MA01

Numerical Methods for Applied Mathematics.

Métodos Numéricos para Matemáticas Aplicadas

Organizers **Organizadores** **Antolatzaileak**

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Description **Descripción** **Deskribapena**

Numerical methods play a crucial role in solving mathematical problems that cannot be tackled analytically. These methods involve approximating solutions using computational techniques. Over the years, advancements in technology have significantly enhanced our ability to handle complex problems numerically. This fact allows us to study more realistic situations.
Numerical methods can be applied in a broad variety of fields, like economy, engineering, industry, physical and natural science. Furthermore, they can be applied to different mathematical objects, like differential equations and neural networks, among others.

Los métodos numéricos desempeñan un papel crucial en la resolución de problemas matemáticos que no pueden abordarse analíticamente. Estos métodos implican aproximar soluciones mediante técnicas computacionales. A lo largo de los años, los avances tecnológicos han mejorado significativamente nuestra capacidad para manejar problemas complejos de manera numérica. Este hecho nos permite estudiar situaciones más realistas.
Los métodos numéricos se aplican en una amplia variedad de campos, como la economía, la ingeniería, la industria, las ciencias físicas y naturales. Además, se pueden aplicar a diferentes objetos matemáticos, como ecuaciones diferenciales y redes neuronales, entre otros.

MSC Codes **Códigos MSC** **MSC Kodeak**

65-XX

(primary)

65Mxx; 65Zxx; 68T07

(secondary)

Slots **Bloques** **Blokeak**

1.A (Aula 0.8); 1.B (Aula 0.8); 2.C (Aula 0.15)

QR Code **Código QR** **QR Kodea**

Session Schedule **Horario de la Sesión** **Saioaren Ordutegia**

L13 | 17:30-17:50 | 0.8
Data-Driven Reduced-Order Modeling for Multiscale Dynamical Systems Using POD-based techniques
Alejandro Bandera Moreno (Universidad Loyola Andalucía)

L13 | 18:30-18:50 | 0.8
On the stiff stochastic models
Ignacio Roldán Bocanegra (Universidad de Sevilla)

M14 | 15:00-15:20 | 0.8
Universality for non-linear convex variational problems
Pablo M. Berná (CUNEF Universidad)

M14 | 15:30-15:50 | 0.8
A mathematical approach to the Grover-Rudolph quantum algorithm
Daniela Falcó-Pomares (Grupo de investigación BISITE)

M14 | 16:00-16:20 | 0.8
Stochastic quadrature rules for solving PDEs using Neural Networks
Jamie M. Taylor (CUNEF Universidad)

V17 | 9:00-9:20 | 0.8
Well-balanced semi-implicit schemes for shallow water models
Celia Caballero Cárdenas (Universidad de Málaga)

V17 | 9:30-9:50 | 0.8
Evaluation of augmented Riemann solvers applied to the shallow water equations using intrusive POD-based reduced-order models
Pablo Solán-Fustero (University of Zaragoza)

V17 | 10:00-10:20 | 0.8
POD-based reduced order models for parameter-dependent hyperbolic PDEs: dealing with nonlinearities and well-balancedness
Irene Gómez Bueno (Universidad de Málaga)

V17 | 10:30-10:50 | 0.8
Avoiding order reduction in evolutionary PDEs with rational and exponential methods.
Carlos Arranz Simón (Universidad de Valladolid)

Monday 13 | **Lunes 13** | **Astelehena 13**
17:30-17:50 | **17:30-17:50** | **17:30-17:50**
[Room 0.8] | **[Aula 0.8]** | **[Gela 0.8]**

Data-Driven Reduced-Order Modeling for Multiscale Dynamical Systems Using POD-based techniques

Alejandro Bandera Moreno
(Universidad Loyola Andalucía)

We present a novel ROM technique based on the POD for dynamical systems with multiple timescales. Our method retains the original model's structure, often lost in traditional POD, while significantly reducing the number of equations and computational time. Using a data-driven analysis, it automatically identifies the optimal structure for the reduced system. Numerical tests on three neural network models with multiple timescales validate the technique's effectiveness.

Joint work with Soledad Fernández García, Macarena Gómez Mármol and Alexandre Vidal.

doi:10.1016/j.cnsns.2024.107844

Monday 13 | **Lunes 13** | **Astelehena 13**
18:30-18:50 | **18:30-18:50** | **18:30-18:50**
[Room 0.8] | **[Aula 0.8]** | **[Gela 0.8]**

On the stiff stochastic models

Ignacio Roldán Bocanegra
(Universidad de Sevilla)

This work introduces a new second-order stochastic scheme based on the TR-BDF2 method, applied to the numerical analysis of stochastic differential equations. While numerical resolution in deterministic contexts is well-established, stochastic terms capture the inherent randomness in natural processes. We analyze the stability and accuracy of the proposed scheme in stiff stochastic scenarios, validating the theoretical results with numerical tests.

Tuesday 14	**Martes 14**	**Asteartea 14**
15:00-15:20	**15:00-15:20**	**15:00-15:20**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

Universality for non-linear convex variational problems

Pablo M. Berná
(CUNEF Universidad)

In this talk we will introduce a mathematical framework designed to tackle non-linear convex variational problems in reflexive Banach spaces. The approach employs a versatile technique that can handle a broad range of variational problems, including standard ones.

Joint work with Antonio Falcó.

Tuesday 14	**Martes 14**	**Asteartea 14**
15:30-15:50	**15:30-15:50**	**15:30-15:50**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

A mathematical approach to the Grover-Rudolph quantum algorithm

Daniela Falcó-Pomares
(Grupo de investigación BISITE)

This talk explores the mathematical approach around the Grover-Rudolph algorithm, which provides an efficient method to create quantum states representing probability distributions. Grounded in quantum probability theory and operator algebras, it offers a formal basis for understanding quantum algorithm implementations. It bridges theoretical cryptography with practical quantum computing, exploring quantum algorithm advancements.

Joint work with Antonio Falcó and Hermann Mathies.

Tuesday 14	**Martes 14**	**Asteartea 14**
16:00-16:20	**16:00-16:20**	**16:00-16:20**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

Stochastic quadrature rules for solving PDEs using Neural Networks

Jamie M. Taylor
(CUNEF Universidad)

When solving PDEs using Neural Networks, most errors and computational costs arise from the numerical integration of the loss. In this talk, we demonstrate how using fixed integration rules in the Deep Ritz Method lead to disastrous overfitting, whilst biased stochastic integration rules lead to erroneous results. We propose the use of high-order, unbiased, stochastic rules, which provide significant gains in convergence for low-dimensional problems compared to existing techniques.

Joint work with David Pardo.

Friday 17	**Viernes 17**	**Ostirala 17**
9:00-9:20	**9:00-9:20**	**9:00-9:20**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

Well-balanced semi-implicit schemes for shallow water models

Celia Caballero Cárdenas
(Universidad de Málaga)

This work focuses on the design of well balanced semi-implicit schemes for one dimensional shallow water models, such as the two-layer one or shallow water with moments. In order to do so, splitting and relaxation techniques are employed. The proposed methods outperform standard explicit schemes in the low Froude regime, where celerity is larger than fluid velocity, avoiding the need for many iterations on large time intervals.

Joint work with M.J. Castro, C. Chalons, T. Morales de Luna, and M.L. Muñoz-Ruiz.

Friday 17	**Viernes 17**	**Ostirala 17**
9:30-9:50	**9:30-9:50**	**9:30-9:50**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

Evaluation of augmented Riemann solvers applied to the shallow water equations using intrusive POD-based reduced-order models

Pablo Solán-Fustero
(University of Zaragoza)

The numerical resolution of the shallow water equations by means of augmented Roe-based Finite Volume methods involves high computational costs. Intrusive reduced-order models (ROMs) are presented as alternative to speed up computational calculations without compromising the accuracy of the solutions. In this contribution, we study whether the inclusion of numerical corrections in the ROM strategy is necessary to obtain proper solutions or not.

Joint work with José Luis Gracia, Adrián Navas-Montilla, and Pilar García-Navarro.

Friday 17	**Viernes 17**	**Ostirala 17**
10:00-10:20	**10:00-10:20**	**10:00-10:20**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

POD-based reduced order models for parameter-dependent hyperbolic PDEs: dealing with nonlinearities and well-balancedness

Irene Gómez Bueno
(Universidad de Málaga)

This work studies 1D hyperbolic systems of balance laws. These systems have stationary solutions which are important to be preserved. We explore reduced-order models (ROMs) using Proper Orthogonal Decomposition (POD) to reduce computational costs. Our results show that ROMs based on well-balanced full-order models (FOMs) preserve balance. Furthermore, we extend the analysis to parameter-dependent systems to provide accurate approximations for different values of the parameter.

Joint work with Enrique D. Fernandez-Nieto, and Samuele Rubino.

Friday 17	**Viernes 17**	**Ostirala 17**
10:30-10:50	**10:30-10:50**	**10:30-10:50**
[Room 0.8]	**[Aula 0.8]**	**[Gela 0.8]**

Avoiding order reduction in evolutionary PDEs with rational and exponential methods.

Carlos Arranz Simón
(Universidad de Valladolid)

It is well known that a Runge-Kutta method of order p applied to time integrate a initial boundary value problem (IBVP) suffers from the so called order reduction. It occurs that the method exhibits a lower order of convergence which is related to the stage order of the method, rather than to p itself. New numerical schemes, based on rational and exponential methods, are introduced to avoid order reduction for typical evolutionary PDEs, such as diffusion-reaction equations or advection equation.

From joint works with César Palencia, Begoña Cano and Alexander Ostermann.

arXiv:2405.04195