonal with respect to each other. Demmel applied CA-GMRES on various application areas in 1D, 2D and 3D.

In this work, we adapt Demmels CA-GMRES to the 4D case of QCD (Quantum Chromodynamics), specifically the Wilson-Dirac equation, using OpenCl. The software implementation has been done on the development platform EUCLID of the Cyprus Institute. We will present the obtained results so far.

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Reduced basis method for numerical simulation of blood flows in tissues

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Abstract

Blood flow at the level of the microvascularised tissues can be considered as a flow through a porous media. This gives rise to models of homogenization types in which we solve elliptic partial differential equations (Darcy's law) on structures having two scales. Due to inhomogeneity, the homogenization is not periodic and the simulations involve the resolution of a large number of parameterized cell problems. After the various cell problems are solved a global macroscopic homogenized problem can be set up and solved. The purpose of this work is to show how the reduced-basis techniques of numerical simulations allows to speed up the computation of this large number of cells problems without any loss of precision. This reduced-basis method is based on the weak variational form and relies on a Galerkin method on an appropriate discrete space built from preliminary generic computations. The control of the approximation's error on some output of interest is performed through a posteriori error estimation.

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Numerical results for iterative image reconstruction in half-scan and non-uniform attenuated SPECT

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Abstract

The quality of reconstructed image in Single-Photon Emission Computed Tomography (SPECT) is strongly degraded by the photon attenuation. In general, the attenuation correction on SPECT images requires the data to be known over 2π (full-scan). The reduction of data acquisition from 2π to π (half-scan) in SPECT is recommended because it reduces the scanning time; thereby, it minimizes the patientÕs motion and makes the exam less uncomfortable for the patient. Furthermore, one can disregard projections which undergo high attenuation. Previous studies have analytically shown that exact reconstruction does not require the data to be known over 2π and that data acquired over only π can be used to correct completely the effect of uniform attenuation in SPECT. Algorithms and numerical research has been developed on image reconstruction from data acquired over π in SPECT with non-uniform attenuation. The results were comparable to those of images reconstructed from the data acquired over 2π in SPECT when attenuation is non-uniform. However, it remains theoretically unknown whether data, acquired only over π in SPECT with non-uniform attenuation, contain complete information for accurate image reconstruction. In this work, we present numerical results on image reconstruction in half-scan SPECT with non-uniform attenuation. The numerical simulations are based on a new iterative reconstruction algorithm that introduces exact and implicit attenuation correction derived from the attenuated Radon transform operator at each step of the algorithm. Specifically, we show that the algorithm is able to reconstruct images, in half-scan SPECT, with quality very similar to those reconstructed in full-scan SPECT. Moreover, the numerical simulations show that the algorithm is stable and convergent.

Mathematics subject classification:

65F10, 65R10, 65R32, 92C55, 94A08.

Keywords:

Half-scan, Single-photon emission computed tomography, Attenuated radon transform, Iterative algebraic reconstruction technique, Attenuation correction.

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The union of closed balls conjecture: origin and validity

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We present the origin of the union of closed balls conjecture introduced, apparently for the first time, in the papers [1, 2]. We also discuss the validity of the weak version of this conjecture proved in [3] and the validity of its strong version which remains an open question.

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Understanding Student Learning and Thinking Styles as a Way to Improve Math and Science Education

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Abstract

In teaching Math and Science skills teachers usually emphasize instructional methods and techniques that accommodate analytic (left-brain) modalities at the expense of global (right-brain) modalities. Studies have shown that some students are predominantly Analytic, while other students are more Global processors. The two modalities are responsible for different ways of thinking. Still some students are known to be integrated (can use both sides of the brain equally). Emphasizing one mode of teaching might benefit some students, while putting other students at risk. This paper will briefly describe the different modes of learning styles, especially those concerned with thinking and the processing of information. The differences between analytic left-brain and global right-brain thinking will be explored. Research which was done at Zayed University by the Author and his team on student learning and thinking styles will also be presented and discussed as a mean to promote effective classroom instructional and research methods that aim at improving Math and Science Education.

Keywords

Learning Styles; Analytic-Left Brain; Global-Right Brain; Classroom Research; Math & Science Education.

About the Author

Dr. Rahal is an American Citizen born Lebanese with 2 Master & a Doctorate degrees in Science & Math Ed from Columbia University, USA. He has joined Zayed University - UAE since its onset in 1998, where he assumed many teaching, curriculum & coordination responsibilities in the College of Arts & Sciences, the College of

Education, and the University College. Dr. Tofi is a certified specialist in Learning and Thinking Style-Based Education & the building of multi-sensory instructional packages that cater for various learning preferences. He also has an extensive experience in outcome-based education and assessment. Recently, he won a large grant project on the measurement & analysis of students learning styles as requirement to build instruction & curriculum that cater for different students needs & preferences. His proficiency in educational technology and the use of multimedia resources allowed him to serve as the president of the educational technology committee & as a member of the UAE High Educational Council for the school improvement project for 2 years. Dr. Tofi strongly believes in the scholarly nature of teaching, where research becomes an integral part of teaching.

Chains of holomorphic contractions and Fatou-Bieberbach domains

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Abstract

When $k > 1$, there exists domains not belonging to $\mathbb{C}^k$ which are biholomorphically equivalent to $\mathbb{C}^k$, these are the domains called Fatou-Bieberbach. Our work was to know if the basin of attraction of a chain of holomorphic contractions is a Fatou-Bieberbach domain. Our proposed method permitted establishing new results which generalizes all known results till nowadays. For this purpose, we proved a linearization theorem of Poincare for chains and a perturbed Poincare-Dulac theorem as well.

Finite-Time Lyapunov Stability of Evolution Variational Inequalities

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Abstract

Stability analysis of dynamical systems in the sense of Lyapunov is one of the most important topic in control theory. There are many concrete systems in engineering which have Non-smooth Dynamics. This the case of mechanical systems subject to unilateral constraints and/or Coulomb friction and/or impacts or electrical circuits with switches, diodes, hybrid dynamical systems in control and engineering. It seems that the formalism of evolution variational inequalities represents a large class of unilateral dynamical systems.
The aim of this talk is to present some conditions ensuring the finite-time stability of a general class of evolution variational inequalitites. More precisely, we are concerned with the study of the finite-time stability of first-order Non-Smooth dynamical systems given by following Differential Inclusion:

$$\frac{du}{dt} \in -F(u(t)) - \partial\phi(u(t)) \quad a.e. \quad t \geq 0. \qquad (S)$$

Where $\Phi : \mathbb{R}^n \to \mathbb{R} \cup \{+\infty\}$ is an extended real-valued proper convex and lower semicontinuous function. and ∂ stands the subdifferential of convex analysis and $F : \mathbb{R}^n \to \mathbb{R}^n$ is a k-Lipschitzian vector field, for some $k > 0$.
An important case is obtained when the function $\phi = \psi_C$ (the indicator function of a closed convex cone in $\mathbb{R}^n$). In this case, problem (S) is reduced to the complementarity problem. Finally, we show that our theoretical results are applicable to some examples in nonregular electronical circuits involving nonsmooth devices like ideal diodes, pratical diodes or Zener diodes.

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Continued Fraction Evaluation of $J_n(x)/J_{n-1}(x)$

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Abstract

In this paper, continued fraction expansion for the Bessel functions ratio $J_n(x)/J_{n-1}(x)$ was developed. An efficient and simple computational algorithm based on this expansion was also developed using top-down evaluation procedure. Numerical results of the algorithm are in full agreement at least to fifteen digits accuracy with that of the standard tables.

Keywords

Bessel functions, continued fraction, special functions, number theoroy.

Modeling Approach for the Physiological Tick Life Cycle

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Abstract

Tick-borne diseases (theleriosis, rickettsiosis, Lyme disease, Ehrlichiosis, relapsing fever, tick-borne encephalitis) are serious health problems affecting humans as well as domestic animals in many parts of the world. These infections are generally transmitted through a bite of an infected tick, and it appears that most of these infections are widely present in some wildlife species; hence, an understanding of tick population dynamics and its interaction with hosts is essential to understand and control such diseases.

In this presentation, we first intend to describe the different evolution stages associated with the tick life-cycle as well as the tick-host epidemiological interaction level. This allows us to identify and clarify all the physiological parameters affecting the development of the tick population. Thus, we are able to describe the tick life-cycle model formulated to study the effect of temperature and seasonality on the density of ticks. The model used here is a system of partial differential equations, (PDE). This model will be the foundation of a later epidemiological model which describes the tick-host interactions.

To obtain a numerical solution of the tick life-cycle model, Petrov-Galerkin approximations based on variational formulations are derived using finite element functions.

[1]Supported by the Lebanese National Council for Scientific Research

This leads to a system of ordinary differential equations whose computations are carried in view of investigating and understanding the tick population dynamics. Numerical results will be presented to illustrate basic features of the mathematical model and its solution.

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Math XL Online Platform: Beyond Procedural Competence

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Abstract

The presence of technological tools (graphical calculators, computer software programs, internet access) makes the teaching and learning experience richer for students, and prompts instructors to find new ways to integrate technology effectively in their pedagogies. The presence of a variety of online software platforms that deliver content and test students online is helpful in enabling students' building skills, but does not directly target students' conceptual knowledge, simply because many of those tools are used as homework collectors, a limited benefit that does not portray their potential. In this talk, I am going present a summary of the features of an online platform, MathXL, discuss with participants some of the software's perceived limitations, and introduce a number of ways to use it to promote conceptual competence as well as deep procedural knowledge.

Participants

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Akpan Anthonia	Cogid'S Resources Ltd
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Al-Ghoul Mazen	American University of Beirut
Al-Labban Reem	Saint Mary Orthodox School
Alazwi Saad Naji	Science Women College
Alhakim Abbas	American University of Beirut
Ali Nidal	Lebanese University
Alkutubi Hadeel	Kufa University
Almahameed Mohammad	Irbid National University
Antar Ghassan	American University of Beirut
Ayad Mohamed	Littoral University
Azar Monique	American University of Beirut
Bagher-Ghaemi Mohammad	Iran University of Science and Technology
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Boulos Racha	Saint Joseph University
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Coupez Thierry	CEMEF - MINES ParisTech
Dakroub Jad	Saint Joseph University
Dib Dayana	Saint Joseph University
Doma Salah	Alexandria University
Edde Michel	Lebanese University
El-Chami Fida	Lebanese University
El-Haddad Rami	Saint Joseph University
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El-Khatib Yehya	Saint Joseph University
El-Sahily Amine	Lebanese University
Ezz Eddine Ali	Tabriz University
Francis Ziad	Saint Joseph University
Ghostine Rabih	Institut National des Sciences Appliquees
Hamdan May	Lebanese American University
Habre Samer	Lebanese American University
Hello Riham	Saint Joseph University
Henoud Leila	Lebanese University
Hobeika Kallas Rachel	Lebanese University
Hoteit Ibrahim	KAUST
Jawad Anwar	University of Technology
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Khuri-Makdisi Kamal	American University of Beirut
Klaiany Charbel	Lebanese University

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Maalouf Ramez	Notre Dame University
Mahmoodian Ebadollah	Sharif University of Technology
Mansour Gihane	Saint Joseph University
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Morcos Noura	Saint Joseph University
Moufawad Sophie	American University of Beirut
Mourad Ayman	Lebanese University
Moussa Ouannas	
Nasr Elie	University of Balamand
Nassif Nabil	American University of Beirut
Nour Chadi	Lebanese American University
Nusayr Abdulmajid	Jordan University of Science And Technology
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Puppo Gabriella	Politecnico di Torino
Rached Ziad	Notre Dame University
Rahal Tofi	Zayed University
Sabiini Rishmany Guitta	Notre Dame University
Saoud Hassan	Lebanese University
Sayah Toni	Saint Joseph University
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