

Abstracts Book

of the

XXVI Congreso de Ecuaciones Diferenciales y Aplicaciones XVI Congreso de Matemática Aplicada

> Gijón (Asturias), Spain June 14-18, 2021







CEDYA CMA 2020

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Foreword

It is with great pleasure that we present the Abstracts Book of the 26th Congress of Differential Equations and Applications / 16th Congress of Applied Mathematics (XXVI CEDYA / XVI CMA), the biennial congress of the Spanish Society of Applied Mathematics SeMA, which is held in Gijón, Spain from June 14th to June 18th, 2021.

In this volume we gather the abstracts of the almost three hundred and twenty communications presented in the conference. Short papers sent by some of the participants can be found in the Proceedings of the congress and full papers by invited lecturers will shortly appear in a special issue of the SeMA Journal.

The first CEDYA was celebrated in 1978 in Madrid, and the first joint CEDYA / CMA took place in Málaga in 1989. Our congress focuses on different fields of applied mathematics: Dynamical Systems and Ordinary Differential Equations, Partial Differential Equations, Numerical Analysis and Simulation, Numerical Linear Algebra, Optimal Control and Inverse Problems and applications of Mathematics to Industry, Social Sciences, and Biology. Communications in other related topics such as Scientific Computation, Approximation Theory, Discrete Mathematics and Mathematical Education are also common.

For the last few editions, the congress has been structured in mini-symposia. In Gijón, we will have eighteen minis-symposia, which have been proposed by different researchers and groups, and also five thematic sessions organized by the local organizing committee to distribute the individual contributions. We will also have a poster session and ten invited lectures. Among all the mini-symposia, we want to highlight the one dedicated to the memory of our colleague Francisco Javier "Pancho" Sayas, which gathers two plenary lectures, thirty-five talks, and more than forty invited people that have expressed their wish to pay tribute to his figure and work.

This edition has been deeply marked by the COVID-19 pandemic. First scheduled for June 2020, we had to postpone it one year, and move to a hybrid format. Roughly half of the participants will attend the conference online, while the other half have declared their intention to come to Gijón. Taking a normal conference and moving to a hybrid format in one year has meant a lot of efforts from all the parties involved. Not only did we, as organizing committee, see how much of the work already done had to be undone and redone in a different way, but also the administration staff, the scientific committee, the mini-symposia organizers, and many of the contributors had to work overtime for the change.

Just to name a few of the problems that all of us faced: some of the already accepted minisymposia and contributed talks had to be withdrawn for different reasons (mainly because of the lack of flexibility of the funding agencies); it became quite clear since the very first moment that, no matter how well things evolved, it would be nearly impossible for most international participants to come to Gijón; reservations with the hotels and contracts with the suppliers had to be cancelled; and there was a lot of uncertainty, and even anxiety could be said, until we were able to confirm that the face-to-face part of the congress could take place as planned.



On the other hand, in the new open call for scientific proposals, we had a nice surprise: many people that would have not been able to participate in the original congress were sending new ideas for mini-symposia, individual contributions and posters. This has meant that the total number of communications is about fifteen percent greater than the original one, with most of the new contributions sent by students.

There are almost one hundred and twenty students registered for this CEDYA / CMA. The hybrid format allows students to participate at very low expense for their funding agencies, and this gives them the opportunity to attend different conferences and get more merits. But this, which can be seen as an advantage, makes it harder for them to obtain a full conference experience. Alfréd Rényi said: "a mathematician is a device for turning coffee into theorems". Experience has taught us that a congress is the best place for a mathematician to have a lot of coffee. And coffee cannot be served online.

In Gijón, June 4, 2021

The Local Organizing Committee from the Universidad de Oviedo



Scientific Committee

- Juan Luis Vázquez, Universidad Autónoma de Madrid
- María Paz Calvo, Universidad de Valladolid
- Laura Grigori, INRIA Paris
- José Antonio Langa, Universidad de Sevilla
- Mikel Lezaun, Euskal Herriko Unibersitatea
- Peter Monk, University of Delaware
- Ira Neitzel, Universität Bonn
- José Ángel Rodríguez, Universidad de Oviedo
- Fernando Terán, Universidad Carlos III de Madrid



Sponsors

- Sociedad Española de Matemática Aplicada
- Departamento de Matemáticas de la Universidad de Oviedo
- Escuela Politécnica de Ingeniería de Gijón
- Gijón Convention Bureau
- Ayuntamiento de Gijón
- Mathematics, an Open Access Journal by MDPI



Local Organizing Committee from the Universidad de Oviedo

- Pedro Alonso Velázquez
- Rafael Gallego
- Mariano Mateos
- Omar Menéndez
- Virginia Selgas
- María Luisa Serrano
- Jesús Suárez Pérez del Río



Conference venue

The conference takes place at the Escuela Politécnica de Ingeniería de Gijón, in the <u>Edificio</u> <u>Polivalente</u> building.

Finding your room

Schematic plans of the building can be found in this <u>link</u>. Notice that the building is star shaped with a ring structure.

After entering the building through the main door, go to the right. A **reception desk** will be installed in the **main hall**, thirty meters from the entrance.

The **plenary lectures** will be delivered at the **Salon de Actos**. To arrive there, you just need to go upstairs from the main hall. In case the Salon de Actos has reached its full capacity, mirror rooms will be opened in classrooms A2, A3, ...

Parallel sessions will take place in rooms A2, A3, A4, A5, A6, A8, B1 and B2. To go to the Ax rooms, from the Salon de Actos, just walk around the inner ring of the building. If you have to go to rooms B1 or B2, go back downstairs to the main hall and downstairs again; then go left to find B1; continue right around the inner ring to find B2.

There will be voluntary students to guide you through the building in case you cannot find your room.

Getting to the Campus

There are six bus routes getting to the campus. Routes 2, 4, 18 have a bus stop by the conference venue. In the linked pdf maps, its name is E.U. Ingenieros Técnicos. In the App Gijon EMTUSA, it is the bus stop Escuela Politecnica de Ingenieria (P27).

- Línea 2 El Corte Inglés Hospital de Cabueñes see route
- Línea 4 El Lauredal Campus Universitario see route
- Línea 18 Nuevo Gijón Hospital de Cabueñes see route

Routes 1, 15, 26 have a bus stop at the Escuela de Marina, 10 minutes walking from our building.

- **Línea 1** El Cerillero Hospital de Cabueñes <u>see route</u>
- Línea 15 Nuevo Roces Hospital de Cabueñes see route
- **Línea 26** Gijón Deva <u>see route</u>



Online access

The online part of the CEDYA / CMA 2020 will be done on the platform **MS Teams** of the Universidad de Oviedo.

You can access MS teams through the page https://teams.microsoft.com. It is possible to access using a web browser or through the official app available for Windows, Linux, macOS, iOS and Android.

A few days before the congress, every participant will receive in the email account they have provided, an invitation from an official Microsoft email as "Microsoft Teams noreply@email.teams.microsoft.com" with a subject similar to "You have been added as a guest to Universidad de Oviedo in Microsoft Teams".

Accept the invitation.

To accept, click on the link "Open Microsoft Teams" and follow the instructions that will appear.

You may be in either one of the following situations.

1. If your email address belongs to **an organization that has a MS Teams licence** (as happens with many universities, for instance), after acceptance of the invitation, select "Universidad de Oviedo" in the upper right dropdown menu of the app.



 If your email address does not belong to an organization that has a MS Teams licence (this is the case, for instance, of many personal addresses), you must create a Microsoft user associated to your email address (unless you already have one). This account is completely free. This step can be done in advance at https://teams.microsoft.com/ or https://signup.live.com/

Access the conference online.

Open your MS Teams app. Remember to use the same user that has received the invitation. Select "Universidad de Oviedo" in the upper right dropdown menu of the app. On the left side menu, select Teams and click on the team **CEDYA CMA 2020 Gijón.** In that team there will be a channel for every minisymposium, every thematic area, the poster session, and the plenary talks. In each channel, the sessions are already scheduled. Notice that **many channels will be hidden** by default. Click on "Hidden channels" to show them up.



In each channel, you will find an abstract and scheduled meetings for all the sessions. Check also the "Files" section for more information.

Access a session online.

There are, at least, two ways.

- 1. Access the conference online as indicated above, select your channel, and join when the meeting has begun.
- 2. You may also access a session by clicking on the links in the abstract book or in the detailed program. Just remember that, when the MS Teams app pops up, you must identify yourself as user that has received the invitation. For security reasons, other users will not be allowed.

Chair a session.

1. From home. Access your session as indicated above, with the camera and the microphone on. Open the participant list clicking on the icon



You act as moderator, opening the microphone to whoever needs to speak.

2. From the onsite room. There will be an open session in the computer of the classroom.

Deliver a talk.

1. From home. Access your session as indicated above, with the camera and the



microphone on. When the person that chairs the session gives you the floor, share your screen using the icon

2. From the onsite room. There will be an open session in the computer of the classroom. Load your presentation on the desktop of that computer. The computer has a virtual whiteboard, digital pen, and touch screen in case you need them. Notice that, since this is a hybrid conference, you will not be able to do some of the things that are usually done when lecturing, like using the physical blackboard, pointing with a laser beam or even walk around the room.

Attend a talk.

1. From home. Access your session as indicated above, with the camera and the microphone off. If you want to ask something, raise your hand with the icons



It is also possible to ask questions from the chat.

2. From the onsite room. Just go to the room the session is scheduled. Even if the lecturers and the chairperson are not onsite, there will be someone from the local organizing committee in the room and the session will be broadcast. Questions will also be possible. Please, notice that there is a special capacity limitation in the rooms due to COVID restrictions.



Poster session. In the poster channel, you will find all the posters in pdf, as well as five-minute video presentations. You may send public questions to the author clicking on the link



You may also send private question through a chat.



Invited talks



All the invited talks are in the room Salón de Actos.

Click on the day and time to access through MS Teams.

Speaker	Organization	Contribution title	
•	Chair: Vázquez, Juan Luis		
ivioriday, 10.00.	ilali. Vazquez, Juali Luis	Condinat flavor in markets was done walls	
Mazón, José M.	Universitat de València	Gradient flows in metric random walk spaces	
Monday, 16:30. C	Chair: Meddahi, Salim		
COCKBURN, BERNARDO	University of Minnesota	Variational principles for HDG methods	
Tuesday, 9:00. Ch	air: Díaz, Jesús Ildefonso		
Ruiz, David	Universidad de Granada	Traveling waves for the Gross-Pitaevskii equation in the subsonic regime	
Tuesday, 16:30. C	Chair: De Terán Vergara, Ferna	ndo	
SAAD, YOUSEF	University of Minnesota	Numerical Linear Algebra for data-related applications	
Wednesday, 9:00	. Chair: Ibáñez, Santiago		
SEARA, TERE M	Universitat Politècnica de Catalunya	Breakdown of small amplitude breathers for some Klein-Gordon equations	
Thursday, 9:00. C	hair: Rodríguez, José Ángel		
PERALTA SALAS,	Instituto de Ciencias	Vortex reconnections in classical and	
DANIEL	Matemáticas ICMAT	quantum fluids	
Thursday, 10:00.	Chair: Casas, Eduardo		
VEXLER, BORIS	Technische Universität München	Numerical Analysis of sparse initial data identification for parabolic problems	
Thursday, 16:30.	Chair: Heuer, Norbert		
Meddahi, Salim	Universidad de Oviedo	Mixed Finite Element Methods in Elastodynamics	
Friday, 9:00. Chair: Parés, Carlos			
ELLERO, MARCO	Basque Center for Applied	GENERIC-compliant stochastic particle	
LLLEKU, IVIAKCU	Mathematics BCAM	models of discrete hydrodynamics	
Friday, 10:00. Cha	air: Román, José E.		
ESTRADA, ERNESTO	Universidad de Zaragoza	Communicability function in complex networks. Theory and applications	



Cockburn, Bernardo

Organization

University of Minnesota

Email

cockburn@math.umn.edu

Title

Variational principles for HDG methods

Abstract

We propose a framework, based on variational principles, for the devising of general Galerkin methods for a second-order elliptic model equation. The framework is based on the classic energy and on the complementary energy minimization principles. For each of these priciples, three additional formulations are obtained by relaxing continuity constraints and by relaxing constitutive relations. This framework, which displays eight variational formulations, allows us to place and compare the development of the HDG methods with that of many other methods including the continuous Galerkin, the mixed and the old hybrid methods. Special attention will be put on the contributions that Francisco-Javier Sayas made to the development of the HDG methods. I will also share photos and stories which, I hope, will bring us closer to who was Francisco-Javier, a man of grit, of service, of passion, great to play with, and a talented mathematician whose life was tragically, and untimely, cut short.



Ellero, Marco

Organization

Basque Center for Applied Mathematics BCAM

Email

mellero@bcamath.org

Title

GENERIC-compliant stochastic particle models of discrete hydrodynamics

Abstract

Fluids at the macroscopic scales can be regarded as a continuum and, under certain approximations, evolution equations for fields can be derived in the form of partial differential equations (PDE) reflecting local conservation laws (e.g. mass, momentum, energy). Navier-Stokes equations, for example, represent an accurate model for simple Newtonian fluids and their discretization using classical computational fluid dynamics techniques (e.g. Finite Difference, Finite Elements) represents a formal way to translate those general laws into a discrete setting. Conservation laws are therefore properties embedded into the original PDE, whereas convergence of the numerical scheme towards the exact continuum limit implies the thermodynamic consistency of the computed solution.

In this talk I will discuss a different strategy in which physical laws are enforced "a priori" into discrete particle models of hydrodynamics, and their validity does not formally require a link to the underlying PDE (although it is useful to have it). In particular, I will present the so-called Smoothed Dissipative Particle Dynamics (SDPD) method, a stochastic particle-based technique for fluctuating hydrodynamics. Application of the GENERIC formalism (General Equation for Non-Equilibrium Reversible Irreversible Coupling) allows to derive a stochastic particle model maintaining its thermodynamic consistency, i.e. enforcement of First/Second Laws of Thermodynamics and Fluctuation-Dissipation Theorem, exactly at the level of the spatial discretization. Beside simple fluids, examples will be given for more general non-Newtonian viscoelastic liquids (e.g., polymer suspensions) as well as for the simulation of complex particulate systems.



Estrada, Ernesto

Organization

Universidad de Zaragoza

Email

estrada66@unizar.es

Title

Communicability function in complex networks. Theory and applications

Abstract

I will start with a gentle introduction to the study of complex networks. Then, I will motivate the problem of "information" transmission in such complex systems. I will provide evidence against the use of shortest topological paths as the main routes for the transmission of information in complex systems. Then, I will introduce the concept of network communicability and its connection with the theory of functions of the adjacency matrix, in particular with the exponential of such matrix. I will show several ways of interpreting the communicability function in complex networks using: (i) combinatorial theory, (ii) networks of coupled harmonic oscillators, (iii) diffusion on networks, (iv) epidemic propagation on networks. I will then show how the communicability function induces an embedding of a given network into a Euclidean hypersphere. Finally, I will illustrate a few applications of the communicability function in the study of several problems in networks, ranging from detection of human brain diseases to the deformation of granular materials.



Mazón, José M.

Organization

Universidad de Valencia

Email

Jose.M.Mazon@uv.es

Title

Gradient flows in metric random walk spaces

Abstract

In our digital world many different kinds of data are now available (images, social networks, etc). To represent these data the most natural and flexible representation consist in using weighted graphs. Historically the main tools for the study of graphs came from combinatorial graph theory. Recently, there has been increasing interest in the research of partial differential equations (PDE's) in graphs. On the other hand, in recent years there has been a great development of the study of nonlocal PDE's motivated by problems in image processing, the analysis of the peridynamic formulation of the continuous mechanic, Markov jump processes, etc. In the last years we have studied some gradient flows in the general framework of metric random walk spaces, that is, metric spaces together with a probability measure assigned to each point of the space that encode the jumps of a Markov process, that include, in particular, PDE's in weighted graphs and some nonlocal PDE's. In this lecture we summarize these results.



Meddahi, Salim

Organization

Universidad de Oviedo

Email

salim@uniovi.es

Title

Mixed Finite Element Methods in Elastodynamics

Abstract

The Cauchy stress tensor is a variable of primary interest in many elasticity problems. Great efforts had been made to design stable mixed finite elements for a direct approximation of this field in steady state elasticity problems.

Do these mixed finite elements provide spectrally correct approximations of elasticity eigenproblems? How can the mixed formulation of time harmonic elastodynamic problems be analyzed? What can be done to solve time dependent problems? We will address answers to these questions and extend our discussion to deal with the interaction between a deformable structure and an internal or surrounding acoustic fluid.



Peralta Salas, Daniel

Organization

Instituto de Ciencias Matemáticas ICMAT

Email

dperalta@icmat.es

Title

Vortex reconnections in classical and quantum fluids

Abstract

The evolution of a classical viscous fluid is described by the Navier-Stokes equations, while the dynamics of a quantum fluid (or Bose-Einstein condensate) is modelled by the Gross-Pitaevskii equation. In both cases the dynamics of the vortex lines plays a fundamental role in the analysis of the equations.

Recent experiments and extensive numerical computations show that the vortices of both classical and quantum fluids cross during their evolution, each of them breaking into two parts and reconnecting part of itself for part of the other. This phenomenon, known as vortex reconnection, occurs even though the fluid does not lose its smoothness.

In this talk, I will show how classical and quantum vortices, of arbitrarily complicated topologies, are created and destroyed in smooth solutions to the corresponding equations. Key to prove this result is a new inverse localization principle for Beltrami fields and a novel flexibility property of the linear Schrodinger equation.

This talk is based on joint works with Enciso, Alberto, Lucà, Renato and Torres de Lizaur, Francisco.



Ruiz, David

Organization

Universidad de Granada

Email

daruiz@ugr.es

Title

Traveling waves for the Gross-Pitaevskii equation in the subsonic regime

Abstract

The Gross-Pitaevskii equation is a Schrödinger equation under the effect of a Ginzburg-Landau potential and has been proposed to study different phenomena like Bose-Einstein condensation. In this talk we will first study the qualitative behavior of traveling waves, like uniform boundedness, regularity and asymptotic behavior.

Regarding existence, some previous existence results have been obtained via a constrained minimization procedure. This has the advantage of providing orbital stability of the solutions but, as a drawback, the speed of propagation appears as a Lagrange multiplier and is not controlled. We will present a recent general existence result for almost all speeds in the subsonic regime.



Saad, Yousef

Organization

University of Minnesota

Email

saad@umn.edu

Title

Numerical Linear Algebra for data-related applications

Abstract

Numerical linear algebra is undergoing momentous changes as it starts to cope with the problems that arise from applications related to machine learning and, generally, from datacentered methodologies. A common tool that is exploited in many methods that rely on large data sets is that of dimension reduction'. Dimension reduction is based on the precept that the observed data often lies in a noisy version of a low-dimensional subspace and so it is critical to work in this subspace not only to reduce computational cost but also to improve accuracy. The talk will start with an overview of the key concepts and then illustrate dimension reduction methods with applications such as information retrieval, face recognition and matrix completion for recommender systems. It will also illustrate the important role that graph Laplaceans, and other graph theory tools, play in applications that range from clustering and image segmentation, to the analysis of networks.



Seara, Tere M

Organization

Universitat Poltècnica de Catalunya

Email

tere.m-seara@upc.edu

Title

Breakdown of small amplitude breathers for some Klein-Gordon equations

Abstract

Breathers are periodic in time spatially localized solutions of evolutionary PDEs. They are known to exist for the sine-Gordon equation but are believed to be rare in other Klein-Gordon equations. Breathers can be seen as homoclinic solutions to a steady solution in an infinite dimensional space. In this talk, we prove an asymptotic formula for the distance between the stable and unstable manifold of the steady solution when the steady solution has weakly hyperbolic one dimensional stable and unstable manifolds. This formula allows to say that for a wide set of Klein-Gordon equations breathers do not exist. The distance is exponentially small with respect to the amplitude of the breather and therefore classical perturbative techniques, like Melnikov theory, cannot be applied.



Vexler, Boris

Organization

Technische Universität München

Email

vexler@ma.tum.de

Title

Numerical Analysis of sparse initial data identification for parabolic problems

Abstract

We consider a problem of identification of initial data for a homogeneous parabolic equation from an observation of the final state.

In general, such problems are known to be exponentially ill-posed. We are interested in the situation, where the initial data, we are looking for, is known to be sparse, i.e., to have a support of Lebesgue measure zero. The strong smoothing property of parabolic equations makes it difficult to identify such sparse initial data. The remedy is the incorporation of the information that the unknown initial data should be sparse into the optimal control formulation. This allows for robust identification of initial data consisting of finitely many Dirac impulses with unknown number and positions. For the resulting optimal control problem, we discuss finite element discretization and provide precise error analysis



Tribute to Francisco-Javier Sayas

Thematic area: Numerical Analysis and Simulation (NAS)

Organizers: Heuer, Norbert (P. Universidad Católica de Chile) and Meddahi, Salim (Universidad de Oviedo)

Abstract

During the celebration of the congress CEDYA CMA 2020, a minisymposium will be organized in memory of Francisco-Javier Sayas (1968-2019). The sessions of this minisymposium will gather many friends of his, as well as close students and colleagues, and will be devoted to share research results from the areas of Pancho's interests.

Keywords Francisco-Javier Sayas



Session 2. Monday 18:00 – 20:00. Room A3.

Chair: Heuer, Norbert (P. Universidad Católica de Chile)

Speaker	Organization	Contribution title
		Tribute to FJ. Sayas
		Tribute to FJ. Sayas
Rapún, María Luisa	Technical University of Madrid	Numerical methods for direct and inverse multiple scattering problems for mixed sound-soft, sound-hard and penetrable objects
PERUGIA, ILARIA	University of Vienna	DGFEM-BEM mortar coupling for the Helmholtz problem
BANJAI, LEHEL	Heriot-Watt University	FEM/BEM, explicit/implicit discretization of the wave equation in the second order formulation
SÁNCHEZ-VIZUET, TONATIUH	University of Arizona	Coupling BIE and HDG: an application to a free boundary problem from plasma physics.

Session 4. Tuesday 12:15 – 13:55. Room A3.

Chair: Rapún, María Luisa (Technical University of Madrid).

Speaker	Organization	Contribution title
JEON, YOUNGMOK	Ajou University	The Immersed Hybrid Difference Method for
	(Korea)	Interface Problems
DIEDED ALEXANDED	University of	A superconvergence phenomenon in Runge-Kutta
RIEDER, ALEXANDER	Vienna	convolution quadrature for the wave equation
HIPTMAIR, RALF	Seminar for	
	Applied	Acoustic scattering problems with convolution
	Mathematics,	quadrature and the method of fundamental
	ETH Zurich	solutions
	(Switzerland)	
HOHAGE, THORSTEN	University of	
	Göttingen	Learned Infinite Elements
	(Germany)	
LOLY DATRICK	ENSTA	A convolution quadrature approach to wave
JOLY, PATRICK	ParisTech	propagation in fractal trees



Session 5. Tuesday 18:00 – 20:00. Room A3.

Chair: Hohage, Thorsten (University of Göttingen (Germany))

Speaker	Organization	Contribution title
DOMÍNGUEZ, VÍCTOR	Public University of Navarre	deltaBEM: a rigorous theoretical analysis
Turc, Catalin	New Jersey Institute of Technology	Planewave Density Interpolation Methods for the EFIE on Simple and Composite Surface
BESPALOV, ALEX	University of Birmingham (United Kingdom)	Raviart-Thomas interpolation on anisotropic elements with application to the BEM for Maxwell's equations
COSTABEL, MARTIN	University of Rennes	On the coercivity of space-time boundary integral equation
GÓMEZ, MACARENA	University of Sevilla	A Posteriori error for parabolic linear equations using TR-BDF2 and FEM methods
		Tribute to FJ. Sayas

Session 6.1. Wednesday 16:15 – 17:55. Room A3.

Chair: Domínguez, Víctor (Universidad Pública de Navarra)

Speaker	Organization	Contribution title
SELGAS, VIRGINIA	University of Oviedo	Steklov and modified transmission eigenvalues as target signatures in an inverse fluid-solid interaction problem
NIGAM, NILIMA	Simon Fraser University	Steklov eigenvalue problems
Bruno, Oscar	Caltech	Waves, scattering, eigenfunctions, and electromagnetic design
MONK, PETER	University of Delaware (USA)	An HDG method for the Steklov eigenvalue problem
CAKONI, FIORALBA	Rutgers University (USA)	Solvability of the Time Dependent Interior Transmission Problem



Session 6.2. Wednesday 18:00 – 20:00. Room A3.

Chair: Cakoni, Fioralba (Rutgers University, USA)

Speaker	Organization	Contribution title
Du, Shukai	University of Wisconsin- Madison (USA)	Generalized projection-based error analysis of HDG methods
SÁNCHEZ, MANUEL	Pontifical Catholic University of Chile	Symplectic Hamiltonian finite element methods for elastodynamics
SOLANO, MANUEL	University of Concepción	An HDG method for Maxwell's equations in heterogeneous media
BACUTA, CONSTANTIN	University of Delaware (USA)	Least Squares Discretization and Preconditioning for the Reaction-Diffusion Problem
HEUER, NORBERT	P. Universidad Católica de Chile	DPG for Reissner-Mindlin plates
		Tribute to FJ. Sayas

Session 8. Thursday 18:00-20:00. Room A3.

Chair: Meddahi, Salim (Universidad de Oviedo)

Speaker	Organization	Contribution title
OYARZÚA, RICARDO	University of Bío-Bío (Chile)	A priori and a posteriori error analysis of a momentum conservative mixed-FEM for the stationary Navier-Stokes problem
MÁRQUEZ, ANTONIO	University of Oviedo	A decoupled preconditioning method for a mixed Stokes-Darcy model
PRAETORIUS, DIRK	Institute of Analysis and Scientific Computing (Austria)	Goal-oriented adaptive finite element methods with optimal computational complexity
GASPAR, FRANCISCO	Universidad de Zaragoza	A parallel-in-time fixed-stress split method for the Biot's consolidation model
NEILAN, MICHAEL	University of Pittsburgh (USA)	Scott-Vogelius finite elements on curved domains
		Tribute to FJ. Sayas



Bacuta, Constantin

Organization

University of Delaware (USA)

Email

bacuta@udel.edu

Title

Least Squares Discretization and Preconditioning for the Reaction-Diffusion Problem

Abstract

We consider a saddle point least squares method for discretizing the singularly perturbed reaction-diffusion problem. Choices for discrete stable spaces are considered for the mixed formulation and a preconditioned conjugate gradient iterative process for solving the saddle point reformulation is proposed. We provide a preconditioning strategy that works for a large range of the perturbation parameter. Using the concepts of optimal test norm and saddle point reformulation we provide an efficient discretization strategy that works for uniform and non-uniform refinements.

Joint work with Jacavage, Jacob from Lafayette College and Hayes, Daniel from University of Delaware



Banjai, Lehel

Organization

Heriot-Watt University

Email

L.Banjai@hw.ac.uk

Title

FEM/BEM, explicit/implicit discretization of the wave equation in the second order formulation

Abstract

We consider acoustic scattering of waves by bounded inhomogeneities in an unbounded homogeneous domain. We make use of a symmetric FEM/BEM formulation. The solution in the interior is discretized in space by a finite element method. In the unbounded outer domain, the solution is represented by layer potentials and discretized on the boundary by the boundary element method. In time we discretize the boundary integral operators by convolution quadrature based on the trapezoidal rule, whereas the interior equation is discretized by leapfrog under a CFL condition. We give a stability and convergence analysis and illustrate the method with numerical results.



Bespalov, Alex

Organization

University of Birmingham (United Kingdom)

Email

a.bespalov@bham.ac.uk

Title

Raviart-Thomas interpolation on anisotropic elements with application to the BEM for Maxwell's equations

Abstract

We study stability properties of the Raviart--Thomas interpolation of low-regular vector fields on anisotropic elements.

The underlying vector fields live in a fractional Sobolev space $H^s \cap H(\text{div})$ with $0 < s \le 1/2$.

For such vector fields, the trace of the normal component only exists in a weak sense.

Therefore, instead of the standard trace argument, we use Green's formula and employ anisotropic H^s -seminorms in order to analyse componentwise stability of the Raviart-Thomas interpolant and prove the associated interpolation error estimates.

The results of this type are required in the analysis of the boundary element method (BEM) for Maxwell's equations. In particular, we apply them to establish quasi-optimal convergence of the Galerkin BEM for the electric field integral equation on polyhedral surfaces discretised by anisotropic meshes.

Joint work with Nicaise, Serge (Université de Valenciennes).



Bruno, Oscar

Organization

Caltech

Email

oscar.p.bruno@gmail.com

Title

Waves, scattering, eigenfunctions, and electromagnetic design

Abstract

We present fast integral solvers for the evaluation of waves and eigenstates. Based on novel high-order methods for evaluation of integral operators, these algorithms can accurately calculate scattering solutions, eigenvalues and eigenfunctions in a variety of important settings, including setups leading to singular solutions and exponentially-decaying eigenfunctions, challenging engineering geometries, and problems of very high frequency. Electromagnetic solvers for large and complex three-dimensional structures will be described in some detail, and the mathematically related problem of optimization of photonic devices will be discussed briefly.



Cakoni, Fioralba

Organization

Rutgers University (USA)

Email

fc292@math.rutgers.edu

Title

Solvability of the Time Dependent Interior Transmission Problem

Abstract

A fundamental tool for justification of qualitative reconstruction methods in inverse scattering theory for inhomogeneous media is the solvability of time domain interior transmission problem. This problem has a simple formulation, namely two wave equations with different sound speed in a bounded domain coupled through the Cauchy data on the boundary along with the causality condition, but it presents a perplexing mathematical structure. In particular, its solvability relies on understanding the location in the complex plane of the eigenvalues of a non-selfadjoint eigenvalue problem known as the transmission eigenvalue problem. We present a recent result on the solvability of this problem obtained jointly with Monk, Peter and Selgas, Virginia.



Costabel, Martin

Organization

University of Rennes

Email

martin.costabel@univ-rennes1.fr

Title

On the coercivity of space-time boundary integral equations

Abstract

As is the case for elliptic problems, first kind boundary integral operators for parabolic and hyperbolic problems inherit some positivity properties from the variational formulation of the corresponding transmission problems. Sometimes their positivity is even stronger than expected. This coercivity is, of course, an essential ingredient in the analysis of boundary element methods.

There has recently been some progress on coercivity for both variational formulations for parabolic problems and for boundary integral operators for parabolic and hyperbolic problems. The talk focusses on a common feature of these new developments, namely the role of the time-axis Hilbert transform.



Domínguez, Víctor

Organization

Public University of Navarre

Email

victor.dominguez@unavarra.es

Title

deltaBEM: a rigorous theoretical analysis

Abstract

In this talk we describe the latest advances in the analysis of the deltaBEM method, a simple but still powerful algorithm for discretization of the boundary layer operators associated to Laplace, Helmholtz, Elasticity and Elastodynamics PDE in two dimensional smooth domains. The method was designed mainly from intuitive arguments so that a full mathematical foundation was missing. We present a theoretical analysis which covers most, but not all yet, of the direct and indirect formulations, and rigorously prove what has been extensively observed in numerous computations: stability of the method(s) and (globally) third-order convergence.



Du, Shukai

Organization

University of Wisconsin-Madison (USA)

Email

sdu49@wisc.edu

Title

Generalized projection-based error analysis of HDG methods.

Summary

The projection-based error analysis of mixed finite element methods can be extended to a limited class of hybridizable discontinuous Galerkin (HDG) methods. Consequently, the analysis of these HDG methods becomes simple and concise. However, how to generalize these analysis techniques to other HDG methods is highly non-trivial. We show how this can be done by introducing the so-called generalized projection-based error analysis.



Gaspar, Francisco

Organization

Universidad de Zaragoza

Email

fjgaspar@unizar.es

Title

A parallel-in-time fixed-stress split method for the Biot's consolidation model

Summary

In recent years, intensive research has been focused on the design of efficient methods for solving the large linear systems arising from the discretization of the Biot's model, since in real simulations it is the most consuming part. There are mainly two approaches, the fully coupled methods and the iterative coupling methods. At each time step, the fully coupled methods solve simultaneously the system of equations for all the unknowns, whereas iterative coupling methods solve sequentially the equations for fluid flow and geomechanics, until a converged solution within a prescribed tolerance is achieved. A big advantage of these methods is their flexibility since two different codes for fluid flow and geomechanics can be linked for solving the Biot's model. Due to its unconditional stability, one of the most frequently used schemes of this type is the so-called fixed stress split method. This sequential-implicit method basically consists in solving the flow problem first fixing the volumetric mean total stress, and then the mechanic part is solved from the values obtained at the previous flow step. In this work, we propose a new algorithm based on this method, which results in a very appealing alternative due to its parallelizable properties. The convergence of this iterative scheme is proved and illustrated by numerical experiments.

Joint work with Rodrigo, C. (U. of Zaragoza).



Gómez, Macarena

Organization

University of Sevilla

Email

macarena@us.es

Title

A Posteriori error for parabolic linear equations using TR-BDF2 and FEM methods

Summary

Some problems of interest corresponding to real situations need to be solved efficiently, with acceptable calculation times. Nowadays, one of the techniques to do this are the so-called reduced order models. For some of these methods, the availability of an "a posteriori" error estimator is a fundamental tool. In this work we study "a posteriori" error estimators for parabolic partial differential equations, using the TR-BDF2 method in time and the Finite Element Method in space. We will also present some numerical results that confirm the effectiveness of this estimator.



Heuer, Norbert

Organization

P. Universidad Católica de Chile

Email

nheuer@mat.uc.cl

Title

DPG for Reissner-Mindlin plates

Abstract

The discontinuous Petrov-Galerkin method with optimal test functions (DPG) is a Galerkin framework that aims at satisfying discrete stability in an automatic way. One of its advantages is that, for a given model problem, it gives flexibility in the choice of a variational formulation. We discuss this strategy, and results, for the Reissner-Mindlin model of plate bending. This is a collaboration with Führer, Thomas (UC, Chile) and Sayas, Francisco-Javier "Pancho" initiated during Pancho's last visit to Santiago in January 2018.



Hiptmair, Ralf

Organization

Seminar for Applied Mathematics, ETH Zurich (Switzerland)

Email

hiptmair@sam.math.ethz.ch

Title

Acoustic scattering problems with convolution quadrature and the method of fundamental solutions

Abstract

We study time domain acoustic scattering problems in two and three dimensions. The numerical scheme relies on the convolution quadrature (CQ) method to reduce the time domain problem to frequency domain Helmholtz equations with complex wave numbers. These equations are solved with the method of fundamental solutions (MFS), which approximates the solution by a linear combination of fundamental solutions defined at source points inside (outside) the scatterer for exterior (interior) problems. Numerical results show that the coupling of both methods works efficiently and accurately for multi-step and multi-stage based CQ.

Joint work with Larbarca, Ignacio



Hohage, Thorsten

Organization

University of Göttingen (Germany)

Email

hohage@math.uni-goettingen.de

Title

Learned Infinite Elements

Abstract

We study a new class of infinite elements for time-harmonic wave equations in separable exterior domains. Although the Dirichlet-to-Neumann (DtN) map can be computed by separation of variables, it is a nonlocal operator with dense matrix representations, and hence computationally inefficient. Therefore, approximations of DtN maps by sparse matrices, usually involving additional degrees of freedom, have been studied intensively in the literature using, e.g., different types of infinite elements, local non-reflecting boundary conditions, and perfectly matched layers. The entries of these sparse matrices are derived analytically, e.g. from transformations or asymptotic expansions of solutions to the differential equation in the exterior domain. In contrast, we propose to 'learn' the matrix entries from the DtN map in its separated form by solving an optimization problem as a preprocessing step. Theoretical considerations exponential convergence with the number of infinite element degrees of freedom, which is confirmed in numerical experiments.

Joint work with Preuss, Janosch and Lehrenfeld, Christoph.



Jeon, Youngmok

Organization

Ajou University (Korea)

Email

yjeon@ajou.ac.kr

Title

The Immersed Hybrid Difference Method for Interface Problems

Summary

We present the immersed hybrid difference method (IHD method) for a class of interface problems. In the IHD method the key idea lies in the VR transformation. The VR transformation is composed of the interface and consistency conditions, and it relates the virtual solutions (the extended part of the sub-solutions) to the real solutions uniquely. The main advantages of the IHD method are that it is easily implementable and derivation of high order methods is convenient.

The hybrid difference methods (HDM) are developed by the author and his colleagues, which can be understood as a finite difference version of the hybridized DG method. The HDM is locally conservative. Bearing the structure of the hybridized finite element method, numerical analysis of the HDM is possible in a variational setting. The IHD method is the HDM applied to the interface problems.

Numerical tests on several types of interfaces with low and high order methods are presented, which demonstrate efficiency of the suggested method.



Joly, Patrick

Organization

ENSTA ParisTech

Email

patrick.joly@inria.fr

Title

A convolution quadrature approach to wave propagation in fractal trees

Summary

In this work we consider a weighted wave equation posed on a fractal (i.e. self-similar) 1D tree. An application is the sound propagation in a bronchial network. The main difficulty for the numerical resolution of the problem is the 'infiniteness' of the geometry. To deal with this issue, we will construct transparent boundary conditions used to truncate the computational domain via a Dirichlet-to-Neumann (DtN) operator, whose symbol is a meromorphic function of the frequency that satisfies a certain non-linear functional equation. For the numerical approximation we shall present an approach based on an adaptation the convolution quadrature (cf. [Lubich 1988], [Banjai, Lubich, Sayas 2016]), constructs an exact DtN for an implicit semi-discretization in time of the wave equation in the cut subtrees tree, combined with the explicit leapfrog method inside the computational domain.



Márquez, Antonio

Organization

University of Oviedo

Email

amarquez@uniovi.es

Title

A decoupled preconditioning method for a mixed Stokes-Darcy model.

Abstract

We propose an iterative method for the coupling of fluid flow with porous media flow. The weak formulation of this problem is obtained by coupling the velocity-pressure mixed formulation in the Stokes domain with the mixed formulation in the porous domain. The mixed finite element discretization leads to an indefinite and ill-conditioned linear system of algebraic equations. We apply a decoupled preconditioning technique requiring only good solvers for the Poisson problem in each subdomain.

Joint work with Meddahi, Salim (U. of Oviedo).



Monk, Peter

Organization

University of Delaware (USA)

Email

monk@udel.edu

Title

An HDG method for the Steklov eigenvalue problem

Abstract

The mixed Steklov eigenvalue problem for the Helmholtz equation arises in certain specialized inverse scattering algorithms. It is then useful to compute such eigenvalues precisely for comparison. We have used a Hybridizable Discontinuous Galerkin (HDG) approach successfully for this problem. I shall describe an analysis of the HDG method applied to the mixed Steklov eigenvalue problem for the related Laplace equation. In particular, I shall discuss the proof of optimal convergence rates for the eigenvalues and the eigenfunctions, and additionally a superconvergent rate for the eigenvalues. The theory will be illustrated by numerical results.

Joint work with Zhang, Yangwen (University of Delaware).



Neilan, Michael

Organization

University of Pittsburgh (USA)

Email

neilan@pitt.edu

Title

Scott-Vogelius finite elements on curved domains

Abstract

We construct and analyze an isoparametric finite element pair for the Stokes problem in two dimensions. The pair is defined by mapping the Scott-Vogelius finite element space via a Piola transform. The velocity space has the same degrees of freedom as the Lagrange finite element space, and therefore, the proposed spaces reduce to the Scott-Vogelius pair in the interior of the domain. We prove that the resulting method converges with optimal order, is divergence-free, and is pressure robust.

This is joint work with Baris Otus, M. (Univ. of Pittsburgh).



Nigam, Nilima

Organization

Simon Fraser University

Email

nigam@math.sfu.ca

Title

Steklov eigenvalue problems

Abstract

In this talk we present some recent results on the theory and computation of Steklov eigenproblems for the Laplacian, as well as for the Lame operator. The discretization approach we take is via integral operators. The talk is dedicated to Pancho Sayas, whose contributions to the study of boundary integral equations and elasticity are deeply influential.



Oyarzúa, Ricardo

Organization

University of Bío-Bío (Chile)

Email

royarzua@ubiobio.cl

Title

A priori and a posteriori error analysis of a momentum conservative mixed-FEM for the stationary Navier-Stokes problem

Abstract

In this talk we present a new conforming mixed finite element method for the Navier-Stokes problem posed on non-standard Banach spaces, where a pseudostress tensor and the velocity are the main unknowns of the system. The associated Galerkin scheme can be defined by employing Raviart-Thomas elements of degree \$k\$ for the pseudostress and discontinuous piecewise polynomials of degree \$k\$ for the velocity. Next, by extending standard techniques commonly used on Hilbert spaces to the case of Banach spaces we derive a reliable and efficient residual-based a posteriori error estimator for the corresponding mixed scheme. Joint work with Camaño, J. (UCSC), Caucao S. (UCSC), Garcia C. (PUC) and Villa, S. (UBB).



Perugia, Ilaria

Organization

University of Vienna

Email

ilaria.perugia@univie.ac.at

Title

DGFEM-BEM mortar coupling for the Helmholtz problem

Abstract

We present a mortar-type coupled finite element-boundary element discretization of the Helmholtz problem in three dimensions, where the mortar variable is related to an impedance trace on an artificial boundary. In particular, we focus on discontinuous Galerkin discretizations in the interior domain. Compared to the case of a conforming finite element discretization, here a modification in the discrete coupling condition is required in order to satisfy a discrete Gårding inequality. The resulting method presents a block structure with subblocks that are nonsingular, independently of the choice of the artificial boundary.

Joint work with Erath Christoph (PH Vorarlberg), Mascotto, Lorenzo (U. of Vienna), Melenk, Markus (TU Vienna), and Rieder, Alexander (U. of Vienna).



Praetorius, Dirk

Organization

Institute of Analysis and Scientific Computing (Austria)

Email

dirk.praetorius@asc.tuwien.ac.at

Title

Goal-oriented adaptive finite element methods with optimal computational complexity.

Abstract

We consider a linear symmetric and elliptic PDE and a linear goal functional. We design a goal-oriented adaptive finite element method (GOAFEM), which steers the adaptive mesh-refinement as well as the approximate solution of the arising linear systems by means of a contractive iterative solver like the optimally preconditioned conjugate gradient method (PCG). We prove linear convergence of the proposed adaptive algorithm with optimal algebraic rates with respect to the number of degrees of freedom as well as the computational cost.

The talk is based on joint work with Becker, Roland (U Pau, FR), Gantner, Gregor (U Amsterdam, NL), and Innerberger, Michael (TU Wien, AT).



Rapún, María Luisa

Organization

Universidad Politécnica de Madrid

Email

marialuisa.rapun@upm.es

Title

Numerical methods for direct and inverse multiple scattering problems for mixed sound-soft, sound-hard and penetrable objects.

Abstract

We consider the scattering of time-harmonic acoustic waves in an unbounded medium where some objects of different nature are present. In the first part of the talk, we study an equivalent system of boundary integral equations to solve the direct problem. In the second part, we propose a numerical method based on the computation of the topological energy to find the shape of the objects (without knowing their nature) from measurements of the total field at a set of observation points.



Rieder, Alexander

Organization

University of Vienna

Email

alexander.rieder@univie.ac.at

Title

A superconvergence phenomenon in Runge-Kutta convolution quadrature for the wave equation

Abstract

When discretizing a scattering problem for the wave equation using Runge-Kutta based convolution quadrature and boundary element methods, in some cases there is a discrepancy between the theoretically predicted and the observed convergence rate. Namely, in some situations the usual Laplace-domain estimates do not appear to tell the whole story.

We explain, how such increased rates can be explained by a novel decomposition result of the Dirichlet-to-Neumann map into a scalar multiple of the identity and an operator with improved frequency domain estimates.



Sánchez, Manuel

Organization

Pontifical Catholic University of Chile

Email

manuel.sanchez@ing.puc.cl

Title

Symplectic Hamiltonian finite element methods for elastodynamics

Abstract

We present a class of high-order finite element methods that can conserve the linear and angular momenta as well as the energy for the equations of linear elastodynamics. These methods are devised by exploiting and preserving the Hamiltonian structure of the equations of linear elastodynamics. We show that several mixed finite element, discontinuous Galerkin, and hybridizable discontinuous Galerkin (HDG) methods belong to this class. We discretize the semidiscrete Hamiltonian system in time by using a symplectic integrator in order to ensure the symplectic properties of the resulting methods, which are called symplectic Hamiltonian finite element methods. For a particular semidiscrete HDG method, we obtain optimal error estimates and present, for the symplectic Hamiltonian HDG method, numerical experiments that confirm its optimal orders of convergence for all variables as well as its conservation properties.



Sánchez-Vizuet, Tonatiuh

Organization

University of Arizona

Email

tonatiuh@math.arizona.edu

Title

Coupling BIE and HDG: an application to a free boundary problem from plasma physics.

Abstract

In magnetic confinement fusion devises, the equilibrium configuration of a plasma is determined by the balance between the hydrostatic pressure in the fluid and the magnetic forces generated by an array of external coils and the plasma itself. The location of the plasma is not known a priori, leading to a free boundary problem involving a nonlinear elliptic equation for the stream function of the magnetic field. We propose an efficient high order discretization based on the a Johnson-Nedeléc style coupling of a boundary integral equation and the hybridizable discontinuous Galerkin method.



Selgas, Virginia

Organization

University of Oviedo

Email

selgasvirginia@uniovi.es

Title

Steklov and modified transmission eigenvalues as target signatures in an inverse fluid-solid interaction problem

Abstract

We investigate an inverse scattering problem for the interaction of a linearly elastic solid and an acoustic fluid by using two sets of eigenvalues: Steklov eigenvalues and modified transmission eigenvalues. For both sets of eigenvalues, we first define them for the problem at hand. We then characterize them by means of operators suitable for the analysis of their location in the complex plane. We also discuss their approximation using scattering data via some modified far-field equations, and provide numerical examples that show their approximation from synthetic far-field measures and their application as target signatures.



Solano, Manuel

Organization

University of Concepción

Email

msolano@ing-mat.udec.cl

Title

An HDG method for Maxwell's equations in heterogeneous media

Abstract

We analyze a hybridizable discontinuous Galerkin (HDG) method for the time harmonic Maxwell's equations arising from modeling photovoltaic solar cells. The problem is set in an inhomogeneous domain where the electric permittivity is a complex-valued piecewise constant function. We prove the HDG scheme is well-posed, up to some frequencies, and derive a stability estimate. Moreover, we perform an error analysis and validate the method with numerical simulations.

Joint work with Camargo, Liliana, López-Rodríguez, Bibiana and Osorio, Mauricio (U. Nacional de Colombia, Medellín).



Turc, Catalin

Organization

New Jersey Institute of Technology

Email

catalin.c.turc@njit.edu

Title

Planewave Density Interpolation Methods for the EFIE on Simple and Composite Surfaces

Abstract

We present an extension of the recently introduced planewave density interpolation (PWDI) method to the electric field integral equation (EFIE) formulation of problems of scattering and radiation by perfect electric conducting (PEC) objects. Relying on local interpolation of surface current densities that regularize the kernel singularities, the PWDI method enables off-and onsurface EFIE operators to be re-expressed in terms of integrands that are globally bounded (or even more regular) over the whole domain of integration, regardless of the magnitude of the distance between target and source points. The proposed technique can be applied to simple and composite surfaces comprising two or more simply-connected overlapping components. A variety of examples, including multi-scale and intricate structures, demonstrate the effectiveness of the proposed methodology.

Joint work with Pérez-Arancibia, C. (PUC, Chile), Faria, L. (ENSTA, Paris), and Sideris, C. (USC).



SeMA Awards

Organizers: SeMA

Abstract

Every year since 1998, the Spanish Society for Applied Mathematics SeMA, awards the most outstanding young researcher to promote excellence in original mathematical work with a strong applied component. The award is named after Antonio Valle, the first president of the society. This year, for the first time, it has been awarded ex aequo to Rafael Granero-Belinchón and to Jezabel Curbelo.

The European Community on Computational Methods in Applied Sciences ECCOMAS awards the two best PhD Theses among the candidates presented by the local ECCOMAS associations. The candidate selected by SeMA for the 2019 prize was Judit Muñoz Matute and the candidate for the 2020 prize is Amanda Carreño.

In this session, both the winners of the "Antonio Valle" award and our candidates for the best theses will lecture about analysis, numerical analysis and applications of selected topics in partial differential equations.

Keywords: SeMA Awards

Session 6. Wednesday 10:30 – 12:10.

Room A3. Chair: Castro Díaz, Manuel Jesús (Universidad de Málaga)

Speaker	Organization	Contribution title
SeMA candidate for the ECCOMAS Awards for the Two Best PhD Theses in 2020 on		
Computational Methods in Applied Sciences and Engineering		
CARREÑO,	Universitat Politècnica de València	Variable time-step modal methods to
AMANDA		integrate the time-dependent neutron
AIVIANDA GE		diffusion equation
SeMa 2020 Award "Antonio Valle" to young researchers (ex-aequo)		
GRANERO-	Universidad de	
BELINCHÓN,	Cantabria	Interfaces in incompressible flows
RAFAEL		
SeMA candidate for the ECCOMAS Awards for the Two Best PhD Theses in 2019 on		
Computational Methods in Applied Sciences and Engineering		
Muñoz	Basque Center for	A Discontinuous Petrov-Galerkin method for
MATUTE, JUDIT	Applied Mathematics	solving linear transient parabolic problems
WIATOTE, JODIT	(BCAM)	301VIIIg IIIIeai transient parabone problems
SeMa 2020 Award "Antonio Valle" to young researchers (ex-aequo)		
CURBELO,	Universitat Politècnica	Lagrangian methods to characterize transport
JEZABEL	de Catalunya	and mixing in geophysical flows



Carreño, Amanda

Organization

Universitat Politècnica de València

Email

amcarsan@iqn.upv.es

Title

Variable time-step modal methods to integrate the time-dependent neutron diffusion equation

Summary

The time-dependent neutron diffusion equation can describe the power evolution inside a nuclear reactor core. One approach to integrate this equation is the modal method.

These methods are based on assuming that the solution can be decomposed a sum of time-dependent amplitudes multiplied by shape functions (obtained from different eigenvalue problems), which are updated along the transient. In this work, different controls, that adapt the time-step according to the state of the transient analyzed, are implemented. Several benchmark problems are tested showing the competitiveness of the methodology.



Curbelo, Jezabel

Organization

Universitat Politècnica de Catalunya

Email

jezabel.curbelo@upc.edu

Title

Lagrangian methods to characterize transport and mixing in geophysical flows.

Abstract

Transport and mixing processes play key roles in the spatial distribution of heat, momentum and trace gases in the atmosphere and oceans. Finding order in the apparent chaos that seems to govern transport processes is a challenge.

The theory of dynamical systems provides guidance addressing this challenge. Lagrangian methods applied to geophysical flows synthesize the information provided by parcel trajectories for visualization of complex flow structures.

Our approach, in the Lagrangian framework, identifies transport pathways and quantifies the spatial distribution of mixing. This talk presents several examples of our methodology revealing beautiful time dependent geometries.



Granero-Belinchón, Rafael

Organization

Universidad de Cantabria

Email

rafael.granero@unican.es

Title

Interfaces in incompressible flows

Abstract

The simplest water waves are modeled by the free-surface irrotational incompressible Euler equations of fluid dynamics. However, the Euler equations are sufficiently complicated that for many physical scenarios, a precise understanding of the dynamics of the solutions to the full water waves problem is not known yet. Consequently, since the XIX century, there has been a sustained effort to find suitable approximations of the Euler equations in certain asymptotic regimes. In this talk we will introduce some new models for interfaces in incompressible flows. These models take the form of nonlinear and nonlocal dispersive PDEs. Several well-posedness and large time behavior results will be presented. The content of this talk has been the subject of a series of joint works with Cheng, A. (NCU, Taiwan), Ortega, A. (UC3M, Spain), Scrobogna, S. (US, Spain), Shkoller, S. (UC Davis, USA) and Wilkening, J. (UC Berkeley, USA).



Muñoz Matute, Judit

Organization

Basque Center for Applied Mathematics (BCAM)

Email

judith.munozmatute@gmail.com

Title

A Discontinuous Petrov-Galerkin method for solving linear transient parabolic problems

Abstract

The Discontinuous Petrov Galerkin (DPG) method is a well established numerical method for solving Partial Differential Equations (PDEs). In contrast to previous works on DPG for time-dependent problems, we apply the DPG method in the time variable for linear parabolic problems that have been previously discretized in space. We calculate the optimal test functions analytically and we obtain a time-marching scheme that is equivalent to exponential integrators for the trace variables. We show the performance of the method for first-order ordinary differential equations and 1D/2D + time parabolic PDEs after discretizing in space by a finite element method.



Minisimposya



Minisymposium:

Advances in multiresolution and subdivision techniques and its applications

Thematic area: Other: Scientific Computation, Approximation Theory, Discrete Mathematics, Mathematical Education, ... (O)

Organizers: Yáñez Avendaño, Dionisio F. (Departamento de Matemáticas, U. Valencia), Ruiz, Juan (Departamento de Matemática Aplicada y Estadística, Universidad Politécnica de Cartagena), Trillo, Juan Carlos (Departamento de Matemática Aplicada y estadística, Universidad Politécnica de Cartagena)

Abstract

Multiresolution and subdivision techniques are used in several applications as computer aided design and image processing. For instance, Harten's multiresolution framework allows to design new methods based on linear and non-linear reconstruction techniques. In nonlinear subdivision schemes, crucial questions such as convergence and stability of the schemes, order of approximation, preservation of monotonicity or convexity, and elimination of Gibbs effects near jump discontinuities need to be studied with specific techniques. In turn, subdivision schemes and their properties play an important role in order to construct and study new multiresolution schemes. The selected talks will deal with these issues.

Keywords: multiresolution; subdivision; image processing

Session 5: Tuesday, 18:00-20:00. Room B1.

Chair: Trillo, Juan Carlos (Universidad Politécnica de Cartagena)

Speaker Organization **Contribution title** Non tensor product reconstructions in MAGREÑAN, Universidad de La Rioja 2D. Applications to subdivision and **ÁNGEL ALBERTO** multiresolution schemes Universidad Politécnica de On how to adapt splines to the presence RUIZ, JUAN Cartagena of discontinuities On the PPH nonlinear subdivision and TRILLO, JUAN Universidad Politécnica de multiresolution schemes for non uniform **CARLOS** Cartagena meshes **Y**ÁÑEZ Subdivision schemes based on local AVENDAÑO, Universidad de Valencia polynomial regression DIONISIO F. LÓPEZ-UREÑA, Design of non-linear filters for piecewise Universidad de Valencia **SERGIO** smooth data affected by noise



López-Ureña, Sergio

Organization

Universidad de Valencia

Email

sergio.lopez-urena@uv.es

Title

Design of non-linear filters for piecewise smooth data affected by noise

Abstract

Linear filters can be used to successfully denoise signals. However, they may produce oscillations in the presence of a large gradient in the data. In order to avoid this phenomenon, non-linear filters, as well as non-linear subdivision schemes, have been developed. For instance, WENO strategies have proven to be a suitable choice to process piecewise smooth data.

In this work, inspired by the WENO success, we combine several linear denoising filters in order to obtain a non-linear denoising filter which handles properly large gradients in the data. Some examples are performed to validate the theoretical results.



Magreñan, Ángel Alberto

Organization

Departamento de Matemáticas y computación, Universidad de La Rioja

Email

angel-alberto.magrenan@unirioja.es

Title

Non tensor product reconstructions in 2D. Applications to subdivision and multiresolution schemes

Abstract

We introduce a new nonlinear reconstruction operator in 2D into the context of Harten's pointvalue reconstruction operators for subdivision and multiresolution processes. This reconstruction is non separable, in the sense that it is builded directly in 2D, not via tensor product approach. Once the reconstruction is defined for pointvalues, we will use it to get another reconstruction for the cell average case. This fact will allow to define the associated subdivision and multiresolution schemes as much in the pointvalue as in the cell average case. Analysis of the resultant schemes is carried out, and numerical experiments are also given.



Ruiz, Juan

Organization

Departamento de Matemática Aplicada y Estadística, Universidad Politécnica de Cartagena

Email

juan.ruiz@upct.es

Title

On how to adapt splines to the presence of discontinuities

Abstract

When interpolating data with certain regularity, spline functions are useful. They are defined as piecewise polynomials that satisfy certain regularity conditions at the joints. In the literature about splines it is possible to find several references that study the apparition of Gibbs phenomenon close to jump discontinuities in the results obtained by spline interpolation. This work is devoted to the construction and analysis of a new nonlinear technique that allows to improve the accuracy of splines near jump discontinuities eliminating the Gibbs phenomenon. The adaption is easily attained through a nonlinear modification of the right-hand side of the system.



Trillo, Juan Carlos

Organization

Departamento de Matemática Aplicada y estadística, Universidad Politécnica de Cartagena

Email

jc.trillo@upct.es

Title

On the PPH nonlinear subdivision and multiresolution schemes for non uniform meshes

Abstract

In this talk we present a nonlinear subdivision scheme for non-uniform meshes, generalizing the already existing PPH subdivision scheme in uniform grids. From construction the nonlinear subdivision scheme is adapted to the presence of numerical discontinuities in the initial data.

Apart of the basics properties of the operator, that is convergence, reproduction of polynomials, order of convergence, adaption to singularities, we will also address issues such as smoothness of the limit function, and stability of the schemes. Moreover, we will also study the associated multiresolution schemes. Some numerical experiments will be offered.



Yáñez Avendaño, Dionisio F.

Organization

Departamento de Matemáticas, U. Valencia

Email

dionisio.yanez@uv.es

Title

Subdivision schemes based on local polynomial regression

Abstract

Subdivision schemes are a powerful tool to design curves and surfaces. In Multiresolution context subdivision schemes have been used as predictor operators. Aràndiga and Yáñez in [Generalized wavelets design using Kernel methods. Application to Signal Processing, J. Comput. Appl. Math. (2013)] construct new operators based on weighted linear regression with interesting properties for noisy data. In this talk, we develop these operators and their properties from subdivision schemes theory. Several experiments are performed comparing the new methods with the classical schemes.



Minisymposium:

Algorithms and structure in Numerical Linear Algebra

Thematic area: Numerical Linear Algebra (NLA)

Organizers: Barreras, Álvaro (Universidad Internacional de La Rioja), De Terán Vergara, Fernando (Universidad Carlos III de Madrid)

Abstract

Matrices are ubiquitous and arise in several fields of maths and science, including statistics, mechanics, computer science, or economics. In most applications, the matrices involved have some kind of structure.

The numerical treatment of matrices lies within the field of Numerical Linear Algebra (NLA). The general goals of this minisymposium are:

- To show several recent algorithms that aim to solve particular problems in NLA.
- To provide some examples of structured matrices arising in other mathematical problems (like root-finding) and to show how to deal with them.
- To emphasize the relevance of preserving the structure in matrix problems

Keywords: Structured matrices, Matrix algorithms, Canonical forms



Session 7: Thursday, 11:30-13:35. Room A5.

Chair: De Terán Vergara, Fernando (Universidad Carlos III de Madrid)

Speaker	Organization	Contribution title
BARRERAS, ÁLVARO	Universidad Internacional de La Rioja	Tridiagonal M-matrices whose inverse is tridiagonal
CANTÓ, RAFAEL	Universitat Politècnica de València	A method to construct irreducible TN matrices with a given Jordan canonical form
JIMÉNEZ M EANA, JORGE	Universidad de Oviedo	An algorithmic characterization of almost strictly sign regular matrices
PALACIO MUÑIZ, ANTONIO	Universidad de Oviedo	Algorithmic construction of Jacobi ASSR matrices
ORERA, HÉCTOR	Universidad de Zaragoza	Nekrasov matrices: accurate computations and applications

Session 8. Thursday 18:00 – 20:00. Room A5.

Chair: De Terán Vergara, Fernando (Universidad Carlos III de Madrid)

Speaker	Organization	Contribution title	
0.0000 0.000	Universidad de	Accurate computations with rectangular totally	
MARCO, ANA	Alcalá	positive h-Bernstein-Vandermonde matrices	
DELGADO,	Universidad de	Accurate algorithms for the collocation matrices of	
JORGE	Zaragoza	some orthogonal polynomials	
ROMÁN, JOSE E.	Universitat Politècnica de València	Two-sided methods for the nonlinear eigenvalue problem	
YAKOUBSOHN,	Université Paul	Newton-Type Methods For The Singular Value	
JEAN-CLAUDE	Sabatier, Toulouse	Decomposition	
HERNANDO,		A class of quasi spare companion matrices	
CARLA		A class of quasi-spare companion matrices	

Session 9. Friday 11:30 – 13:10. Room A5.

Chair: Barreras, Álvaro (Universidad Internacional de La Rioja)

Speaker	Organization	Contribution title
MAS, JOSÉ	Universitat Politècnica de València	Solving least squares overdetermined linear systems with dense rows by preconditioned iterative methods
MARÍN MATEOS- APARICIO, JOSÉ	Universitat Politècnica de València	Pivoting on the ISM factorization
De Terán Vergara, Fernando	Universidad Carlos III de Madrid	Generalized companion pencils in the monomial basis



Barreras, Álvaro

Organization

Universidad Internacional de La Rioja

Email

alvaro.barreras@unir.net

Title

Tridiagonal M-matrices whose inverse is tridiagonal

Abstract

A tridiagonal matrix A is a nonsinguar M-matrix if it has nonpositive off-diagonal entries and its inverse has nonnegative entries. In this talk, we provide a necessary and sufficient condition for tridiagonal M-matrices, in order to guarantee that their inverses are also tridiagonal. That condition is provided in terms of the zero pattern of the matrices.

This is a joint work with Peña, Juan Manuel.



Cantó, Rafael

Organization

Universitat Politècnica de València

Email

rcanto@mat.upv.es

Title

A method to construct irreducible TN matrices with a given Jordan canonical form

Abstract

The triple (n,r,p) is called realizable if there exists an $n\times n$ irreducible totally nonnegative (ITN) matrix A with rank r and principal rank p. Each ITN matrix A has p positive and distinct eigenvalues, and for the zero eigenvalue it is verified that n-r and n-p are the geometric and the algebraic multiplicity, respectively. We know all different zero Jordan canonical forms of A, and we construct an ITN matrix A associated with each Jordan structure.

Work by Cantó, B. Cantó, Rafael and Urbano, Ana María. Supported by the Ministerio de Economía y Competitividad under the Spanish DGI grant MTM2017-85669-P-AR.



De Terán Vergara, Fernando

Organization

Universidad Carlos III de Madrid

Email

fteran@math.uc3m.es

Title

Generalized companion pencils in the monomial basis

Abstract

Companion matrices are a widely used tool in the polynomial root-finding, but they are only valid for monic polynomials. However, from the numerical point of view, it may be desirable to work with with general (not necessarily monic) polynomials. Companion pencils are generalizations of companion matrices that are valid for arbitrary polynomials. In this talk, we will present and analyze a new notion of "generalized companion pencils" for scalar polynomials over an arbitrary field expressed in the monomial basis. Our definition is quite general and extends some previous recent notions in this context.



Delgado, Jorge

Organization

Universidad de Zaragoza

Email

jorgedel@unizar.es

Title

Accurate algorithms for the collocation matrices of some orthogonal polynomials

Abstract

Bessel polynomials arise in many fields such as partial differential equations, number theory, algebra and statistics. Bessel polynomials are important in static potentials, signal processing and electronics. Reverse Bessel polynomials have applications in Electrical Engineering. In this talk, we will show that any collocation matrix of Bessel polynomials at positive points is strictly totally positive. Moreover, we will show how to compute with high relative accuracy the eigenvalues, singular values and inverses of these matrices. Similar results for the reverse Bessel polynomials will be also presented. We will illustrate the theoretical results with numerical examples.



Hernando, Carla

Organization

Email

cahernan@math.uc3m.es

Title

A class of quasi-spare companion matrices

Abstract

In this talk, we introduce a general class of potential companion pencils for arbitrary square matrix polynomials over an arbitrary field, which extends the class introduced in [1] for monic scalar polynomials. We provide a canonical form, up to permutation, for companion pencils in this class. Finally, we are mainly interested in sparse companion pencils, namely those with the smallest number of nonzero entries, and we determine the number of different sparse companion pencils in the class, up to permutation.

[1] B. Eastman, I-J. Kim, B.L. Shader, and K.N. Vander Meulen. Companion matrix patterns. Linear Algebra Appl., 463:255–272, 2014.



Jiménez Meana, Jorge

Organization

Universidad de Oviedo

Email

meana@uniovi.es

Title

An algorithmic characterization of almost strictly sign regular matrices

Abstract

Sign Regular (SR) matrices are matrices whose minors of the same order have the same sign. Among the SR matrices, an important subclass is that of the Almost Strictly Sign Regular (ASSR) matrices, defined as those whose nontrivial minors of the same order have all the same strict sign. In this work an algorithmic characterization of the ASSR matrices by Neville elimination is presented. For this purpose, different algorithms have been implemented using MatLab.

This is a joint work with Peña, Juan Manuel (U. de Zaragoza), Serrano, María Luisa (U. de Oviedo) and Alonso, Pedro (U. de Oviedo).



Marco, Ana

Organization

Universidad de Alcalá

Email

ana.marco@uah.es

Title

Accurate computations with rectangular totally positive h-Bernstein-Vandermonde matrices

Abstract

The h-Bernstein-Vandermonde (hBV) matrices are a generalization of the Vandermonde matrices obtained when replacing the monomial basis by the h-Bernstein basis, a generalization of the Bernstein basis used in the area of CAGD. In this talk accurate and efficient algorithms for solving numerical linear algebra problems (such as the least squares problem or the singular value computation problem) involving rectangular totally positive h-Bernstein-Vandermonde (hBV) matrices are presented. An essential step of the algorithms is the fast and accurate computation of the bidiagonal decomposition of these rectangular matrices. Numerical experiments showing the good performance of our approach are also included.



Marín Mateos-Aparicio, José

Organization

Universitat Politècnica de València

Email

jmarinma@mat.upv.es

Title

Pivoting on the ISM factorization

Abstract

In this work we study pivonting strategies for preconditioners based on the ISM factorization [1, 2], which computes the LDU factorization of a matrix A using recursion formulas derived from the Sherman-Morrison formula. We present a modification in the recursion formulas of the ISM factorization that allows pivoting and so the construction of preconditioners for any nonsingular matrix. The ISM algorithm computes a vector at each step. By contrast the new pivoting algorithm in the kth-step modifies all the vectors from k to n. Thus, it can be seen as a right-looking version of the ISM factorization.

References

- [1] Bru, R., Cerdán, J., Marín, J., Mas, J., Preconditioning sparse nonsymmetric linear systems with the Sherman-Morrison formula, SIAM J. Sci. Comput., 25 (2), (2003), 701-715.
- [2] Bru, R., Marín, J., Mas, J., Tůma, M., Balanced incomplete factorization, SIAM J. Sci. Comput., 30(5), (2008), 2302-2318.



Mas, José

Organization

Universitat Politècnica de València

Email

jmasm@imm.upv.es

Title

Solving least squares overdetermined linear systems with dense rows by preconditioned iterative methods

Abstract

Iterative methods can be used to solve the least squares linear system Ax = b, mainly if the matrix A is large and sparse. Most iterative methods used to solve this problem are variants of the Conjugate Gradient Method applied to the normal equations and can be preconditioned. A natural choice is to compute an incomplete Cholesky factorization of the coefficient matrix of the normal equations which is symmetric and positive (semi)definite. However, if A has dense rows these matrix becomes dense which makes difficult to compute a preconditioner. We propose some techniques to deal with this situation.



Palacio Muñiz, Antonio

Organization

Universidad de Oviedo

Email

palacioantonio@uniovi.es

Title

Algorithmic construction of Jacobi ASSR matrices

Abstract

It is well known the importance of numerical methods to test algorithms, so that, it is interesting to generate tools with low computational cost. In this way, it is necessary to provide an algorithm that generate quickly, efficiently and safely matrices of any order to study the goodness of their methods. In this paper, we present a constructive method to obtain large tridiagonal almost strictly sign regular matrices (ASSR) with low computational cost. This method is based on extending a tridiagonal ASSR matrix A to another tridiagonal ASSR matrix B such that $B[1,\ldots,n]=A$.

This is a joint work with Abascal, Policarpo, Jiménez Meana, Jorge and Serrano, María Luisa (University of Oviedo).



Orera, Héctor

Organization

Universidad de Zaragoza

Email

hectororera@unizar.es

Title

Nekrasov matrices: accurate computations and applications

Abstract

Nekrasov matrices form a class of nonsingular matrices that contains the class of strictly diagonally dominant matrices. In this talk, we introduce a parameterization that allows us to compute the inverse of Nekrasov Z-matrices to high relative accuracy. The proposed method uses a modification of Gaussian elimination. We also discuss how diagonal scaling can serve as a good starting point for some applications of Nekrasov matrices.

This is a joint work with Peña, Juan Manuel.



Román, Jose E.

Organization

Universitat Politècnica de València

Email

jroman@dsic.upv.es

Title

Two-sided methods for the nonlinear eigenvalue problem

Abstract

We discuss solvers for the general nonlinear eigenvalue problem that are able to compute both left and right eigenvectors. A possible application is the approximation of the resolvent of a matrix-valued function. Our focus is on large-scale problems, in the context of SLEPc, the Scalable Library for Eigenvalue Problem Computations. We present a two-sided variant of the NLEIGS and SLP methods. For the latter, we have implemented a non-equivalence deflation scheme. The accuracy and performance of the methods are analyzed for several problems coming from real applications. This is joint work with Campos, Carmen.



Yakoubsohn, Jean-Claude

Organization

Université Paul Sabatier, Toulouse

Email

yak@mip.ups-tlse.fr

Title

Newton-Type Methods For The Singular Value Decomposition

Abstract

We present a way to construct Newton-type operator for the singular value decomposition problem in the case of clusters of singular values. A convergence analysis of the associated method to this Newton operator suggests to consider another Newton-type operator in order that to improve the result of local quadratic convergence. This framework helps to define a method with a cubic local convergence which generalizes and improves the Davies-Smith method to update the SVD. Moreover, numerical experiments confirm the theoretical results both in the case of distinct singular values and in the singular case of multiple or clustered singular values.



Minisymposium:

Dynamical Systems: Qualitative aspects and applications

Thematic area: Dynamical Systems and Ordinary Differential Equations (DS-ODE)

Organizer: Grupo de Sistemas Dinámicos de la Universidad de Oviedo

Abstract

Results related to population dynamics, neuroscience, fluid mechanics and celestial mechanics are presented. They are examples of the variety of contexts showing a fruitful interaction with the world of dynamical systems. In addition, attention is paid to aspects of Qualitative Theory, from the study of bifurcations to the determinacy of the number of limit cycles exhibited by a differential system, including issues of integrability and global dynamics. This minisymposium offers broad strokes to illustrate the vitality of the research on dynamical systems in our country; 20 years of activities of the DANCE network also give evidence of a great strength.

Keywords: Bifurcation Theory; Applied Dynamical Systems; Global Dynamics



Session 1. Monday 11:30 – 13:35. Room A2.

Chair: Fernández-Sánchez, Fernando (Universidad de Sevilla)

Speaker	Organization	Contribution title
IBÁÑEZ,	Universidad de	Self-sustained oscillations and global climate
SANTIAGO	Oviedo	changes
DRUBI, FÁTIMA	Universidad de Oviedo	A study of the unfolding of Hopf-Bogdanov-Takens singularities
RODRIGUES, ALEXANDRE	Centro de Matemática da Universidade do Porto	Unfolding a Bykov attractor: from an attracting torus to strange attractors
CASAS, PABLO S.	Universidad de Oviedo	Homoclinic bifurcations in the unfolding of the nilpotent singularity of codimension 4 in ℝ⁴

Session 2. Monday 18:00 – 20:00. Room A2.

Chair: Teruel, Antonio (Universitat de les Illes Balears)

Speaker	Organization	Contribution title
SEARA, TERE M.	Universitat Politècnica de Catalunya	Some results about oscillatory orbits
FERNÁNDEZ-SÁNCHEZ, FERNANDO	Universidad de Sevilla	The Falkner-Skan equation revisited
FERNÁNDEZ-GARCÍA, SOLEDAD	Universidad de Sevilla	Saddle-node bifurcation of canard limit cycles in piecewise linear systems
CARMONA, VICTORIANO	Universidad de Sevilla	Uniqueness of limit cycles in sewing planar piecewise linear systems

Session 3. Tuesday 10:55 – 12:10. Room A2. Chair: Liz, Eduardo (Universidade de Vigo)

Speaker	Organization	Contribution title
BRAVO, JOSÉ LUIS	Universidad de Extremadura	Alien limit cycles in Abel equations
CALDERÓN PÉREZ, LUIS ÁNGEL	Universidad de Extremadura	Upper bounds of limit cycles in Abel differential equations with invariant curves
PÉREZ- GONZÁLEZ, SET	Universidad de Oviedo	Limit cycles in piecewise linear vector fields having polynomial first integral



Session 4. Tuesday 12:15 – 13:55. Room A2.

Chair: Bravo, José Luis (Universidad de Extremadura)

Speaker	Organization	Contribution title
MARTÍNEZ, M. ÁNGELES	Universidad de Zaragoza	Dynamical systems and cardiac arrhythmia
PÉREZ, LUCÍA	Universidad de Oviedo	The Hindmarsh-Rose neuron model: Global homoclinic structure and spike-adding process
RODERO, ANA LIVIA	Universidade Estadual Paulista	Centers and their cyclicity for linear and quadratic systems defined on R^3 with $H(x, y, z) = x^2 + y^2 + z^2$ as a first integral

Session 5. Tuesday 18:00 – 20:00. Room A2.

Chair: Rodríguez, J. Ángel (Universidad de Oviedo)

Speaker	Organization	Contribution title
PERALTA- SALAS, DANIEL	Instituto de Ciencias Matemáticas	Constructing Turing complete Euler flows in dimension 3
Núñez, Carmen	Universidad de Valladolid	R-tipping and saddle-node bifurcation for quadratic nonautonomous ODEs
Liz, Eduardo	Universidade de Vigo	Destabilization and chaos induced by harvesting in discrete-time population models

Session 6. Wednesday 10:55 – 12:10. Room A2.

Chair: Ollé, Mercè (Universitat Politècnica de Catalunya)

Speaker	Organization	Contribution title
PALACIÁN, JESÚS	Universidad Pública de Navarra	Nonlinear stability of Hamiltonian systems with more than two degrees of freedom: the case of the levitron
YANGUAS, PATRICIA	Universidad Pública de Navarra	The co-orbital motion of two Saturn's moons
LANCHARES, VICTOR	Universidad de la Rioja	Stability of a one degree of freedom Hamiltonian system in a case of zero quadratic and cubic terms



Session 7. Thursday 11:30 – 13:35. Room A2. Chair: Núñez, Carmen (Universidad de Valladolid)

Speaker	Organization	Contribution title
OLLÉ, MERCÈ	Universitat Politècnica de	Ejection-collision orbits in the collinear 4
OLLE, WIERCE	Catalunya	body problem and beyond
NICOLÁS,	Universitat de Barcelona	Invariant manifolds near L_3 and their role in
BEGOÑA	Oniversitat de Barcelona	the Sun perturbed Earth-Moon system
PARADELA, JAIME	Universitat Politècnica de	Oscillatory motions in the Elliptic Isosceles
PARADELA, JAINIE	Catalunya	Restricted 3-Body Problem
CIDALE MAD	Universitat Politècnica de	Exponentially small splitting of separatrices
GIRALT, MAR	Catalunya	for L_3 in the restricted 3-body problem

Session 8. Thursday 18:00 – 20:00. Room A2. Chair: Drubi, Fátima (Universidad de Oviedo)

Speaker	Organization	Contribution title
RODRÍGUEZ DEL	Universitat Poliècnica	Regularization techniques and ejection-
Río, Óscar	de Catalunya	collision orbits in the RTBP
DUARTE,	Universitat de	Invariant manifolds near L_1 and L_2 in the
GLADSTON	Barcelona	planar elliptic restricted three-body problem
		Complex dynamics in discrete- time
Lois-Prados,	Universidade de	piecewise-smooth models for populations
CRISTINA	Santiago de Compostela	subject to combinations of constant-quota
		and threshold harvesting
LOMBARDERO,	Universidad de Oviedo	Quasi-homogeneous differential systems in
ANTÓN	Offiversidad de Oviedo	\mathbb{R}^3

Session 9. Friday 11:30 – 13:10. Room A2.

Chair: Carmona, Victoriano (Universidad de Sevilla)

Speaker	Organization	Contribution title
PENALVA,	Universitat de les	Bifurcations in a piecewise linear version of the
JORDI	Illes Balears	Morris-Lecar neural model
VIGIL, ENRIQUE	Universidad de Oviedo	Coexistence of finitely many two-dimensional strange attractors: renormalization scheme and analytic proof
TERUEL, ANTONIO	Universitat de les Illes Balears	Poincaré maps in slow-fast piecewise linear differential systems
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Bravo, José Luis

Organization

Universidad de Extremadura

Email

trinidad@unex.es

Title

Alien limit cycles in Abel equations

Abstract

We study the existence of limit cycles for a family of generalized Abel equations $x' = A(t)x^m + B(t)x^n$, $m, n \ge 2$. Under certain assumptions, it is proved that there exists a non-trivial limit cycle. This limit cycle has the characteristic that it arises from neither a Hopf bifurcation nor a perturbation of periodic orbits in a period annulus around the centre at the origin.



Calderón Pérez, Luis Ángel

Organization

Universidad de Extremadura

Email

lucalderonp@unex.es

Title

Upper bounds of limit cycles in Abel differential equations with invariant curves

Abstract

New criteria are established for upper bounds on the number of limit cycles of periodic Abel differential equations having two periodic invariant curves, one of them bounded. The criteria are applied to obtain upper bounds of either zero or one limit cycle for planar differential systems.



Carmona, Victoriano

Organization

Universidad de Sevilla

Email

vcarmona@us.es

Title

Uniqueness of limit cycles in sewing planar piecewise linear systems

Abstract

By using a novel integral characterization of Poincaré half-maps for linear systems, we prove that the piecewise linear systems with two zones of linearity separated by a straight line and without sliding regions admit at most one limit cycle. In addition, the limit cycle, if any, is hyperbolic and its stability is determined by a simple expression in terms of the parameters of the systems. The proof does not distinguish the configurations of the spectra of the matrices of the systems and avoid the case-by-case study performed in the (classical) analysis of piecewise linear systems.



Casas, Pablo S.

Organization

Universidad de Oviedo

Email

pabloscasas@uniovi.es

Title

Homoclinic bifurcations in the unfolding of the nilpotent singularity of codimension 4 in \mathbb{R}^4

Abstract

The four-dimensional differential system

$$\begin{cases} x_1' &=& x_2 \\ x_2' &=& x_3 \\ x_3' &=& x_4 \\ x_4' &=& \lambda_1 + \lambda_2 x_2 + \lambda_3 x_3 + \lambda_4 x_4 + x_1^2 \end{cases}$$

is obtained as a limit family after rescaling any generic unfolding of a four-dimensional nilpotent singularity of codimension-four. We have obtained a partial bifurcation diagram which includes, besides a suggestive catalogue of local bifurcations of equilibria, folds and period doublings of periodic orbits. The rich variety of homoclinic phenomena exhibited by the family will also be discussed. These results are the first steps towards a general understanding of these four-parameter unfoldings, but this is a much more ambitious goal.



Drubi, Fátima

Organization

Universidad de Oviedo

Email

drubifatima@uniovi.es

Title

A study of the unfolding of Hopf-Bogdanov-Takens singularities

Abstract

Singularities of 4-dimensional vector fields whose 1-jet is linearly conjugated to

$$y\frac{\partial}{\partial x} - v\frac{\partial}{\partial u} + u\frac{\partial}{\partial v}$$

are called Hopf-Bogdanov-Takens (HBT) singularities. Some motivations to study these singularities are that they appear naturally in the context of coupled oscillators and are also essential to understand the unfolding of the 4-dimensional nilpotent singularity of codimension four. In addition, numerical simulations show that unfoldings of HBT singularities exhibit an extraordinary richness. We present a classification of HBT singularities of codimension 3 and discuss how some local bifurcations of codimension two that arise in the generic unfoldings of these singularities can explain chaotic dynamics.



Duarte, Gladston

Organization

Universitat de Barcelona

Email

gladston@maia.ub.es

Title

Invariant manifolds near $L_{\rm 1}$ and $L_{\rm 2}$ in the planar elliptic restricted three-body problem

Abstract

In this work we investigate the connections between the stable and unstable manifolds of periodic orbits and tori around the points L_1 and L_2 of the Restricted Three-Body Problem (RTBP).

In the Planar Circular RTBP, there is a connection of these manifolds on the phase space in certain energy levels, which means that there is a mechanism working as a bridge connecting orbits inside with orbits outside.

In the Planar Elliptic RTBP, these orbits turn out to be tori. We analyse them and the heteroclinic connections between their invariant manifolds when describing the dynamics and comet 39P/Oterma.



Fernández-García, Soledad

Organization

Universidad de Sevilla

Email

soledad@us.es

Title

Saddle-node bifurcation of canard limit cycles in piecewise linear systems

Abstract

We study saddle-node bifurcations of canard limit cycles in PWL systems by using singular perturbation theory tools. We distinguish two cases: the subcritical and the supercritical. In the subcritical case, we find saddle-node bifurcations of canard cycles both with head and without head. Moreover, we detect a transition between them. In the supercritical case, we find situations with two saddle-node bifurcations, which take place exponentially close in the parameter space; one of headless canards and another of canards with head. There, three canard cycles can coexist.



Fernández-Sánchez, Fernando

Organization

Universidad de Sevilla

Email

fefesan@us.es

Title

The Falkner-Skan equation revisited

Abstract

The Falkner-Skan equation is a third order differential equation which arises in the study of some boundary layer problems in fluid mechanics. Besides its physical meaning, the equation also exhibits a very interesting mathematical behavior that involves no equilibria but invariant straight lines, complex periodic phenomena, heteroclinic orbits...

In this talk, a brief summary of known properties of the solutions of the Falkner-Skan equation will be given and new ideas and approaches will be presented.

This is a joint work with Ibáñez, Santiago and Rodríguez, José Ángel



Giralt, Mar

Organization

Universitat Politècnica de Catalunya

Email

mar.giralt@upc.edu

Title

Exponentially small splitting of separatrices for L3 in the restricted 3-body problem

Abstract

The restricted planar circular 3-body problem (RPC3BP) has a critical point called L3, which is a saddle-center. If the ratio between the mass of the primaries is small, the hyperbolic eigenvalues are larger than the elliptic ones.

In this talk, we present the first steps towards the computation of the distance between the stable and unstable manifolds of L3, which is exponentially small (and therefore, classical perturbative methods do not apply).

We present an analysis of the complex singularities of a certain separatrix and the so-called inner equation.

This is a joint work with Baldoma, Inma and Guardia, Marcel.



Ibáñez, Santiago

Organization

Universidad de Oviedo

Email

mesa@uniovi.es

Title

Self-sustained oscillations and global climate changes

Abstract

We will show how oscillations emerge in a family of 3-dimensional vector fields modelling a closed photochemical system exposed to a constant illumination source. Oscillations are intrinsic to the system and occur even in the absence of periodic radiative forcing, namely, they emerge through a Hopf bifurcation. With proper adaptations to the Earth system, this oscillator explains the main features of past climate dynamics, placing photosynthesis and the carbon cycle as key drivers of climate change. Model allows to explain some features of past climate which are not addressable by the Earth's orbital changes described by Milankovitch theory. Moreover, including in the simulations the pulse of CO2 given by the industrial activities, our model predicts a warmer and wetter future with more pronounced glaciation cycles. Results have been published in [L. Arnaut, S. Ibáñez (2020); Self-sustained oscillations and global climate changes, Scientific Reports 10 (11200)].



Lanchares, Victor

Organization

Universidad de la Rioja

Email

vlancha@unirioja.es

Title

Stability of a one degree of freedom Hamiltonian system in a case of zero quadratic and cubic terms

Abstract

We consider the stability of an equilibrium point of a periodic Hamiltonian system with one degree of freedom. We assume that the series expansion of the Hamiltonian function, in a small neighborhood of the equilibrium, does not include terms of second and third degree. Moreover, we focus on a degenerate case, when fourth degree terms are not enough to obtain rigorous conclusions on stability.

In this case, we give sufficient conditions for stability and instability, in the Lyapunov sense, expressed in the form of inequalities with respect to the coefficients of the Hamiltonian, normalized up to terms of sixth order.



Liz, Eduardo

Organization

Universidade de Vigo

Email

eliz@uvigo.es

Title

Destabilization and chaos induced by harvesting in discrete-time population models

Abstract

It is commonly assumed that increasing harvesting tends to stabilize the dynamics of exploited populations. Population responses to the removal of individuals have been studied using discrete-time models of population dynamics at least since the influential Ricker's paper from 1954, but many questions remain as open problems even for simple models.

We present some new results for typical maps used in population dynamics, providing precise conditions under which increasing harvesting can stabilize or destabilize the equilibrium. We emphasize the role played by harvest policies, stock-recruitment relationships and agestructure.

The talk is based on joint work with Jiménez López, Víctor.



Lois-Prados, Cristina

Organization

Universidade de Santiago de Compostela

Email

cristina.lois.prados@usc.es

Title

Complex dynamics in discrete- time piecewise-smooth models for populations subject to combinations of constant-quota and threshold harvesting

Abstract

Fisheries management requires to determine harvest strategies or control rules that are consistent with management objectives. On the one hand, to prevent overexploitation, management agencies consider harvest estrategies based on thresholds. On the other hand, to achive predictable conditions for industry, they propose yield stabilizing rules. Thus, in joint works with E. Liz and F. M. Hilker, we consider two harvesting strategies combining constant catches and threshold levels. The simplest rule consists of allowing to harvest a fixed annual quota if the population size is above the threshold (TCC); if we require the additional condition that a minimum biomass level must remain after harvesting, we obtain a more protective and difficult to apply control rule (PTCC).

In this talk we show the results obtained in the context of discrete piecewise-smooth dynamical systems. We pay special attention to those bifurcations and dynamic features related with specific characteristics of the associated maps, such as the flat-branches for PTCC and the discontinuity at the threshold level for TCC. The main focus is on the study of population dynamics, but we also consider a more exploitaition-oriented perspective and observe that these control rules overcome undesirable problems of traditional harvesting strategies.



Lombardero, Antón

Organization

Universidad de Oviedo

Email

lombarderoanton@uniovi.es

Title

Quasi-homogeneous differential systems in \mathbb{R}^3

Abstract

Quasi-homogeneous systems, and in particular those 3-dimensional, are currently a thriving line of research. The weight vectors of a quasi-homogeneous system are grouped into families. We found that the maximal three-dimensional quasi-homogeneous systems have the property of having only one family with minimum weight vector. This minimum vector is unique to the system, thus acting as identification code. We develop an algorithm that provides all normal forms of maximal three-dimensional quasi-homogeneous systems for a given degree. All other three-dimensional quasi-homogeneous systems can be trivially deduced from these maximal systems. With this algorithm we make available to the researchers all three-dimensional.



Martínez, M. Ángeles

Organization

Universidad de Zaragoza

Email

gelimc@unizar.es

Title

Dynamical systems and cardiac arrhythmia

Abstract

Early depolarizations (EADs) are voltage oscillations in cardiac action potential during the repolarization phase. Since they have been related to the appearance of cardiac arrhythmias and other heart problems, it is a priority to have a better understanding of the mechanisms that cause them. In this work we use a three-dimensional version of the Luo-Rudy model for mammalian ventricular cells, and we connect the appearance of EADs with several bifurcations in the system. In the analysis we use different techniques, such as fast-slow decomposition, spike-counting technique and numerical continuation. Joint work with Barrio, Roberto, Pérez, Lucía, Serrano, S. and Pueyo, E.



Nicolás, Begoña

Organization

Universitat de Barcelona

Email

bego@maia.ub.es

Title

Invariant manifolds near ${\cal L}_3$ and their role in the Sun perturbed Earth-Moon system

Abstract

This presentation focuses on the dynamics near the L_3 equilibrium point in the planar Earth-Moon system under solar gravitational effect. First, a family of hyperbolic quasi-periodic orbits around L_3 is computed and their stability analyzed. The computation of their associated stable and unstable manifolds gives us trajectories connecting the Earth and the Moon as well as connecting them with the outside system. Special attention is given to the trajectories that go from the Moon towards Earth, as they may explain the travel of lunar meteorites. Finally, these last results are checked in a realistic model based on the JPL ephemeris.



Núñez, Carmen

Organization

Universidad de Valladolid

Email

carnun@wmatem.eis.uva.es

Title

R-tipping and saddle-node bifurcation for quadratic nonautonomous ODEs

Abstract

An in-depth analysis of the dynamical possibilities for the nonautonomous scalar equation $x' = -x^2 + p(t)$,

where $p: \mathbb{R} \to \mathbb{R}$ is bounded and uniformly continuous, is the base to explain the absence or occurrence of (rate-induced) tipping for the parametric equations

$$y' = \left(y - \left(\frac{2}{\pi}\right) \arctan\left(ct\right)\right)^2 + p(t)$$

as c varies on $[0,\infty)$. A classical attractor-repeller pair, whose existence for c=0 is assumed, may persist for any c>0, or disappear for a certain value c_0 giving rise to a critical transition. In addition, this tipping may be reversible, as a suitable example shows. The required analysis can be understood as the description of a nonautonomous bifurcation pattern of saddle-node type.



Ollé, Mercè

Organization

Universitat Politècnica de Catalunya

Email

merce.olle@upc.edu

Title

Ejection-collision orbits in two degrees of freedom problems

Abstract

We study the mechanism that explains the birth of ejection-collision orbits (ECO) in a general Hamiltonian problem of two degrees of freedom with some specific properties. The model is a generalization of some N body problems, in which ejection-collision orbits (ECO) are solutions that start at (eject from) the total collision of the particles involved and go back to a total collision after some time.

We describe the main tools to prove the existence of such ECO and discuss some results.

This is a joint work with Álvarez-Ramírez M., Barrabés, E. and Medina, M.



Palacián, Jesús

Organization

Universidad Pública de Navarra

Email

palacian@unavarra.es

Title

Nonlinear stability of Hamiltonian systems with more than two degrees of freedom: the case of the Levitron

Abstract

In the framework of nonlinear stability of elliptic equilibria in Hamiltonian systems with more than three degrees of freedom we focus on formal stability results with asymptotic estimates. A criterion to determine Lie stability, that is a kind of formal stability, is presented. The result is applied to the Levitron, that consists of a magnetic spinning top that levitates in the air over a repelling base magnet. The system is modelled as a Hamiltonian with six degrees of freedom.

This is a joint work with Iñarrea, M., Lanchares, Victor, Pascual, A. I., Salas, J. P. and Yanguas, Patricia.



Paradela, Jaime

Organization

Universitat Politècnica de Catalunya

Email

jaime.paradela@upc.edu

Title

Oscillatory motions in the Elliptic Isosceles Restricted 3-Body Problem

Abstract

In this talk we show the existence of oscillatory orbits for the elliptic isosceles restricted three body problem (EIR3BP), which, for large values of the angular momentum G of the third body, can be seen as a fast non-autonomous perturbation of a two body problem.

The proof relies on proving that the stable and unstable manifolds associated to a degenerate periodic orbit at infnity intersect transversally. As it usually occurs in fast non-autonomous perturbations, we have to deal with exponentially small phenomena.



Penalva, Jordi

Organization

Universitat de les Illes Balears

Email

H_Jorch@hotmail.com

Title

Bifurcations in a piecewise linear version of the Morris-Lecar neural model

Abstract

One of the most used simplified models to describe the behaviour of a single neuron is the Morris-Lecar model. This is a 2-dimensional differential system exhibiting a wide catalog of bifurcations. The analytical study of such bifurcations is a difficult task which has been mainly approached by numeric analysis. In this talk we present a piecewise linear simplification of the Morris-Lecar model that mimics the original one but allowing us an analytical study of its bifurcations set. In particular, we prove the existence of SN bifurcations of equilibria, Hopf-like bifurcations and homoclinic bifurcation.



Peralta-Salas, Daniel

Organization

Instituto de Ciencias Matemáticas

Email

dperalta@icmat.es

Title

Constructing Turing complete Euler flows in dimension 3

Abstract

I will show how to construct a Turing complete stationary solution of the Euler equations on a Riemannian 3-dimensional sphere, thus implying, in particular, the existence of undecidable particle paths of fluid flows. The proof combines techniques from contact geometry with Moore's theory of generalized shifts. This is based on joint work with Cardona, Robert, Miranda, Eva and Presas, Francisco.



Pérez, Lucía

Organization

Universidad de Oviedo

Email

perezplucia@uniovi.es

Title

The Hindmarsh-Rose neuron model: Global homoclinic structure and spike-adding process

Abstract

Bursting is a common behaviour exhibited by neurons and has an important role in brain activity. A bursting neuron shows sequences of spikes alternating with periods of quiescence. We work with the Hindmarsh-Rose neuron model (a model consisting of three ODE's) and study the bifurcation diagram of the system and its relationship with bursting. We are interested in the process of spike-adding and in the role of homoclinic bifurcations as organizing centers of the phenomenon (in the case of fold/homoclinic bursters). Continuation techniques as well as spike-counting methods are used.

Joint work with Barrio, Roberto, Ibáñez, Santiago and Serrano, S.



Pérez-González, Set

Organization

Universidad de Oviedo

Email

perezset@uniovi.es

Title

Limit cycles in piecewise linear vector fields having polynomial first integral

Abstract

There exists a large amount of papers dealing with the study of algebraic limit cycles of smooth planar polynomial vector fields. Our aim in this work is to answer the question: "How many algebraic limit cycles does a piecewise linear differential system have?" On this paper, we include procedures and partial answers we have found.



Rodero, Ana Livia

Organization

Universidade Estadual Paulista

Email

analivia.alr@gmail.com

Title

Centers and their cyclicity for linear and quadratic systems defined on \mathbb{R}^3 with $H(x,y,z)=x^2+y^2+z^2$ as a first integral

Abstract

In this work we consider X a vector field that has the first integral $H(x,y,z)=x^2+y^2+z^2$. So, every sphere is invariant by X. We also consider that (0,R,0) is a singular point of the center type. We show that if X is linear, (0,R,0) is a center for X, for all R>0. This is not the case for quadratic vector fields on the sphere. In this case, we study the existence of some centers and its cyclicity, showing that there exists at least one center with cyclicity at least three in the class of quadratic vector fields on the sphere.



Rodrigues, Alexandre

Organization

Centro de Matemática da Universidade do Porto

Email

alexandre.rodrigues@fc.up.pt

Title

Unfolding a Bykov attractor: from an attracting torus to strange attractors

Abstract

We present a comprehensive mechanism for the emergence of strange attractors in a two-parametric family of differential equations acting on a 3-sphere. When both parameters are zero, its flow exhibits an attracting heteroclinic network (Bykov network) made by two 1-dimensional and one 2- dimensional separatrices between two saddle-foci. After slightly increasing both parameters, while keeping the one-dimensional connections unaltered, we focus our attention in the case where the two-dimensional invariant manifolds of the equilibria do not intersect. We prove the existence of many complicated dynamical objects, ranging from an attracting quasi-periodic torus to Hénon-like strange attractors.



Rodríguez del Río, Óscar

Organization

Universitat Politècnica de Catalunya

Email

oscar.rodriguez@upc.edu

Title

Regularization techniques and ejection-collision orbits in the RTBP

Abstract

In this talk, we discuss the advantages and disadvantages of Levi-Civita and McGehee regularizations. In particular, we use them to study ejection-collision orbits. We introduce the concept of n-ejection-collision orbits and we present some analytical and numerical results in the existence and the evolution of this kind of orbits.

This is joint work with Ollé, Mercè and Soler, Jaume.



Seara, Tere M.

Organization

Universitat Politècnica de Catalunya

Email

tere.m-seara@upc.edu

Title

Some results about oscillatory orbits

Summary

The restricted planar four body problem describes the motion of a massless body under the Newtonian gravitational force of other three bodies (the primaries). The motion of the primaries follows the law of the general three body problem. A trajectory is called oscillatory if it goes arbitrarily far away but returns infinitely many times to the same bounded region. In this talk we prove the existence of such type of trajectories provided the primaries evolve in suitable periodic orbits.



Teruel, Antonio

Organization

Universitat de les Illes Balears

Email

antonioe.teruel@uib.es

Title

Poincaré maps in slow-fast piecewise linear differential systems

Abstract

The Poincaré map in piecewise linear (PWL) differential systems reduces to the composition of transitory maps between the switching lines. These transitory maps are defined through the flow of the linear differential systems involved, and they can be parametrized by using particular Krylov bases. This parametrization provides some advantages for the study of these maps, as for instance their independence by linear transformations and in the particular case of slow-fast PWL systems this parametrization can be explicitly obtained. From this fact some results are derived.



Vigil, Enrique

Organization

Universidad de Oviedo

Email

vigilenrique@uniovi.es

Title

Coexistence of finitely many two-dimensional strange attractors: renormalization scheme and analytic proof

Abstract

For a two parameter family of two-dimensional piecewise linear maps and for every natural number n, we prove the existence of intervals of parameters for which the respective maps are n times renormalizable and we show the existence of intervals of parameters where the coexistence of at least 2^n strange attractors takes place.



Yanguas, Patricia

Organization

Universidad Pública de Navarra

Email

yanguas@unavarra.es

Title

The co-orbital motion of two Saturn's moons

Abstract

We provide a qualitative explanation of the co-orbital motion of two Saturn's moons: Janus and Epimetheus. The two small bodies revolve about Saturn in nearly circular orbits with almost equal radii. The system is modelled as a planar three-body problem whose Hamiltonian is expanded as a perturbation of two uncoupled Kepler problems. A combination of normal form and symplectic reduction theories and the application of a KAM theorem for high-order degenerate systems allow us to establish the existence of quasi-periodic motions and KAM 4-tori related to the co-orbital motion of the moons.

Joint work with Cors, J. M. and Palacián, Jesús.



Minisymposium:

Efficient time integrators for ordinary differential equations

Thematic area: Numerical Analysis and Simulation (NAS)

Organizers: Roldán, Teo (Universidad Pública de Navarra), Rández, Luis (Universidad de

Zaragoza)

Abstract

This special session deals with recent advances on time stepping methods for differential equations with applications to some relevant PDEs. These equations arise in different contexts, either directly or after the spatial discretization of partial differential equations. Special emphasis is placed on the efficient integration of problems arising in different applications. This special session also aims at promoting and enhancing collaborations between researchers with interest in the above-mentioned topics.

Keywords: Runge-Kutta methods; Initial Value Problems; Low-storage Runge-Kutta methods

Session 9. Friday 11:30 - 13:10. Room B2.

Chair: Roldán, Teo (Universidad Pública de Navarra)

Speaker	Organization	Contribution title
ROLDÁN, TEO	Universidad Pública de Navarra	Numerical Positiviy for Runge-Kutta methods
RÁNDEZ, LUIS	Universidad de Zaragoza	Low order, low storage exponentially fitted explicit Runge-Kutta methods
CALVO CABRERO, MARIA PAZ	Universidad de Valladolid	Efficient time integrators in HMC computations



Calvo Cabrero, Maria Paz

Organization

Universidad de Valladolid

Email

mariapaz.calvo@uva.es

Title

Efficient time integrators in HMC computations

Abstract

In the talk we give numerical evidence that the standard Verlet algorithm may not be the best integrator to use within the Hamiltonian Monte Carlo (HMC) method. When the dimensionality of the target distribution is high, the number of accepted proposals obtained with a given computational effort may be multiplied by a factor of three or more by switching to alternative integrators as easy to implement as the standard Verlet scheme. In addition, we provide some theoretical results relating the acceptance rate of HMC with the expected energy error.



Rández, Luis

Organization

Universidad de Zaragoza

Email

randez@unizar.es

Title

Low order, low storage exponentially fitted explicit Runge-Kutta methods

Abstract

In this talk we present the class of numerical methods called Low Storage Exponentially Fitted Explicit Runge-Kutta (LSEFRK) schemes with the property of minimum storage requirements for systems with large dimension and whose solution is oscillatory or periodic. A study of minimum storage schemes with orders p = 3, 4 that require only two storage locations is carried out. Two optimal third-order and two optimal fourth-order LSEFRK formulae are deduced taking into account accuracy and stability. Finally, some numerical experiments are presented to show the behaviour of the new schemes for some periodic problems.

This is a joint work with Franco, José María, Higueras, Inmaculada and Montijano, Juan Ignacio.



Roldán, Teo

Organization

Universidad Pública de Navarra

Email

teo@unavarra.es

Title

Numerical positivity for Runge-Kutta methods

Abstract

The aim of this work is the study of the effective step-size restrictions for positivity when implicit Runge-Kutta schemes are used. To achieve this goal, we consider the numerical time integration of some advection-diffusion problems. Classical results in the literature ensure positivity for the numerical solution under certain step-size restrictions. However, these results are given for the exact numerical solution whereas in practice the numerical solution available is only an approximation of it. For example, when implicit Runge-Kutta methods are used, the numerical solution obtained comes out from the inexact numerical resolution of nonlinear systems.

Joint work with Higueras, Inmaculada



Minisymposium:

Electromagnetic problems arising in industry: modelling and numerical techniques

Thematic area: Numerical Analysis and Simulation (NAS), Mathematics Applied to Industry, Social Sciences and Biology (MA)

Organizers: Gómez, Dolores and Salgado, Pilar (Universidade de Santiago de Compostela; Technological Institute for Industrial Mathematics (ITMATI))

Abstract

Numerical simulation in electromagnetism has undergone a relevant development in recent years since it represents a key tool in the design of devices and processes, as well as in obtaining improvements in the operation of existing prototypes.

Many industrial applications involve electromagnetic problems which are often coupled with other physical models that require the solution of a coupled multiphysics problem. Therefore, it is essential to have suitable and efficient numerical schemes to approximate the electromagnetic submodel derived from Maxwell's equations. Furthermore, nowadays the numerical solution of electromagnetic goes frequently accompanied with numerical control and optimization; thus, the development of efficient algorithms is crucial to get an affordable optimization model from a computational point of view.

In the literature we can distinguish two great approaches in the research field of electromagnetism: development of new models and algorithms and mathematical and numerical analysis of the models to give a theoretical support to the numerical techniques. Both approaches have provided relevant results both in the applied mathematics and in the electric engineering fields. In this context, the aim of the proposed minisymposium is to offer a forum for the discussion of recent advances in computational electromagnetism with a special focus in industrial applications. The minisymposium will try to cover several topics: techniques in modelling and discretization, multiphysics approaches, coupling between distributed and lumped models, numerical optimization, material modelling, mathematical and numerical analysis, etc.

Keywords: Computational electromagnetism, Maxwell equations, electromagnetic waves, control problems, numerical analysis, circuit-coupling, industrial applications



Session 4. Tuesday 12:15-13:55. Room B2.

Chair: Gómez, Dolores (Universidade de Santiago de Compostela; (ITMATI))

Speaker	Organization	Contribution title
CORTÉS GARCÍA, IDOIA	Technische Universität Darmstadt, Germany	Optimized Field/Circuit Coupling for the Simulation of Quenches in Superconducting Magnets
FERROUILLAT, PAULINE	Altair, France	Speed-up the 2D Transient Solving by the Space-Time Finite Element Method
OMELLA, ÁNGEL JAVIER	University of the Basque Country (UPV/EHU)	Multi-objective Optimization for the Design of Electric Motors
HOLLEY, JONAS	Robert Bosch GmbH, Stuttgart, Germany	Topology Optimization of Electrical Machines subject to Pointwise Stress Constraints

Session 5. Tuesday 18:00-20:00. Room A8.

Chair: Alonso, Ana (U. de Trento)

Speaker	Organization	Contribution title
Arenas Jaén, Manuel Jesús	Technische Universität Berlin. Germany	Thermal cutting of steel plates - modelling, simulation and optimal control of preheating strategies
LÓPEZ, BIBIANA	Universidad Nacional de Colombia	Numerical analysis of an axisymmetric eddy current model with an in-plane current
VENEGAS, PABLO	Universidad del Bio- Bio (Chile)	State of charge battery estimation using Preisach hysteresis model and Kalman filter
GARCÍA, BRANCA	Universidade de Santiago de Compostela	Induction heating in SisAl project: Innovative pilot for silicon production

Session 6. Wednesday 10:30-12:10. Room A8.

Chair: Salgado, Pilar (Universidade de Santiago de Compostela; (ITMATI))

Speaker	Organization	Contribution title
SELGAS, VIRGINIA	Universidad de Oviedo	The time domain Linear Sampling Method for Maxwell's equations with an impedance boundary condition.
BENI-HAMAD, AKRAM	INRIA (Poems). France	Comparison between 3D and 1D approaches for the computation of electromagnetic wave propagation in coaxial cables
VÁZQUEZ, RAFAEL	Ecole Polytechnique Fédéral de Lausanne. Switzerland	Dual complex with splines, and analysis of possible discrete Hodge operators
ALONSO, ANA	University of Trento. Italy	High order Whitney forms: degrees of freedom and interpolation



Alonso, Ana

Organization

University of Trento. Italy

Email

ana.alonso@unitn.it

Title

High order Whitney forms: degrees of freedom and interpolation

Abstract

Finite element spaces extending Whitney forms to higher degrees are widely used for discretizing physical balance laws in electromagnetism, fluid dynamics or elasticity. The degrees of freedom (dofs) associated with Whitney differential forms have a direct physical relevance (as circulation, fluxes, densities).

When considering polynomial interpolation of higher degree, dofs can be chosen in different ways. The so-called weights, dofs introduced by Rapetti and Bossavit, preserve this meaning and allow to consider quite general distributions of the supports of the degrees of freedom.

We exploit this flexibility to investigate distributions that reduce the growth of the generalized Lebesgue constant when increasing the polynomial degree.



Arenas Jaén, Manuel Jesús

Organization

Technische Universität Berlin. Germany

Email

arenas@math.tu-berlin.de

Title

Thermal cutting of steel plates - modelling, simulation and optimal control of preheating strategies

Abstract

Flame cutting is a common and versatile method to produce steel plates but it can cause undesired side effects. The present work describes a 3D quasi-stationary state (QSS) model to understand the distribution of heat in a steel plate including solid-solid and solid-liquid transitions during the flame cutting process.

Recent experimental research has proved adding a preheating stage helps reducing the side effects of flame cutting. We study a novel preheating method wherein, local induction is applied just before flame cutting.

This preheating concept is influenced by many parameters which makes finding the optimal setting a difficult task with an electromagnetic model. To overcome this, we substitute the electromagnetic joule heat source by a parametric heat source and optimise it by an optimal control approach.



Beni-Hamad, Akram

Organization

INRIA (Poems). France

Email

Akram.Beni-Hamad@ensta-paris.fr

Title

Comparison between 3D and 1D approaches for the computation of electromagnetic wave propagation in co-axial cables

Abstract

In thin co-axial cables, 1D simplified models can be derived from an asymptotic analysis of 3D Maxwell's equations. These were developed in particular in the PhD thesis of Geoffrey Beck. In this work, we aim at validating such an approach in a quantitative manner via a comparison with 3D computations. For the latter, we develop a specific numerical method based on (1) a generalization of Nédélec edge elements to prismatic meshes and (2) the use of a hybrid implicit / explicit time discretization procedure that treats differently the longitudinal and transverse space variables.

This is a joint work with Imperiale, Sébastien and Joly, Patrick.



Cortés García, Idoia

Organization

Technische Universität Darmstadt, Germany

Email

cortes@temf.tu-darmstadt.de

Title

Optimized Field/Circuit Coupling for the Simulation of Quenches in Superconducting Magnets

Abstract

In this paper, we propose an optimized field/circuit coupling approach for the simulation of magnetothermal transients in superconducting magnets. The approach improves the convergence of the iterative coupling scheme between a magnetothermal partial differential model and an electrical lumped-element circuit. Such a multiphysics, multirate, and multiscale problem requires a consistent formulation and a dedicated framework to tackle the challenging transient effects occurring at both the circuit and magnet level during normal operation and in case of faults. We derive an equivalent magnet model at the circuit side for the linear and the nonlinear settings and discuss the convergence of the overall scheme in the framework of optimized Schwarz methods. The efficiency of the developed approach is illustrated by a numerical example of an accelerator dipole magnet with accompanying protection system.

This is a joint work with Schops, Sebastian, Maciejewski, Michal, Bortot, Lorenzo, Prioli, Marco, Auchmann, Bernhard, and Verweij, Arjan.



Ferrouillat, Pauline

Organization

Altair, France

Email

pferrouillat@altair.com

Title

Speed-up the 2D Transient Solving by the Space-Time Finite Element Method

Abstract

In general, the finite element method (FEM) is only used in the space domain. In the time domain, finite difference methods (FDM) such as the Euler method are used. However, the FEM can also be used in the time domain in addition to the space domain.

The main advantage is to speed up the solving of transient problems, in return for a higher memory consumption that can be compensated by distributed solvers. Moreover, this spacetime FEM is naturally stable unlike the Euler method, is more accurate and allows to interpolate the unknowns at any time steps.



García, Branca

Organization

Instituto Tecnológico de Matemática Industrial (ITMATI) Universidade de Santiago de Compostela, Spain

Email

branca.garcia.correa@usc.es

Title

Induction heating in SisAl project: Innovative pilot for silicon production

Abstract

The SisAl Pilot is an Horizon 2020 funded project which main objective is to demonstrate a patented novel industrial process to produce silicon. The actual carbothermic Submerged Arc Furnace (SAF) process is replaced by a far more environmentally and economically sustainable alternative: the aluminothermic reduction of quartz, which allows to use secondary raw material instead of carbon reductants. To attain this goal, different types of furnaces are being analyzed. In this talk we will focus on modelling and simulation of induction heating furnaces devoted to melting some materials which will be used in the subsequent process. The objective of this task is to support the experimental trials in plant of the industrial partners.

This is a joint work with Bermúdez, Alfredo, Gómez, Dolores and Salgado, Pilar.



Holley, Jonas

Organization

Robert Bosch GmbH, Stuttgart, Germany

Email

Jonas.Holley@de.bosch.com

Title

Topology Optimization of Electrical Machines subject to Pointwise Stress Constraints

Abstract

This talk addresses a novel adjoint-based optimization method for the multiphysical design of the rotor of a permanent magnet synchronous machine. The maximization of the mean torque is considered in order to improve the electromagnetic performance of the machine. Additionally, pointwise stress constraints are incorporated into the problem formulation in order to guarantee mechanical stability at high rotational speeds and prevent material failure. A line search type gradient descent scheme is presented for the numerical solution of the optimization problem, where the topological gradient serves as a descent direction. Numerical results are shown and discussed.



López, Bibiana

Organization

Universidad Nacional de Colombia

Email

blopezr@unal.edu.co

Title

Numerical analysis of an axisymmetric eddy current model with an in-plane current

Abstract

The aim of this talk is to analyze an axisymmetric eddy current problem characterized by the fact that the current density ${\bf J}$ lies in a meridional section of the revolution domain. This work is motivated by the study of the electromagnetic behavior of a steel bar submitted to a preforming process called electro-upsetting. This problem has a great interest due it governs the electromagnetic behavior of many applications related with induction heating involving cylindrical pieces. We will focus on an axisymmetric formulation of the linear time-harmonic eddy current model written in terms of the azimuthal component of the magnetic field, H_Θ , by imposing currents and voltages excitations on the boundary of the conducting domain.



Omella, Ángel Javier

Organization

University of the Basque Country (UPV/EHU)

Email

ajaome@gmail.com

Title

Multi-objective Optimization for the Design of Electric Motors

Abstract

Automotive industry is immersed in the innovation race of electric motors design. The requirements that the car companies make to electric motor manufacturers are tough. In this talk, as a result of the collaboration between the UPV/EHU and the company GKN automotive Zumaia, we expose the optimization process to design the geometry of the rotor of an electric motor. Permanent magnets are embedded inside the rotor, and they are responsible for the magnetic bond once the stator winding is energized. The size and location of the magnets are crucial since they are strongly related to the efficiency of the motor and the torque ripple (source of noise and vibrations). On the other hand, as the magnets are expensive components, it is desirable to reduce their volume. Moreover, the design needs to guarantee imposed structural requirements to avoid the rotor breakdown. To deal with all of this, we propose a multi-objective and multi-physics optimization that employs different commercial software packages used within the company.

This is a joint work with Pardo, David, Alberdi, Elisabete, Gorria, Carlos, Lezaun, Mikel, Palomar, Diego, Martinez, Iago, Garate, Maite, Diez, Marta, Martinez, Joxe and Peña, Alberto.



Selgas, Virginia

Organization

Universidad de Oviedo

Email

selgasvirginia@uniovi.es

Title

The time domain Linear Sampling Method for Maxwell's equations with an impedance boundary condition

Abstract

We study an inverse problem for Maxwell's equations in the time domain with an impedance boundary condition. More precisely, the unknown scattering object is illuminated with incident fields that are due to regularized point sources placed on a fixed screen (the transmitter). In order to locate and reconstruct the shape of the scatterer from measurements of the scattered fields corresponding to such incident fields on a (possibly different) screen (the measurement device), we propose to use the Linear Sampling Method in the Time Domain (TD-LSM). We show how to adapt the TD-LSM to the problem at hand and prove its usual theoretical justification.

This is a joint work with Lähivaara, Timo and Monk, Peter.



Vázquez, Rafael

Organization

Ecole Polytechnique Fédéral de Lausanne. Switzerland

Email

rafael.vazquez@epfl.ch

Title

Dual complex with splines, and analysis of possible discrete Hodge operators

Abstract

The high continuity of splines, along with their tensor-product structure, allows a very simple definition of a dual De Rham complex compared to other existing methods. In particular, the construction of the dual spaces does not require the construction of a dual mesh. We will present the construction of this dual complex, and analyze the properties of some realizations of discrete Hodge operators between the spaces of the primal and the dual complex.



Venegas, Pablo

Organization

Universidad del Bio-Bio (Chile)

Email

pvenegas@ubiobio.cl

Title

State of charge battery estimation using Preisach hysteresis model and Kalman filter.

Abstract

The goal of this work is first to include the Preisach hysteresis model in the classical equivalent circuit model (ECM) for a battery system and then to improve the estimation of the state of charge (SoC) by applying the Extended Kalman Filter (EKF). The construction of the Preisach operator is made by means of the Everett function identified from experimental data involving the charging curves of the battery. The model is assessed with some laboratory experiments performed on a lithium-ion battery and the results show that with this procedure hysteresis is well reproduced, even when interior loops are present. In addition, the use of the EKF allows us to eliminate the measurements noise and ensure the accuracy of SoC estimation. The high computational efficiency of the method make it particularly suitable for real-time embedded battery management system (BMS) applications.

This is a joint work with Arrinda, M., Bermúdez, Alfredo, Gómez, Dolores, Macicior, H. and Oyarbide, M.



Minisymposium:

Industrial Problems and PDEs

Thematic area: Mathematics Applied to Industry, Social Sciences and Biology (MA)

Organizer: Tello, J. Ignacio (Universidad Nacional de Educación a Distancia)

Abstract

Nonlinear P.D.E.s have been used to modelize different type of phenomena, from Biology, as Chemotaxis systems (see talks 5,6 and 7), to social (see talks 1 and 2) and industrial problems (see Talks 3 and 4). Nonlinear problems represent a huge field of research, from theoretical point of view and applications. In particular non-local problems have been used to describe different types of situations (see talk 8). The importance of theoretical studies is not only due to the applications, it is also inherent to the field.

Keywords: Chemotaxis, Lithium-ion battery model, Nonlinear PDEs, Models of traffic.



Session 7. Thursday 11:30-13:35. Room B1.

Chair: Tello, J. Ignacio (Universidad Nacional de Educación a Distancia)

Speaker	Organization	Contribution title
PÉREZ-LLANOS, MAYTE	Universidad de Sevilla	Some heterogeneous opinion formation models
PADIAL, J. FRANCISCO	Universidad Politécnica de Madrid	On the uniqueness of weak solutions for a class of doubly degenerate parabolic systems.
GALÁN DEL SASTRE, PEDRO	Universidad Politécnica de Madrid	A new finite element stabilization technique for convection dominated-diffusion problems using the method of characteristics
Muñoz Villarragut, Víctor	Universidad Politécnica de Madrid	Numerical solution of a Lithium-ion battery model with nano scale particles

Session 9. Friday 11:30-13:10. Room B1.

Chair: Tello, J. Ignacio (Universidad Nacional de Educación a Distancia)

Speaker	Organization	Contribution title
DÁGER, RENÉ	Universidad Politécnica de Madrid	Uniform asymptotic behavior of solutions for predator-prey systems with diffusion and chemotaxis
MORALES- RODRIGO, CRISTIAN	Universidad de Sevilla	Global bifurcation for a cross-diffusion systems and applications
AQUINO, MYRIAM	Universidad de Castilla-La Mancha	Two-species taxis model with interspecific and intraspecific competition
SASTRE, SILVIA	Universidad de Sevilla	Nonlocal Equations in Perforated Domains



Aquino, Myriam

Organization

Universidad de Castilla-La Mancha

Email

myriamaq@ucm.es

Title

Two-species taxis model with interspecific and intraspecific competition

Abstract

We study a non-linear system of parabolic-ODE-parabolic differential equations which models the behavior of two species in competition for a resource. The parabolic equations describe the behavior of the resource -subject to diffusion- and one of the species -subject to diffusion and chemotaxis- while the ODE models the other species, which is static. We are able to prove the existence and uniqueness of global solutions through classical results in the analysis of PDEs and the Moser-Alikakos iterative method. We study the asymptotic behavior of the system for a special case, obtain its homogeneous and constant solutions and find their stability. This paper extends the results obtained by Krzyanowski, Winkler, and Wrzosek (2019) and presents a framework to justify the study of the asymptotic behavior of the system.



Dáger, René

Organization

Universidad Politécnica de Madrid

Email

rene.dager@upm.es

Title

Uniform asymptotic behavior of solutions for predator-prey systems with diffusion and chemotaxis

Abstract

We study two novel non-linear predator-prey models with dormant predators and chemotaxis. In the first model, chemotaxis is considered to affect the behavior of active predators so that they try to move towards the regions where the density of dormant predators is higher. In the second model, a similar chemotactic effect is assumed to affect also the behavior of preys. For both systems, uniform boundedness and global existence of solutions is proved by means of the Moser-Alikaos iterative method and the uniform asymptotic behavior of the solutions is analyzed for the constant stationary states in order to understand their time and spatial dynamics.

This is a joint work with Negreanu, Mihaela.



Galán del Sastre, Pedro

Organization

Universidad Politécnica de Madrid

Email

pedro.galan@upm.es

Title

A new finite element stabilization technique for convection dominated-diffusion problems using the method of characteristics

Abstract

There exists a wide variety of problems where convection-diffusion equations play an important role, such as in the fluid dynamics field. The finite element method is comomly used to compute the approximate solution of such problems, but when convection becomes dominant with respect to diffusion, it is well known that the numerical solution can develop spurious oscillations.

If mesh refinement cannot be performed due to computational cost, a stabilization technique is requiered. In this work we propose a stabilization technique based on an error indicator used in adaptive mesh refinement that we use to selectively apply monoticity through the method of the characteristic. This is a joint work with Alcaide, Pablo.



Morales-Rodrigo, Cristian

Organization

Universidad de Sevilla

Email

cristianm@us.es

Title

Global bifurcation for a cross-diffusion systems and applications

Abstract

In this talk we will establish a unilateral bifurcation result for a class of quasilinear elliptic systems strongly coupled. Then, we will apply the previous result to some particular systems arising from population dynamics and determine a region of existence of coexistence states.



Muñoz Villarragut, Víctor

Organization

Universidad Politécnica de Madrid

Email

victor.munoz@upm.es

Title

Numerical solution of a Lithium-ion battery model with nano scale particles

Abstract

This work is devoted to the development of a numerical scheme that computes the solutions of the pseudo-2D model for Lithium-ion batteries with particles at the nano scale. The computation of the transport submodel in the electrolyte is performed by using an IMEX-RKC method. The proposed numerical scheme uses a different time step for the computation of the electrochemical potentials and the Li concentration of the particles to circumvent their nonlinear coupling and to avoid explicit schemes at the nano scale. Moreover, the transport submodel in the solid phase is modeled by an ODE instead of a PDE.



Padial, J. Francisco

Organization

Universidad Politécnica de Madrid

Email

jf.padial@upm.es

Title

On the uniqueness of weak solutions for a class of doubly degenerate parabolic systems.

Abstract

We study the uniqueness of weak solutions for a class of parabolic systems that arise in modeling traffic flows on a two-lane road going in a direction that allows cars to pass and drivers continually adjusting their speed toward what they consider ideal, under the local traffic conditions. From the point of view of the macroscopic scale, we obtain this mathematical model in terms of a doubly degenerate stochastic parabolic system. The proof of the uniqueness of weak solutions is inspired by S.N. Kruzhkov (L1-contraction property for entropy solutions).



Pérez-Llanos, Mayte

Organization

Universidad de Sevilla

Email

mpperez@us.es

Title

Some heterogeneous opinion formation models

Abstract

In the last decades, a large body of problems that traditionally belonged to Sociology or Economy, attracted the interest of the physicists community, giving rise to the born of the new fields: Sociophysics and Econophysics. The main strategy lays on specifying appropriate interaction equations and build agent based models.

Our talk will focus on opinion dynamics and formation of consensus. We describe several heterogeneous models, in the sense that each agent is characterized not only by her / his opinion. Other aspects such us persuasion, stubborness or even the influence that determined opinions could exert on the interacting agents will be taken into account in the master equations.



Sastre, Silvia

Organization

Universidad de Sevilla

Email

ssastre@us.es

Title

Nonlocal Equations in Perforated Domains

Abstract

In this work we analyze the behavior of the solutions to nonlocal evolution equations with a nonlocal nonlinear reaction term in a perturbed perforated domain. This perforated domain is thought as a fixed set from where we remove a subset called the holes. We choose appropriated families of bounded functions in order to deal with both Neumann and Dirichlet conditions in the holes setting a Dirichlet condition outside the domain. Under the assumption that the characteristic functions of the perturbed domain have a weak limit, we study the limit of the solutions providing a nonlocal homogenized equation.



Minisymposium

Iterative Processes and Non-Linear Equations

Thematic area: Numerical Analysis and Simulation (NAS)

Organizers: Gutiérrez Jiménez, José Manuel (Universidad de La Rioja), Hernández-Verón, Miguel A. (Universidad de La Rioja)

Abstract

Solving nonlinear equations is one of the problems that appears more frequently in different scientific disciplines. Iterative processes play a key role for approximating the solutions of such equations. The target of this session is to show some research lines developed in this discipline, such as the study of the convergence of the considered iterative process, the analysis of their dynamical behavior or the numerical treatment of some particular problems, such as systems of nonlinear equations, optimization problems, matrix equations, differential or integral equations, etc.

Keywords: Nonlinear equations; Newton's method; Iterative methods



Sesssion 7. Thursday 11:30 - 13:35. Room A6.

Chair: Gutiérrez Jiménez, José Manuel (Universidad de La Rioja)

Speaker	Organization	Contribution title
TORREGROSA, JUAN R.	Universidad Politécnica de Valencia	Iterative methods with memory for approximating generalized inverses
MARTÍNEZ MOLADA, EULALIA	Universidad Politécnica de Valencia	A predictor-corrector iterative scheme for improving the accessibility of the Steffensentype methods
YAKOUBSOHN, JEAN- CLAUDE	Université Paul Sabatier, Toulouse	High order numerical methods for systems of equations
ROMERO ÁLVAREZ, NATALIA	Universidad de La Rioja	On iterative schemes for matrix equations

Session 8. Thursday 18:00 – 20:00. Room A6.

Chair: Martínez Molada, Eulalia (Universidad Politécnica de Valencia)

Speaker	Organization	Contribution title
CORDERO, ALICIA	Universidad Politécnica de Valencia	Fractional iterative methods for solving nonlinear problems
GARRIDO, NEUS	Universidad Politécnica de Valencia	Iterative processes for the solution of fuzzy equations
CHICHARRO, FRANCISCO I.	Universidad Internacional de La Rioja	Different approximations of the parameter for low-order iterative methods with memory

Session 9. Friday 11:30 – 13:10. Room A6.

Chair: Yakoubsohn, Jean-Claude (Université Paul Sabatier, Toulouse)

Speaker	Organization	Contribution title
AMAT, SERGIO	Universidad Politécnica de Cartagena	A general progressive strategy to improve the order of accuracy of WENO schemes
GUTIÉRREZ JIMÉNEZ, JOSÉ MANUEL	Universidad de La Rioja	Picard-type iterations for solving Fredholm integral equations
Magreñán, Ángel Alberto	Universidad de La Rioja	New results on Convergence and Dynamics of a High-Order Method



Amat, Sergio

Organization

Universidad Politécnica de Cartagena

Email

sergio.amat@upct.es

Title

A general progressive strategy to improve the order of accuracy of WENO schemes

Abstract

In this talk, we review some new WENO schemes for the approximation of piecewise smooth functions. These schemes obtain full order of accuracy near the singularities according to the support of the used stencil. We include both: theoretical results and numerical applications.



Chicharro, Francisco I.

Organization

Universidad Internacional de La Rioja

Email

francisco.chicharro@unir.net

Title

Different approximations of the parameter for low-order iterative methods with memory

Abstract

A technique for generating iterative methods for solving nonlinear equations with memory can be constructed from a method without memory that includes a parameter, provided the parameter is present in the error equation.

Generally, the parameter depends on the evaluation of the function and its derivatives in the solution. However, this information is not available. So this parameter is approximated using interpolation techniques, taking the current iterate x_k and the previous iterates $x_{k-1}, x_{k-2}, ...$

In this paper we explore different interpolation techniques to obtain both the convergence order of the new methods and their stability characteristics.



Cordero, Alicia

Organization

Universidad Politécnica de Valencia

Email

acordero@mat.upv.es

Title

Fractional iterative methods for solving nonlinear problems

Abstract

The first references about fractional calculation date back to 1695, when Leibnitz and L'Höpital created the concept of the semi-derivative. Other researchers were also interested in this idea, such as Riemann, Liouville or Euler. From the 19th century to the present day, fractional calculus has evolved from theoretical aspects to the appearance in many real-world applications: mechanical engineering, medicine or economics, among others. In this area, our main questions are: how does replacing derivatives with fractional ones affect the convergence order of the iterative method? We are interested in answering this and other questions for both point-to-point and multipoint methods.



Garrido, Neus

Organization

Universidad Politécnica de Valencia

Email

neugarsa@doctor.upv.es

Title

Iterative processes for the solution of fuzzy equations

Abstract

A nonlinear equation over fuzzy real numbers (triangular, trapezoidal, etc.) is called a fuzzy nonlinear equation, that is, an equation of the form $f(\mu)=0$ is called a fuzzy nonlinear equation of fuzzy variable. In this work, fuzzy version of secant method is introduced to solve a fuzzy nonlinear equation where the coefficients are triangular fuzzy numbers.

We present the corresponding algorithms and analyse its convergence. Several test equations confirm the theoretical results and allow us to compare our results with that obtained by the different variants of Newton's method over fuzzy nonlinear equations that there exist in recent publications.



Gutiérrez Jiménez, José Manuel

Organization

Universidad de La Rioja

Email

jmguti@unirioja.es

Title

Picard-type iterations for solving Fredholm integral equations

Abstract

The theoretical solution of Fredholm integral equations involves the calculus of the inverse of an operator. However, for practical purposes, the calculus of this inverse could be not possible or very complicated. For this reason, our aim in this talk is to use iterative methods for approaching such inverse and therefore the solution of the given integral equation. In fact, we use Newton's method to obtain a method with quadratic convergence. Finally, we can extend this idea to other iterative methods with a given order of convergence.



Magreñán, Ángel Alberto

Organization

Universidad de La Rioja

Email

angel-alberto.magrenan@unirioja.es

Title

New results on Convergence and Dynamics of a High-Order Method

Abstract

We first present a local convergence analysis for some families of fourth and six order methods in order to approximate a locally unique solution of a nonlinear equation in a Banach space setting. We use hypotheses only on the first Fréchet-derivative in one local convergence analysis. This way, the applicability of these methods is extended. Moreover, the radius of convergence and computable error bounds on the distances involved are also given in this study based on Lipschitz constants. Numerical examples illustrating the theoretical results are also presented



Martínez Molada, Eulalia

Organization

Universidad Politécnica de Valencia

Email

eumarti@mat.upv.es

Title

A predictor-corrector iterative scheme for improving the accessibility of the Steffensen-type methods

Abstract

Solving equations of the form H(x) = 0 is usually done by applying iterative methods. The Steffensen-type methods, defined by means divided differences and derivative free, are usually considered to solve these problems when \$H\$ is a non-differentiable operator due its accuracy and efficiency. But, in general, the accessibility of iterative methods that use divided differences in their algorithms is reduced. The main interest of this paper is to improve the accessibility, domain of starting points, for Setffensen-type methods. So, by using a predictor-corrector iterative process we can improve this accessibility. For this, we use a predictor iterative process with a good accessibility and after we consider a Steffensen-type iterative method for a good accuracy, since this type of iterative process has quadratic convergence. Thus we will obtain a predictor-corrector iterative process with good accessibility, given by the predictor iterative process, and an accuracy like the Steffensen-type methods. Moreover, we analyze the semilocal convergence of the predictor-corrector iterative process proposed in two cases: when \$H\$ is differentiable and \$H\$ is non-differentiable. The dynamical properties show that this iterative process also improves the region of accessibility of Steffensen-type methods. So, we present a good alternative for the non-applicability of Newton's method to non-differentiable operators. The theoretical results are illustrated with numerical experiments.



Romero Álvarez, Natalia

Organization

Universidad de La Rioja

Email

natalia.romero@unirioja.es

Title

On iterative schemes for matrix equations

Abstract

In this paper we will focus on solving quadratic matrix equations. We start by transforming the quadratic matrix equation into a fixed point equation. From this transformation, we propose a stable iterative scheme of successive approximations. We study the global convergence of this iterative scheme. Furthermore, we consider the well-known Picard method and, by using auxiliary points, we obtain a result of restricted global convergence. We analyze, from the obtained results, the location and separation of the solutions of the considered quadratic matrix equation considered. We will finish our work by building stable fixed point iterative schemes. This construction will be carried out under the assumption that its si possible to describe the solution of the quadratic matrix equation by means of a power series.



Torregrosa, Juan R.

Organization

Universidad Politécnica de Valencia

Email

jrtorre@mat.upv.es

Title

Iterative methods with memory for approximating the inverse and generalized inverse of a complex matrix

Abstract

Iterative methods with memory for estimating the inverse of a nonsingular square complex matrix A, and some generalized inverses (Moore-Penrose, Drazin, ...) of a rectangular complex matrix A are designed. Sufficient conditions that guarantee the convergence of the methods are presented as well as the order of convergence. The stability of the new methods is also analyzed.

Some numerical tests allow us to confirm the theoretical results and to compare the performance of our methods with other known ones. With these results, the iterative methods with memory appear for the first time for approximating the solution of nonlinear matrix equations.



Yakoubsohn, Jean-Claude

Organization

Université Paul Sabatier, Toulouse

Email

yak@mip.ups-tlse.fr

Title

High order numerical methods for systems of equations

Abstract

Can we imagine numerical analysis without Newton's method? The purpose of this talk is to learn more about this method to construct a new class of high order method to approximate regular roots of analytic systems. From a truncated series expansion about a point closed to the root up to order p, we show how to cancel judiciously parts of terms of series expansion to define a map which generalize the Newton's map. We also give an analysis of the iteration defined from this construction with two new results of convergence. Finally, we exhibit numerical results which confirm this analysis.



Minisymposium:

Local and Non-Local Partial Differential Equations

Thematic area: Partial Differential Equations (PDE)

Organizers: Molino, Alexis, Martínez Aparicio, Pedro J. (University of Almería) and Segura de

León, Sergio (Universidad de València)

Abstract

Partial Differential Equations are often used to construct models of the most basic theories underlying physics and engineering. The main topics that would be addressed in this minisymposium can be summarized as systems with coupled NLS and NLS-KdV equations, fractional and non-local gradients and applications in Solid Mechanics, evolution problems of Leray-Lions type, reaction-diffusion models with nonlinear diffusion terms, fractional Laplacian, 1-Laplacian, etc.

The speakers will use techniques coming from Nonlinear Analysis: variational methods and minmax, Leray-Schauder degree, singular perturbation method, etc. Other tools from PDE's will also be used, like homogenization, blow-up analysis, sub-supersolutions, moving planes, etc.

Keywords: KdV equation; Fractional Laplacian;1-Laplacian

Session 1. Monday 11:30 - 13:35. Room A6.

Chair: Martínez Aparicio, Pedro J., U. de Almería

Speaker	Organization	Contribution title
MOLINO, ALEXIS	Universidad de Almería	Approximating local equations by non-local equations
SABINA, JOSÉ	U. de La Laguna	Asymptotic profiles of the logistic equation under diffusion
ORTEGA, ALEJANDRO	Universidad Castilla La Mancha	On a volume constraint problem related to the fractional Laplacian
CUETO, JAVIER	Universidad Castilla La Mancha	New results on fractional and non-local gradients and applications in Solid Mechanics
DEL TESO, FÉLIX	Universidad Complutense de Madrid	The Liouville Theorem for Nonlocal Operators (and its relation to irrational numbers and subgroups of \mathbb{R}^N)



Session 2. Monday 18:00 – 20:00. Room A6.

Chair: Molino, Alexis (University de Almería)

Speaker	Organization	Contribution title
Toledo, Julián	Universidad de Valencia	Evolution problems of Leray-lions type with nonhomogeneous Neumann boundary conditions in metric random walk spaces
MOLL, SALVADOR	Universidad de Valencia	The 1-harmonic flow
CARMONA, JOSÉ	Universidad de Almería	Fractional elliptic problems with mixed Dirichlet-Neumann boundary data
CALVO, JUAN	Universidad de Granada	Initial-boundary value problem for the Lifshitz- Slyozov system with inflow boundary conditions
CINTRA, WILLIAN	Universidade de Brasília, Brazil	Stationary solutions of some reaction- diffusion models with nonlinear diffusion terms

Session 3. Tuesday 10:30 – 12:10. Room A6.

Chair: Sabina, José (Universidad de La Laguna)

Speaker	Organization	Contribution title
SEGURA DE LEÓN,	Universidad de	A singular elliptic equation and the
SERGIO	Valencia	minimization of a related functional
MARTÍNEZ	Universidad de	Singular quasilinear elliptic problems with a
APARICIO, PEDRO J.	Almería	changing sign datum
LÓPEZ-MARTÍNEZ,	Universidad de	A priori estimates via blow-up in elliptic
SALVADOR	Granada	problems with natural growth in the gradient
THROM, SEBASTIAN	Universidad de	NAC destation acceptance for many level DDF/s
	Muenster	Modulation equations for non-local PDE's

Session 4. Tuesday 12:15 – 13:55. Room A6.

Chair: Segura de León, Sergio (Universidad de Valencia)

Speaker	Organization	Contribution title
LATORRE, MARTA	King Juan Carlos University	The regularizing effect of the superlinear gradient term in an elliptic equation
VILLEGAS, SALVADOR	Universidad de Granada	Optimal power in Liouville theorems



Calvo, Juan

Organization

Universidad de Granada

Email

juancalvo@ugr.es

Title

Initial-boundary value problem for the Lifshitz-Slyozov system with inflow boundary conditions

Abstract

The Lifshitz-Slyozov system describes the temporal evolution of a mixture of monomers and aggregates, where monomers can attach to or detach from already existing clusters. The aggregate distribution follows a transport equation with respect to a size variable, whose transport rates are coupled to the dynamic of monomers in a nonlocal fashion. Recent applications introduce attachment and detachment rates that require a nonlinear boundary condition at zero size. Up to date, the mathematical results on this new setting are scarce. In this contribution we study existence and uniquenes of local-in-time solutions, together with continuation criteria.



Carmona, José

Organization

U. Almería

Email

jcarmona@ual.es

Title

Fractional elliptic problems with mixed Dirichlet-Neumann boundary data

Abstract

In this talk we present some result obtained in collaboration with Eduardo Colorado, Tommaso Leonori and Alejandro Ortega. We study a nonlinear elliptic boundary value problem (P_l) in a bounded domain which involves the spectral fractional Laplacian operator with mixed Dirichlet-Neumann boundary conditions confronted with a concave-convex nonlinear term l,u^q+u^r with $0 < q < 1 < r < \frac{N+2s}{N-2s}$. We prove that $L = \sup\{l > 0 \colon (P_l) \text{ admits solution}\}$ is finite. Moreover, we prove multiplicity of solutions to for every $l \in (0,L)$.



Cintra, Willian

Organization

Universidade de Brasília, Brazil

Email

willian_matematica@hotmail.com

Title

Stationary solutions for some reaction-diffusion models with nonlinear diffusion terms

Abstract

In this lecture we present some models of reaction-diffusion arising from Population Dynamics. We focus our attention on cases where the diffusion term is nonlinear. We will discuss some results of existence, uniqueness and qualitative properties of positive steady states.



Cueto, Javier

Organization

Universidad Castilla La Mancha

Email

Javier.Cueto@uclm.es

Title

New results on fractional and non-local gradients and applications in Solid Mechanics

Abstract

In our work we have considered two operators, the fractional gradient and the nonlocal one (which gathers information from bounded domains, aiming at applications) and focused on searching for optimal deformations in broader spaces (including singularity phenomena) of a nonlocal functional associated with the energy of a system (mainly in Solid Mechanics) as well as the recovery of the classical model when the singularity fades.

Several tools are required such as nonlocal Piola Identity and weak convergence of the determinant, localization of the fractional gradient or compact embedding and nonlocal Poincaré inequality regarding the nonlocal gradient.



del Teso, Félix

Organization

Universidad Complutense de Madrid

Email

fdelteso@ucm.es

Title

The Liouville Theorem for Nonlocal Operators (and its relation to irrational numbers and subgroups of \mathbb{R}^N)

Abstract

The classical Liouville Theorem states that bounded harmonic functions are constant. The talk will revisit this result for the class of linear operators satisfying the maximum principle. This class naturally includes fractional and convolution type operators, as well as discretizations of both local and nonlocal operators. We give a precise classification for which the Liouville Theorem holds. In dimension one, the condition will be related to irrational numbers while in general we provide a characterization in terms of subgroups. Finally, we provide properties of the solutions when then Liouville property does not hold.



Latorre, Marta

Organization

Universidad Rey Juan Carlos

Email

marta.latorre@urjc.es

Title

The regularizing effect of the superlinear gradient term in an elliptic equation

Abstract (max 100 words)

We consider the homogeneous Dirichlet problem for an elliptic equation having the gradient term $g(u)|\nabla u|^q(1 < q < 2)$ and the data f belongs to the Lebesgue space L^m . Given q and 1 < m < N/2, we show the proper behaviour of g near infinity for which there exists a solution.

The presence of the function g has a regularizing effect in the existence and regularity of the solution. Our results agree with previous works in the limit cases where g is taken to be constant or q=2.

This is a joint work with Magliocca, M. and Segura de León, Sergio.



López-Martínez, Salvador

Organization

Inria Lille-Nord Europe

Email

salvadorlopez@ugr.es

Title

A priori estimates via blow-up in elliptic problems with natural growth in the gradient

Abstract

The talk will address a Dirichlet problem which involves two different nonlinear terms: a quadratic gradient term and a superlinear zero order term. It is known that the interaction between them gives rise to several existence results depending on the parameters. However, the literature deals exclusively with a gradient term with constant coefficients. Our aim is to consider non-constant coefficients and to extend the known results to this setting, where the usual techniques do not work. The key point in our approach consists of proving a priori estimates by adapting the blow-up method due to Gidas and Spruck.



Martínez Aparicio, Pedro J.

Organization

Universidad de Almería

Email

pedroj.ma@ual.es

Title

Singular quasilinear elliptic problems with a changing sign datum

Abstract

We study singular quasilinear elliptic equations whose model is

$$-\Delta u = \lambda u + \mu(x) \frac{|\nabla u|^q}{|u|^{q-1}} + f(x) \text{ in } \Omega, u = 0 \text{ on } \partial\Omega$$

where Ω is a bounded domain of \mathbb{R}^N with smooth boundary, $\lambda \in \mathbb{R}$, 1 < q < 2, $0 \le \mu \in L^\infty(\Omega)$ and the datum $f \in L^p(\Omega)$, for some $p > \frac{N}{2}$, may change sign. We prove existence of solution and we deal with the homogenization problem posed in a sequence of domains Ω^ε obtained by removing many small holes from a fixed domain Ω .



Molino, Alexis

Organization

University of Almeria

Email

amolino@ual.es

Title

Approximating local equations by non-local equations

Abstract

In this talk we will show how solutions of different types of local problems can be approximated by solutions of non-local equations of type

$$u_t(x,t) = \int_{\mathbb{R}^N} K_{\varepsilon}(x,y) \big(u(y,t) - u(x,t) \big) dy,$$

for a suitable rescaled kernel K_{ϵ} , as ϵ tends to zero.



Moll, Salvador

Organization

Universidad de Valencia

Email

j.salvador.moll@uv.es

Title

The 1-harmonic flow

Abstract

Let (N,g) be a complete, n-dimensional Riemannian manifold. We consider the formal steepest descent flow with respect to the L^2 distance of the p-Dirchlet energy functional for smooth functions defined from a smooth domain in \mathbb{R}^N and with values into N.

In this talk I will present some recent results in collaboration with Giacomelli, L., Lasica, M. concerning existence (and uniqueness) of solutions to the flow in the limit case p=1 in two different scenarios:

- 1) Lipschitz initial data
- 2) The case N=1; i.e., curves with bounded variation into manifolds.



Ortega, Alejandro

Organization

Universidad Carlos III de Madrid

Email

alortega@math.uc3m.es

Title

On the common spectral structure of Laplace operator and the Fractional Laplace operator

Abstract

We introduce volume constraint problems driven by a nonlocal operator $(-\Delta)^S_\delta$ closely related to the fractional Laplacian $(-\Delta)^s$ and depending upon a parameter $\delta>0$ called horizon. We study the associated linear and spectral problems and the behavior of these problems when $\delta\to 0^+$ or $\delta\to +\infty$. Through this limit process on $(-\Delta)^S_\delta$ we derive common structural spectral properties, such as same multiplicity of eigenvalues, for both $(-\Delta)$ and $(-\Delta)^s$ as well as we prove the convergence of solutions of these problems to solutions of a local Dirichlet problem when $\delta\to 0^+$ or to solutions of a nonlocal fractional Dirichlet problem when $\delta\to +\infty$.



Sabina, José

Organization

U. de La Laguna

Email

josabina@ull.es

Title

Asymptotic profiles of the logistic equation under diffusion

Abstract

A simple model describing the equilibrium configuration of a single species which diffuses through its natural environment Ω is

$$-\Delta_p u = \lambda |u|^{p-2} u - |u|^{q-2} u \quad x \in \Omega, \qquad u = 0 \quad x \in \partial \Omega.$$

Exponents satisfy $1 while <math>\lambda > 0$ is a bifurcation parameter. Here the species follows a logistic growth while the migration effects are described by the p--Laplacian operator. This talk is reviewing some asymptotic features of the problem as $p \to 1$. Special emphasis is put on the several "limit" diffusion problems arisen. Some of the reported results are part of joint works with Segura de León, Sergio.



Segura de León, Sergio

Organization

Universitat de València

Email

sergio.segura@uv.es

Title

A singular elliptic equation and the minimization of a related functional

Abstract

We study a class of Dirichlet problems driven by a linear operator whose main features are the presence of a singular term and a datum which possibly changes its sign. We introduce a notion of solution and we prove an existence result for such a solution. We also analyze a minimization problem for a non-differentiable functional on $H^1_0(\Omega)$ whose formal Euler-Lagrange equation is an equation of the considered type.



Throm, Sebastian

Organization

Universidad de Muenster

Email

throm@ma.tum.de

Title

Modulation equations for non-local PDE's

Abstract

For many classical PDEs the dynamical behaviour at the onset of instability can be described by modulation equations. In this talk, we will consider non-local partial differential equations. More precisely, for a non-local version of the Swift-Hohenberg equation, we will show that close to the region of instability solutions can be approximated on a large time-scale by a basic pattern modulated by the solution of a corresponding Ginzburg-Landau equation".



Toledo, Julián

Organization

Universidad de Valencia

Email

jose.toledo@uv.es

Title

Evolution problems of Leray-lions type with nonhomogeneous Neumann boundary conditions in metric random walk spaces

Abstract

In this talk we present existence and uniqueness results for nonlinear evolution problems of Leray-Lions type with nonhomogeneous Neumann boundary conditions in the framework of metric random walk spaces. This includes as particular cases evolution problems with nonhomogeneous Neumann boundary conditions for the p-Laplacian operator in weighted discrete graphs and for nonlocal operators with nonsingular kernel.

This is a joint work with Mazón, José. M. and Solera Diana, Marcos.



Villegas, Salvador

Organization

Universidad de Granada

Email

svillega@ugr.es

Title

Optimal power in Liouville theorems

Abstract

Consider the equation $\operatorname{div}(\varphi^2 \nabla \sigma) = 0$ in R^N , where $\varphi > 0$. It is well-known [BCN, AC] that if there exists C > 0 such that $\int_{B_R} (\varphi \sigma)^2 dx \leq C R^2$ for every $R \geq 1$, then σ is necessarily constant. We present a simple proof that this result is not true if we replace R^2 with R^k for k > 2 in any dimension N. This question is related to a conjecture by De Giorgi [DG]. In addition, we prove some results concerning the Dirichlet and potential energies of the energy functional associated to the Allen-Cahn equation.

[AC] L. Ambrosio, X. Cabré, Entire solutions of semilinear elliptic equations in \mathbb{R}^3 and a conjecture of De Giorgi, J. Amer. Math. Soc. 13 (2000), 725-739.

[BCN] H. Berestycki, L. Caffarelli, L. Nirenberg, Further qualitative properties for elliptic equations in unbounded domains, Ann. Scuola Norm. Sup. Pisa Cl. Sci. 25 (1997), 69-94.

[DG] E. De Giorgi, Convergence problems for functionals and operators, Proc. Int. Meeting on Recent Methods in Nonlinear Analysis (Rome, 1978), Pitagora, Bologna, 1979, 131-188.



Minisymposium:

math-in: Success Stories between Academia and Industry

Thematic area: Mathematics Applied to Industry, Social Sciences and Biology (MA)

Organizers: Quintela Estévez, Peregrina (Universidade de Santiago de Compostela; Red Española Matemática – Industria), Coll Vincens, Bartomeu (Universitat de les Illes Balears)

Abstract

The main goal of this mini-symposium is to give visibility to the importance of mathematical transfer nowadays For that, different successful real-world collaborations between the academia and the industry will be introduced. In the different presentations, we will show how mathematical tools enhance the industrial world using different techniques adapted to the company requirements. In particular, emphasis will be placed on positive changes derived from mathematical results, the improvement of processes or dispositive, or on the benefit to their productivity. In total, there will be three sessions with four presentations each one. Each session will be classified by industrial sectors.

Keywords: Transfer; success stories; innovation

Session 1. Monday 11:30-13:35. Room A4.

Chair: Coll Vincens, Bartomeu (Universitat de les Illes Balears)

Speaker	Organization	Contribution title
QUINTELA ESTÉVEZ, PEREGRINA	Universidade de Santiago de Compostela; Red Española Matemática - Industria	Presentation of math-in and EU-MATHS-IN initiatives to promote new success stories
GARCÍA-SÁNCHEZ, GUILLERMO	ICMAT	Dynamical systems and marine litter monitoring
LOUREIRO GARCIA, MARCOS	Instituto de Investigación Sanitaria Galicia Sur (IISGS); Hospital Alvaro Cunqueiro	The use of numerical simulation in cardiology: towards patient-specific medicine
LEZAUN, MIKEL	Universidad del País Vasco - UPV/EHU	Algorithm and programming of the optimal assignment of incidences in the Customer Efficient Integral Service (SIEC)
SIERRA- PARADINAS, MARÍA	IDOM	The slitting problem in the steel industry: A case study



Session 2. Monday 18:00-20:00. Room A4.

Chair: Coll Vincens, Bartomeu (Universitat de les Illes Balears)

Speaker	Organization	Contribution title
VÁZQUEZ, SARA	ArcelorMittal, INNVEL	Real stress-strain curves associated with uniaxial tests for compressible materials
MÁRQUEZ SÁNCHEZ, ALBA	Universidade de Santiago de Compostela	Thermo-mechanical simulation of the main trough of a Blast Furnace
DURANY CASTRILLO, JOSE	Universidad de Vigo	Modeling and simulation of metal casting processes: validation of the CastFEM code
OMELLA, ÁNGEL JAVIER	Repsol YPF S.A.	Computing Effective P-Wave Velocity in Heterogeneous Rocks

Session 5. Tuesday 18:00-20:00. Room A4.

Chair: Quintela Estévez, Peregrina (Universidade de Santiago de Compostela; Red Española Matemática – Industria)

Speaker	Organization	Contribution title
PÉREZ, ARITZ	BCAM	Prediction of the number of own damages of the vehicle
GONZÁLEZ DEL PINO, ALEJANDRO	CN-IGME (CSIC) Grupo EDANYA - Universidad de Málaga	Study on the estimation of economic losses due to tsunamis in Spain
GORRIA, CARLOS	Universidad del País Vasco - UPV/EHU	Scheduling of the promissory notes issue planed to fund big companies under linear constraints
GONZÁLEZ VIDA, JOSÉ MANUEL	Universidad de Málaga	What is the humanitarian aid required after tsunami?



Durany Castrillo, Jose

Organization

Universidad de Vigo

Email

durany@dma.uvigo.es

Title

Modeling and simulation of metal casting processes: validation of the CastFEM code

Abstract

This work was initially proposed by the Spanish company Fundiciones Rey S.L. . It was aimed at developing a numerical simulation model of thermal processes in the metallurgical industry. The final code is a registered trademark software named CastFEM. But, CastFEM code does not include the pouring phase of the casting into the mold, so it is necessary to validate the initial temperature of both metal and mold in CastFEM code. For this, a 2D simulation of the pouring process (using possible symmetries) has been developed using the VOF method and the Pressure-Based-Solver in the commercial software Ansys-Fluent.

Joint work with Hidalgo, M. and Martín, Elena.



García-Sánchez, Guillermo

Organization

ICMAT

Email

guillermo.garcia@icmat.es

Title

Dynamical systems and marine litter monitoring

Abstract

The goal of this presentation is to discuss the combined use of dynamic systems ideas and remote sensing techniques (drones, satellite images) to explore the effectiveness of their combination for the management of plastic waste in protected coastal areas in Galicia. In particular, our focus is on uncovering the geometry associated to changing dynamics of the ocean and to use it to understand the origin and fates of plastic waste, e.g. where it comes from and where it tends to accumulate.

Joint work with Mancho, Ana María, Martín, Fernando and Margarit, Gerard.

Acknowledgements: This work is supported by Fundación Biodiversidad.



Gorria, Carlos

Organization

Universidad del País Vasco - UPV/EHU

Email

carlos.gorria@ehu.eus

Title

Scheduling of the promissory notes issue planed to fund big companies under linear constraints

Abstract

The aim of the promissory notes issued by the big companies is to have an effective mechanism for guaranteeing the flow of cash as well as the financial reserves. The promissory notes issue programme have to fulfill certain restrictions regarding the lead time and the bounds of the issuance of notes. These restrictions are imposed by the market regulator and the operational reality of the company. A discretization in time allows us to find optimum scheduling of the promissory notes issuance by a integer linear programing methods.

Joint work with Lezaun, Mikel.



Pérez, Aritz

Organization

BCAM

Email

aperez@bcamath.org

Title

Prediction of the number of own damages of the vehicle

Abstract

The study presented in this work is the prediction of the probability distribution of the number of own damages of the vehicle. For the solution of this problem, three stages were considered: data preprocessing of the database provided, modeling and validation of the model. In addition, techniques based on "Machine Learning (ML)" such as classification trees, random forest, support vector machine and, neural networks were used in order to get a model and, finally, a software has been created based on a series of scripts written in Python that allow the process to be replicated when necessary.

Joint work with Hernández-Hernández, César.



Lezaun, Mikel

Organization

Universidad del País Vasco - UPV/EHU

Email

mikel.lezaun@ehu.eus

Title

Algorithm and programming of the optimal assignment of incidences in the Customer Efficient Integral Service (SIEC)

Abstract

Eroski is developing a project to offer its centers a single point of contact for the resolution of all incidents. The call center is divided into three hierarchical levels. First level agents receive the initial call. Unresolved problems go to a second level where they are distributed in different specialized queues. Finally, if necessary, the incidences are assigned to technical experts in their resolution. The project consists in developing an algorithm and computer program that assigns the incidents to the agents, optimizing the waiting time in the call center, the resources used and the established quality levels are satisfied.

Joint work with Gorria, Carlos.



Loureiro Garcia, Marcos

Organization

Instituto de Investigación Sanitaria Galicia Sur (IISGS); Hospital Alvaro Cunqueiro

Email

marcos.loureiro@iisgaliciasur.es

Title

The use of numerical simulation in cardiology: towards patient-specific medicine

Abstract

We will present the employed methodology used to introduce numerical simulation in the cardiology clinical world. The problem is initially approached from the aortic stenosis point of view, which is solved by using transcatheter aortic valve replacement, a non-invasive technique. With the proposed methodology, different sizes of devices can be virtually implanted in the selected patient by using numerical simulation. This allows predicting the behavior of those devices in advance, showing extra data before the intervention which could help in clinical decision making.

Joint work with Veiga, Cesar, Fdez-Manin, Generosa, Jimenez, Victor A, Salvadores, Pablo Juan, Baz, José Antonio and Iñiguez, Andrés.



González del Pino, Alejandro

Organization

CN-IGME (CSIC) - Grupo EDANYA - Universidad de Málaga **Email**

alexgp@uma.es

Title

Study on the estimation of economic losses due to tsunamis in Spain

Abstract

The "GEOMEP Tsunamis" Project (Study on the estimation of economic losses due to tsunamis in Spain) is funded by the Consorcio de Compensación de Seguros (CCS) and the Spanish Geological Survey (IGME) under a common agreement. In order to deal with a catastrophe of natural origin, a set of aspects must be taken into consideration, including among others landuse planning and management, civil protection and insurance. This research work seeks to shed light on the consequences for the insurance in the event of a tsunamigenic-earthquake affecting the Spanish coasts.

Joint work with Macias, Jorge, Llorente, Miguel and Espejo, Francisco.



González Vida, José Manuel

Organization

Universidad de Málaga

Email

jgv@uma.es

Title

What is the humanitarian aid required after a tsunami?

Abstract

On October 2019, the University of Malaga became the Spanish partner of the ARISTOTLE-ENHSP consortium, a project funded by the EC DG-ECHO (European Civil Protection and Humanitarian Aid Operations of the European Commission). The objective of this project is to provide 24*7 scientific advice on various hazards and natural disasters to the Emergency Response Coordination Center (ERCC). The role of the UMA in ARISTOTLE project is the implementation of the Tsunami Service. The objective of this service is to provide an early estimate of the magnitude of a tsunami event anywhere in the world and in the shortest possible time.

Joint work with Macías, Jorge, Ortega, Sergio, Castro Díaz, Manuel Jesús, Sánchez, Carlos, Azzarone Adriano and Michelini, Alberto.



Márquez Sánchez, Alba

Organization

Universidade de Santiago de Compostela

Email

a.marquez@usc.es

Title

Thermo-mechanical simulation of the main trough of a Blast Furnace

Abstract

Blast furnace is used to produce steel. In it, raw materials react to produce slag and hot metal which, then, fall into a main trough made of refractory concrete.

Since the temperature of both fluids is around 1500°C, big thermal stresses are expected in the refractories. Therefore, the goal of this work is to analyse the mechanical strains caused by these high temperatures.

One of the difficulties of this problem is the complicated computational geometry that main trough has. It is a piece consisting of 1D, 2D and 3D computational domains.

We have used ANSYS MECHANICAL to solve this problem.

Joint work with Barral, Patricia and Quintela Estévez, Peregrina.



Omella, Ángel Javier

Organization

Repsol YPF, S.A.

Email

ajaome@gmail.com

Title

Computing Effective P-Wave Velocity in Heterogeneous Rocks

Abstract

Determination of the effective compressional (P) wave velocity of an elastic wave traveling through the Earth's subsurface enables to identify gas saturated rocks as well other key petrophysical properties. The analysis of this information by oil companies is critical for an initial assessment of a reservoir. The oil company Repsol needed to estimate the P-wave velocity of heterogeneous rocks in the entire frequency spectrum. For that, Repsol possessed a micro-CT image of the rocks' samples. To do this, we developed a set of numerical methods and techniques:

- (a) for the low/medium frequency spectrum, we solve the acoustic equation in the frequency domain by the Finite Element Method (FEM), and we postprocess the solution to estimate the homogenized P-wave velocity. To reduce the computational cost inside this regime, we use non-fitting meshes with precomputed blocks of the stiffness matrix.
- (b) At high frequencies, we solve the Eikonal equation by the Fast Marching Method (FMM) to estimate the effective P-wave velocity.

In this presentation, we expose the mathematical technology used in the project and the obtained numerical results.

This is a joint work with Pardo, David, Struagaru, Magdalena, Alvarez-Aramberri, Julen, Darrigrand, Vincent, Santos, Carlos, González, Héctor.



Quintela Estévez, Peregrina

Organization

Universidade de Santiago de Compostela; Red Española Matemática - Industria

Email

peregrina.quintela@usc.es

Title

Presentation of math-in and EU-MATHS-IN initiatives to promote new success stories

Abstract

In this talk, we will present various initiatives from math-in and EU-MATHS-IN to promote greater collaboration with industry and increase the visibility of Mathematics in the institutions that define investment in research in Spain and Europe.

In particular, some success stories of EU-MATH-IN will be presented as well as the European Strategic Agenda on Modelling, Simulation, and Optimisation in a Digital based Environment (MSODE) promoted by EU-MATHS-IN.

Contributors:

Coll Vincens, Bartomeu University of Balearic Islands; and Spanish Network for Mathematics & Industry (math-in)

Quintela, Peregrina, University of Santiago de Compostela; math-in; and Technological Institute for Industrial Mathematics (ITMATI)



Sierra-Paradinas, María

Organization

IDOM

Email

msierra@idom.com

Title

The slitting problem in the steel industry: A case study

Abstract

From an economic point of view, the steel industry plays an important role and, when it comes to responding to new challenges, innovation is a crucial factor. This paper proposes a mathematical methodology to solve the slitting problem in a steel company located in Europe. The slitting problem occurs when large width steel coils are slit into narrower coils, known as strips, to meet the requirements of the customers. A major challenge here is defining a slitting plan to full all these requirements, as well as ongoing operational constraints and customer demands. The company looks for a reduction of the leftovers generated in the entire process, while maximising the overall accuracy of the orders. These leftovers may be used in the future as part of new orders provided they are able to respond to specific requirements, or otherwise they are discarded and considered as scrap. The methodology is validated with real data and it outperforms the results obtained by the company in different ways: by adjusting the orders that are to be served, by reducing the amount of scrap and by using the retails for future orders. Furthermore, planning times are reduced to only a few minutes, while the company needs several hours to prepare the scheduling in the current operating process.

Joint work with Soto-Sánchez, Óscar, Alonso-Ayuso, Antonio, Martín-Campo, F. Javier and Gallego, Micael.



Vázquez, Sara

Organization

ArcelorMittal, INNVEL

Email

saravf90@gmail.com

Title

Real stress-strain curves associated with uniaxial tests for compressible materials

Abstract

In a uniaxial test, the stress-strain engineering curves are calculated with respect to the initial dimensions of the tested sample. However, its section and length may vary during the test. For incompressible materials, there are mathematical relationships in the bibliography that transform the engineering curves into the real ones, taking into account these variations. However, most structural materials are compressible, as refractory concretes, and the relations mentioned above are not adequate. In this talk, it will be shown the attainment of the relations between engineering and true stress and strains for compressible materials, and for different types of uniaxial tests.

Joint work with Quintela Estévez, Peregrina.



Minisymposium:

Modelling and computational methods in quantitative finance

Thematic area: Applied Mathematics to Industry, Social Sciences and Biology (AM)

Organizer: Vázquez Cendón, Carlos (Universidade da Coruña)

Abstract

Some recent advances in the mathematical methods to address problems arising in quantitative finance will be presented in this minisimposium. These advances are mainly related to the mathematical modelling, mathematical analysis of the models, appropriate numerical methods and efficient computational techniques. Different mathematical methods will be applied to the pricing of financial products with stochastic and local stochastic volatility models, the valuation adjustments arising from the presence of counterparty risk, the pricing of derivatives in energy markets, the solution of optimal investment situations under uncertainty, the inclusion of current scenarios of negative rates, etc.

Keywords: mathematical finance; numerical methods; computational finance



Session 1. Monday 11:30 – 13:35 Room A5.

Chair: Vázquez Cendón, Carlos (Universidade da Coruña)

Speaker	Organization	Contribution title
LEITAO, ÁLVARO	Universidade da Coruña	Neural Networks for extracting implied information from American options
SALVADOR -MANCHO, BEATRIZ	Universidade da Coruña	XVA for American options with two stochastic factors: modelling, mathematical analysis and numerical methods
SUÁREZ TABOADA, María	Universidade da Coruña	New mathematical models for pricing a mine extraction project
RÁFALES, JONATAN	Universidade da Coruña	Pricing TARN options with a local stochastic volatility model

Session 2 Monday 18:00 - 20:00 Room A5.

Chair: Vázquez Cendón, Carlos (Universidade da Coruña)

Speaker	Organization	Contribution title
CALVO-GARRIDO,	Universidade da	PDE model and numerical methods for
MARIA DEL CARMEN	Coruña	pricing renewable energy certificates
BAAMONDE SEOANE,	Universidade da	Free boundary SABR model for possible
María A.	Coruña	negative rates: computation of the volatility surface
PÉREZ RODRÍGUEZ, SOLEDAD	Universidad de La Laguna	AMFR-W-methods for parabolic PDEs with mixed derivatives. Application to the Heston problem
GATÓN, VICTOR	Universidad de Valladolid	A study over the n-dimensional optimal investment model with transaction costs and potential utility



Baamonde Seoane, María A.

Organization

Universidade da Coruña

Email

maria.baamonde1@udc.es

Title

Free boundary SABR model for possible negative rates: computation of the volatility surface

Abstract

The local volatility model captures the static volatility pattern, however it predicts the wrong dynamics. To overcome this problem, several models of stochastic volatility have been developed, in which volatility follows a stochastic process such as the SABR model (Stochastic, Alpha, Betha, Rho). Moreover, taking into account the negative value of the current interest rates, we consider the Free Boundary SABR model, as an extension of the SABR model that can handle these negative rates. We will consider an approximation for Bachelier volatility to obtain the prices of the corresponding option, which will be the CAPs prices in our case.



Calvo-Garrido, Maria del Carmen

Organization

Universidade da Coruña

Email

mcalvog@udc.es

Title

PDE model and numerical methods for pricing renewable energy certificates

Abstract

The valuation problem of renewable energy certificates can be posed as a PDE model where the underlying stochastic processes are the accumulated green certificates sold by an authorized producer and the renewable generation rate. Moreover, the PDE operator is nonlinear, thus adding an extra difficulty to the problem. In this work, the nonlinear convection term is treated with the Bermúdez-Moreno algorithm. This duality method is based on the aproximation of a nonlinear maximal monotone operator by means of its Yosida regularization.

For the numerical solution of the resulting linear problem, we propose a Lagrange-Galerkin method for time and space discretizations.



Gatón, Victor

Organization

Universidad de Valladolid

Email

vgaton@mac.uva.es

Title

A study over the n-dimensional optimal investment model with transaction costs and potential utility

Abstract

This talk concerns the numerical solution of the finite-horizon Optimal Investment problem with transaction costs under Potential Utility. In 2 dimensions (a risk-free asset and a stock), the problem is initially posed in terms of evolutive HJB equation with gradient constraints and reformulated as a non-linear parabolic double obstacle problem posed in one spatial variable.

In a previous work, the restatement of the problem in polar coordinates and the employment of a spectral numerical method proved to be an efficient technique. Current work involves the extension of the numerical method such that it can handle an n-dimensional model (multiple stocks).



Leitao, Álvaro

Organization

Universidade da Coruña

Email

alvaro.leitao@udc.es

Title

Neural Networks for extracting implied information from American options

Abstract

Extracting implied information, from observed option prices is a challenging task when dealing with American options. We propose a data-driven machine learning approach to estimate the Black-Scholes implied volatility and the dividend yield for American options in a fast and robust way. To determine the implied volatility, the inverse function is approximated by an artificial neural network on the computational domain of interest, which decouples the offline (training) and online (prediction) phases. For the implied dividend yield, we formulate the inverse problem as a calibration problem and determine simultaneously the implied volatility and dividend yield.



Pérez Rodríguez, Soledad

Organization

Universidad de La Laguna

Email

sperezr@ull.edu.es

Title

Time integration with AMF-W-type methods and applications to the Heston problem

Abstract

The Heston model is widely used in financial option pricing theory. For the time integration of the ODE-systems that come from the application of the method of lines on the PDE-version of this model, we propose the use of AMFR-W-methods. In order to avoid order reduction on problems with time-dependent boundary conditions, we propose a simple algorithm to convert the model into one with homogeneous boundary conditions. We also propose a simplification of the methods that reduces the number of LU-decompositions required, so the final cost also does, and a very efficient integration of the problem is presented.



Ráfales, Jonatan

Organization

Universidade da Coruña

Email

jonatan.rafales.perez@udc.es

Title

Pricing TARN options with a local stochastic volatility model

Abstract

Target Accumulation Redemption Notes (TARNs) are financial derivatives which give their holders the right to receive periodic coupons until the accumulated sum of those ones reaches an agreed target. In this work, we solve a partial differential equations (PDEs) model for pricing TARN options by implementing an alternating-direction implicit finite difference method (ADI method). We combine the numerical resolution with a stochastic local volatility (SLV) technique and show the numerical results for a particular test example.



Salvador - Mancho, Beatriz

Organization

Universidade da Coruña

Email

beasalman@gmail.com

Title

XVA for American options with two stochastic factors: modelling, mathematical analysis and numerical methods

Abstract

New linear and nonlinear partial differential equations (PDEs) models are proposed to price American options and total value adjustment in the presence of counterparty risk. An innovative aspect comes from the consideration of stochastic spreads, which increases the dimension of the problem. In this setting, we pose new complementarity problems associated to linear and nonlinear PDEs. Moreover, the existence and uniqueness of a solution for these models is proved. For the numerical solution, we combine several numerical methods. Finally, the numerical examples illustrate the behaviour of the XVA. The results are also compared with those obtained by Monte Carlos techniques.



Suárez Taboada, María

Organization

Universidade da Coruña

Email

maria.suarez3@udc.es

Title

New mathematical models for pricing a mine extraction project

Summary

New mathematical models for pricing mine extraction projects under uncertainty are proposed. The underlying stochastic factors are the commodity price and the remaining quantity of resource. The main innovative aspect comes from the consideration that the extraction rate is proportional to the commodity price. This more realistic hypothesis leads to a PDE governed by a ultraparabolic hypoelliptic PDE. We obtain the existence and uniqueness of solution. For the numerical solution, a Lagrange-Galerkin method is proposed. Numerical examples are discussed. We also present the model when there is the option to abandon the extraction project.

This is a joint work with Pignotti, M. and Vázquez Cendón, Carlos.



Minisymposium:

Nonlinear PDEs and its applications in Natural Sciences

Thematic area: Mathematics Applied to Industry, Social Sciences and Biology (MA)

Organizers: Rodríguez Bellido, María Ángeles (Universidad de Sevilla), Morales-Rodrigo, Cristian (Universidad de Sevilla), Shmarev, Sergey (Universidad de Oviedo)

Abstract

The objective of the session is to present recent results in the theory of nonlinear PDEs, with special attention to the equations that come from the mathematical modelling of real processes and phenomena, such as the population dynamics, chemistry, medicine, or processing of digital images. The session will contribute to the theoretical and numerical study of the equations and systems of nonlinear equations arising in natural sciences.

Keywords: biology models; nonlinear PDEs; models in medicine



Session 3. Tuesday 10:30-12:10. Room A4

Chair: Shmarev, Sergey (U. de Oviedo)

Speaker	Organization	Contribution title
VÁZQUEZ, JUAN LUIS	Universidad Autónoma de Madrid	Nonlinear fractional Laplacian operators and equations
CARPIO, ANA	Universidad Complutense de Madrid	Well posedness and numerical solution of kinetic models for angiogenesis
GRANERO- BELINCHÓN, RAFAEL	Universidad de Cantabria	Keller-Segel type systems with fractional diffusion
SUÁREZ, ANTONIO	Universidad de Sevilla	Inclusion of non-local terms in population dynamics PDEs models

Session 4. Tuesday 12:15-13:55. Room A4

Chair: Suárez, Antonio (Universidad de Sevilla)

Speaker	Organization	Contribution title
Díaz, Jesús Ildefonso	Universidad Complutense de Madrid	Spatial symmetrization of solutions of some diffusive age-structured population models and applications
TELLO, LOURDES	Universidad Politécnica de Madrid	On a nonlinear problem with diffusive boundary condition
GALIANO, GONZALO	Universidad de Oviedo	Turing instability analysis of a singular cross- diffusion problem
HIDALGO, ARTURO	Universidad Politécnica de Madrid	Numerical simulation of an atherosclerosis model



Session 6. Wednesday 10:30-12:10. Room A4.

Chair: Guillén, Francisco (Universidad de Sevilla)

Speaker	Organization	Contribution title
CALVO, JUAN	Universidad de Granada	Model calibration for aggregation-sedimentation dynamics
CONTE, MARTINA	Universidad de Granada	Modelling the emergence of invasion patterns during glioblastoma progression
SÁNCHEZ ROMERO, OSCAR	Universidad de Granada	Morphogenetic modelling revisited.
LOGIOTI,	Universität Bonn,	A free boundary problem modeling cell
ANNA	Germany	polarization

Session 7. Thursday 11:30-13:35. Room A4

Chair: Rodríguez Bellido, María Ángeles (Universidad de Sevilla)

Speaker	Organization	Contribution title
GUILLÉN, FRANCISCO	Universidad de Sevilla	An optimal bilinear control problem related to a chemo-repulsion with nonlinear production model
SAAD, MAZEN	École Normale de Nantes (France)	Pattern formation a nonlinear degenerate chemotaxis model
RODRÍGUEZ GALVÁN, J.	Universidad de	Flux-Corrected Methods for Chemotaxis
RAFAEL	Cádiz	Equations
ACOSTA SOBA, DANIEL	Universidad de Cádiz	On Numerical Approximations to Diffuse- Interface Models with Application to Tumor Growth
VIGLIALORO, GIUSEPPE	Università degli Studi di Cagliari	On the L^p blow-up time of unbounded solutions to a nonlinear chemotaxis system



Session 8. Thursday 18:00-20:00. Room A4

Chair: Morales-Rodrigo, Cristian (Universidad de Sevilla)

Speaker	Organization	Contribution title
TELLO, J.	Universidad Nacional de Educación a Distancia	Blow up of solutions for a Parabolic-Elliptic Chemotaxis System with nonlinear gradient dependent chemotactic coefficient
NEGREANU, MIHAELA	Universidad Complutense de Madrid	Global existence and asymptotic behavior of solutions to a chemotaxis system with chemicals and prey-predator terms
VELASCO VALDÉS, JULIAN	Universidad de Oviedo	Weakly nonlinear analysis of a system with non- local diffusion
CINTRA, WILLIAN	Universidade de Brasília, Brazil	On positive solutions for a class of quasilinear elliptic equations

Session 9. Friday 11:30-13:10

Chair: Galiano, Gonzalo (Universidad de Oviedo)

Speaker	Organization	Contribution title
SHMAREV, SERGEY	Universidad de Oviedo	Nonlocal parabolic equations with the nonlinearity depending on the solution
BORGES DE OLIVEIRA, HERMENEGILDO	Universidade do Algarve (Portugal)	Numerical confinement of a viscous fluid by a feedback forces field
SERT, UGUR	Hacettepe University, Ankara (Turkey)	On a class of nonlocal evolution equations of Kirchhoff type
MAESTRE CABALLERO, FAUSTINO	Universidad de Sevilla	On a non-linear system of PDEs with application to tumor identification



Acosta Soba, Daniel

Organization

Universidad de Cádiz

Email

daniel.acosta@uca.es

Title

On Numerical Approximations to Diffuse-Interface Tumor Growth Models

Abstract

This work is devoted to developing new numerical schemes for a tumor-nutrient PDE model. It is based on phase-field equations for the tumor variable and a diffusive equation for the nutrient one, coupled by reaction and cross-diffusion terms. The model conserves the sum tumor+nutrient and has a non-increasing energy law.

We introduce two different time-discrete schemes: one based on an Eyre-type energy decomposition and the other on an energy quadratization. Both FEM and DG are used for space discretization. The schemes are compared analytically and computationally.

Joint work with Guillén, Francisco (Universidad de Sevilla) and Rodríguez Galván, J. Rafael (Universidad de Cádiz).



Borges de Oliveira, Hermenegildo

Organization

Universidade do Algarve (Portugal)

Email

holivei@ualg.pt

Title

Numerical confinement of a viscous fluid by a feedback forces field

Abstract

In this talk, we consider planar flows of viscous fluids under the action of a feedback forces field.

We present a penalty continuous/discontinuous finite element method to approximate the solutions of the stream-function version of the problem.

Then, we analyse the existence and uniqueness of the discrete solutions, we show that the discrete problem is consistent, and we proceed with an error analysis.

Finally, some numerical experiments are reported to confirm the theoretical results regarding the solutions confinement.



Calvo, Juan

Organization

Universidad de Granada

Email

juancalvo@ugr.es

Title

Model calibration for aggregation-sedimentation dynamics

Abstract

Sedimentation processes in lakes and oceans drag CO2 to their bottom, helping the mitigation of global warming. There are quantitative models (both ODE and PDE) that try to capture the aggregation-sedimentation dynamics of particulate organic carbon aggregates; however, our knowledge about how does aggregation work in this context is presently quite limited. Model calibration (particularly in its non-parametric version) can be used as a mean to determine the nature of aggregation interactions indirectly. We will review some of the existing techniques and show some preliminary results on specific applications. Related issues arise in the modelling of neurodegenerative diseases.



Carpio, Ana

Organization

Universidad Complutense de Madrid

Email

carpio@mat.ucm.es

Title

Well posedness and numerical solution of kinetic models for angiogenesis

Abstract

Angiogenesis processes including the effect of stochastic motion and branching of blood vessels can be described coupling a (nonlocal in time) integrodifferential kinetic equation of Fokker–Planck type with a diffusion equation for the angiogenic factor. We develop an existence, uniqueness and stability theory for this system under natural assumptions on the initial data in unbounded and bounded domains. We are able to construct numerical solutions devising order one positivity preserving schemes and show that soliton-like asymptotic solutions are correctly captured. Higher order positivity preserving schemes can be devised combining WENO and SSP procedures.

Joint work with Duro, G., and Cebrián, E.



Cintra, Willian

Organization

Universidade de Brasília, Brazil

Email

willian@mat.unb.br

Title

On positive solutions for a class of quasilinear elliptic equations

Abstract

In this talk we discuss the existence, nonexistence and uniqueness of positive solutions for a class of quasilinear equations. We also analyze the behavior of these solutions with respect to two parameters that appear in the equation. The proof of our main results relies on bifurcation techniques, the sub and supersolution method and a priori bounded.



Conte, Martina

Organization

Universidad de Granada

Email

conte.martina.93@gmail.com

Title

Modelling the emergence of invasion patterns during glioblastoma progression

Abstract

Glioblastoma (GB) growth and migration inside the brain tissue is driven by specific signaling pathways and by several interactions between tumor cells and their extracellular microenvironment. Recent studies on tumor cell activity have highlighted the important role of the cell membrane protrusions located at the tumor invasion front in the process of tumor progression.

In this work, our main interest is focused on the study of the tumor cell membrane dynamics involved in cell transport and in the cell interactions with different molecular substrates during tumor evolution. Starting from biological experiments in a Drosophila model of GB, we formulate a nonlinear macroscopic model based on flux-saturated mechanisms [1,2]. We exploit the ability of the mathematical model to partially guide the biological experiments on protein signaling distribution. We numerically analyze the evolution of the tumor propagation front and the emergence of a coordination between self-organized collective processes characterizing the different agents involved in tumor progression.

Joint work with Casas Tintò, S. (Instituto Cajal - CSIC) and Soler, Juan (U. de Granda)

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- [2] Calvo, J., Campos, J., Caselles, V., Sánchez, O., Soler, J. (2016). Pattern formation in a flux limited reaction-diffusion equation of porous media type. Inventiones mathematicae, 206(1), 57-108.



Díaz, Jesús Ildefonso

Organization

Universidad Complutense de Madrid

Email

jidiaz@ucm.es

Title

Spatial symmetrization of solutions of some diffusive age-structured population models and applications

Abstract

We consider an age-dependent structured population model with a spatial diffusion that can be nonlinear and slow (such as proposed by Gurtin and Mc Camy on 1974). Our aim is to find sufficient conditions on the coefficients in order to get some useful information on this population through the comparison with a virtual parallel population spatially symmetric obtained by the symmetrization of the spatial domain and the data of the problem. Our mathematical conclusions are quite coincident with the ones obtained by a multidisciplinary team of the CSIC who analyzed the 174 more populated cities. (Joint work with Diaz, G.).



Galiano, Gonzalo

Organization

Universidad de Oviedo

Email

gonzalo@galianocasas.es

Title

Turing instability analysis of a singular cross-diffusion problem

Abstract

The population model of Busenberg and Travis is a paradigmatic model in ecology and tumour modelling due to its ability to capture interesting phenomena like the segregation of populations. Its singular mathematical structure enforces the consideration of regularized problems to deduce properties as fundamental as the existence of solutions. In this article we perform a weakly nonlinear stability analisys of a general class of regularized problems to study the convergence of the instability modes in the limit of the regularization parameter. We demonstrate with some specific examples that the pattern formation observed in the regularized problems, with unbounded wave numbers, is not present in the limit problem due to the amplitude decay of the oscillations. We also check the results of the stability analysis with direct finite element simulations of the problem.

This is a joint work with González-Tabernero, Víctor (Universidad de Oviedo).



Granero-Belinchón, Rafael

Organization

Universidad de Cantabria

Email

rafael.granero@unican.es

Title

Keller-Segel type systems with fractional diffusion

Abstract

In this talk we are going to present a series of results on various Keller-Segel type systems with fractional diffusion.

Specifically, we will treat the parabolic-parabolic, parabolic-elliptic and parabolic-hyperbolic cases and we will present various results of global existence.

If possible, we will present a new finite-time singularity result.



Guillén, Francisco

Organization

Universidad de Sevilla

Email

guillen@us.es

Title

An optimal bilinear control problem related to a chemo-repulsion with nonlinear production model

Abstract

We will study a parabolic chemo-repulsion model with nonlinear production $u^p (1 \le p \le 2)$ and a related control problem, where the control acts in a bilinear form in the chemical equation. For 2D domains, we show the existence and uniqueness of global strong state solution for each control, and the existence of global optimum solution. Afterwards, we deduce the optimality system for any local optimum via a Lagrange multiplier Theorem, proving regularity of the Lagrange multipliers. The case p>2 remains as an open problem. Finally, some comments about the difficulties for 3D domains will be presented.



Hidalgo, Arturo

Organization

Universidad Politécnica de Madrid

Email

arturo.hidalgo@upm.es

Title

Numerical simulation of an atherosclerosis model

Abstract

A mathematical model describing the first stages of atherosclerosis development as an inflammatory disease is solved numerically in this work (see [1]). The mathematical model is a system of 2D reaction-diffusion equations with nonlinear source term. The numerical solution is achieved by a finite volume scheme with WENO reconstruction in space whilst ADER approach for time integration is applied.

[1] A. Hidalgo, L. Tello, E.F. Toro, Numerical and analytical study of an atherosclerosis inflammatory disease model. Journal of Mathematical Biology 68(7) (2014), 1785–1814.



Logioti, Anna

Organization

Universität Bonn, Germany

Email

logioti@iam.uni-bonn.de

Title

A free boundary problem modeling cell polarization

Abstract

We study a model for cell polarization as a response to an external signal which results in a system of PDEs for different variants of a protein on the cell surface and interior respectively. We study the evolution of this model for several reaction rates on the membrane and the diffusion coefficient inside the cell being large. Under suitable scaling limits, solutions converge to solutions of obstacle type problems, for which we show uniqueness. Further, we prove the global stability of steady states. For the steady states the occurrence of polarization has been shown by Niethammer, Röger and Velázquez (2019)



Maestre Caballero, Faustino

Organization

Universidad de Sevilla

Email

fmaestre@us.es

Title

On a non-linear system of PDEs with application to tumor identification

Abstract

In this work we present the analysis of a non-linear system of PDEs in relation with a solution of an inverse problem in conductivity with application in tumor detection. This non-linear system of PDEs corresponds with the Euler-Lagrange optimality systems associated to a non-convex vector variational problem. We study the (quasi-)convexification of the vector variational problem and present a strategy to solve the inverse problem numerically.



Negreanu, Mihaela

Organization

Universidad Complutense de Madrid

Email

negreanu@mat.ucm.es

Title

Global existence and asymptotic behavior of solutions to a chemotaxis system with chemicals and prey-predator terms

Abstract

We consider the dynamics of a mathematical model involving two biological species, both of which move according to random diffusion and are attracted/ repulsed by chemical stimulus produced by the other. The biological species present the ability to orientate their movement towards the concentration of the chemical secreted by the other species. The nonlinear system consists of two parabolic equations with Lotka-Volterra-type kinetic terms coupled with chemotactic cross-diffusion, along with two elliptic equations describing the behavior of the chemicals. We prove that the solution is global and bounded for some initial data and converges to a spatially constant homogeneous state.



Rodríguez Galván, J. Rafael

Organization

Universidad de Cádiz

Email

rafael.rodriguez@uca.es

Title

Flux-Corrected Methods for Chemotaxis Equations

Abstract

Chemotaxis (movement of biological cells in response to chemical signals) has been deeply sudied in recent years. Design of numerical schemes reproducing the properties of classical chemotaxis equations is an interesting challenge. This work is focused on development and comparison of positivity preserving numerical schemes based on flux-corrected transport (FCT) techniques. They have been successfully applied to numerical approximation of convection problems and, recently, they have been applied also to chemotaxis equations. We extend these results to other time approximations which split the computation of variables. Also, different space approximations are explored, e.g. higher order discontinuous finite elements.

This is a joint work with Navarro, Alba (Univ. Cádiz)



Saad, Mazen

Organization

École Centrale de Nantes (France)

Email

mazen.saad@ec-nantes.fr

Title

Pattern formation a nonlinear degenerate chemotaxis model

Abstract

A rigorous mathematical description for the pattern dynamics of aggregating regions of biological individuals possessing the property of chemotaxis is presented. We identify a generalized nonlinear degenerate chemotaxis model where a destabilization mechanism may lead to spatially non homogeneous solutions. Given any general perturbation of the solution nearby a homogeneous steady state, we prove that its nonlinear evolution is dominated by the corresponding linear dynamics along the finite number of fastest growing modes. The theoretical results are tested against two different numerical results in two dimensions showing an excellent qualitative agreement.



Sánchez Romero, Oscar

Organization

Universidad de Granada

Email

ossanche@ugr.es

Title

Morphogenetic modelling revisited.

Abstract

In a morphogenetic system parts of an initially homogeneous tissue differentiate due to the spreading of a signal (morphogen). So, the morphogen spreading and cells/tissular reaction are the two key mechanisms in the understanding of these processes.

This talk is devoted to revise the role of flux limited and BEWARE operators in the modelling of each of these mechanisms.

- *) J. Calvo, J. Campos, V. Caselles, O. Sánchez, J. Soler, Pattern formation in a flux limited reaction-diffusion equation of porous media type, Inventiones Mathematicae 206 (2016), 57-108. D.O.I.
- *) J. Calvo, J. Campos, V. Caselles, O. Sánchez, J. Soler, Qualitative behavior for flux-saturated mechanisms: traveling waves, waiting time and smoothing effects, J. Eur. Math. Soc. 19 (2017), 441--472.
- *) M. Cambón, O. Sánchez, Analysis of the transcriptional logic governing differential spatial expression in Hh target genes, Plos One 14(1), (2019), e0209349..



Sert, Ugur

Organization

Hacettepe University, Ankara (Turkey)

Email

usert@hacettepe.edu.tr

Title

On a class of nonlocal evolution equations of Kirchhoff type

Abstract

In this talk, we present the study of a Dirichlet problem for a certain type degenerate nonlocal parabolic equation. We find sufficient conditions to prove the global in time solvability and uniqueness, possible extinction of solutions in a finite time and their asymptotic behaviour at infinity. Moreover, we prove that nonnegative solutions of the problem blow-up in a finite time under some appropriate conditions.



Shmarev, Sergey

Organization

Universidad de Oviedo

Email

shmarev@uniovi.es

Title

Nonlocal parabolic equations with the nonlinearity depending on the solution

Abstract

We study the Dirichlet problem for the class of parabolic equations which involve the p[u]-Laplace operator. It is assumed that the exponent p is a function of time and depends on the sought solution. For example, the argument of p may depend on the average of the solution in the space domain. We find sufficient conditions for global and local in time existence of a solution, prove the uniqueness and show that under certain restrictions on p every solution vanishes in a finite time. This is joint work with Antontsev, S.



Suárez, Antonio

Organization

U. Sevilla

Email

suarez@us.es

Title

Inclusion of non-local terms in population dynamics PDEs models

Abstract

In most PDEs models that come from population dynamics the relation between the unknown (the population density) and its derivatives is local in space; that is, in the model these functions are taken at the same point of the habitat. However, there is no real justification for assuming that the interactions are local. In fact, there are many examples where such an assumption is clearly untenable.

In this talk, we show some non-locals models arising in population dynamics and we analyze its main differences with respect to the classical local models.

Tello, J. Ignacio

Organization

Universidad Nacional de Educación a Distancia

Email

jtello@mat.uned.es

Title

Blow up of solutions for a Parabolic-Elliptic Chemotaxis System with nonlinear gradient dependent chemotactic coefficient.

Abstract

We consider a Parabolic-Elliptic system of PDE's with a chemotactic term in an N-dimensional unit ball describing the behavior of the density of a biological species u and a chemical stimulus v. The system includes a nonlinear chemotactic coefficient depending on ∇v , i.e. the chemotactic term is given in the form

$$-div(\chi u|\nabla v|^{p-2}\nabla v), \quad \text{for } p \in \left(\frac{N}{N-1}, 2\right), \quad N > 2$$

for a positive constant χ when v satisfies the Poisson equation

$$-\Delta v = u - \frac{1}{|\Omega|} \int_{\Omega} u_0 \, dx.$$

We study the radially symmetric solutions under the assumption in the initial mass

$$\frac{1}{|\Omega|} \int_{\Omega} u_0 \, dx > 6.$$

For χ large enough, we present conditions in the initial data such that any regular solution of the problem blows up at finite time.



Tello, Lourdes

Organization

Universidad Politécnica de Madrid

Email

I.tello@upm.es

Title

On a nonlinear problem with diffusive boundary condition

Abstract

We study a non linear model with nonlinear diffusion and diffusive boundary condition. Our purpose is to analyze the stabilization of solutions as well as the multiplicity of steady states.

References:

- [1] J.I. Diaz, A. Hidalgo, L. Tello, Multiple solutions and numerical analysis to the dynamic and stationary models coupling a delayed energy balance model involving latent heat and discontinuous albedo with a deep ocean. Proc. R. Soc. A. 2014 470 20140376.
- [2] A. Hidalgo, L. Tello, On a climatological energy balance model with continents distribution. DCDS A 35(4) (2015): 1503-1519.



Vázquez, Juan Luis

Organization

Universidad Autónoma de Madrid

Email

juanluis.vazquez@uam.es

Title

Nonlinear fractional Laplacian operators and equations

Abstract

We consider equations involving nonlinear fractional Laplacian operators where progress has been obtained in recent months. Examples include fractional p-Laplacian operators appearing in elliptic and parabolic equations and a number of variants. Numerical analysis is performed.



Velasco Valdés, Julian

Organization

Universidad de Oviedo

Email

julian@uniovi.es

Title

Weakly nonlinear analysis of a system with non-local diffusion

Abstract

We study, through a weakly nonlinear analysis, the pattern formation for a system of partial differential equations of the Shigesada-Kawasaki-Teramoto type with nonlocal diffusion in the one-space dimensional case and periodic boundary conditions.

We obtain the pattern of the solutions for values of the bifurcation parameter in the proximity of the onset of instabilities.

We compare the local and nonlocal case.



Viglialoro, Giuseppe

Organization

Università degli Studi di Cagliari

Email

giuseppe.viglialoro@unica.it

Title

On the blow-up time of unbounded solutions to a nonlinear chemotaxis system

Abstract

This investigation deals with unbounded classical solutions to a zero--flux chemotaxis system from mathematical biology. The model, defined in bounded domains, involves two unknowns coupled each other through a taxis-driven term. From the literature, it is known that under proper assumptions on the data, the system possesses a unique classical solution which becomes unbounded, in the sense of the uniform norm, at some finite time. In this work we show that, actually, this blow-up occurs also in other norms. Additionally, an estimate for the blow-up time is as well given. This is a joint paper with Marras M. and Nishino, T.



Minisymposium:

Numerical integration of partial differential equations

Thematic area: Numerical Analysis and Simulation (NAS)

Organizers: Reguera López, Nuria (U. de Burgos), Portillo de la Fuente, Ana María (U. de Valladolid), Moreta, María Jesús (Universidad Complutense de Madrid)

Abstract

As is well known, solving numerically partial differential equations is an important subject in Mathematics and it is essential when addressing applications of Mathematics in other fields of Science and Technology.

The purpose of this minisymposium is to discuss recent progresses in the numerical integration of partial differential equations: integer or fractional-order nonlinear problems, avoiding order reduction when integrating nonlinear initial-boundary value problems, domain decomposition methods or splitting methods for convection-diffusion systems among others.

Keywords: Numerical methods; Partial differential equations



Session 7. Thursday 11:30 -13:35 Room A8.

Chair: Moreta, María Jesús (Universidad Complutense de Madrid)

Speaker	Organization	Contribution title
HERRERO, HENAR	Universidad de Castilla-La Mancha	Two levels of mesh alternating Schwarz domain decomposition method
ALONSO-MALLO, ISAÍAS	Universidad de Valladolid	Modified Splitting methods to integrate nonlinear wave problems with non vanishing boundary values
CANO, BEGOÑA	Universidad de Valladolid	How to avoid order reduction when explicit exponential Runge-Kutta methods integrate reaction-diffusion initial boundary value problems

Session 8. Thursday 18:00 -20:00. Room A8.

Chair: Reguera López, Nuria (Universidad de Burgos)

Speaker	Organization	Contribution title
MACÍAS-DÍAZ, JORGE E.	Universidad Autónoma de Aguascalientes, México	Fractional generalization of the Fermi-Pasta- Ulam-Tsingou media and theoretical analysis of a variational scheme
SERNA-REYES, ADAN J.	Universidad Autónoma de Aguascalientes	Numerical Method to solve the Gross-Pitaevskii system using Caputo time-fractional derivatives
MARTÍNEZ JIMÉNEZ, LUIS R.	Universidad Autónoma de Aguascalientes, México	Conservative numerical model for a double fractional Klein-Gordon-Zakharov system
Muñoz Pérez, Luis Fernando	Universidad Autónoma de Aguascalientes, México	On the solution of a time fractional extension for Higgs Boson equation in the de Sitter space-time
Alba Pérez, Joel	Universidad Autónoma de Aguascalientes, México	A positive and bounded scheme for predator-prey systems with diffusion and Caputo fractional derivative in time



Session 9. Friday 11:30 – 12:45. Room A8.

Chair: Portillo de la Fuente, Ana María (U. de Valladolid)

Speaker	Organization	Contribution title
MORETA, MARÍA JESÚS	Universidad Complutense de Madrid	A modified Gautschi's method without order reduction when integrating boundary value nonlinear wave problems
REGUERA LÓPEZ, NURIA	Universidad de Burgos	Avoiding order reduction when integrating nonlinear initial boundary value problems with Lawson methods.
HERRERA DE LA CRUZ, JORGE	Universidad Complutense	Design of an algorithm to solve numerically the Hamilton-Jacobi-Bellman PDE equations based on Semi-Lagrangian discretization



Alba Pérez, Joel

Organization

Universidad Autónoma de Aguascalientes

Email

joelalbaperez@gmail.com

Title

A positive and bounded scheme for predator-prey systems with diffusion and Caputo fractional derivative in time

Abstract

In this work, we investigate numerically a system of partial differential equations that describes the interactions between populations of predators and preys. The system considers the effects of anomalous time and generalized Michaelis-Menten-type reactions. For the sake of generality, we consider an extended form of that system in various spatial dimensions, and propose two finite-difference methods to approximate its solutions. Both methodologies are presented in alternative forms to facilitate their analyses and computer implementations. We show that both schemes are structure-preserving techniques, in the sense that they are capable of preserving the positivity and boundedness of the numerical approximations. This is in agreement with the relevant solutions of the original population model. Moreover, we prove rigorously that the schemes are consistent discretization of the generalized continuous model, that they are stable and convergent. The methodologies were implemented efficiently using MATLAB. Some computer simulations are provided for illustration purposes. In particular, we use our schemes in the investigation of complex patterns in some two- and three-dimensional predator-prey systems with anomalous time.

Join work with Macías-Díaz, Jorge E.

References

- 1. Xiao, Y.; Chen, L. Modeling and analysis of a predator–prey model with disease in the prey. Mathematical Biosciences 2001, 171, 59–82.
- 2. Song, Q.; Yang, R.; Zhang, C.; Tang, L. Bifurcation analysis in a diffusive predator–prey system with Michaelis–Menten-type predator harvesting. Advances in Difference Equations 2018, 2018, 329.



Alonso-Mallo, Isaías

Organization

Universidad de Valladolid

Email

isaias@mac.uva.es

Title

Modified Splitting methods to integrate nonlinear wave problems with non vanishing boundary values

Abstract

The nonlinear wave equation with non vanishing boundary values is integrated by means of an explicit time method obtained from high order splitting schemes. The splitting method does not directly specify the way in which the boundary values should be incorporated in order to preserve the optimal order in time. We show in this talk that it can be achieved in a very simple way.



Cano, Begoña

Organization

Universidad de Valladolid

Email

bego@mac.uva.es

Title

How to avoid order reduction when explicit exponential Runge-Kutta methods integrate reaction-diffusion initial boundary value problems

Abstract

In this paper a technique is given to recover the classical order of the method when explicit exponential Runge-Kutta methods integrate reaction-diffusion problems. Although methods of high stiff order for problems with vanishing boundary conditions can be constructed, that may imply increasing the number of stages and therefore, the computational cost seems bigger than the technique which is suggested here, which just adds some terms with information on the boundaries. Moreover, time-dependent boundary conditions are directly tackled here.



Herrera de la Cruz, Jorge

Organization

Universidad Complutense

Email

jorherre@ucm.es

Title

Design of an algorithm to solve numerically the Hamilton-Jacobi-Bellman PDE equations based on Semi-Lagrangian discretization

Abstract

We present RaBVItG, an original algorithm to solve numerically the coupled system of HJB equations that arise in Feedback Nash equilibria in Differential Games. We discuss the approach of the algorithm, involving a Semi-Lagrangian discretization of the problem, to obtain a discrete space-time version of the equation's system, the use of Radial Basis functions as approximators (avoiding to use meshes in the design) and a combination of value iterations and game iterations. We show the performance of our algorithm in some problems with known analytical solution both in deterministic and stochastic differential games problems for more than 2 players.



Herrero, Henar

Organization

Universidad de Castilla-La Mancha

Email

Henar.Herrero@uclm.es

Title

Alternating Schwarz domain decomposition method

Abstract

The aim of this work is to study a Schwarz domain decomposition numerical method with for a stationary Rayleigh-Bénard convection problem. The model equations are the stationary incompressible Navier-Stokes equations coupled with a heat equation under Boussinesq approximation. Each step in the Newton method is solved with a Schwarz domain decomposition method with the domain partitioned into several subdomains with appropriate interface conditions. Their convergence properties are studied theoretically. The numerical resolution of the problem confirms the theoretical results. The convergence rate is less than one when overlap is considered. Two levels mesh speed up the simulations.



Macías-Díaz, Jorge E.

Organization

Universidad Autónoma de Aguascalientes, México

Email

jemacias@correo.uaa.mx

Title

Fractional generalization of the Fermi-Pasta-Ulam-Tsingou media and theoretical analysis of a variational scheme

Abstract

In this work, we consider a partial differential equation that extends the well-known Fermi-Pasta-Ulam-Tsingou chains from nonlinear dynamics. The continuous model under consideration includes the presence of both a damping term and a polynomial function in terms of Riesz space-fractional derivatives. Initial and boundary conditions on a closed and bounded interval are considered in this work. The mathematical model has a fractional Hamiltonian which is conserved when the damping coefficient is equal to zero, and dissipated otherwise. Motivated by these facts, we propose a finite-difference method to approximate the solutions of the continuous model. The method is an explicit scheme



Martínez Jiménez, Luis R.

Organization

Universidad Autónoma de Aguascalientes

Email

romeo_mjz@hotmail.com

Title

Conservative numerical model for a double fractional Klein-Gordon-Zakharov system

Abstract

In this talk, we consider the fractional extension of the well known Klein-Gordon-Zakharov system, with two different parameters for the fractional derivatives in space in the Riesz sense. We propose an implicit scheme to approximate the solutions, with its discrete energy functional to estimate the total energy of the continuous system. We proved that the discrete energy conserved. The existence of solutions is proved using fixed-point arguments. We show rigorously that the scheme is capable of preserving the boundedness of the approximations and that it yields consistent of the true solution. In similar fashion we proved the stability and convergence. Finally, we provided simulations. Joint work with Dr. Macías-Díaz, Jorge E., Universidad Autónoma de Aguascalientes, México.

References

- 1. Martínez, Romeo & Macías-Díaz, J. E., (2020). An energy-preserving and efficient scheme for a double-fractional conservative Klein-Gordon-Zakharov system. Applied Numerical Mathematics, 158, 292-313.
- 2. Martínez, Romeo & Macías-Díaz, J. E. (2019). Theoretical analysis of an explicit energy-conserving scheme for a Klein-Gordon-Zakharov system. Applied Numerical Mathematics, 146, 245-259.



Moreta, María Jesús

Organization

Universidad Complutense de Madrid

Email

mjesusmoreta@ccee.ucm.es

Title

A modified Gautschi's method without order reduction when integrating boundary value nonlinear wave problems

Abstract

In this talk we show the main results we have obtained when analysing the order reduction which turns up when integrating nonlinear wave problems with non-homogeneous and time-dependent boundary conditions with the well-known Gautschi's method. Moreover, we will suggest a technique to avoid that order reduction so that the classical local order 4 and global order 2 are recovered. On the other hand, the usual approximation for the derivative which is used together with this method is also analysed and a substantial improvement is suggested. We will also present some numerical results that corroborate the performed analysis.



Muñoz Pérez, Luis Fernando

Organization

Universidad Autónoma de Aguascalientes

Email

oefher@gmail.com

Title

On the solution of a time fractional extension for Higgs Boson equation in the de Sitter spacetime.

Abstract

In this talk, we consider a time-fractional differential equation extension of the Higgs boson in the de Sitter space-time, and its theoretical analysis. More precisely, we design herein a numerically efficient finite-difference Hamiltonian technique for the solution of a Caputo time-fractional extension of the Higgs boson equation in the de Sitter space-time. The model under investigation is a multidimensional equation with generalized potential and Caputo time-fractional derivatives. An energy integral for the model is readily available, and we propose a nonlinear, implicit and consistent numerical technique based on the L1 formula, with similar Hamiltonian properties in the discrete scenario. A fractional energy approach is used then to prove the properties of stability and convergence of the technique. For simulation purposes, we consider both the classical and the fractional Higgs real-valued scalar fields in the de Sitter space-time, and find results qualitatively similar to those available in the literature.

Joint work with Macías-Díaz, Jorge E

References

- 1. Muñoz-Pérez, L. F., & Macías-Díaz, J. E. (2020). On the solution of a generalized Higgs boson equation in the de Sitter space-time through an efficient and Hamiltonian scheme. Journal of Computational Physics, 417, 109568.
- 2. Yagdjian, K., & Balogh, A. (2018). The maximum principle and sign changing solutions of the hyperbolic equation with the Higgs potential. Journal of Mathematical Analysis and Applications, 465(1), 403-422.
- 3. Yagdjian, K. (2012). On the global solutions of the Higgs boson equation. Communications in Partial Differential Equations, 37(3), 447-478.



Reguera López, Nuria

Organization

Universidad de Burgos

Email

nreguera@ubu.es

Title

Avoiding order reduction when integrating nonlinear initial boundary value problems with Lawson methods.

Abstract

In this talk we focus on the numerical resolution of nonlinear initial boundary value problems with Lawson methods. One of the advantages of these numerical integrators is that Lawson methods of classical order as high as desired can be constructed associated to a Runge -Kutta of that order. However, this advantage is affected by the order reduction suffered by Lawson methods in the general case. In this work, we propose a technique to avoid such order reduction and we will explain how to achieve this by using only the the given data of the problem.



Serna-Reyes, Adan J.

Organization

Universidad Autónoma de Aguascalientes

Email

ajserna@correo.uaa.mx

Title

Numerical Method to solve the Gross-Pitaevskii system using Caputo time-fractional derivatives.

Abstract

In this talk, we propose a fractional extension of the multi-dimensional Gross--Pitaevskii system that describes a two-component Bose--Einstein condensate with an internal atomic Josephson junction. The problem is governed by two parabolic partial differential equations with Caputo fractional time derivatives and coupling terms. We prove that the total energy of the system is dissipated. We design a finite-difference discretization based on the use of fractional-order centered differences. The scheme is a second-order consistent discretization of the continuous model. Moreover, we prove the stability and quadratic convergence of the numerical model. We provide some computer simulations to illustrate the validity of the conservation properties.

Joint work with Macías-Díaz, Jorge E. (UAA)

References

- 1. Wang, T., Zhao, X. (2014) Optimal I ∞ error estimates of finite difference methods for the coupled Gross-Pitaevskii equations in high dimensions. Sci. China Math. 57, 2189–2214.
- 2. A.J. Serna-Reyes and J.E. Macías-Díaz, (2021) Theoretical analysis of a conservative finite-difference scheme to solve a Riesz spacefractional Gross–Pitaevskii system, Journal of Computational and Applied Mathematics.



Minisymposium:

Numerical methods for balance laws and non-conservative hyperbolic systems

Thematic area: Numerical Analysis and Simulation (NAS)

Organizers: Escalante Sánchez, Cipriano (Universidad de Córdoba) and Castro Díaz, Manuel Jesús (Universidad de Málaga)

Abstract

Balance laws and non-conservative hyperbolic systems naturally appear in many real world applications and, in particular, in many fluid models in different contexts: shallow water models, multiphase flow models, gas dynamic, etc. The main goal of the minisymposium will be the discussion and presentation of state-of-the-art computational and numerical methods for balance laws and nonconservative hyperbolic systems and their applications.

Keywords: Finite volume methods; Finite difference methods; Discontinuous Galerkin methods; High-order methods; Well-balanced methods; Structure preserving methods; Balance laws; Nonconservative hyperbolic systems



Session 5. Tuesday 18:00-20:00. Room A6.

Chair: Castro Díaz, Manuel Jesús (Universidad de Málaga)

Speaker	Organization	Contribution title
HIDALGO, ARTURO	Universidad Politécnica de Madrid	A finite volume ADER-LSTDG scheme for a global climate model
GALLARDO, JOSÉ M.	Universidad de Málaga	Multidimensional approximate Riemann solvers for hyperbolic nonconservative systems
DEL GROSSO, ALESSIA	Université Versailles	On second-order well-balanced Lagrange- projection schemes for shallow water Exner system
MACCA, EMANUELE	University of Catania	Adaptive Compact Approximate Taylor Methods

Session 6. Wednesday 10:30-12:10. Room A6.

Chair: Escalante Sánchez, Cipriano (Universidad de Córdoba)

Speaker	Organization	Contribution title
CABALLERO	Universidad de	A semi-implicit LP finite volume scheme exactly
CÁRDENAS, CELIA	Málaga	well-balanced for 1D shallow-water system
CHECA, ANTONIO	Universidad de	Well balanced high order finite volume schemes
CHECA, ANTONIO	Málaga	for 1D balance laws defined on plain curves
GÓMEZ BUENO, IRENE	Universidad de Málaga	Collocation methods for high-order well-balanced methods for one-dimensional systems of balance laws
PIMENTEL GARCÍA,	Universidad de	Well-balanced algorithms for relativistic fluids on
ERNESTO	Málaga	a Schwarzschild background

Session 7. Thursday 11:30-13:35. Room A3.

Chair: Castro Díaz, Manuel Jesús (Universidad de Málaga)

Speaker	Organization	Contribution title
DUMBSER,	University of	On structure-preserving schemes for continuum
MICHAEL	Trento	mechanics
BUSTO ULLOA,	University of	ADER discontinuous Galerkin schemes for first order
SARAY	Trento	reformulations of dispersive models
PARÉS PULIDO,	ETH Zürich	Well-balanced high-order finite difference methods for
CARLOS		systems of balance laws
ESCALANTE	Universided	Numerical approximation of dispersive shallow flows on
SÁNCHEZ,	Universidad	Numerical approximation of dispersive shallow flows on
CIPRIANO	de Córdoba	spherical coordinates



Busto Ulloa, Saray

Organization

University of Trento

Email

saray.busto@unitn.it

Title

ADER discontinuous Galerkin schemes for first order reformulations of dispersive models

Abstract

We focus on the solution of first order hyperbolic reformulations of nonlinear dispersive systems using high order accurate fully-discrete one-step ADER discontinuous Galerkin methods with a posteriori subcell finite volume limiter. In particular, the hyperbolic reformulations of the Serre-Green-Naghdi model for dispersive shallow waters and of the defocusing nonlinear Schrödinger equation are considered. High order of accuracy is attained at the aid of a local space-time predictor. Besides, to account for the natural involution constraint of the Schrödinger equation, a novel thermodynamically compatible GLM curl cleaning approach is proposed. The methodology is carefully validated against analytical, experimental and reference solutions. This work has been done in collaboration with Bassi, Caterina; Dumbser, Michael; Escalante Sánchez, Cipriano; and Gavrilyuk, Sergey.



Caballero Cárdenas, Celia

Organization

Universidad de Málaga

Email

celiacaba@uma.es

Title

A semi-implicit LP finite volume scheme exactly well-balanced for 1D shallow-water system.

Abstract

This work focuses on the numerical approximation of the shallow water equations using a semi-implicit Lagrange-projection-type finite volume scheme that it is positive preserving. Here we follow the strategy described in Castro-Chalons-Morales 2018 to the definition of the LP scheme and Castro-Parés 2020 to ensure its well-balanced character. Comparison with other strategies to construct semi-implicit solvers for the shallow-water system will be performed. Several numerical experiments will be shown to illustrate the good behavior of the scheme.



Checa, Antonio

Organization

Universidad de Málaga

Email

antonio.checa.molina@gmail.com

Title

Well balanced high order finite volume schemes for 1D balance laws defined on plain curves.

Abstract

We focus on the numerical discretization of 1D balance laws defined on plain curves by means of high order finite volume schemes. In particular, we analyze how the parametrization of the curve affects to the continuous model and its corresponding numerical approximation, with special emphasis on the well-balanced character of the scheme. Here we follow the general procedure described in Castro-Pares 2020 to construct high-order well-balanced schemes for general 1D balance laws, that can be extended to this framework. Finally, some numerical tests will be presented showing our first results for first, second and third order well-balanced methods for Burgers' equation and the 1D shallow-water defined over an arbitrary plain curves.



Del Grosso, Alessia

Organization

Université Versailles

Email

alessia.del-grosso@ens.uvsq.fr

Title

On second-order well-balanced Lagrange-projection schemes for shallow water Exner system

Abstract

Our work is devoted to the numerical approximation of the shallow water Exner system with Grass closure formula, where the Exner equation expresses the evolution in time of the bed sediment. The numerical schemes are all based on the Lagrange-projection formalism which consists in splitting the mathematical model into the acoustic and transport system. Since decomposing the Exner equation in this framework is not straightforward, we investigate different numerical strategies. The methods and their second-order accurate extensions are designed in such a way to satisfy the well-balanced property.



Dumbser, Michael

Organization

University of Trento

Email

michael.dumbser@unitn.it

Title

On structure-preserving schemes for continuum mechanics

Abstract

We present two new structure-preserving schemes for symmetric hyperbolic and thermodynamically compatible (SHTC) systems with involution constraints. First, we present a new staggered semi-implicit method that is able to preserve curl constraints exactly on the discrete level and which is also compatible with the stiff relaxation limit of the governing equations. In the second part of the talk we present a new thermodynamically compatible finite volume scheme that is exactly compatible with the overdetermined structure of the model at the semi-discrete level, making use of a discrete form of the continuous formalism introduced by Godunov in 1961 (semi-discrete Godunov formalism). This work has been done in collaboration with Busto Ulloa, Saray; Peshkov, Ilya and Romenski, Evgeniy.



Escalante Sánchez, Cipriano

Organization

Universidad de Córdoba

Email

escalante@uma.es

Title

Numerical approximation of dispersive shallow flows on spherical coordinates

Abstract

This work aims to develop and implement a numerical model, including dispersion suitable for tsunami simulations. Therefore, including more physics but still computing much Faster than Real-time.

We will present a latitude-longitude coordinate formulation to account for the effects of curvature. The system is hyperbolic and is obtained throughout a relaxation procedure from a parabolic non-hydrostatic system. Some essential aspects of their numerical approximation will be underlined. We will show some simulations on real test cases and computational times using GPU architectures that show promising results with excellent computational efficiency. : This work has been done in collaboration with Castro Díaz, Manuel Jesús.



Gallardo, José M.

Organization

Universidad de Málaga

Email

jmgallardo@uma.es

Title

Multidimensional approximate Riemann solvers for hyperbolic nonconservative systems

Abstract

This work deals with the construction of efficient incomplete two-dimensional Riemann solvers for nonconservative hyperbolic systems. Multidimensional features are introduced through the approximate solutions of two-dimensional Riemann problems at the vertices of the computational mesh. A simple version of a well-balanced 2d HLL scheme is presented, which is readily extended to a class of incomplete Riemann solvers of PVM type, which allows to control the amount of numerical diffusion of the resulting scheme. The performances of the proposed schemes are shown with a number of challenging numerical experiments in one- and two-layer shallow water systems, including source and coupling terms. This is a joint work with Schneider, Kleiton A.; Parés, Carlos; Nkonga, Boniface and Balsara, Dinshaw.



Gómez Bueno, Irene

Organization

Universidad de Málaga

Email

igomezbueno@uma.es

Title

Collocation methods for high-order well-balanced methods for one-dimensional systems of balance laws

Abstract

The goal of this work is to develop high-order well-balanced schemes for systems of balance laws. Following two of the authors, we apply a general methodology for developing such numerical methods which requires the computation, at every cell and at every time step, of the stationary solution whose cell average is equal to the numerical approximation already obtained. Since solving these problems can be difficult and expensive, our goal is to present general implementation that can be applied to any one-dimensional balance laws based on the application of the collocation RK methods. Joint work with and Castro Díaz, Manuel Jesús (Universidad de Málaga), Parés, Carlos (Universidad of Málaga) and Russo, G. (University of Catania).



Hidalgo, Arturo

Organization

Universidad Politécnica de Madrid

Email

arturo.hidalgo@upm.es

Title

A finite volume ADER-LSTDG scheme for a global climate model

Abstract

We apply a methodology based on the finite volume method with WENO reconstruction in space and a LSTDG-ADER numerical scheme to obtain the numerical solution of a coupled model ocean atmosphere relevant in climate applications. The mathematical model under study is based on that proposed by Watts and Morantine, but modified with a nonlinear diffusive boundary condition in the upper part of the domain, as described in Hidalgo-Tello 2020.



Macca, Emanuele

Organization

University of Catania

Email

emanuele.macca@phd.unict.it

Title

Adaptive compact approximate Taylor methods

Abstract

A new family of high-order shock-capturing finite difference numerical methods for systems of conservation laws is presented. These methods, called Adaptive Compact Approximation Taylor (ACAT) schemes, use centered (2p+1)-point stencils, where p may take values in $\{1,2,\ldots,P\}$ according to a new family of smoothness indicators in the stencils. The methods are based on a combination of a robust first order scheme and the Compact Approximate Taylor (CAT) methods introduced in Carrillo, Parés (2019). These latter methods are an extension to nonlinear problems of the Lax-Wendroff methods in which the Cauchy-Kovalesky (CK) procedure is circumvented following the strategy introduced by Zorío, Baeza and Mullet (2017) that allows one to compute time derivatives in a recursive way using high-order centered differentiation formulas combined with Taylor expansions in time. The expression of ACAT methods for 1D and 2D systems of conservative laws and its well-balanced extension to systems of balance laws will be presented together with their applications several linear and nonlinear problems.



Parés Pulido, Carlos

Organization

ETH Zürich

Email

carlos.pares-pulido@sam.math.ethz.ch

Title

Well-balanced high-order finite difference methods for systems of balance laws

Abstract

This work focuses on the design of high order well-balanced finite difference weighted essentially non-oscillatory methods to solve general systems of balance laws is presented. Two different families are introduced: while the methods in the first one preserve every stationary solution, those in the second family only preserve a given set of stationary solutions that depend on some parameters. The accuracy, well-balancedness, and conservation properties of the methods are discussed, as well as their application to systems with singular source terms. The strategy is applied to derive third and fifth order well-balanced methods for a linear scalar balance law, Burgers' equation with a nonlinear source term, and for the shallow water model. In particular, numerical methods that preserve every stationary solution or only water at rest equilibria are derived for the latter.



Pimentel García, Ernesto

Organization

Universidad de Málaga

Email

erpigar@uma.es

Title

Well-balanced algorithms for relativistic fluids on a Schwarzschild background

Abstract

We are interested in the design of first, second and third order finite volume algorithms for computing relativistic fluid flows and apply it to study the global dynamics of a flow evolving around a (spherically symmetric) Schwarzschild black hole. We will consider both the relativistic Burgers-Schwarzschild model and the relativistic Euler-Schwarzschild model. Our purpose in this presentation is to design shock-capturing schemes that are high-order accurate and well-balanced in the sense that they preserve the spatially homogeneous solutions. These methods allow us to investigate the global asymptotic behavior of such flows and reach definite conclusions about the behavior of the mass density and velocity field.



Minisymposium:

Optimal Control and Inverse Problems

Thematic area: Optimal Control and Inverse Problems (OCIP)

Organizer: Red Española de Control Óptimo y Problemas inversos COPI

Abstract

Optimal Control theory and Inverse Problems are nowadays well consolidated research areas among Spanish mathematicians.

Although the scope of these fields is slightly different, both share techniques and results.

In this session, researchers from different universities will present their recent results in this fields, covering analysis, numerical methods, computational issues and applications.

Keywords Optimal control; Inverse problems

Session 3. Tuesday 10:30-12:10. Room A5.

Chair: Mateos, Mariano (Universidad de Oviedo)

Speaker	Organization	Contribution title
FERNÁNDEZ-CARA, ENRIQUE	Universidad de Sevilla	New contributions to the control of PDEs and their applications
CASTRO BARBERO, CARLOS	Universidad Politécnica de Madrid	Singular asymptotic expansion of the exact control for the perturbed wave equation
APRAIZ IZA, JONE	University of the Basque Country	The Propagation of Smallness Property and its Utility in Controllability Problems
Doubova, Anna	Universidad de Sevilla	Theoretical and numerical results for some inverse problems for PDEs



Session 4. Tuesday 12:15-13:55 Room A5.

Chair: Fernández-Cara, Enrique (Universidad de Sevilla)

Speaker	Organization	Contribution title
GONZÁLEZ-BURGOS, MANUEL	Universidad de Sevilla	On the controllability of some non-scalar systems
PEDREGAL, PABLO	Universidad de Castilla La Mancha	A div-curl variational problem coming from inverse problems in conductivity
VÁZQUEZ VALENZUELA, RAFAEL	Universidad de Sevilla	Estimation and Control of the Rijke Tube and other PDE-ODE-PDE systems

Session 5. Tuesday 18:00-20:00 Room A5.

Chair: Pedregal, Pablo (Universidad de Castilla La Mancha)

Speaker	Organization	Contribution title
	Universidad	
PERIAGO, FRANCISCO	Politécnica de	Optimal control in nonlinear elasticity
	Cartagena	
	Universidad	
ORTIGOSA, ROGELIO	Politécnica de	Optimal control in nonlinear electromechanics
	Cartagena	
	Universidad de	
ARANDA, ERNESTO	Castilla La	Computational aspects in topology optimization
	Mancha	
BELLIDO, JOSÉ	Universidad de	Optimal design of hyperelastic structures under
CARLOS	Castilla La	electromechanical actuation
CAKLUS	Mancha	electromechanical actuation

Session 6. Wednesday 10:30 – 12:10. Room A5.

Chair: González-Burgos, Manuel (Universidad de Sevilla).

Organization	Contribution title
Universidad Autónoma de Madrid	Averaged dynamics and control for heat equations with random diffusion
Universidad de Cantabria	Optimization problems related to chemotherapy and radiotherapy for tumor growth models
Universidad de Cantabria	Optimal Control of the 2D Evolutionary Navier- Stokes Equations with Measure Valued Controls
	Autónoma de Madrid Universidad de Cantabria Universidad de



Apraiz Iza, Jone

Organization

University of the Basque Country

Email

jone.apraiz@ehu.eus

Title

The Propagation of Smallness Property and its Utility in Controllability Problems

Summary

With this talk we would like to transmit the origins and the importance of the propagation of smallness property, delving into its origins and analyzing its utility in parabolic controllability problems.

Generally speaking, the propagation of smallness property analyzes and tries to quantify the rate of growth of a function in one domain knowing its values in two other domains related to the first one.

We will mention the first historical ideas and results related to this property (harmonic measure, two-constants theorem, Hadamard three-circles theorem), and, then, we will see how we have applied it in order to solve parabolic evolution's interior and boundary controllability problems.



Aranda, Ernesto

Organization

Universidad de Castilla La Mancha

Email

Ernesto.Aranda@uclm.es

Title

Computational aspects in topology optimization

Abstract

Software parallelization is nowadays a key tool to solve problems with highly computational cost such as structural topology optimization problems in 3D. In this work we present the parallelization of a code based on the classical SIMP method using unstructured meshes, implemented through MFEM and HYPRE libraries. We also show how to adapt a non parallel optimization library as NLOPT into the parallel process. These ideas can be used in other optimization process as well.



Bárcena Petisco, Jon Asier

Organization

Universidad Autónoma de Madrid

Email

jon.barcena@uam.es

Title

Averaged dynamics and control for heat equations with random diffusion

Summary

In this talk we deal with the averaged dynamics for heat equations in the degenerate case where the diffusivity coefficient, assumed to be constant, is allowed to take the null value. First we prove that the averaged dynamics is analytic. This allows to show that, most often, the averaged dynamics enjoys the property of unique continuation and is approximately controllable. We then determine if the averaged dynamics is actually null controllable or not depending on how the density of averaging behaves when the diffusivity vanishes. In the critical density threshold the dynamics of the average is similar to the $\frac{1}{2}$ -fractional Laplacian, which is well-known to be critical in the context of the controllability of fractional diffusion processes. Null controllability then fails (resp. holds) when the density weights more (resp. less) in the null diffusivity regime than in this critical regime.

This talk is based on joint work with Zuazua, Enrique.



Bellido, José Carlos

Organization

Universidad de Castilla La Mancha

Email

JoseCarlos.Bellido@uclm.es

Title

Optimal design of hyperelastic structures under electromechanical actuation

Abstract

This talk presents a novel computational approach for topology optimization of hyperelastic materials at large strains. Our approach relies on the well-known SIMP (Solid Isotropic Material with penalization). During the optimization process for structures subjected to very large deformations, and especially in the presence of intermediate density regions, the standard Newton-solver (or its arc length variant) has been reported not to converge. In this investigation, a new stabilization technique will be proposed. We will introduce our methodology and validate its success with challenging numerical examples in the context of both purely mechanical and electromechanical (piezoelectric and dielectric polymers) problems.



Casas, Eduardo

Organization

Universidad de Cantabria

Email

eduardo.casas@unican.es

Title

Optimal Control of the 2D Evolutionary Navier-Stokes Equations with Measure Valued Controls

Abstract

In this talk, we consider an optimal control problem for the two-dimensional evolutionary Navier-Stokes system. Looking for sparsity, we take controls as functions of time taking values in a space of Borel measures. The cost functional does not involve directly the control but we assume some constraints on them. We prove the well-posedness of the control problem and derive necessary and sufficient conditions for local optimality of the controls.

This is a joint work with Kunisch, Karl (University of Graz, Austria).



Castro Barbero, Carlos

Organization

Universidad Politécnica de Madrid

Email

carlos.castro@upm.es

Title

Singular asymptotic expansion of the exact control for the perturbed wave equation

Abstract (max 100 words)

In this work we deal with the asymptotic expansion of the null boundary control for the wave equation with a fourth order singular perturbation. The convergence and limit characterization of the controls are known. Here we focus on the characterization of the higher order terms in the asymptotic expansion. One of the main difficulties is the presence of a boundary layer, where the control acts. This produces a singular behavior of the control. The asymptotic expansion provides a simple and efficient approach to approximate numerically the controls. This is a joint work with Munch. A.



Doubova, Anna

Organization

Universidad de Sevilla

Email

doubova@us.es

Title

Theoretical and numerical results for some inverse problems for PDEs

Abstract

Two types of inverse problems (parameter identification and determination of geometric inclusions) will be considered for some PDE's.

We will present theoretical results on the uniqueness and stability and on the other hand, numerical reconstructions and methods for the unknown parameters and geometric structures.



Fernández-Cara, Enrique

Organization

Universidad de Sevilla

Email

cara@us.es

Title

New contributions to the control of PDEs and their applications

Abstract

This contribution deals with the solution of some multi-objective optimal control problems for several PDEs: linear and semilinear elliptic equations and stationary Navier-Stokes systems. More precisely, we look for Nash and Pareto equilibria associated to standard cost functionals. First, we analyze the existence of equilibria and we deduce appropriate optimality systems. Then, we present some iterative algorithms and we exhibit the results of several numerical experiments. This research can be viewed as a first step in the solution of appropriate hierarchical control problems.



Fernández Fernández, Luis Alberto

Organization

Universidad de Cantabria

Email

luisal.fdez@unican.es

Title

Optimization problems related to chemotherapy and radiotherapy for tumor growth models

Abstract

We study some optimal control and associated optimization problems that arise when modeling:

- 1) usual radiotherapy schedules for cancer, assuming that radiation effect on the tumor and nearby tissues is well described by the classical linear-square model. Hyperfractionated and hypofractionated treatments are considered.
- 2) usual cancer chemotherapy schedules, under the assumptions of Gompertz-type tumor growth and that the drug effect is proportional to the growth rate of the untreated tumor (Norton-Simon hypothesis). We include classical pharmacokinetics and pharmacodynamics (Skipper and Emax) together with maximum tolerated dose and metronomic treatments.

Joint work with Fernández, Lucía, Pola, Cecilia and Sáinz-Pardo, Judith (Univ. de Cantabria). This work was partially supported by the Spanish "Ministerio de Economía, Industria y Competitividad (Agencia Estatal de Investigación)", under project MTM2017-83185-P.



González-Burgos, Manuel

Organization

Universidad de Sevilla

Email

manoloburgos@us.es

Title

On the controllability of some non-scalar systems

Abstract

In this talk we will present new results on the cost of the boundary controllability of parabolic systems at time T>0. In particular, we will study sharp estimates of the control cost at time T (T small enough) when the eigenvalues of the generator of the C_0 semigroup accumulate and do not satisfy a gap condition. The main ingredient that we will use is the moment method.



Ortigosa, Rogelio

Organization

Universidad Politécnica de Cartagena

Email

rogelio.ortigosa@upct.es

Title

Optimal control in nonlinear electromechanics

Abstract

When subjected to large electric fields, Dielectric Elastomers can undergo very large deformations. Therefore, these materials have interesting potential applications in the field of soft robotics. Computational simulation in this context becomes extremely challenging and must be addressed ab initio by the definition of well-posed constitutive models. Recently, a new Convex Multi-Variable definition of the electromechanical internal energy for single-phase dielectric elastomers was postulated, guaranteeing the ellipticity or rank-one convexity condition in the context of (nonlinear) electromechanics. In this contribution, the optimal control problem in this context is formulated and analysed numerically by means of a series of numerical examples.



Pedregal, Pablo

Organization

Universidad de Castilla La Mancha

Email

Pablo.Pedregal@uclm.es

Title

A div-curl variational problem coming from inverse problems in conductivity

Abstract

We explore a viewpoint on inverse problems in conductivity based on non-convex vector variational problems. In the 3D case, it leads to an optimization problem for a div-curl-free pair, that is in need of relaxation. Surprisingly, the relaxed functional can be computed quite explicitly. The unknown conductivity coefficient is then sought in a very specific way through the two-component minimizer of the underlying vector problem; or, equivalently, from the corresponding Euler-Lagrange system. After analyzing this mechanism, we proceed to test it numerically on several examples with synthetic data.



Periago, Francisco

Organization

Universidad Politécnica de Cartagena

Email

f.periago@upct.es

Title

Optimal control in nonlinear elasticity

Abstract

The talk addresses, from both theoretical and numerical standpoints, the problem of optimal control of hyperelastic materials characterised by means of polyconvex stored energy functionals. Specifically, a bio-inspired type of control, which resembles the electro-activation mechanism of the human heart, is considered. The main contribution resides in the consideration of the Hausdorff metric as cost functional. The existence of a solution for a regularised version of the control problem is proved. A gradient-based method, which makes use of the concept of shape derivative, is proposed as numerical resolution method. Several numerical experiments will be presented.



Vázquez Valenzuela, Rafael

Organization

Universidad de Sevilla

Email

rvazquez1@us.es

Title

Estimation and Control of the Rijke Tube and other PDE-ODE-PDE systems

Abstract

In this talk, we consider a one and half-century-old phenomenon, thermoacoustic instability in a Rijke tube. This experiment illustrates the unstable interplay of heat exchange and gas dynamics, and provides an easily accessible platform within which to explore the myriad issues relevant to boundary control in PDEs. The mathematical model of this system can be described by a system of hyperbolic PDEs coupled with an ODE. Throughout the talk, the emphasis will be on the control and state observer methods we developed specifically for the Rijke tube, using the backstepping methodology, with illustrations of experimental results.



Minisymposium:

Progress on numerical modeling of geophysical flows for environment and natural hazards

Thematic area: Numerical Analysis and Simulation (NAS)

Organizer: Morales de la Luna, Tomás y Garres Díaz, José (Universidad de Córdoba)

Abstract

It is undisputed that the numerical simulation of geophysical processes plays nowadays a central role for understanding the interactions of complex natural phenomena and for making predictions when systems are perturbed.

The main goal of the mini-symposium will be the discussion and presentation of state-of-the-art computational and numerical methods for the next generation of geophysical flow models for environment and natural hazards with a focus on finite volume discretizations.

Keywords: geophysical flows, hyperbolic systems, depth-averaged models.

Session 9. Friday 11:30-13:10. Room A3.

Chair: Morales de la Luna, Tomás (Universidad de Córdoba)

Speaker	Organization	Contribution title
KOELLERMEIER, JULIAN	KU Leuven	Modeling free-surface flows with vertically-resolved velocity profiles using moments
GUERRERO FERNÁNDEZ, ERNESTO	Universidad de Málaga	An arbitrary high order ADER Discontinous Galerking (DG) numerical scheme for the multilayer shallow water model with variable density.
GARRES DÍAZ, JOSÉ	Universidad de Córdoba	Bedload transport models with gravitational effects: general formulation and semi-implicit approach
FERNÁNDEZ NIETO, ENRIQUE DOMINGO	Universidad de Sevilla	A correction of the motion/stop criteria in depth- averaged granular flow models



Fernández Nieto, Enrique Domingo

Organization

Universidad de Sevilla

Email

edofer@us.es

Title

A correction of the motion/stop criteria in depth-averaged granular flow models

Abstract

To model gravitational granular flows, due to its lower number of unknowns, and consequently its lower computational cost, depth-averaged models are introduced under the shallow flow assumption, the pioneer work being a paper of Savage & Hutter in 1989. For this model it is assumed that the material flows down a slope, thus local coordinates are introduced over a reference plane and the average of the governing equations is performed in the perpendicular direction to this plane. The rheology in depth-averaged models is reduced to the friction boundary condition at the bottom level. In this work we show that the motion criterion is not well defined when an integration of equations in the normal direction to the topography is performed under the shallow flow assumption. We also propose a correction of the friction depth-averaged term. Several numerical tests will be presented in order to analyse the proposed correction.



Garres Díaz, José

Organization

Universidad de Córdoba

Email

jgarres@uco.es

Title

Bedload transport models with gravitational effects: general formulation and semi-implicit approach

Abstract

In this talk we present an efficient semi-implicit scheme for bedload transport models taking into account gravitational effects. This scheme is based on a reformulation of the model, which allows us to apply a classical semi-implicit approach, and therefore to obtain a less restrictive CFL stability restriction. Furthermore, this method can be immediately adapted to a wide family of bedload models with gravitational effects. Some numerical tests are presented showing the influence of these effects, in particular for steady solutions. We show that the proposed scheme notably reduces the computational efforts without a significant loss of accuracy.



Guerrero Fernández, Ernesto

Organization

Universidad de Málaga

Email

ernesto.guerrero@uma.es

Title

An arbitrary high order ADER Discontinous Galerking (DG) numerical scheme for the multilayer shallow water model with variable density.

Abstract

In this work, we present a novel numerical discretization a of a variable pressure multilayer shallow water model. The model allows the simulation of density driven gravity currents in a shallow water framework. The proposed discretization consists of an unlimited high order accurate (ADER) Discontinuous Galerkin (DG) method, which is then limited a posteriori with the MOOD technique. The resulting numerical scheme is arbitrary high order in space and time for smooth solutions and does not destroy the natural subcell resolution inherent to the DG methods in the presence of strong gradients or discontinuities. Some numerical result will be also presented.



Koellermeier, Julian

Organization

KU Leuven (Bélgica)

Email

julian.koellermeier@kuleuven.be

Title

Modeling free-surface flows with vertically-resolved velocity profiles using moments

Abstract

Shallow Water Moment models are non-linear PDEs for free-surface flows that allow for vertical variations in the horizontal velocity. The model is an extension of the standard shallow water equations. However, we show that the model lacks global hyperbolicity and the loss of hyperbolicity already occurs for small vertical variations of the velocity. This leads to instabilities in numerical test cases. We present new Hyperbolic Shallow Water Moment models based on a modified derivation. Recently, the model has been extended by consideration of sediment transport and bottom topographies, for which new well-balanced numerical schemes and a stability analysis will be presented. Numerical tests of a smooth problems and standard dam break problems using the new models yield accurate and fast solutions while vertically resolving the velocity profile.



Minisymposium:

Reduced Order Modelling

Thematic area: Numerical Analysis and Simulation (NAS)

Organizer: Chacón Rebollo, Tomás (Universidad de Sevilla)

Abstract

Reduced Order Modeling (ROM) provides reductions of several orders of magnitude in the computational cost of the numerical simulation of processes and design problems that involve large numbers of degrees of freedom. Therefore, its use makes affordable the numerical simulation of parametric systems, evolutionary and inverse problems, data assimilation and design of complex devices, among others, that would be out of reach using standard numerical simulation techniques. The mathematical analysis and development of ROMs is today a very active research field. This minisymposium presents some recent developments of Reduced Order Modeling.

Keywords: Reduced Order Modelling



Session 1. Monday 11:30 - 13:35. Room A3.

Chair: Gómez, Macarena (Universidad de Sevilla)

Speaker	Organization	Contribution title
RAPÚN, MARÍA LUISA	Universidad Politécnica de Madrid	Collocated POD and Galerkin projection on the fly for fast time integration of PDEs
MORA JIMÉNEZ, MARÍA	CEU Cardenal Herrera	A Laplacian approach to the Greedy Rank-One Algorithm for a class of linear systems
OULGHELOU, MOURAD	Université de La Rochelle	Real-time flow optimal control by interpolated reduced order models
SÁNCHEZ MUÑOZ, ISABEL	Universidad de Sevilla	Low-rank approximations for parametric non- symmetric elliptic partial differential equations

Session 3. Tuesday 10:30 - 12:10. Room A3.

Chair: Gómez, Macarena (Universidad de Sevilla)

Speaker	Organization	Contribution title
CHACÓN	Universidad de	Development of an evolutionary Smagorinsky
REBOLLO, TOMÁS	Sevilla	Reduced Model
DELGADO ÁVILA,	SISSA, Trieste	A non-Intrusive reduced order model for fluid flow
ENRIQUE		in glass industry
FALCÓ, ANTONIO	CEU Cardenal	Geometry of tree-based tensor formats in tensor
	Herrera	Banach spaces



Chacón Rebollo, Tomás

Organization

Universidad de Sevilla

Email

chacon@us.es

Title

Development of an evolutionary Smagorinsky turbulence Reduced Model

Abstract

The Smagorinsky Model is a LES turbulence model introduced by Joseph Smagorinsky in 1963. This model solves the large scales of a turbulent flow approximating the effect of the unresolved scales on the large scales by a non-linear eddy diffusion term. In order to construct the Reduced Model, we apply a POD+Greedy algorithm. This construction is based upon a posteriori error estimator of the error between the high fidelity solution and our reduced basis solution. In this talk, we present a space-time error estimator and the complexity of the numerical implementation.



Delgado Ávila, Enrique

Organization

SISSA, Trieste

Email

edelgado1@us.es

Title

A non-Intrusive reduced order model for fluid flow in glass industry

Abstract

In this work, we present a non-intrusive POD model of a molten glass flow inside of a furnace. The impossibility of observing the real flow of the molten glass inside of a furnace, makes interesting the construction of a CFD model that could be of big interest for the glass industry. With the CFD simulation, we can better understand how the molten glass behaves, letting the glass industry to optimize the process of glass production. We first present the CFD model, for the molten glass flow, based on industrial data. The CFD model for the glass flow consists in a multiphysics problem, where the electricity equation is coupled to the Navier-Stokes equation with Boussinesq approximation, to modelize the Joule effect produced by the boosters located inside the furnace for the glass heating. Moreover, since this model may depend on several parameters, we present a non-intrusive POD model that let us to compute the numerical solutions in real time. This non-intrusive POD model is constructed for helping the glass industry in the decisions adopted for the quality improvement in the glass production. We present numerical results for both the CFD and the non-intrusive POD model.



Falcó, Antonio

Organization

CEU Cardenal Herrera

Email

afalco@uchceu.es

Title

Geometry of tree-based tensor formats in tensor Banach spaces

Abstract

In the paper `On the Dirac-Frenkel Variational Principle on Tensor Banach Spaces', we provided a geometrical description of manifolds of tensors in Tucker format with fixed multilinear (or Tucker) rank in tensor Banach spaces, that allowed to extend the Dirac-Frenkel variational principle in the framework of topological tensor spaces. The purpose of this talk is to extend these results to more general tensor formats. More precisely, we provide a new geometrical description of manifolds of tensors in tree-based (or hierarchical) format, also known as tree tensor networks, which are intersections of manifolds of tensors in Tucker format associated with different partitions of the set of dimensions. The proposed geometrical description of tensors in tree-based format is compatible with the one of manifolds of tensors in Tucker format.



Mora Jiménez, María

Organization

CEU Cardenal Herrera

Email

mamoji7@upv.edu.es

Title

A Laplacian approach to the Greedy Rank-One Algorithm for a class of linear systems

Abstract

Many of today's problems require techniques that involve the resolution of arbitrarily large systems. A popular numerical approach is the so-called Proper Generalized Decomposition algorithm, based on a particular tensor decomposition.

This algorithm converges especially fast when the matrix of the linear system is Laplacian-Like, that is, it has the form

$$A = \sum_{i=1}^{m} \operatorname{Id}_{1} \otimes \operatorname{Id}_{2} \otimes ... \otimes \operatorname{Id}_{i-1} \otimes A_{i} \otimes \operatorname{Id}_{i+1} \otimes ... \otimes \operatorname{Id}_{n}$$

(for example, the matrix that appears by discretizing the Poisson equation). This fact made us wonder if a generic square matrix could be decomposed in some way so that the study of the associated linear problem $A\mathbf{x}=b$ would be simpler.



Oulghelou, Mourad

Organization

Université de La Rochelle

Email

mourad.oulghelou@univ-lr.fr

Title

Real-time flow optimal control by interpolated reduced order models

Abstract

By using the tools of differential geometry, a non-intrusive reduced real coded genetic algorithm (RGA) for near real time optimal control is proposed. This algorithm allows to predict well the solution snapshots for chromosomes over generations by relying only on a bunch of precalculated parametrized solution snapshots stored in the POD (Proper Orthogonal Decomposition) reduced form. Potential of RGA in terms of accuracy and CPU time is demonstrated on flow control problems when the Reynolds number value varies.



Rapún, María Luisa

Organization

Universidad Politécnica de Madrid

Email

marialuisa.rapun@upm.es

Title

Collocated POD and Galerkin projection on the fly for fast time integration of PDEs

Abstract

In this work we speed up time-dependent solvers of PDEs by using a ROM that combines on demand (on the fly) short runs of a numerical solver (full model) with a POD-based Galerkin projection. We propose a collocation strategy to select a reduced number of collocation points and snapshots from the snapshots matrix by performing Gauss elimination with double pivoting. POD is then applied to the selected snapshots considering the inner product based on the selected collocation points, which highly improves the computational efficiency in comparison with standard POD.

This is a joint work with Terragni, F. and Vega, J.M.



Sánchez Muñoz, Isabel

Organization

Universidad de Sevilla

Email

isanchez@us.es

Title

Low-rank approximations for parametric non-symmetric elliptic partial differential equations

Abstract

In this work we obtain low-rank approximations for the solution of parametric non symmetric elliptic problems. We prove the existence of finite-dimensional optimal subspaces that minimize the error between the solution and its approximation on this subspace, with respect to a mean quadratic norm associated to the elliptic operator. Using a deflation algorithm, we build a series of approximating solutions and prove the strong convergence. For one-dimensional approximations, we apply a Power Iteration method to compute the modes of the series and prove linear convergence for small data. We present some numerical results that confirm the theoretical analysis.



Minisymposium:

Successful cases of mathematical applications in biology, ecology and medicine

Thematic area: Mathematics Applied to Industry, Social Sciences and Biology (MA)

Organizers: Belmonte, Juan (UCLM), Martínez Gonzalez, Alicia (UBU)

Abstract

These special sessions encompassing topics on mathematical approaches to gain biological understanding or explain biological phenomena.

We will focus our attention on successful cases of mathematical applications in areas such as: diseases and treatments, cell biology, physiology, development, neurobiology, genetics, population biology, ecology, behavioral biology, evolution, epidemiology, immunology, molecular biology, biofluids, DNA and protein structure and function. Mathematical approaches including computational and visualization approaches will be appropriate.

Keywords: Ecology; Biology; Applied Mathematics

Session 1. Monday 11:30 - 13:55. Room A8.

Chair: Belmonte, Juan (Universidad de Castilla La Mancha)

Speaker	Organization	Contribution title
MARTÍNEZ GONZALEZ, ALICIA	Universidad de Burgos	Real time mapping of intraoperative brain tumor using RGB images
FERNANDEZ CALVO, GABRIEL	UCLM	Biomarkers of tumor metabolism based on reaction-diffusion equations
CHULIAN GARCÍA, SALVADOR	UCA	A mathematical model of B-cell dynamics using human bone marrow data
LEÓN TRIANA, ODELAISY	UCLM	Mathematical model of CAR T cell therapies for B-acute lymphoblastic leukemia
VELA PÉREZ, MARÍA	Instituto de Matemática Interdisciplinar, UCM	A Mathematical Model for Low Grade Gliomas and the effects of chemotherapy



Session 2. Monday 18:00 – 20:00. Room A8.

Chair: Martínez Gonzalez, Alicia (Universidad de Burgos)

Speaker	Organization	Contribution title
GUERRERO, PILAR	Universidad Carlos III	Vertex model of the pseudo-stratified neural tube epithelium
Martínez Rubio, Álvaro	Universidad de Cádiz	A Mathematical Description of Bone Marrow Dynamics of CAR-T Cell Therapy.
STEPANOVA, DARIA	CRM	Multiscale modelling of complex cell dynamics in angiogenesis

Session 3. Tuesday 10:30 – 12:10. Room A8.

Chair: Fernandez Calvo, Gabriel (Universidad de Castilla La Mancha)

Speaker	Organization	Contribution title
BARRIO, ROBERTO	Universidad de	Patterns in CPGs: insect gait movements
DAKKIU, KUBEKIU	Zaragoza	ratterns in Cros. insect gait movements
BOSQUE MARTINEZ,	UCLM	Modelling key processes in hyperthermia
JESÚS	UCLIVI	treatment of cancer
PORTILLO DE LA	Universidad de	Mathematical model to study the aging of
FUENTE, ANA MARÍA	Valladolid	the human follicle
JUMANIYAZOV,	Universidad de	Numerical solution of degenerate diffusion
NIZOMJON	Gonzaga	equations for the transport of electrons

Session 4. Tuesday 12:15 – 13:55. Room A8.

Chair: Chulian García, Salvador (Universidad de Cádiz)

Speaker	Organization	Contribution title
IVORRA, BENJAMIN	Universidad Complutense de Madrid	$\theta ext{-SIR}$ type models to study the COVID-19 pandemic
KUBIK, ALICJA	Universidad Complutense de Madrid	Modeling the evolution of the spread of COVID-19 with real data, considering the impact of vaccines and different variants



Barrio, Roberto

Organization

Universidad de Zaragoza

Email

rbarrio@unizar.es

Title

Patterns in CPGs: insect gait movements

Abstract

The study of the synchronization patterns that control biological processes has become a growing discipline. We study small networks, CPGs, for insect locomotion where each neuron follows the model of Ghigliazza-Holmes. We introduce two new numerical techniques: the lateral phase delay analysis and automatic detection techniques combined with quasi-Monte-Carlo sweeping methodologies. These methods permit us to obtain a complete scheme of the patterns evolution on the movement gaits of the insect once some of the parameters is changed.

Joint work with Lozano, Álvaro, Martínez, María Ángeles, Mayora, Ana, Mayora, Carmen, Rodríguez, Marcos and Serrano, Sergio.



Bosque Martinez, Jesús

Organization

UCLM

Email

jesus.bosque@uclm.es

Title

Modelling key processes in hyperthermia treatment of cancer

Abstract

Hyperthermia treatment (HT) of cancer is an adjuvant therapy that consists in increasing the local temperature of tumour tissues to improve the efficacy of radiotherapy (RT) and chemotherapy. Clinical trials have shown benefits in its use, however, the underlying biological mechanisms by which heat exerts its therapeutic effect remain unclear. Several hypotheses have been put forward, including direct cell killing, DNA repair inhibition, or improvement of oxygenation through vasodilation. Mathematical models can help shed light on such mechanisms, and also quantify the different processes that are triggered by heat to, altogether, optimise the outcome in patients.



Chulian García, Salvador

Organization

UCA

Email

salvador.chulian@uca.es

Title

A mathematical model of B-cell dynamics using human bone marrow data

Abstract

Non-linear mathematical models are presented describing the role of signalling in B lymphocyte development. Stability analysis of the steady states of the model are studied, always considering the biological background. Bone marrow data from 9 patients with normal B cell subpopulations are used in order to provide realistic parameters. The influence of the model parameters is considered to better understand full reconstitution of B lymphocytes, providing biological interpretations of the results. Combination of data and mathematical modelling may provide a better insight into hematological dynamical processes, and enable a future application for hematological disorders.



Fernandez Calvo, Gabriel

Organization

UCLM

Email

gabriel.fernandez@uclm.es

Title

Biomarkers of tumor metabolism based on reaction-diffusion equations

Abstract

Human malignant solid tumors are biologically heterogeneous. This heterogeneity can be addressed in vivo by means of positron emission tomography imaging combined with in silico simulations based on evolutionary dynamics. Here we investigate the spatio-temporal change of the metabolic activity in cancers using reaction-diffusion equations. Our mathematical models reveal that, during progression, increasingly proliferating cells tend to cluster around the tumor rim leading to a gradually more aggressive phenotypic structure. This gives rise to a new radiomic biomarker for aggressiveness that we can quantify with our models. Our predictions are verified in breast and non-small cell lung carcinoma patients.



Guerrero, Pilar

Organization

Universidad Carlos III

Email

pguerrer@math.uc3m.es

Title

Vertex model of the pseudo-stratified neural tube epithelium

Abstract

In the context of development, it is important to understand the mechanisms that coordinate growth and patterning of tissues. These processes occur as a result of cell adhesion, migration, division, differentiation and death, and involve multiple processes acting at the cellular and molecular level. We are working in modelling the spatial patterning of the neural tube in the vertebrate embryo. In order to describe three-dimensionally packed cells in the vertebrate neural tube tissue both mathematically and physically, we have developed novel geometrical model using vertex model where we introduce the inter-kinetic movement as a new interpretation of target area.



Ivorra, Benjamin

Organization

Universidad Complutense de Madrid

Email

ivorra@mat.ucm.es

Title

 θ -SIR type models to study the COVID-19 pandemic

Abstract

Since the start of the COVID-19 pandemic in China, many models have appeared in the literature. Focusing on modeling the biological and sociological mechanisms which influence the disease spread, the basic reference example is the SIR model. However, it is too simple to be able to model those mechanisms (including control measures: social distancing, contact tracing and health system measures), to fit real data and to simulate possible future scenarios.

Thus, we develop a θ -SIR type model, which satisfies the mentioned requirements for arbitrary territories. We show its very good performance and study different future scenarios.



Jumaniyazov, Nizomjon

Organization

Urgench branch of Tashkent University of Information Technologies named after Muhammad al-Khwarizmi

Email

nizomjon_jumaniyazov@yahoo.com

Title

Numerical solution of degenerate diffusion equations for the transport of electrons

Abstract

We compute numerically the angular flux density of electrons in the 1D slab by solving a degenerate diffusion PDE which is sometimes called the Fokker-Planck equation in the nuclear engineering community.

In the equation the unknown function depends on three variables: polar angle, azimuthal angle and one spatial variables. Present work is a logical continuation of the paper published in 2016 and no results on this work appear in the literature.

The numerical method developed is based on finite differences and on a Fourier series of the angular flux density with respect to the azimuthal angle variable, and exhibits order 2 of convergence when the solution is regular. Moreover, one of the coefficients in the equation has singularities at the bound of the interval in polar angular variable for which we developed a technique to treat.



Kubik, Alicja

Organization

Universidad Complutense de Madrid

Email

akubik@ucm.es

Title

Modeling the evolution of the spread of COVID-19 with real data, considering the impact of vaccines and different variants

Abstract

These last months, new SARS-CoV-2 variants have emerged and many vaccination campaigns against COVID-19 have started all around the world. We present a θ -SIR type model that has been tested with real data during this pandemic. It is an improvement of previous models that we incorporate new compartments in order to consider those vaccination campaigns and divide each infectious compartment depending on the amount of different SARS-CoV-2 variants, to finally apply it to a particular territory.



León Triana, Odelaisy

Organization

UCLM

Email

Odelaisy.Leon@uclm.es

Title

Mathematical model of CAR T cell therapies for B-acute lymphoblastic leukemia

Abstract

Immunotherapies use components of the patient immune system to selectively target cancer cells. The use of CAR T cells to treat B-cell leukemias is one of the most successful examples. This treatment works by extracting the patient's T cells and adding them to the CAR group, which enables them to recognize and target cells carrying the antigen CD19+. We put forward a mathematical model describing the time response of leukemias to the injection of CAR T-cells. The model accounts for mature and progenitor B-cells, tumor cells, CAR T cells, and side effects by incorporating the main biological processes involved.



Martínez Gonzalez, Alicia

Organization

Universidad de Burgos

Email

aliciamg@ubu.es

Title

Gliomap: Real time mapping of intraoperative brain tumors using RGB images

Abstract

In order to radically remove a brain tumor, it is essential to precisely identify the exact transition line between tumor and brain tissue. The surgeon is at risk to either harm healthy brain tissue or to not extract the entire tumor during surgery.

Gliomap uses RGB images to automatically classify different regions on the target tissue.

GlioMap is: non-invasive, feasible, real time, accurate, ecological, accessible to most hospitals, it can be used continuously, it does not occupy much, it does not delay surgery, non-expensive maintenance is required and the patient is not harmed in any way.



Martínez Rubio, Álvaro

Organization

Universidad de Cádiz

Email

alvaro.martinezrubio@uca.es

Title

A Mathematical Description of Bone Marrow Dynamics of CAR-T Cell Therapy.

Abstract

Despite the recent success of CAR-T cell therapy in B-cell malignancies, a fraction of patients still relapse. Relapses are often preceded by recovery of healthy B cells, which suggests loss of the CAR-T cells in bone marrow, where B cells are produced. This anatomic site is harder to access and thus not as monitored as peripheral blood. Understanding the interplay between B cells, cancer cells and CAR-T cells in the bone marrow is paramount to ascertain causes for the lack of response. We present a mathematical model describing the interaction between constantly renewing B cells, CAR-T cells and leukemic cells in the bone marrow. We perform numerical simulations to understand the influence of parameters in therapy outcome, and conclude the importance of CAR-T product attributes in determining response.



Portillo de la Fuente, Ana María

Organization

Universidad de Valladolid

Email

anapor@mat.uva.es

Title

Mathematical model to study the aging of the human follicle

Abstract

A human preantral follicle takes approximately 85 days to achieve the preovulatory size, going through several stages (Gougeon, 1996). Granulosa cells (GCs) are somatic cells which determine the development of the oocyte. The telomere length of GCs of each class of follicles, during folliculogenesis, are modelled using a chemical master equation formalism similar to the one in (Wesch el al., 2016). Seven differential ordinary systems of equations, corresponding to seven stages of the follicule maturation, concatenated in time, are considered. The influence of different telomerase activity rates and the telomere shortening of the preovulatory follicle is studied.



Stepanova, Daria

Organization

CRM

Email

dstepanova@crm.cat

Title

Multiscale modelling of complex cell dynamics in angiogenesis

Abstract

Angiogenesis, the process whereby endothelial cells (ECs) migrate from a pre-existing vascular bed guided by local environmental cues and interacting with each other to eventually create a new vascular network.

We introduce a multiscale model of migration-driven angiogenic sprouting which accounts for the individual gene expression pattern of ECs, cell-cell and cell-extracellular matrix interactions. The model, calibrated and validated against various experimental data, captures the characteristic behavior of ECs: branching, cell mixing and, chemotactic sensitivity. These properties, instead of being hard-wired into the model, emerge naturally due to accounting for heterogeneous behavior of ECs depending on their gene expression pattern.



Vela Pérez, María

Organization

Instituto de Matemática Interdisciplinar, UCM

Email

maria.vela@ucm.es

Title

A Mathematical Model for Low Grade Gliomas and the effects of chemotherapy

Abstract

The optimal management of low grade gliomas remains an open problem. Although complete surgical resection is recommended they often result in tumors that are incompletely resected or simply biopsied. For this reason, the use of TMZ combined with other options is increasingly used. We present a modification of a recent model to understand the late response to the chemotherapy observed in LGG without using an excessive number of unknown parameters. In our approach we consider separately the proliferation process and natural death process. This allows us to obtain a good agreement of model solutions with medical data.



Thematic Sessions



Thematic area:

Applied Mathematics to Industry, Social Sciences and Biology (AM)

Session 3. Tuesday 10:30-12:10. Room B2. Chair: González Vida, José Manuel (U. de Málaga)

Speaker	Organization	Contribution title
Navarro, María Cruz	Universidad de Castilla-La Mancha	Microwave irradiation vs conventional heating: numerical experiments with solvents of different physical and dielectric properties
MARTÍ RAGA, CARMEN	Universitat de València	Numerical solution of a system of conservation laws with discontinuous flux modelling flotation with sedimentation
FREIRE- TORRES, MARIO	Universidad Politécnica de Madrid	Mathematical modelling and numerical simulation of welding process

Session 5. Tuesday 18:00-20:00. Room B2. Chair: Donat, Rosa (Universitat de València)

Speaker	Organization	Contribution title	
FONT,	Centre de Recerca	Modelling gas flow through a porous media for	
FRANCESC	Matemàtica	contaminant removal applications	
CALVO PEREIRA,	Universidad de	CCIDD model with non-level diffusion	
ALFREDO	Salamanca	SEIRD model with non-local diffusion	
DEL RÍO	University of A	Acoustic characterization of rigid porous materials	
MARTÍN, LAURA	Coruña	by using a data-driven approach	
PÉREZ SINUSÍA,	Universidad de	Generalization of Zernike basis and its application in	
ESTER	Zaragoza	Optics	

Session 6. Wednesday 10:55-12:10. Room B2. Chair: Barrio, Roberto (Universidad de Zaragoza)

Speaker	Organization	Contribution title
GONZALEZ-	Universitat	Comparison of QR and SVD Based Methods for
ZUMBA, JORGE	Politècnica de	Computing Lyapunov Exponents of SDEs, with
ANDRÉS	València	Application to Power Systems
BAEZA,	Universitat de	A model for the evolution of the COVID-19 pandemic in
ANTONIO	València	Spain including mobility
	Universidad	Analysis of a CCIDC western and sting westerly feet
ATIENZA	Politécnica de	Analysis of a SEIRS metapopulation model with fast
GRACIA, PILAR	Madrid	migration



Atienza Gracia, Pilar

Organization

Universidad Politécnica de Madrid

Email

pilar.atienza.gracia@alumnos.upm.es

Title

Analysis of a SEIRS metapopulation model with fast migration

Summary

We propose a model for the study of the dynamics of a disease in a population spread out among several sites. The local dynamics of the disease in each site is of SEIRS type, whereas migration of individuals among sites is linear. We assume that migration is fast with respect to the disease dynamics and make use of approximate reduction techniques in order to reduce the system's dimension. We carry out the model's analysis, providing conditions for the disease to become endemic (resp. die out) and showing that certain counterintuitive behaviors can arise. (Joint work with Sanz Lorenzo, Luis, Universidad Politécnica de Madrid).



Baeza, Antonio

Organization

Universitat de València

Email

bamanan@uv.es

Title

A model for the evolution of the COVID-19 pandemic in Spain including mobility

Summary

This work deals with the simulation of infectious disease outbreaks due to imported cases. We present a model that includes mobility data terms that aim to mimic the flow of people between different regions and uses the SAIR compartmental model for the local spread. The model is applied to the COVID-19 in various areas of Spain, for which the authorities made available mobility data. We also introduce a method for the estimation of incomplete mobility data. Numerical experiments show the importance of data completion and indicate that the model is able to qualitatively simulate the spread tendencies of small outbreaks.

Joint work with Aràndiga, Francesc, Cordero Carrión, Isabel, Donat, Rosa, Martí Raga, Carmen, Mulet Mestre, Pep and Yáñez Avendaño, Dionisio F. (U. Valencia)



Calvo Pereira, Alfredo

Organization

Universidad de Salamanca

Email

alcalvo@usal.es

Title

SEIRD model with non-local diffusion

Summary

Some non-local diffusion processes may be described by an integral operator such as

$$\int K(x,y)\big(u(y)-u(x)\big)dy.$$

In the compartmental models in epidemiology, the diffusion terms may be replaced by an integral terms similar to above, to describe the dispersion of population. Classical numerical approximations, like FEM or finite differences, lead to systems of equations with dense matrices.

Wavelets are a kind of functions whose some of their properties make them a very useful tool for discretizing the convolution operators, getting sparse matrices, thus saving compute time and storage memory.



del Río Martín, Laura

Organization

University of A Coruña

Email

laura.rmartin@udc.es

Title

Acoustic characterization of rigid porous materials by using a data-driven approach

Summary

The acoustic characterization of rigid porous materials plays an important role in many industrial applications. To obtain an accurate characterization of a material, the knowledge of its intrinsic parameters is essential. Although a classical parametric model can be considered, a wrong choice of the model can lead to get a frequency-dependent response far from the available experimental data.

In this work, a non-parametric approach is used for the acoustic characterization of rigid porous materials. This data-driven methodology allows to avoid the a priori choice of an unsuitable model since the mathematical modeling is based only on the available experimental measurements.



Font, Francesc

Organization

Centre de Recerca Matemàtica

Email

ffont@crm.cat

Title

Modelling gas flow through a porous media for contaminant removal applications

Summary

The issue of excessive amounts of carbon in the atmosphere, which is still being added to at an alarming rate, and the resultant effect on the climate is well-documented. Consequently, mankind must look to a range of solutions including a reduction in current production, removing existing carbon from the environment and safe storage or reuse. The process of carbon capture falls within these measures.

In this talk we will present a mathematical model for the flow of a CO_2 laden gas through an adsorbing filter. The model consists of an advection-diffusion equation for the gas concentration, coupled to a momentum equation for the gas velocity and an ordinary differential equation for the rate of adsorption. By nondimensionalizing the model, we will retain the most dominant terms and neglect the less important ones. We will show how the method of characteristics, travelling wave solutions, asymptotic analysis and numerical methods can all be applied to gain understanding on the industrial process of contaminant removal by adsorption.

This is a joint work with Prof. Myers, Tim.



Freire-Torres, Mario

Organization

Universidad Politécnica de Madrid

Email

mario.freire.torres@alumnos.upm.es

Title

Mathematical modelling and numerical simulation of welding process

Summary

This present work describes a model of the thermal and hydrodynamic phenomena of the welding process. First, we used the energy equation expressed only in terms of enthalpy to analyze the solid-liquid phase, usually called the mushy zone. On the other hand, to study the liquid phase within the melted material, we used the Navier-Stokes equations with a term for fluid flow through porous medium according to Darcy's model and the buoyancy term according to Boussinesq's model. A numerical solution of this model was built using the finite element method, applying Lagrange-Galerkin framework, emphasizing the method of characteristics, and established the BDF2 scheme for the time discretization.

Joint work with Carpio, Jaime (Universidad Politécnica de Madrid).



Gonzalez-Zumba, Jorge Andrés

Organization

Universitat Politècnica de València

Email

jandresgz@gmail.com

Title

Comparison of QR and SVD Based Methods for Computing Lyapunov Exponents of SDEs, with Application to Power Systems

Summary

Lyapunov Exponents (LEs) are an essential tool in the study of asymptotic stability of random dynamical systems (RDS) generated by stochastic differential equations. Unfortunately, just in few cases the LEs can be determined analytically. In the vast majority of cases, one must compute the LEs through numerical techniques. In the present contribution, we compare the efficiency and accuracy of different methods based on QR and singular value decomposition of the linear matrix cocycle over an ergodic RDS. The proposed methods are applied to interesting study cases of power systems under uncertainty, where asymptotic stability is assessed via the LEs computation.



Martí Raga, Carmen

Organization

Universitat de València

Email

maria.c.marti@uv.es

Title

Numerical solution of a system of conservation laws with discontinuous flux modelling flotation with sedimentation

Summary

Flotation is a separation process widely used for the recovery of valuable minerals in mineral processing and in related applications. The hydrodynamics of a one-dimensional flotation column can be described in simplified form by a triangular system of two scalar conservation laws with a multiply discontinuous flux. Based on the theory of conservation laws with discontinuous flux, steady-state solutions that satisfy all jump and entropy conditions are constructed. A numerical method that ensures approximate concentration values between zero and one is formulated and employed for the simulation of the fill-up and transitions between steady states of the flotation column.



Navarro, María Cruz

Organization

Universidad de Castilla-La Mancha

Email

MariaCruz.Navarro@uclm.es

Title

Microwave irradiation vs conventional heating: numerical experiments with solvents of different physical and dielectric properties

Summary

In this work we compare numerically the behavior of several solvents under two different mechanisms of heating: microwave irradiation (MW) and conventional heating (CH). In experiment 1 the samples are irradiated with microwaves at a frequency of 2.45 GHz, and two different fixed powers: 60 W and 80 W. In experiment 2 we impose a constant temperature of 60°C at the boundary. MW is shown to be more homogeneous and faster than CH for solvents highly susceptible to MW. For CH, more heterogeneities are found during the heating process.

Joint work with Castaño Torrijos, Damián (Universidad de Castilla-La Mancha).



Pérez Sinusía, Ester

Organization

Universidad de Zaragoza

Email

ester.perez@unizar.es

Title

Generalization of Zernike basis and its application in Optics

Summary

Zernike polynomials are commonly used to represent the wavefront phase on circular optical apertures, since they form a complete and orthonormal basis on the unit disk. We present a generalization of the Zernike basis for a variety of important optical apertures. We apply a diffeomorphism (or piece-wise diffeomorphism) that transforms the unit circle into the new optical aperture: elliptical annulus, ellipses, rings, angular sectors, polygons, etc. Different applications in optics are presented, in particular, to segmented mirror telescopes.



Thematic area:

Dynamic Systems and Ordinary Differential Equations (DS-ODE)

Session 1. Monday 11:30 – 13:35. Room B1.

Chair: Seara, Tere M. (U. Politècnica de Catalunya)

Speaker	Organization	Contribution title
UZAL, JOSÉ MANUEL	Universidade de Santiago de Compostela	Impulsive evolution processes: existence and continuity of the pullback attractor
CABALLERO TORO, RUBEN	Universidad Miguel Hernández de Elche	A reaction-diffusion model with nonlocal viscosity and Lyapunov structure
CAO LABORA, DANIEL	Universidade de Santigo de Compostela	The "fractional" abstraction of IVPs
Muñoz Hernández, Eduardo	Universidad Complutense de Madrid - Instituto de Matemática Interdisciplinar	Minimal complexity of subharmonics in a class of planar periodic predator-prey models

Session 2. Monday 18:00 – 20:00. Room B1.

Chair: Suárez Pérez del Río, Jesús (Universidad de Oviedo)

Speaker	Organization	Contribution title
GARZÓN, MANUEL	Universidad de Granada	Periodic solutions for the Lorentz force equation.
PÉREZ MARTÍNEZ, CARMEN	Universidad de Cádiz	Stabilization of a SIR model by using switched systems
ARNAL PONS, ANA MARIA	Universitat Jaume I	Exponential perturbative expansions and coordinate transformations



Arnal Pons, Ana Maria

Organization

Universitat Jaume I

Email

parnal@uji.es

Title

Exponential perturbative expansions and coordinate transformations

Abstract

We propose a unified treatment of different exponential perturbation expansions for time-dependent linear differential equations based on continuous changes of coordinates. It turns out that several well known exponential approximations can be described within this framework, in particular the Magnus expansion, the Floquet-Magnus and Lie-Deprit expansions for periodic or quasi-periodic systems and even the standard perturbation theory. We illustrate the main features of the different procedures on relevant examples in quantum mechanics. We also show how the formalism can be extended to the nonlinear case. This is a joint work with Chiralt, Cristina and Casas, Fernando.



Caballero Toro, Ruben

Organization

Universidad Miguel Hernández de Elche

Email

ruben.caballero@umh.es

Title

A reaction-diffusion model with nonlocal viscosity and Lyapunov structure

Abstract

We consider a nonlocal reaction diffusion equation. We assume growth and continuity conditions in the nonlocal term. Moreover, the reaction function is supposed to fulfil the classical dissipation and growth condition. Following this framework, new challenging difficulties raises on the problem. Under certain conditions in the initial data, we prove existence and uniqueness of solution. Furthermore, we have distinguished several cases where the existence of a compact global attractor is ensured in each case to obtain a characterization of it.



Cao Labora, Daniel

Organization

Universidade de Santiago de Compostela

Email

daniel.cao@usc.es

Title

The "fractional" abstraction of IVPs

Abstract

It is well known that, under very general assumptions, "an ODE of order n has a uniquely determined solution, after providing the value of the unknown function and its first n-1 derivatives at a certain point".

In the field of Fractional Calculus, it has been widely discussed what is the natural generalization of the previous result. In other words: what is the most reasonable way to impose initial values? In this talk, we will provide a coherent answer for the case of equations involving the Riemann-Liouville fractional derivative.

The talk will be based on the contents of the paper https://arxiv.org/abs/1910.02946



Garzón, Manuel

Organization

Universidad de Granada

Email

manuelgarzon@ugr.es

Title

Periodic solutions for the Lorentz force equation.

Abstract

I shall present a joint work with Torres Villarroya, Pedro. We provide sufficient conditions for the existence of periodic solutions of the relativistic Lorentz force equation, which models the motion of a charged particle under the action of an electromagnetic field. The basic assumptions cover relevant models with singularities like Coulomb-like electric potentials or the magnetic dipole.

These first results were developed using nonlinear analysis tools as the Leray-Schaüder Degree. We are currently approaching the problem from a variational point of view. Some comments about the ongoing work will be made as well.



Muñoz Hernández, Eduardo

Organization

Universidad Complutense de Madrid - Instituto de Matemática Interdisciplinar

Email

eduardmu@ucm.es

Title

Minimal complexity of subharmonics in a class of planar periodic predator-prey models

Abstract

This contribution analyzes the existence of positive subharmonics of arbitrary order in the planar periodic Volterra predator-prey model. If the support of the birth rate of the prey intersects the support of the death rate of the predator, then the existence of positive subharmonics can be derived with a refinement of the Poincaré—Birkhoff theorem. However, in the "degenerate" case when these supports do not intersect, then, the last Poincaré theorem fails. Still in these degenerate situations, some analytical techniques combined with a refinement of the Poincaré—Birkhoff theorem provide us with the existence of positive subharmonics of arbitrary order.



Pérez Martínez, Carmen

Organization

Universidad de Cádiz

Email

carmen.perez@uca.es

Title

Stabilization of a SIR model by using switched systems

Abstract

In this paper we consider an SIR epidemic model with discontinuous treatment strategies. Hence, we consider the cases where the equilibria are not stable. In these cases, by defining this model as a switched nonlinear system, we apply results about stabilization of switched systems in order to assure the stability of the equilibria when discontinuous treatment strategies are considered. Moreover, in order to illustrate the results, several numerical examples are presented.



Uzal, José Manuel

Organization

Universidade de Santiago de Compostela

Email

josemanuel.uzal@rai.usc.es

Title

Impulsive evolution processes: existence and continuity of the pullback attractor

Abstract

The theory of impulsive dynamical systems describes systems on which a continuous evolution process is interrupted by sudden changes in their state. In this talk the theory of impulsive evolution processes is developed and the concept of pullback attractor is studied. Furthermore, some results on the existence and the continuity of this attractor will be shown. This is based on a joint work with Bortolan, Matheus C. (UFSC, Brazil).



Thematic area:

Numerical Analysis and Simulation (NAS)

Session 3. Tuesday 10:30-12:10. Room B1

Chair: Casas, Fernando (Universitat Jaume I)

Speaker	Organization	Contribution title
ALBELLA MARTÍNEZ, JORGE	Universidade de Santiago de Compostela	A potentials formulation for the resolution of 2D linear isotropic elastodynamics.
RAICHIK, IRINA	Bar Ilan University, Ramat Gan, Israel.	A numerical method to solve Maxwell's equations in 3D singular geometry
LÓPEZ NÚÑEZ, ALEJANDRO	GEAMA - UDC	Numerical discretisation of a pressure source term to model mixed flows with the shallow water equations

Session 4. Tuesday 12:15-13:30. Room B1

Chair: Casas, Fernando (Universitat Jaume I)

Speaker	Organization	Contribution title
ESCORIHUELA I TOMÀS, ALEJANDRO	Universitat Jaume I	Compositions of pseudo-symmetric methods
MULET MESTRE, PEP	University of Valencia	WENO reconstructions with maximal high order
SANTOS PÉREZ, SAMUEL	Universidad de Valencia	Analysis of turbulence models for flow simulation in the aorta

Session 8. Thursday 18:00-20:00. Room B1.

Chair: Calvo Cabrero, Maria Paz (Universidad de Valladolid)

Organization	Contribution title
Universidad de Sevilla	Numerical analysis of a projection-based stabilized POD-ROM for incompressible flows
Universidad Politécnica de Madrid	A nearly-conservative, high-order, forward Lagrange- -Galerkin scheme for scalar hyperbolic conservation laws
Universidad Politécnica de Madrid	An algorithm to create conservative Galerkin projection between meshes
	Universidad de Sevilla Universidad Politécnica de Madrid Universidad Politécnica de



Albella Martínez, Jorge

Organization

Universidade de Santiago de Compostela

Email

jorge.albella@usc.es

Title

A potentials formulation for the resolution of 2D linear isotropic elastodynamics.

Summary

When solving 2D linear elastodynamics equations in homogeneous isotropic media, two types of waves travel with different velocities. In many applications, a high difference on the velocities penalise the classical numerical schemes. In this talk, the authors present an alternative potential formulation that rewrites the problem as two scalar wave equations only interacting on boundaries and interfaces. The resultant is a problem better adapted for discretization, however, as it will be shown in this talk, many difficulties arise on the treatment of boundary and transmission conditions.



Colera, Manuel

Organization

Universidad Politécnica de Madrid

Email

m.colera@upm.es

Title

A nearly-conservative, high-order, forward Lagrange--Galerkin scheme for scalar hyperbolic conservation laws

Summary

We present a novel Lagrange--Galerkin method for the resolution of scalar hyperbolic conservation laws. The scheme considers: (i) a conservative, weak, Lagrangian formulation which is formally discretized in space and in time with arbitrary order of accuracy, (ii) a forward-in-time integration of the fluid trajectories to allow for more stable and efficient time-discretizations, (iii) nodal space-discretizations on unstructured triangular meshes and (iv) a novel residual-based discontinuity-capturing operator. Numerical experiments --which include a hard case of non-convex flux and up to fourth-order elements-- illustrate the accuracy of the method. Joint work with Carpio, Jaime and Bermejo, Rodolfo (UPM).



Escorihuela i Tomàs, Alejandro

Organization

Universitat Jaume I

Email

alescori@uji.es

Title

Compositions of pseudo-symmetric methods

Summary

Given an initial value problem defined by an ODE, composition methods constitute a powerful technique to construct high order numerical integrators to solve the problem whereas preserving qualitative properties. Essentially, the same basic integrator is used with fractional step sizes chosen so as to satisfy certain universal algebraic conditions. Here we concentrate on a new type of composition involving complex coefficients and analyze its main properties with respect to the preservation of the time-symmetry. We illustrate its main features on selected numerical examples, including the semidiscretized complex Ginzburg-Landau equation.

This is a joint work with Casas, Fernando and Chartier, Philippe.



Gómez Molina, Pedro

Organization

Escuela Técnica Superior de Ingenieros Industriales. Universidad Politécnica de Madrid

Email

pedro.gomezm@alumnos.upm.es

Title

An algorithm to create conservative Galerkin projection between meshes

Summary

In this talk we present an algorithm for the implementation of the Galerkin projection, which satisfies conservation up to machine accuracy when we transfer solutions between meshes. The mesh discretization is composed of triangles in 2-dimension and by tetrahedra in 3-dimensions. We will illustrate the good features of the method in terms of stability and accuracy solving convection-dominated problems using the conservative Lagrange-Galerkin method of [1].

[1] M. Colera, J. Carpio, R. Bermejo: "A nearly-conservative high-order Lagrange—Galerkin method for the resolution of scalar convection-dominated equations in non-divergence-free velocity fields" Computer Methods in Applied Mechanics and Engineering, Vol. 372 (2020), 113366.



López Núñez, Alejandro

Organization

Universidade da Coruña

Email

alejandro.lopezn@udc.es

Title

Numerical discretisation of a pressure source term to model mixed flows with the shallow water equations

Summary

A common application of the two-dimensional shallow water equations (2D-SWE) is their use in inundation and flood risk management studies. Most of these models do not account properly for vertically confined flow conditions that appear due to the presence of hydraulic structures such as bridges or culverts. In this talk, a new mathematical modification of the standard 2D-SWE, able to handle transient vertically confined flows including transitions between free surface and pressurised conditions, is presented. The numerical results show the capabilities of the model to produce reliable solutions and endorse its application to risk management and flood prevention.



Mulet Mestre, Pep

Organization

University of Valencia

Email

pep.mulet@uv.es

Title

WENO reconstructions with maximal high order

Summary

We propose a new Weighted Essentially Non-Oscillatory reconstruction technique that avoids accuracy loss near critical points, thus achieving the maximal order for stability. This technique only uses local data from the reconstruction stencil and is not based on any scaling parameter. The key novelty is the use of non-dimensional and scale-independent weights which are based on a new smoothness indicator, thus defining the first WENO reconstruction procedure that never loses accuracy on smooth data.



Raichik, Irina

Organization

Bar Ilan University, Ramat Gan, Israel.

Email

irina.raichik@gmail.com

Title

A numerical method to solve Maxwell's equations in 3D singular geometry

Summary

We propose a new method to solve the 3D Maxwell equations in axisymmetric singular domains, containing reentrant corner or edges. By doing a Fourier analysis, one arrives to a sequence of singular problems set in 2D domains, and 3D solutions are computed by solving 2D problems, depending on a Fourier mode k For each k, the solution is decomposed into a regular and a singular part. The regular part is computed with a finite element method. The singular part belongs to a finite-dimensional subspace and is computed by an appropriate numerical approach, only for the modes $k=0,\pm 1,2$. The total the solution is then reconstructed, based on a non stationary variational formulation. Numerical examples will be shown.

Joint work with Assous, Frank (Ariel University, Ariel, Israel)



Rubino, Samuele

Organization

Universidad de Sevilla

Email

samuele@us.es

Title

Numerical analysis of a projection-based stabilized POD-ROM for incompressible flows

Summary

In this work, we propose a new stabilized projection-based POD-Reduced Order Model (ROM) for the numerical simulation of incompressible flows. The new method draws inspiration from successful numerical stabilization techniques used in the context of Finite Element methods, such as Local Projection Stabilization (LPS). The new LPS-ROM circumvents the standard discrete inf-sup condition for the POD velocity-pressure spaces, whose fulfilment can be rather expensive. The numerical analysis of the fully Navier-Stokes discretization for the new LPS-ROM is presented, by mainly deriving the corresponding error estimates. Numerical simulations are performed to discuss the accuracy and performance of the new LPS-ROM.



Santos Pérez, Samuel

Organization

Universidad de Valencia

Email

samuel.santos@uv.es

Title

Analysis of turbulence models for flow simulation in the aorta

Summary

Computations of Wall Shear Stress (WSS) in the aorta wall is a relevant problem, since it has been related to the appearance of several cardiovascular diseases. In this context, our aim is to solve Navier-Stokes equations with boundary conditions in the aorta. For an accurate estimation of WSS, a proper election of the turbulence model can be of great relevance. We present an study to compare the estimations of WSS with three different turbulence models in the ascending aorta. Our simulations are carried out with the Finite Volume Method solver OpenFoam and the appropriate meshes to use are also discussed.



Thematic area:

Other: Scientific Computation, Approximation Theory, Discrete Mathematics, Mathematical Education, ... (O)

Session 7. Thursday 11:30-13:35. Room B2.

Chair: Selgas, Virginia (Universidad de Oviedo)

Speaker	Organization	Contribution title	
DE LA FUENTE BENITO, DANIEL	Universidad de Oviedo	New Galilean spacetimes to model an expanding universe	
FLORÍA, LUIS	Universidad de Zaragoza. Departamento de Física Teórica, IUMA, and Grupo de Mecánica Espacial (GME)	On the Amplitudes of Spherical Harmonics of Gravitational Potential and Generalised Products of Inertia.	
SÁNCHEZ PELEGRÍN, JOSÉ ANTONIO	Universidad de Granada	Nonlinear Analysis in Lorentzian Geometry: The maximal hypersurface equation in a Generalized Robertson-Walker spacetime	
ARÀNDIGA, FRANCESC	Universitat de València	Reconstruction of discontinuous functions using multiquadric local interpolation	
LÓPEZ BELINCHÓN, JOSÉ MARÍA	Universidad de Castilla- La Mancha	On the application of entropy, time and frequency domain methods to identify hypertensive patients	



Session 8. Thursday 18:00-20:00. Room B2.

Chair: Serrano, María Luisa (Universidad de Oviedo)

Speaker	Organization	Contribution title
ABASCAL,	Universidad de Oviedo	A Parallelization of Horner's Algorithm for
POLICARPO	Offiversidad de Oviedo	Polynomial Evaluation
JIMÉNEZ MEANA, JORGE	Universidad de Oviedo	Parallel Horner and electronic voting
PAGOLA MARTÍNEZ, PEDRO	Universidad Pública de Navarra	A simplified version of the uniform asymptotic method "saddle point near an end point"
OVIEDO UGALDE, NORBERTO GERARDO	Tecnológico de Costa Rica	Teaching experience in the Differential Equations Semi-Virtual Method course of the Tecnológico de Costa Rica
PALACIOS HERRERO, PABLO	Universidad Pública de Navarra	Uniform convergent expansions of integral transforms



Abascal, Policarpo

Organization

Universidad de Oviedo

Email

abascal@uniovi.es

Title

A Parallelization of Horner's Algorithm for Polynomial Evaluation

Summary

Minimizing the cost of computation in the evaluation of a polynomial is a main problem in Computational Science.

Horner's algorithm solves, efficiently, the problem of evaluating a polynomial of degree n in time O(n). Besides, this algorithm is also used to evaluate multivariate polynomials and, as extension, matrix polynomials.

In this paper, a parallelization of Horner's method, based on the polynomial partitioning, which involves a save in computation time is presented. Also, a comparison between the errors obtained when evaluating polynomials using both classic Horner's method and our parallelization is made.

This is a joint work with García Quintas, David, Palacio Muñiz, Antonio, Jiménez Meana, Jorge y Serrano, María Luisa.



Aràndiga, Francesc

Organization

Universitat de València

Email

arandiga@uv.es

Title

Reconstruction of discontinuous functions using multiquadric local interpolation

Summary

We discuss a new approach for the reconstruction of discontinuous one-dimensional functions. It consists in applying a parameter-dependent MQ-RBF local interpolant that incorporates WENO techniques in the computation of the locally optimized shape parameter.

The resulting nonlinear adaptive estimation of the shape parameter leads to accurate reconstructions in the smooth regions and to sharp solution profiles near jump discontinuities avoiding Gibbs phenomena. This is a true RBF-WENO method that does not revert to classical polynomial WENO approximation near discontinuities. We present also some numerical examples that confirm the theoretical approximation orders.



De La Fuente Benito, Daniel

Organization

Universidad de Oviedo

Email

fuentedaniel@uniovi.es

Title

New Galilean spacetimes to model an expanding universe

Summary

We introduce a new family of Galilean spacetimes, the Galilean Generalized Robertson-Walker spacetimes. This new family is relevant in the context of a generalized Newton-Cartan Theory to explain an expanding universe. We study its geometrical structure and analyse the completeness of its inextensible free falling observers. Moreover, this kind of spacetimes constitutes the local geometric model of a much wider family of spacetimes admitting certain conformal symmetry. Finally, we find some sufficient geometrical conditions guaranteeing a global splitting of a Galilean spacetime as a Galilean Generalized Robertson-Walker spacetime.



Floría, Luis

Organization

Universidad de Zaragoza. Departamento de Física Teórica, IUMA, and Grupo de Mecánica Espacial (GME)

Email

Ifloria@unizar.es

Title

On the Amplitudes of Spherical Harmonics of Gravitational Potencial and Generalised Products of Inertia.

Summary

Philip M. Fitzpatrick ("Principles of Celestial Mechanics", Chapter 12, Section 12.7, p. 306; Academic Press, 1970) used the concept of the "inertial integrals" (ibidem, p. 293) to express the terms up to degree 3 in the expansion of the gravitational potential outside of an extended rigid body, with arbitrary geometric shape and arbitrary mass distribution, as a series of spherical harmonics (involving Legendre polynomials and associated Legendre functions of the first kind).

We propose general expressions, in terms of inertia integrals (or generalised products of inertia), for the coefficients of zonal, tesseral, and sectorial harmonics of any degree and order.



Jiménez Meana, Jorge

Organization

Universidad de Oviedo

Email

meana@uniovi.es

Title

Parallel Horner and electronic voting

Summary

Electronic voting has been intensively studied for over the years. Up to now, many electronic voting protocols have been proposed and both the security as well as effectiveness have been improved. An electronic voting protocol is viewed as a set of stages that allow a collection of voters to cast their votes, while enabling a collection of authorities to collect the votes, compute the final tally, and communicate the final result that is checked by talliers. As an application to Parallel Horner, we will show how high-grade polynomials can be very useful in the counting and verification processes.

This is a joint work with Abascal, Policarpo; García Quintas, David; Palacio Muñiz, Antonio and Serrano, María Luisa.



López Belinchón, José María

Organization

Universidad de Castilla-La Mancha

Email

JoseMaria.LBelinchon@uclm.es

Title

On the application of entropy, time and frequency domain methods to identify hypertensive patients

Summary

Mathematical modeling of the human cardiovascular system has provided clinically useful information in a variety of diseases. In this work, characterization of the resulting time series from that physiological system in time, frequency, and complexity domains has proven ability to predict negative events, such as stroke and myocardial infarction, in hypertensive patients with one year of anticipation. More precisely, combination of entropy-based parameters and common time and frequency features computed from the heart rhythm variability through machine learning classifiers has reached an accuracy of about 80\% to discern between patients with high and low risk of suffering from such events.

This is a joint work with López, Miguel A. and Alcaraz, R.



Oviedo Ugalde, Norberto Gerardo

Organization

Tecnológico de Costa Rica

Email

noviedo2008@gmail.com

Title

Teaching experience in the Differential Equations Semi-Virtual Method course of the Tecnológico de Costa Rica

Summary

In 2018, the Differential Equations course for Engineering students is incorporated into the CEDA-TEC Digital Teaching Vice-Rector's Project. The main objective of this work is to disclose my teaching experience in the hard labor of planning, implementation, creation of materials and evaluation of the aspects that are carried out and implemented in this course under the semi-virtual modality. Finally, it shows some relevant results obtained in an assessment questionnaire about the course applied to the students.



Pagola Martínez, Pedro

Organization

Universidad Pública de Navarra

Email

pedro.pagola@unavarra.es

Title

A simplified version of the uniform asymptotic method "saddle point near an end point"

Summary

The main technical difficulties in the application of the uniform asymptotic method for integrals denominated "saddle point near an end point" are originated by a change of variables. We propose a variant of the method which avoids that change of variables and simplifies the computations. On the one hand, the calculation of the coefficients of the asymptotic expansion is remarkably simpler. On the other hand, as in the standard method, the asymptotic sequence is given in terms of parabolic cylinder functions. A new asymptotic expansion of the confluent hypergeometric function $U(a, x + a + 1, \alpha x)$ for large x, a fixed, uniformly valid for $\alpha \in (0, \infty)$ is given as an illustration.



Palacios Herrero, Pablo

Organization

Universidad Pública de Navarra

Email

pablo.palacios@unavarra.es

Title

Uniform convergent expansions of integral transforms

Summary

For most of the special functions of the mathematical physics several convergent expansions or asymptotic expansions are known.

Usually, the convergent expansions provide a good approximation for small values of a certain variable, whereas the asymptotic expansions provide a good approximation for large values of that variable. However, those expansions are usually not uniform: the convergent expansions fail for large values of the variable and the asymptotic expansions fail for small values.

In this paper, we face the problem of designing a general theory of uniform approximations, that is, approximations valid for both, small and large values of the selected variable.

Joint work with López, José L. and Pagola Martínez, Pedro (UPNA and INAMAT²). Research supported by the Spanish Ministry of Economía y Competitividad, project MTM2017-83490-P.



Sánchez Pelegrín, José Antonio

Organization

Universidad de Granada

Email

jpelegrin@ugr.es

Title

Nonlinear Analysis in Lorentzian Geometry: The maximal hypersurface equation in a Generalized Robertson-Walker spacetime

Summary

In this talk we will present some recent uniqueness results for entire solutions of the maximal hypersurface equation in spatially open Generalized Robertson-Walker spacetimes. Namely, under certain natural geometric assumptions like the Null Convergence Condition and by means of several maximum principles we are able to obtain new Calabi-Bernstein type results for this second order nonlinear elliptic equation. These results will be particularized for relevant models like the steady state and Einstein-de Sitter spacetimes.



Thematic area:

Partial Differential Equations (PDE)

Session 1. Monday 11:30-13:35. Room B2.

Chair: Mazón, José M.. (Universitat de València)

Speaker	Organization	Contribution title
SOLERA DIANA, MARCOS	Universitat de València	$(\mathit{BV},\mathit{L}^p)$ -decomposition, $p=1,2$, of functions in Metric Random Walk Spaces
RODRÍGUEZ BELLIDO, MARÍA ANGELES	Universidad de Sevilla	Convergence rates for Galerkin approximation for magnetohydrodynamic type equations
TABOADA VÁZQUEZ, RAQUEL	Universidade da Coruña	Asymptotic analysis of the behavior of a viscous fluid between two very close mobile surfaces
CORDERO CARRIÓN, ISABEL	Universitat de València	FCF formulation of Einstein equations: local uniqueness and numerical accuracy and stability
MIANA, PEDRO J.	Universidad de Zaragoza	Fractional evolution equations in dicrete sequences spaces

Session 2. Monday 18:00-19:15. Room B2.

Chair: Ruiz, David (Universidad de Granada)

Speaker	Organization	Contribution title
VARGAS UREÑA, ANTONIO MANUEL	Universidad Complutense de Madrid	On a parabolic-elliptic system with chemotactic and periodic terms
VALERO, JOSÉ	Universidad Miguel Hernández de Elche	On the properties of non-negative solutions and attractors for a reaction-diffusion equation with discontinuities
Wu, Jing	Universidad de Granada	Overdetermined elliptic problems in onduloid-type domains with general nonlinearities



Cordero Carrión, Isabel

Organization

Universitat de València

Email

isabel.cordero@uv.es

Title

FCF formulation of Einstein equations: local uniqueness and numerical accuracy and stability

Abstract

We will present Einstein equations in the so-called Fully Constrained Formulation (FCF). This formulation has two different sectors: the elliptic sector formed by the Hamiltonian and Momentum constraints together with the derived equations from the chosen gauge, and the hyperbolic sector which encodes the evolution of the rest of degrees of freedom of the metric of spacetime. We will present a modification of both sectors that keeps local uniqueness properties but has a better behaviour regarding the relativistic expansion in the source terms. We will also comment on numerical properties of this reformulation.

Joint work with Santos-Pérez, S. (U. of Valencia) and. Cerdá-Durán, P (U. of Valencia).



Miana, Pedro J.

Organization

Universidad de Zaragoza

Email

pjmiana@unizar.es

Title

Fractional evolution equations in dicrete sequences spaces

Abstract

In this talk, we consider fractional differential equations (in the sense of Caputo) on the sequence Lebesgue spaces l^p with $p \geq 1$. The associated operator to the Cauchy problem is defined by convolution with a sequence of compact support. We use techniques from Functional Analysis to calculate the solution of the problem. In the case of fractional powers of operators, we give explicitly the solution of the problem. As a consequence, we obtain new integral formulae for certain special functions.



Rodríguez Bellido, María Angeles

Organization

Universidad de Sevilla

Email

angeles@us.es

Title

Convergence rates for Galerkin approximation for magnetohydrodynamic type equations

Abstract

The motion of incompressible electrical conducting fluids can be modelled by magnetohydrodynamics equations, which consider the Navier-Stokes equations coupled with Maxwell's equations.

For the classical Navier-Stokes system, there exists an extensively study of the convergence rate for the Galerkin approximations.

Here, we extend the estimates rates of spectral Galerkin approximations for the magnetohydrodynamic equations. We prove optimal error estimates in the $L^2(\Omega)$ and $H^1(\Omega)$ -norms, we obtain a result similar to the Rautmann to the $H^2(\Omega)$ -norm, and we reach basically the same level of knowledge as in the case of the classical Navier-Stokes.

This is a joint work with Rojas-Medar, M. A. (Univ. Tarapacá-Chile) and Sepúlveda-Cerda, A. (Univ. La Frontera-Chile)



Solera Diana, Marcos

Organization

Universitat de València

Email

marcos.solera@uv.es

Title

 $(\mathit{BV}, \mathit{L}^p)$ -decomposition, p=1,2, of functions in Metric Random Walk Spaces

Abstract

We study the (BV, L^p) -decomposition, p=1,2, of functions in metric random walk spaces, a general workspace that includes weighted graphs and other nonlocal models used in image processing. We obtain the Euler-Lagrange equations of the corresponding variational problems and their gradient flows. In the case p=1 we also study the associated geometric problem and the thresholding parameters. Joint work with Mazón, José M.. and Toledo, Julián.



Taboada Vázquez, Raquel

Organization

Universidade da Coruña

Email

raquel.taboada@udc.es

Title

Asymptotic analysis of the behavior of a viscous fluid between two very close mobile surfaces

Abstract

The aim of this work is the study of the behavior of an incompressible viscous fluid moving between two closely spaced surfaces, also in motion. To carry out this work we use the asymptotic expansion method that allows us to formally justify two models starting from the same initial problem: a lubrication model and a shallow water model. The type of model that yields depends on whether the fluid is pressure dominant and on the boundary conditions imposed. We discuss in detail under what conditions each of the models would be applicable.

Joint work with Rodríguez Seijo, J. M. (Universidade da Coruña)



Valero, José

Organization

Universidad Miguel Hernández de Elche

Email

jvalero@umh.es

Title

On the properties of non-negative solutions and attractors for a reaction-diffusion equation with discontinuities

Abstract

In this work, we study properties of non-negative solutions of a reaction-diffusion equation with a discontinuous nonlinearity such as uniqueness, positivity, or existence of solutions backward in time. Using these properties, we describe the dynamics of the global attractor in the positive cone, showing that it consists of the zero solution, the unique positive equilibrium and the heteroclinic connections between them, which can be expressed in terms of the solutions of an associated linear problem. Finally, we extend these results to the nonautonomous problem.



Vargas Ureña, Antonio Manuel

Organization

Universidad Complutense de Madrid

Email

antonvar@ucm.es

Title

On a parabolic-elliptic system with chemotactic and periodic terms

Abstract

We consider a chemotactic PDEs system for the density of a biological population "u" and a chemical substance "v" in a bounded domain. The evolution of the system is described by a parabolic and an elliptic partial differential equation. We study the existence and uniqueness of solutions and their uniform asymptotic stability. In the first equation we consider a logistic growth term with periodic asymptotic behavior. Global existence in any dimension is studied. Under suitable assumptions we prove that the solution of the system also has periodic asymptotic behavior, using a comparison method.



Wu, Jing

Organization

Universidad de Granada

Email

jingwulx@correo.ugr.es

Title

Overdetermined elliptic problems in onduloid-type domains with general nonlinearities

Abstract

In this paper we prove the existence of solutions to a general semilinear elliptic problem with overdetermined boundary conditions. The proof uses a local bifurcation argument from the straight cylinder, in analogy with the onduloids and the theory of Constant Mean Curvature surfaces. Such examples have been found already for linear problems or with nonlinearity f(u)=1. In this work we are able to extend this phenomenon for a large class of functions f(u).

Joint work with Ruiz, David and Sicbaldi, P. (University of Granada).



Poster Session



Thematic area: Partial Differential Equations (PDE)

Author	Organization	Contribution title
ALBERDI CELAYA, ELISABETE	University of the Basque Country UPV/EHU	A Painless Multi-level Automatic Goal- Oriented hp-Adaptive Coarsening Strategy
MÁRQUEZ LOZANO, ALMUDENA DEL PILAR	Universidad de Cádiz	Symmetry analysis and conservation laws of a family of non-linear viscoelastic wave equations
GRANERO- BELINCHÓN, RAFAEL	Universidad de Cantabria	Waves with viscosity

Thematic area: Dynamical Systems and Ordinary Differential Equations (DS-ODE)

Author	Organizatio n	Contribution title
GALILEA MARTÍN, VÍCTOR	Universidad de La Rioja	Basins of attraction of Schröder's method applied to polynomials with two distinct roots
MARQUÉS LOBEIRAS, ALEJANDRO	Universidad de Oviedo	Geometry of the 2-D tents
GAMONAL FERNÁNDEZ, MANUELA	ICMAT - UCM	Distributed Learning-based Control for Unknown Nonlinear Multi-Agent Systems based on Gaussian Processes.



Thematic area: Applied Mathematics to Industry, Social Sciences and Biology (AM)

Author	Organization	Contribution title
GONZÁLEZ- SANTANDER MARTÍNEZ, JUAN LUIS	Universidad de Oviedo	Numerical validation of the analytical solution for the transient temperature field in dry surface grinding

Thematic area: Others: Scientific Computation, Approximation Theory, Discrete Mathematics, Mathematical Education ... (O)

Author	Organization	Contribution title
ASENSIO SEVILLA, María Isabel	Universidad de Salamanca	Simulation models for geospatial environmental problems

Thematic area: Numerical Analysis and Simulation (NAS)

Author	Organization	Contribution title
BANDERA MORENO, ALEJANDRO	Universidad de Sevilla	Numerical simulation by ROM of a network model of intracellular calcium concentration
VARELA RODRÍGUEZ, HIRAM	Universidade da Coruña	A posteriori error analysis of an augmented dual-mixed method of a nonlinear Dirichlet problem
DEMBA, MUSA AHMED	King Mongkut's University of Technology Thonburi, Bangkok, Thailand	A new phase- and amplification-fitted sixth-order explicit RKN method to solve oscillating systems



Asensio Sevilla, María Isabel

Organization

Universidad de Salamanca

Email

mas@usal.es

Title

Simulation models for geospatial environmental problems

Summary

The simulation tool development process for geospatial problems ranges from the design of mathematical models, the analysis and numerical resolution of the corresponding mathematical problems with efficient numerical methods, sensitivity analysis and model parameters adjustment, to the integration into GIS of the designed tools, and their application to real case studies. Interdisciplinary collaboration is essential in order to efficiently integrate mathematical modeling and geospatial technologies. The simulation models developed by the SINUMCC group at the University of Salamanca that will be presented on the poster are: HDWind-high definition windfield model; PhyFire-simplified physical wildfire spread model and PhyNX-air pollutant dispersion model.



Alberdi Celaya, Elisabete

Organization

University of the Basque Country UPV/EHU

Email

elisabete.alberdi@ehu.eus

Title

A Painless Multi-level Automatic Goal-Oriented hp-Adaptive Coarsening Strategy

Summary

Mesh-adaptive finite element algorithms are characterized by using an error estimator to guide the refinement of a given mesh.

Many engineering applications require the approximation of a specific Quantity of Interest (QoI). These inspired the development of Goal-Oriented adaptive (GOA) algorithms. Our main contribution in this work is to combine hp-adaptive strategy and the alternative dual operator for the error representation in the QoI. As a result, we derive an hp-adaptive algorithm for non-SPD problems in the context of GOA. We tested and analyzed our algorithm on two-dimensional (2D) Laplace, Helmholtz, and convection-dominated diffusion problems.

Joint work with Vinicio Caro-Gutiérrez, Felipe, Darrigrand, Vincent, Pardo, David.



Bandera Moreno, Alejandro

Organization

Universidad de Sevilla

Email

abandera@us.es

Title

Numerical simulation by ROM of a network model of intracellular calcium concentration.

Summary

In this work, we analyze numerically the synchronization patterns of a network of coupled oscillators. Each oscillator is a three-dimensional slow-fast system formed by a FitzHugh-Nagumo model with an additional slow variable representing the intracellular calcium concentration. The oscillators are coupled via the coupling of the fast variable of each oscillator upon the recovery slow equation of the other one.

In order to reduce the computational cost, we consider a Reduced Order Model (ROM). The model reduction is performed via a reduced basis method involving a POD of the data.

Joint work with Fernández-García, Soledad, Gómez, Macarena (U. of Seville) and Vidal, A. (U. of Evry Val d'Essonne).



Demba, Musa Ahmed

Organization

King Mongkut's University of Technology Thonburi, Bangkok, Thailand

Email

musdem2004@gmail.com

Title

A new phase- and amplification-fitted sixth-order explicit RKN method to solve oscillating systems.

Summary

Runge-Kutta-Nyström (RKN) methods are specialized Runge-Kutta methods that are intended for solving second-order differential equations directly.

We propose an optimization of a sixth-order explicit RKN method with six stages derived by El-Mikkawy and Rahmo using the phase-fitted and amplification-fitted techniques. The new adapted method integrates exactly the common test y'' = -w2y. The local truncation error of the new method is computed, showing that the order of convergence is maintained. The stability analysis is addressed, showing that the developed method has a periodicity interval. The numerical experiments show the high performance of the new method compared with other existing six-stage RKN codes.

Joint work with Ramos, Higinio (U de Salamanca), Kumam, Poom (KMUTT), and Watthayu, Wiboonsak (KMUTT).



Galilea Martín, Víctor

Organization

Universidad de La Rioja

Email

victor.galilea@unirioja.es

Title

Basins of attraction of Schröder's method applied to polynomials with two distinct roots.

Summary

We have carried out a study of the dynamics in the extended complex plane of the Schröder method applied to polynomials with two distinct roots $a,b\in\mathbb{C}$, with any multiplicities $m,n\in\mathbb{N}$.

Using topological conjugation as a mathematical tool, we have proved analytically that if m>n the Julia set, associated with the corresponding iteration functions, are circles with a centre and radius easily expressed as a function of a, b, m and n. And if m=n the Julia set is the bisector line between the roots a, b. The result has a clear analogy with Cayley's problem for Newton's method, although that problem only considers the case of simple roots.

Joint work with Gutiérrez Jiménez, José Manuel (Universidad de La Rioja).



Gamonal Fernández, Manuela

Organization

ICMAT - UCM

Email

manuela.gamonal@icmat.es

Title

Distributed Learning-based Control for Unknown Nonlinear Multi-Agent Systems based on Gaussian Processes.

Summary

Control Theory is facing more challenges as technology develops. The increasing necessity of new solutions or procedures as well as the possibility of extracting data for them makes control theory an interesting field to explore in the seek of new solutions based on data, creating a whole new field, data-driven control. Besides, formation control algorithms for multi-agent systems have multiple applications due to the increasing amount of mobile and aerial robotic swarms. In this poster I propose a control law reinforced by data for the control of flocking behaviour in a multi-agent system based on Gaussian Process Regression.

Joint work with Leonardo Colombo, D. (ICMAT).



González-Santander Martínez, Juan Luis

Organization

Universidad de Oviedo

Email

gonzalezmarjuan@uniovi.es

Title

Numerical validation of the analytical solution for the transient temperature field in dry surface grinding

Summary

Considering the Samara–Valencia model for heat transfer in dry surface grinding, analytical expressions for the time-dependent temperature field of the workpiece during the transient regime in which the wheel is disengaged from the workpiece are calculated. A constant heat flux profile along the contact zone between the wheel and the workpiece has been considered. Also, a very rapid method is described for the numerical evaluation of maximum temperature at the workpiece edge. The numerical computation of the solution of the boundary-value problem confirms the proposed analytical method.



Granero-Belinchón, Rafael

Organization

Universidad de Cantabria

Email

rafael.granero@unican.es

Title

Waves with viscosity

Summary

The motion of a free boundary incompressible flow is a classical research topic. Even if in most situations in engineering the assumption of inviscid flow leads to accurate results, there are other physical scenarios where the even viscosity needs to be taken into account. In addition, fluids in which both time reversal and parity are broken can display a dissipationless viscosity that is odd under each of these symmetries. This viscosity is called odd viscosity. This poster considers the motion of capillary-gravity waves with both types of viscosities. Based on joint works with Ortega, Alejandro (UC3M) and Scrobogna, Stefano (US).



Marqués Lobeiras, Alejandro

Organization

Universidad de Oviedo

Email

UO225279@uniovi.es

Title

Geometry of the 2-D tents

Summary

The 2-D tent map family, written in complex notation as

$$\Gamma_{a,\theta}(x+iy) = ae^{i\theta}(1-|1-x|+iy),$$

generalizes the classical tent map family to the real plane. Here we carry out a study with a geometric flavour of the strictly invariant sets for $\Gamma_{a,\theta}$ with a>1 and $0<\theta<\pi$ before searching for its two-dimensional strange attractors. This work is strongly motivated towards the proof of the existence of such attractors for the family of two-dimensional quadratic transformations appearing in unfoldings of generalized tangencies.

Joint work with Vigil, Enrique (Universidad de Oviedo)



Márquez Lozano, Almudena del Pilar

Organization

Universidad de Cádiz

Email

almudena.marquez@uca.es

Title

Symmetry analysis and conservation laws of a family of non-linear viscoelastic wave equations

Summary

This work considers a non-linear viscoelastic wave equation with non-linear damping and source terms. We analyze the partial differential equation from the point of view of Lie symmetries. Firstly, we apply Lie's classical method to obtain new symmetries. Hence, we transform the partial differential equation into an ordinary differential equation, by using the symmetries. Afterward, new traveling wave solutions are derived from the ordinary differential equations. Finally, by using the direct method of multipliers, we construct low-order conservation laws depending on the form of the damping and source terms.

Joint work with Prof. Bruzón, M. S. (University of Cadiz)



Varela Rodríguez, Hiram

Organization

Universidade da Coruña

Email

hiram.varela@udc.es

Title

A posteriori error analysis of an augmented dual-mixed method of a nonlinear Dirichlet problem

Summary

We deal with a nonlinear elliptic problem in divergence form, which appears in steady heat conduction and magnetostatics. We present an augmented dual-mixed finite element method with three unknowns and derive an a posteriori error indicator of residual type, which is reliable and locally efficient. We carry out several numerical experiments with singular solutions, compare uniform and adaptive meshings, and check the accuracy of the proposed a posteriori error indicator. This is a joint work with González Taboada, María Universidade da Coruña.

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