



International Workshop on Deterministic and Stochastic Dynamics and Applications

María J. Garrido-Atienza in memoriam

March 23-24, 2023, Elche, Spain

Program and Abstracts



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International Workshop on Deterministic and Stochastic
Dynamics and Applications

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Sponsored by Generalitat Valenciana (Proyecto de Grupos de Investigación de Excelencia Prometeo 2021/063), Centro de Investigación Operativa, Departamento de Estadística, Matemáticas e Informática (Universidad Miguel Hernández), and Project PID2021-122991NB-C21 (Ministerio de Ciencia e Innovación, Spain)

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Preamble

The International Workshop on Deterministic and Stochastic Dynamics and Applications takes place in the city of Elche, Spain, from 23 until 24 of March, 2023. It is hosted by the Center of Operations Reserach (CIO) and the Department of Statistics, Mathematics and Computer Science at the University Miguel Hernández of Elche.

The city of Elche is famous for its palm forest (el Palmeral), which has been declared a World Heritage Site by UNESCO. We are sure that this nice environment will make the meeting comfortable and pleasant for all the participants. We offer our warmest possible welcome to the conference.

This workshop is dedicated to the memory of professor María José Garrido-Atienza, who unfortunately passed away too early on the day of her 49-th birthday, on January 24, 2021. The terrible illness she had in 2013, and which she overcame with great effort and fortitude, returned again in 2020 with much more intensity and, despite the hard fight she fought, it was not able to win the battle this time.

María J. Garrido-Atienza studied Mathematics at the University of Seville during the years 1989-1994, defended her Bachelor's Thesis in June 1995 and, after a short period as an associate professor at the universities of Huelva and Cádiz (from 1995 to 1998), she finally joined the Department of Differential Equations and Numerical Analysis of the University of Seville in November 1998, where she would spend his entire academic career. After obtaining her PhD in May 2002, she got a permanent position as Assistant Professor (Profesor titular de Escuela Universitaria) in May 2004, and later in August 2008 she got promoted to Associate Professor (Profesor Titular de Universidad).

Her first research were in the field of stochastic partial differential equations with delays, and later she enlarged the topics of investigation to mainly analyze random dynamical systems, and more specifically, those problems that contain fractional noise. On this topic, she has published joint works with a good number of recognized researchers, especially with Björn Schmalfuß and some of his collaborators. She is the author or co-author of more than 50 scientific papers published in prestigious international journals and that accredit a high level of citations, and she has been also associate editor of several scientific journals. She has been part of the research group "Stochastic Analysis of Differential Systems (AESDIF)", contributing with her work to its success.

With the departure of María José, the mathematical community in dynamical systems and stochastic partial differential equations has suffered a great loss. She was a very mature and increasingly independent researcher, who had achieved great specialization in some of the aspects of the stochastic dynamics associated with partial differential equations. In her multiple stays and attendances to top-level conferences, she has been able to open these fields of research to a large number of collaborators and international institutions, projecting the reputation and visibility of both the University of Seville and Spanish mathematics. It has been a great pleasure and a privilege to have her with us in our research group all this time. We will never forget her.

The Faculty of Mathematics of the University of Seville, the Mathematics Research Institute (IMUS), the Department of Differential Equations and Numerical Analysis and, very particularly, our research group and her national and international collaborators will miss her very much. We had walked together in our academic lives for several decades. Her students will remember her good teaching, full of true enthusiasm, professionalism and training responsibility.

María José visited the university Miguel Hernández of Elche many times, where she undoubtedly left an indelible mark. People who met her in Elche remember her fondly and warmly. It is sad that her periodic visits to Elche at the beginning of each year have been truncated so suddenly. The Center of Operations Research (CIO) and the Department of Statistics, Mathematics and Computer Science will miss very much as well.



María José Garrido-Atienza

María José was a very kind, brave, warm, vital, joyful, full of life energy and optimism, enthusiastic person, and a source of happiness in any meeting she participated. Since her departure, we are missing her smile, laughter, her special way of being. We have lost a great researcher who was, without any doubt, in the best moment of her professional career, as she had just obtained in 2020 her first big project as a Principal Investigator, and precisely in March 2021 she received her posthumous accreditation to become Full Professor (Catedrático de Universidad). All these facts are the full recognition of her great work, and we, her family, research group and collaborators, feel very proud of her. We will keep her forever in our hearts.

The participants of this workshop knew María José, were friends of her, and most of them have been her collaborators in research papers and meetings. All of them were proud of her mathematical skill and, specially, of her human qualities.

The talks of this meeting are related to the theory of deterministic and stochastic dynamical systems and are close to the research topics María José worked in.

The organizing and scientific committees would like to thank the invited speakers for their contributions, without which this meeting could not take place. Also, special thank go to the sponsors of the event: the University Miguel Hernández (in particular, the University Institute CIO (Center of Operations Research) and the Department of Mathematics, Statistics and Computer Science), the Generalitat Valenciana (Proyecto de Grupos de Investigación de Excelencia Prometeo 2021/063), and the Spanish Ministry of Science and Innovation of Spain (Project PID2021-122991NB-C21).

Finally, as chairmans of the conference, we would like to thank the members of the local organizing committee Óscar Martínez-Boonastre and Raúl Moragues for their effort and dedication to the preparation of the meeting, and also the members of the Scientific Committee

Björn Schmalfuss and Arne Ogrowsky. Thank you all for making this conference possible!

José Valero and Tomás Caraballo
Chairs of the conference
On behalf of the scientific and organizing committees
Elche (SPAIN), March 2023

Venue and Wi-Fi connection

Venue

The workshop takes place at the Center of Operations Research (CIO), Torretamarit building, room 0.1.

Lunches

The lunches will be held at the cafeteria located at the rectorate building.

Workshop dinner

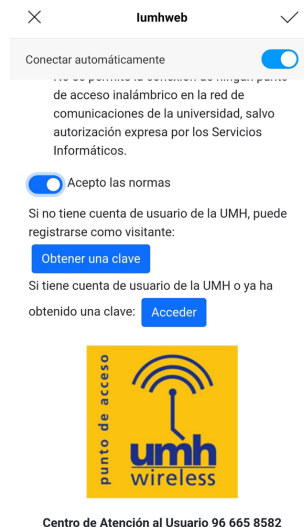
The workshop dinner will be held at the hotel Milenio on Thursday, March 23 at 8:30 p.m.

Intructions for the Wi-Fi connection

The visitors can connect to the institutional Wi-Fi network by registering with a form. See setup instructions below.

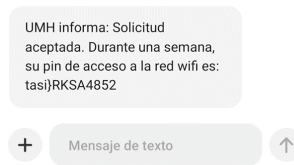
1º Selection of the Wi-Fi network Iumhweb It is an open connection that allows, through a captive portal, to connect to the network with Wi-Fi coverage at the UMH.

2º Validation in the Wi-Fi network Iumhweb Just select the Iumhweb network and open a browser. In the lower part of the window it is necessary to accept the rules of use by checking the check box and two options appear to connect: register as a visitor or access if you already have a password.



When you click on "obtain a password" a screen appears where you have the option of having the UMH send you an SMS with a password. You just have to fill in the form and click on "Generate a password". Indicate the telephone number to send you an SMS with the password for access to the Wi-Fi network (valid for 7 days). For international numbers, indicate the country to select the correct prefix of your country (Spain +34). You will also see a simple question to solve and to validate the request.

You will receive an SMS message on your phone with the access password.



Enter the phone number followed by @umh.es and the password received by SMS (valid for 7 days).

Program

	Thursday, March 23, 2023
	Torretamarit building, room 0.1
9:00-9:15	Opening
9:15-10:00	Tomás Caraballo
	<i>The 49.0 stochastic years of María José Garrido</i>
10:00-10:45	Björn Schmalfuß
	Averaging of a slow-fast system driven by fractional Brownian motions
10:45-11:15	Coffee break
11:15-12:00	Hakima Bessaih
	<i>On the 3D Navier-Stokes equations with delays</i>
12:00-12:45	Javier López
	<i>Comparison between white and real noise to model disturbances on the input flow in chemostats</i>
12:45-13:30	Luu Hoang Duc
	<i>A rough model for asset price under transaction cost</i>
13:30-16:00	Lunch
16:00-16:45	Robert Hesse
	Almost sure averaging for rough slow-fast equations
16:45-17:30	Rubén Caballero
	Inner dynamic for a nonlocal Chafee-Infante problem
17:30-17:45	Coffee break
17:45-18:30	José María Amigó
	Generalized entropies and complexity classes
20:30	Workshop dinner

	Friday, March 24, 2023
	Torretamarit building, room 0.1
9:15-10:00	Andreas Neuenkirch
	<i>SDEs driven by fractional Brownian motion: dependence on the Hurst parameter</i>
10:00-10:45	Peter Kloeden
	Nonautonomous and stochastic bifurcations: a personal history
10:45-11:15	Coffee break
11:15-12:00	Petr Čoupek
	Fractional processes and stochastic integrals
12:00-12:45	Verena Köpp
	Synchronization of stochastic complex networks of reaction diffusion equations
12:45-13:30	José Valero
	Dynamics of an stochastic evolution equation driven by a fractional noise
13:30-16:00	Lunch

Abstracts

Invited speakers

José M. Amigó	Universidad Miguel Hernández de Elche, Spain
Hakima Bessaih	Florida International University, USA
Rubén Caballero	Universidad Miguel Hernández de Elche, Spain
Petr Coupek	Charles University, Czech Republic
Luu Hoang Duc	Max-Planck-Institut für Mathematik in den Naturwissenschaften, Germany
Robert Hesse	Friedrich Schiller Universität Jena, Germany
Peter E. Kloeden	Universität Tübingen, Germany
Verena Köpp	Friedrich Schiller Universität Jena, Germany
Javier López de la Cruz	Universidad Politécnica de Madrid, Spain
Kening Lu	Brigham Young University, USA
Andreas Neuenkirch	Universität Mannheim, Germany
Björn Schmalfuss	University of Paderborn, Germany

GENERALIZED ENTROPIES AND COMPLEXITY CLASSES

José M. Amigó
Universidad Miguel Hernández

In this talk I will review the concepts of symbolic dynamics and complexity classes, and show how a generalized entropy can be built for each complexity class.

ON THE 3D NAVIER-STOKES EQUATIONS WITH DELAYS

Hakima Bessaih
Florida International University

A modified version of the three-dimensional Navier-Stokes equations is considered with periodic boundary conditions. A bounded constant delay is introduced into the convective term, that produces a regularizing effect on the solution. In fact, by assuming appropriate regularity on the initial data, the solutions of the delayed equations are proved to be regular and, therefore, existence and uniqueness of a global weak solution is obtained. Moreover, the associated flow is constructed, and the continuity of the semigroup is proved. Finally, we investigate the passage to the limit on the delay, obtaining that the limit is a weak solution of the Navier-Stokes equations. The long-time behavior is investigated.

INNER DYNAMIC FOR A NONLOCAL CHAFEE-INFANTE PROBLEM

Rubén Caballero Toro⁽¹⁾, Alexandre Nolasco de Carvalho⁽²⁾,
Pedro Marín-Rubio⁽³⁾, José Valero Cuadra⁽¹⁾
⁽¹⁾Universidad Miguel Hernández
⁽²⁾Universidade de São Paulo
⁽³⁾Universidad de Sevilla

If we consider the non-local equation

$$\frac{\partial u}{\partial t} - a(\|u\|_{H_0^1}^2) \frac{\partial^2 u}{\partial x^2} = \lambda f(u) \quad (1)$$

with Dirichlet boundary conditions, then it is possible to define a suitable Lyapunov functional. In [1] it is shown that regular and strong solutions generate (possibly) multivalued semiflows having a global attractor which is described by the unstable set of the stationary points. In the case where the function f is odd and equation (1) generates a continuous semigroup the existence of fixed points of the type given in the Chafee-Infante problem was established in [2]. Moreover, if a is non-decreasing, then they coincide with the ones in the Chafee-Infante problem. In this work we extend these results for a more general function f . Our goal is to describe the structure of the attractor as accurately as possible. For this aim, we focus on the particular situation where the domain is one-dimensional and the function f is of the type of the standard Chafee-Infante problem, for which the dynamics inside the attractor has been completely understood [3].

References

- [1] R. Caballero, P. Marín-Rubio, J. Valero. *Existence and characterization of attractors for a nonlocal reaction-diffusion equation with an energy functional*. J. Dynamics Differential Equations. **34** (2022) 443-480.
- [2] CarLiLuMoA.N. Carvalho, Y. Li, T.L.M. Luna, E. Moreira. *A non-autonomous bifurcation problem for a non-local scalar one-dimensional parabolic equation*. Commun. Pure Appl. Anal. **19** (2020) 5181-5196.
- [3] D. Henry. *Some infinite-dimensional Morse-Smale systems defined by parabolic partial differential equations*. J. Differential Equations. **59** (1985) 165-205.

THE 49.0 STOCHASTIC YEARS OF MARÍA JOSÉ GARRIDO

Tomás Caraballo
Universidad de Sevilla

In this talk I will try to talk about the contributions of María José to the scientific literature during the exact 49 years that she was in person in this world.

FRACTIONAL PROCESSES AND STOCHASTIC INTEGRALS

Petr Čoupek
Charles University

The talk will be devoted to some recent results on stochastic processes represented by iterated Wiener integrals whose covariance function coincides with that of a fractional Brownian motion (FBM). Besides the FBM itself, there are many processes that can be considered; e.g. the Rosenblatt or the fractionally filtered Hermite processes.

In the first part of the talk, we will focus on sample path properties of these processes and we will give sufficient conditions for their trajectories to belong to a certain exponential Besov-Orlicz space. This result extends what is known for the FBM to processes in an arbitrary finite Wiener chaos.

In the second part of the talk, we will focus on integration of deterministic Banach-space-valued functions with respect to these processes. The class of Banach spaces that can be considered includes a large variety of the most commonly used function spaces such as the Lebesgue spaces, Sobolev spaces, or, more generally, the Besov and Lizorkin-Triebel spaces. We will give a characterization of the domains of the integrals - in general, the integrand takes values in the space of γ -radonifying operators from a certain homogeneous Sobolev-Slobodeckii space into the considered Banach space - and apply the results to stochastic convolution for which necessary and sufficient conditions for existence and measurability will be given.

A ROUGH MODEL FOR ASSET PRICE UNDER TRANSACTION COST

Luu Hoang Duc
 Max-Planck-Institut für Mathematik in den Naturwissenschaften
 Leipzig

We develop a general mathematical framework, based on rough path theory, that can incorporate the empirically observed nonlinear mean-variance relation of the logarithmic return in a systematic manner. This model offers the possibility of an additional noise hidden in the rough path lift, hence supporting the idea of mixture of a Gaussian noise that is close to a standard Brownian motion and another source of long memory noise (a fractional Brownian motion for instance), that can account for the multi-scaling phenomenon in financial data. The no-arbitrage principle is then proved under the assumption of transaction costs as long as the driving noise is sticky, e.g. strong Markov or of conditional full support.

(Joint work with Jürgen Jost)

ALMOST SURE AVERAGING FOR ROUGH SLOW-FAST EQUATIONS

Robert Hesse,
 Friedrich Schiller Universität Jena

In this talk we consider a slow-fast system of stochastic differential equations with time scaling parameter $\varepsilon > 0$. The slow component X^ε is driven by a multiplicative noise $h(X^\varepsilon)d\omega^1$, while the fast component Y^ε is driven by an additive noise $d\omega^2$. Here ω^1 and ω^2 are canonically given, independent fractional Brownian motions with Hurst parameters in $(\frac{1}{3}, \frac{1}{2}]$.

By constructing a rough path from the noise (ω^1, ω^2) it is possible to interpret these SDEs as rough ODEs. The latter can be solved by methods provided by the rough paths theory. This allows to state important estimates of both components X^ε and Y^ε . Moreover, we introduce a random fixed point of the fast equation and further the solution of the average equation \bar{X} . Finally, we show by estimating the rough path metric of the slow component that with probability one X^ε converges to \bar{X} , as ε goes to zero.

The talk is based on a joint work with Bin Pei and Björn Schmalfuß.

NONAUTONOMOUS AND STOCHASTIC BIFURCATIONS: A PERSONAL HISTORY

Peter Kloeden
 Universität Tübingen

I visited Ludwig Arnold in Bremen in the early 1980s to talk about stochastic bifurcations. He seemed the natural person to ask since he and his group had been looking at stability and loss of stability in linear stochastic systems. We worked hard on what we thought was a straightforward basic problem and got nowhere, and then turned to other things such as stochastic attractors and stochastic numerics, but always with stochastic bifurcations in the back of our minds. I will discuss the above failed attempt, related ideas and work by myself and others during the twenty year period 1990-2010 on bifurcations in both stochastic and nonautonomous deterministic systems, which have many features in common.

SYNCHRONIZATION OF STOCHASTIC COMPLEX NETWORKS OF REACTION DIFFUSION EQUATIONS

Verena Köpp
Friedrich-Schiller-Universität Jena

We consider a network that consists of reaction-diffusion equations and is connected through both a deterministic and a stochastic coupling. If the intensity of the deterministic coupling is strong enough, we prove that all elements of the network will eventually exhibit the same behavior, resulting in synchronization. This synchronized state can be described by a related deterministic equation.

(This talk is based on joint work with Hakima Bessaih)

COMPARISON BETWEEN WHITE AND REAL NOISE TO MODEL DISTURBANCES ON THE INPUT FLOW IN CHEMOSTATS

Javier López-de-la-Cruz
Universidad Politécnica de Madrid

A chemostat is a laboratory device used to study the growth of some species of microorganisms in presence of a nutrient. There are many applications of chemostats in real life, for instance, they can be used to model waste water treatment processes, antibiotic production, renewable energy development or fermentation processes, to name a few examples.

Even though the classical chemostat model has provided detailed information about the long-time dynamics of the state variables of the corresponding system, it is deterministic and then strong restrictions are taken into account, for instance, the input flow (the coefficient that describes how the nutrient is provided to the species) is assumed to be constant. However, real data from laboratories reveal that the aforementioned input flow is subject to suffer disturbances that seem to be random.

Therefore, the purpose of the talk is to show different ways to model random disturbances on the input flow in the chemostat model. On the one hand, the classical white noise will be used. As a result, some drawbacks will be found from the biological point of view, due to the nature of the noise, which is unbounded on time. On the other hand, another stochastic process will be used to model random perturbations that are bounded. This second way of modeling randomness will allow us to provide conditions under which the persistence of the species can be ensured, the most important goal in practice.

Finally, several numerical simulations will be displayed to compare the differences between both ways of modeling randomness on the input flow in the classical chemostat model, apart from presenting some interesting problems in population dynamics that are currently open and involve bounded random fluctuations.

SDES DRIVEN BY FRACTIONAL BROWNIAN MOTION: DEPENDENCE ON THE HURST PARAMETER

Andreas Neuenkirch
Universität Mannheim

We show that the Mandelbrot-van Ness representation of fractional Brownian motion is almost surely smooth in the Hurst parameter H . This dependence result is transferred to the solution of a stochastic differential equation driven by fractional Brownian motion if the stochastic differential equation is one-dimensional or if $H > 1/2$. In the multidimensional case and $H \in (1/3, 1/2]$ we use rough path theory to make sense of the differential equations. However, despite it being possible to lift fractional Brownian motion as well as its derivative in H to a rough path via the limit of dyadic approximations, they cannot be lifted jointly in the same way. Nevertheless, we obtain that the solution to a rough stochastic differential equation driven by fractional Brownian motion is locally Lipschitz continuous in H .

This talk is based on the PhD thesis of Stefan Koch, which I supervised.

AVERAGING OF A SLOW-FAST SYSTEM DRIVEN BY FRACTIONAL BROWNIAN MOTIONS

Björn Schmalfuß
Friedrich-Schiller-Universität Jena

One topic in the theory of random dynamical systems are random fixed points. When the fast component of our system is driven by a Brownian motion the stationary measure of the Markov semigroup allows to formulate the averaged equation. This is not possible when the driver is a fractional Brownian motion ($H \leq 1/2$). But this kind of equation defines a random dynamical system which has under particular assumptions a random fixed point. This random fixed point allows to formulate an averaged equation. The solution then is the limit of the solution of the slow equation when the averaging parameter goes to zero.

(This is a joint work with Bin Pei (Xi'an, China))

DYNAMICS OF AN STOCHASTIC EVOLUTION EQUATION DRIVEN BY A FRACTIONAL NOISE

José Valero
Universidad Miguel Hernández

We consider a Hilbert-valued evolution equation driven by a fractional Brownian motion with Hurst parameter in $(1/2, 1)$. The assumptions on the drift term are weak, so that we are not able to ensure uniqueness of solutions of the Cauchy problem. Nevertheless, by adopting the multivalued setting, we prove that this equation generate a (multivalued) nonautonomous dynamical system. After that, by constructiong a suitable new metric dynamical system for the noise, we prove the measurability of the process, obtaining in this way a (multivalued) random dynamical system. Finally, we prove the existence of a random attractor.

List of participants

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