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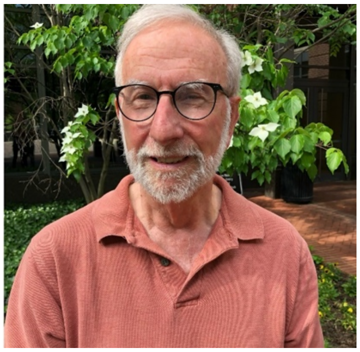

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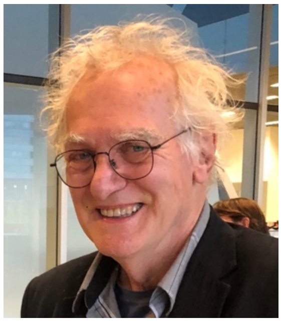

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Plenary Talks

The Ohio State University, USA

Title: Quantifying approximate symmetries in biological systems

Abstract: What do leaves and human faces have in common? What about daisies and sea urchins? They possess bilateral and rotational symmetries! Symmetry is a fundamental feature of natural systems, and is often correlated with survival, fecundity, and evolvability. While symmetry is ubiquitous and often intuitively obvious, symmetry in biological organisms is rarely perfect, making it challenging to apply mathematical definitions of idealized symmetry. To address this challenge, we developed a flexible, entropy-based method for quantifying symmetry that requires very little user input. I will highlight some novel insights arising from applications of this measure, including evidence for convergent evolution in flowering plants, classification of biopolymer networks, and visualization of the emergence and loss of symmetries in pattern formation systems.

Bio: Dr. Adriana Dawes is a Professor at The Ohio State University, with a joint appointment in the Department of Mathematics and the Department of Molecular Genetics. Prof. Dawes' research tightly weaves experimental and theoretical approaches to better understand how biochemical, mechanical and geometric cellular features interact and regulate each other during development to give rise to a functional organism. Her research connects dynamics across multiple scales, using experimentally validated mathematical models to investigate force generation and large scale movement in the cell, and revealing how the structure of signaling networks interacts with genetic backgrounds to produce tissue-specific responses. Prof. Dawes is the recipient of an NSF CAREER award, and has also been funded by NIH and private foundations, including the Gordon and Betty Moore Foundation.

University of Liège, Belgium

Title: Breaking Indecision in Multiagent, Multioption Dynamics

Abstract: How does a group of agents break indecision when deciding about options with qualities that are hard to distinguish? Biological and artificial multiagent systems, from honeybees and bird flocks to bacteria, robots, and humans, often need to overcome indecision when choosing among options in situations in which the performance or even the survival of the group is at stake. Breaking indecision is also important because in a fully indecisive state, where agents are not biased toward any specific option, the agent group is maximally sensitive and prone to adapt to inputs and changes in its environment. Here, we develop a mathematical theory to study how decisions arise from the breaking of indecision. Our approach is grounded in both equivariant and network bifurcation theory. We model decision from indecision as synchrony-breaking in influence networks in which each node is the value assigned by an agent to an option. First, we show that three universal decision behaviors, namely, deadlock, consensus, and dissensus, are the generic outcomes of synchrony-breaking bifurcations from a fully synchronous state of indecision in influence networks. Second, we show that all deadlock and consensus value patterns and some dissensus value patterns are predicted by the symmetry of the influence networks. Third, we show that there are also many "exotic" dissensus value patterns. These patterns are predicted by network architecture but not by network symmetries through a new synchrony-breaking branching lemma. This is the first example of exotic solutions in an application. Numerical simulations of a novel influence network model illustrate our theoretical results.

Bio: Dr Alessio Franci received his Laurea Specialistica Degree in Theoretical Physics from the University of Pisa in 2008 and his PhD in Physics and Control Theory from the University of Paris Sud 11 in 2012. Between 2012 and 2015 he was a postdoctoral researcher at the University of Liege and at INRIA Lille and a long term visiting researcher at the University of Cambridge. Between 2015 and 2022 he was professor in the Math Department of the National Autonomous University of Mexico. Since 2023 he has been professor in the Department of Electrical Engineering and Computer Science of the University of Liege. His research is interdisciplinary but the central focus is on the control-theoretical and computational principles needed to understand and design biological and bio-inspired intelligent behaviors.

University of Porto, Portugal

Title: Network classification using ODE-equivalence

Abstract: It is known that non-isomorphic networks can generate the same space of admissible vector fields, once the cell phase spaces of the networks are identified in a suitable way. Those networks are called ODE-equivalent and previous results on network theory show that two networks are ODE-equivalent if and only if the two networks are linearly equivalent. In this talk we plan to show how to use ODE-equivalence to classify small excitatory-inhibitory networks. This is a joint work with M. Aguiar (Porto) and I. Stewart (Warwick, UK).

Bio: Dr Ana Paula Dias' current position is Associate professor at the Mathematics Department of the Sciences Faculty of the University of Porto, Portugal. Education. Ana Dias received her Ph.D. in Mathematics from the University of Warwick at United Kingdom in 1998 and was awarded a Habilitation in Mathematics from University of Porto, Portugal in 2007. Main research of interest. Impact of the network/hypernetwork at the dynamics and bifurcations of the associated coupled cell systems (dynamical systems with form consistent with the network/hypernetwork). Ana Dias is author of over 45 scientific papers in the area of Dynamical Systems. https://cmup.fc.up.pt/cmup/apdias/publications.html

University of Évora, Portugal

Title: General stochastic differential equation models for population growth and harvesting in random environments: Sustainability, optimization and impact of Allee effects

Joint work with: Clara Carlos and Nuno M. Brites

Abstract: We consider autonomous stochastic differential equation models, one without Allee effects and another with Allee effects, for the growth of a harvested population living in a randomly varying environment, even an environment with density-dependent noise intensities. These models are very general, satisfying only mild regularity assumptions and qualitative biologically driven assumptions, so that the conditions we obtain for population extinction and for the existence of a stochastic equilibrium are robust with respect to model choice. We use Itô calculus but will mention our results on its equivalence to Stratonovich calculus if one takes into account the different physical meaning of the average rates used. For both calculi and for both cases of absence and presence of Allee effects, we show that, if the per capita net growth rate (difference between the geometric average natural growth rate and the harvesting mortality rate) is positive when population size is very small, there is a stochastic equilibriumwith a stationary density. If, however, that rate is negative (overharvesting), the population becomes extinct. The results for Allee effects models are new and extend previous results of members of this team for non-harvested population models and for constant effort particular harvesting models. We then look at the case of constant harvesting effort and constant noise intensity for specific comparable models, namely the logistic (without Allee effects) and the logistic-like Allee effects models, including expressions for stationary densities and expected sustainable profits and yields. We assess the impact of Allee effects by comparing the two models and their optimal profits and yields for the Pacific halibut data.

Bio: Professor Carlos A. Braumann is Emeritus Professor at the Department of Mathematics of the University of Évora (Portugal), elected member of the International Statistical Institute, Honorary Member and 2019 Career Award holder of the Portuguese Statistical Society (SPE) and former President of ESMTB (European Society for Mathematical and Theoretical Biology) and of SPE. He is working on stochastic differential equation models applied to biological phenomena occurring in randomly varying environments, area in which he recently authored a Wiley book.

Acknowledgements: C. A. Braumann (Departamento de Matemática, Escola de Ciências e Tecnologia, Universidade de Évora) and C. Carlos (Escola Superior de Tecnologia do Barreiro, Instituto Politécnico de Setúbal) are members of the Centro de Investigação em Matemática e Aplicações, Instituto de Investigação e Formação Avançada, Universidade de Évora, supported by the Fundação para a Ciência e a Tecnologia (FCT), Project UID/04674/2020, https://doi.org/10.54499/UIDB/04674/2020. N.M. Brites (ISEG/UL – Universidade de Lisboa, Department of Mathematics & REM – Research in Economics and Mathematics, CEMAPRE) was partially funded by FCT, Project CEMAPRE/REM – UIDB/05069/2020, through national funds.

University of Porto, Portugal

Title: On the dynamics of vector fields with univalued solutions

Abstract: We will discuss problems and recent results on the dynamics of differential equations / vector fields with univalued solutions. If time permits we will also discuss potential geometric applications.

Bio: Dr Helena Reis, Associate Professor with habilitation at Faculdade de Economia da Universidade do Porto; Director of CMUP (2023-); Editor-in-chief of Boletim da SPM (2023-) More information: https://www.fep.up.pt/docentes/hreis/

Paderborn University

Title: Glimpse of the Infinite – on the Approximation of the Dynamical Behavior for Delay and Partial Differential Equations

Abstract: Over the last decades so-called set-oriented numerical methods have been developed for the numerical analysis of finite-dimensional dynamical systems. The underlying idea is to approximate the dynamical objects of interest by outer coverings which are created via multilevel subdivision techniques in state space. These schemes have the flexibility to be applied to a variety of problems such as the numerical approximation of invariant manifolds, global attractors or corresponding invariant measures. Since these set-oriented techniques rely on partitions of the (finite-dimensional) state space it is not obvious how to extend them to the situation where the underlying dynamical system is infinite-dimensional. However, in this talk a novel numerical framework for the computation of finite dimensional dynamical objects for infinite dimensional dynamical systems will be presented. Within this framework the classical set-oriented numerical schemes mentioned above are extended to the infinite-dimensional context. The underlying idea is to utilize appropriate embedding techniques for the reconstruction of global attractors in a certain finite dimensional space. This approach will be illustrated by the computation of global attractors both for delay and for partial differential equations such as the Mackey-Glass equation or the Kuramoto-Sivashinsky equation.

Bio: Dr Michael Dellnitz is Chair of Applied Mathematics at Paderborn University, Chairman-Professor at Institut für Industriemathematik, Professor at Paderborn Center for Parallel Computing (PC2), Vorstand, Professor at Paderborn Institute for Scientific Computation (PaSCo). More information here: https://www.uni-paderborn.de/en/person/82

Institute of Complex Systems of the Italian CNR, Florence, Italy

Title: The transition to synchronization of networked systems

Abstract: With the only help of eigenvalues and eigenvectors of the graph's Laplacian matrix, we show that the transition to synchronization of a generic networked dynamical system can be entirely predicted and completely characterized.In particular, the transition is made of a well-defined sequence of events, each of which corresponds to either the nucleation of one(or several) cluster(s) of synchronized nodes or to the merging of multiple synchronized clusters into a single one.The network's nodes involved in each of such clusters can be exactly identified, and the value of the coupling strength at which such events are taking place (and therefore, the complete events' sequence) can be rigorously ascertained.We moreover clarify that the synchronized clusters are formed by those nodes which are indistinguishable at the eyes of any other network's vertex, and as such they receive the same dynamical input from the rest of the network.Therefore, such clusters are more general subsets of nodes than those defined by the graph's symmetry orbits, and at the same time more specific than those described by the network's equitable partitions.Finally, we present large scale simulations which show how accurate our predictions are in describing the synchronization transition of both synthetic and real-world large size networks, and we even report that the observed sequence of clusters is preserved in heterogeneous networks made of slightly non identical systems.

Bio: Professor Stefano Boccaletti received the PhD in Physics at the University of Florence on 1995, and a PhD honoris causa at the University Rey Juan Carlos of Madrid on 2015. He was Scientific Attache' of the Italian Embassy in Israel during the years 2007-2011 and 2014-2018. He is currently Director of Research at the Institute of Complex Systems of the Italian CNR, in Florence. His major scientific interests are i) pattern formation and competition in extended media, ii) control and synchronization of chaos, and iii) the structure and dynamics of complex networks. He is Editor in Chief of the Journal "Chaos, Solitons and Fractals" (Elsevier) from 2013, and member of the Academia Europaea since 2016. He was elected member of the Florence City Council from 1995 to 1999. Boccaletti has published 402 papers in peer-reviewed international Journals, which received more than 36,200 citations (Google Sholar). His h factor is 71 and his i-10 index is 232. With more than 12,300 citations, the monograph ¨Complex Networks: Structure and Dynamics¨, published by Boccaletti in Physics Reports on 2006 converted into the most quoted paper ever appeared in the Annals of that Journal.

University of Copenhagen, Denmark

Title: Estimation of time to a tipping point

Abstract: In recent years there has been an increasing awareness of the risks of collapse or tipping points in a wide variety of complex systems, ranging from human medical conditions, pandemics, ecosystems to climate, finance and society. They are characterized by variations on multiple spatial and temporal scales, leading to incomplete understanding or uncertainty in modelling of the dynamics. Even in systems where governing equations are known, such as the atmospheric flow, predictability is limited by the chaotic nature of the system and by the limited resolution in observations and computer simulations. In order to progress in analyzing these complex systems, assuming unresolved scales and chaotic dynamics beyond the horizon of prediction as being stochastic has proven itself efficient and successful. When complex systems undergo critical transitions by changing a control parameter through a critical value, a structural change in the dynamics happens, the previously statistically stable state ceases to exist and the system moves to a different statistically stable state. To establish under which conditions an early warning for tipping can be given, we consider a simple stochastic model, which can be considered a generic representative of many complex two state systems. We show howthis provides a robust statistical method for predicting the time of tipping. The method is used to give a warning of a forthcoming collapse of the Atlantic meridional overturning circulation.

References: Peter D. Ditlevsen and Susanne Ditlevsen (2023), Warning of a forthcoming collapse of the Atlantic meridional overturning circulation. Nat Commun 14, 4254

Bio: Professor Susanne Ditlevsen is professor of Statistics and Stochastic Models in Biology at Department of Mathematical Sciences at University of Copenhagen in Denmark. She has a Master in Mathematics from Universidad Nacional de Education a Distancia, Spain, and did her PhD in Biostatistics at university of Copenhagen. Her research interests are evolving around stochastic processes and their statistical inference, dynamical systems and biomathematics, with applications in ecology and neuroscience. She is vice-president and heading the section of Natural Sciences of the Danish Royal Academy of Sciences and Letters. She has published around 80 papers.

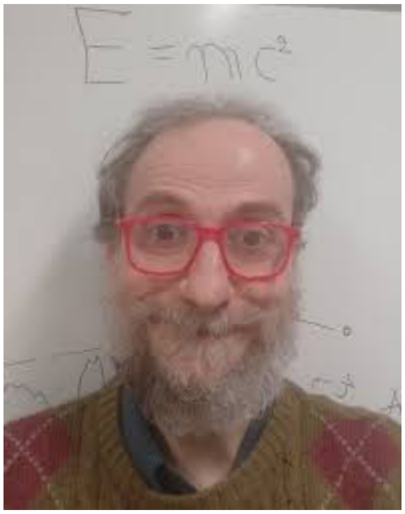
Sapienza University, Italy

Title: Nonlinear wave propagation in metamaterials

Abstract: Wave propagation and stopband behavior of 2D lattices hosting nonlinear resonators made of suspended piezoelectric membranes with a central mass are discussed. A generalized nonlinear version of the plane-wave expansion method is proposed to deliver the nonlinear wave propagation equations. The asymptotic treatment yielding the nonlinear dispersion functions is discussed. An exploration of the design process for semi-adaptively programmable metamaterials is offered, elucidating their potential for wave cloaking applications.

Bio: Walter Lacarbonara is a Professor of Nonlinear Dynamics at Sapienza University and Director of the Sapienza Center for Dynamics. During his graduate education he was awarded a MS in Structural Engineering (Sapienza University) and a MS in Engineering Mechanics (Virginia Tech, USA), and a PhD in Structural Engineering (Sapienza/Virginia Tech). His research interests cover nonlinear structural dynamics; dissipation in carbon nanotube/polymer nanocomposites; asymptotic techniques; nonlinear control of vibrations; experimental nonlinear dynamics; dynamic stability of structures. He is Editor in Chief of Nonlinear Dynamics, former Associate Editor for ASME Journal of Applied Mechanics, Journal of Vibration and Acoustics, Journal of Sound and Vibration. He served as Chair of the ASME Technical Committee on Multibody System and Nonlinear Dynamics, General co-Chair and technical program co-Chair of the ASME 2015 (Boston, USA) and 2013 (Portland, USA) IDETC Conferences. He has organized over 10 international symposia/conference sessions and, very recently, the First, Second, and Third International Nonlinear Dynamics Conferences (NODYCON, www.nodycon.org/2019, www.nodycon.org/2021, www.nodycon.org/2023). His research is supported by national and international sources (EOARD/AFOSR, NSF, European Commission, Italian Ministry of Science and Education). He has published over 250 papers and conference proceedings, 4 international patents (EU/USA/China), 24 book chapters, 6 co-edited Springer books and a single-authored book (Nonlinear Structural Mechanics, Springer, NY, https://link.springer.com/book/10.1007/978-1-4419-1276-3) for which he received the 2013 Texty Award nomination by Springer US.

Invited Talks



University of Trieste, Italy

Title: A spatiotemporoal random walk in Behavioral Epidemiology

Abstract: Human behavior, and in particular vaccine hesitancy, is a critical factor for the control of childhood infectious disease. Human decisions depends on information that is intrinsically non-local in space and in time. We show that under a series of important epidemiological assumption, the interplay between spatial and temporal nonlocality may induce a number of complex patterning and oscillations, including spatio-temporal chaos. Additionally we briefly illustrate a new simple algorithm for the computation of the Maximum Lyapunov Exponent of a chaotic system.

Bio: Dr Alberto d'Onofrio is senior researcher at the department of Mathematics and GEosciences of the University of Trieste (Italy) where he leads the "Computer Science for Complex Systems" laboratory. After a MSc in Control Engineering at Pisa University, he got a PhD i"Medical Computer Sciences" from Rome "La Sapienza" University in 2000. He has been postdoc (2000-2002), researcher (2003-2008) and Group Leader (2008-2013) in biomathematics at the European Institute of Oncology, Milan (Italy). Then from 2014 to 2020 he has been one of principal investigators at the "International Prévention Research Institute", Lyon (France). Alberto d'Onofrio research areas focus on theoretical and mathematical biophysics of complex biological systems. In particular he is a pioneer of Behavioral Epidemiology of Infectious Diseases, and he also works on modeling systems perturbed by bounded stochastic noises. He has published more than 120 papers in isi-indexed journals, 25 papers in books and proceedings, he has edited 5 books for Soringer-Nature group and 4 special issues of isi-indexed scientific journals. His H-index is 37 (WoS) and his Google scholar h index is 45. He is in the editorial boards of "Journal of Mathematical Biology"", of "Journal of Optimization: theory and Applications" and of "PLoS One". More info here: https://www.donofriolab.org/home

Ghent University, Belgium

Title: Measuring and Evaluating BMI Dependent Drug Dynamic Response in Anesthetised Patients

Abstract: In personalized medicine applications such as general anesthesia, an individualised pharmacokinetic (PK) model requires to move away from the classical assumption of homogeneous drug mixing in various tissue compartments in the body. However, the pharmacokinetic distributions are in fact following non-uniform distribution of uptake/clearance time constants for the drugs used to induce and maintain general anesthesia. This follows in the first instance from the tissue properties of muscle, fat, etc. These classical use of patient models assume to calculate these constants from population-based models as a function of age, gender, weight, height, lean body mass. Hitherto, there is no revision of these models for the incoming obesity problem in all adults as reported by WHO is expected to continually increase in coming decades, as co-morbidity correlated to increase of incidence in cardiovascular disease and type II diabetes. When these models are used in computer based optimization algorithms to find the best drug mixture for a personalized management of anesthesia, they do not suitably match the patient at hand. It follows that anomalous diffusion patterns affect the drug dynamic mixing and transforming to the effect site (further linked to its effect by PD pharmacodynamic models), and therefore affects the overall control system performance. As an example, a lean patient will have a faster and more homogeneous distribution of drug in the body than an obese patient. This presentation gives an overview on the opportunities to develop sensing techniques for a framework that will correlate BMI to fat volume in such PK models. There is an opportunity to employ fractional order models for anomalous diffusion characterization in drug accumulation and release dynamics. An experimental setup and data analysis from fat tissue samples is used to illustrate initial steps towards a theory that would offer a revision of the classic patient models.

Bio: Dr Clara Mihaela Ionescu is professor at Faculty of Engineering and Architecture, at Ghent University, Belgium since October 2016. She is a research-member of the laboratory of Dynamical Systems and Control. She holds a master degree is Automation and Applied Informatics in 2003 from Dunarea de Jos University of Galati, Romania, and a PhD degree in Biomedical Engineering from Ghent University in 2009. She was recipient of prestigious excellence scholarship for top-students going abroad from the Romanian Ministry of Research and Innovation during her master Studies at Ghent University in 2002. She was also recipient of prestigious excellent post-doctoral scholarship of Flemish Research Foundation, of Belgium for 6 years, from 2011 – 2017. She is an ERC Consolidator Grant fellow: AMICAS, Adaptive Multi-Drug Infusion Control System for General Anesthesia during Major Surgery.

Texas Tech University, USA

Title: Thermodynamic Insights into Network Dynamics: Statistical Mechanics Perspective

Abstract: Our study delves into the thermodynamic behaviors of extensive walks on non-random, connected graphs with potential random alterations and transportation noise. It employs statistical mechanics to gauge structural attributes crucial for network dynamics, revealing a Fermi–Dirac distribution of node fugacity in response to modifications. Notably, nodes with lower centrality are predisposed to future alterations. The analysis extends to finite graphs, emphasizing the applicability beyond random structures. This approach sheds light on complex network dynamics, especially in urban environments, elucidating the impacts of structural irregularities on mobility patterns. Ultimately, the research elucidates the statistical mechanics governing network evolution, crucial for understanding and optimizing complex systems.

Bio: Dr Dimitri Volchenkov is a Professor of Applied Mathematics and Statistics at the Texas Tech University (USA), former Chair Professor at the Artificial Intelligence Key Laboratory of Sichuan Province, School of Automation and Information Engineering, Sichuan University of Science and Engineering (China), former qualified professor in France and Germany, admitted as the TTU SIAM professor of the year 2021/2022, “Nationally recognized talent” of China (“1000 Talent Plan of China”), awarded by the G. Zaslavsky award in Nonlinear Science and Complexity (USA), Cheung Kong Scholarship (China), Alexander von Humboldt and Volkswagen Fellowships (Germany), NATO/OTAN and C.N.R.S Fellowships (France), George Soros Fellowship (USA), and Scientists Federal Awards (Russia).

University of Lisbon, Portugal

Title: Identifying fractional order transfer functions from frequency responses

Abstract: This paper explores simple methods to identify fractional order models from a frequency response. The models addressed are explicit and commensurate, with one or two pseudo-poles. Such identification methods complement Levy's identification method.

Bio: Dr Duarte Valério is Associate Professor at Instituto Superior Técnico — University of Lisbon, where he got his MSc (2001) and PhD (2005) in Mechanical Engineering, with theses on fractional control, i.e. on the use of fractional (non-integer) order derivatives in control. He has worked with fractional control and fractional dynamic systems, and their applications in several areas, ever since. He also researches in the fields of energy conversion (in particular, the control of Wave Energy Converters, that produce electricity from the energy of sea waves) and bioengineering applications (modelling and control of dynamic systems such as biological processes). He has co-authored over sixty papers in journals with impact factors, three books, over seventy papers in conference proceedings, and nine book chapters.

University Medical Center Utrecht in the Netherlands

Title: Targeted control of COVID-19 post-mass vaccination

Abstract: SARS-CoV-2 infection currently causes common cold- or flu-like illness in most individuals, but patients with chronic conditions still experience a higher chance of COVID-19 hospitalization and death. It is crucial to estimate COVID-19 burden in chronic patients and to determine how best to protect them from severe COVID-19. In this talk, I will present an assessment of the impact of post-pandemic vaccination strategies in chronic patients of different ages. The model population is stratified by age, risk due to chronic conditions, and immunity level before the start of a seasonal post-pandemic outbreak. For risk classification due to pre-existing chronic conditions, we compare different guidelines to stratify the population into three risk groups (low-, moderate-, and high-risk), i.e., the European classification by the European Centre for Disease Prevention and Control and national classifications by the public health institutes in individual European countries. We consider several strategies, namely vaccination of high-risk individuals, high- and moderate-risk individuals, individuals above 60 or 80 years old, and combinations of these strategies. I will discuss how best vaccination strategies differ depending on the metrics used for their evaluation: 1) maximum vaccination impact as quantified by the reduction in the number of hospitalizations due to vaccination; 2) maximum vaccination effectiveness as quantified by the number needed to vaccinate to prevent one hospitalization.

BIo: Dr Ganna Rozhnova is an Associate Professor in Infectious Disease Modeling at the University Medical Center Utrecht in the Netherlands. In addition, she holds an appointment as an Invited Associated Professor at the Faculty of Sciences of the University of Lisbon and a principal investigator at the BioISI—Biosystems & Integrative Sciences Institute in Lisbon, Portugal. Her research centers on the application of infectious disease modeling to answer questions and support evidence-based policymaking in public health. She is interested in understanding emergence, evolution and spatio-temporal dynamics of infectious diseases on different scales (e.g., host, hospital/school or population) and evaluating the impact of interventions on disease transmission. Her most recent research aims to address the prospects of HIV elimination, the impact of promising HIV cure strategies on HIV transmission, and (post-)pandemic dynamics of SARS-CoV-2. Other applications include influenza, CMV and childhood infections. More info here: https://www.umcutrecht.nl/en/research/researchers/rozhnova-g

International Hellenic University

Title: Investigating the dynamical behavior on systems with a positive maximal Lyapunov Characteristic Exponent near zero

Abstract: In this talk, we will try to answer the question: " What is the dynamical behavior when the proposed system has a positive maximal Lyapunov Exponent" near to zero?". To do so, we investigate many dynamical systems with the help of several numerical tools, such as Poincare sections and chaotic indices (SALI, FLI), and categorize the different dynamical behaviors.

Bio: Jamal-Odysseas Maaita is an Academic Fellow at the International Hellenic University physics department. His research interests are nonlinear dynamics, mechanical and electrical oscillations, dynamical systems theory, bifurcation theory,Hamiltonian mechanics, energy transfer in nonlinear oscillators, nonlinear electronic circuits, chaotic behavior, and Hidden attractors.He is an associate editor at "Discontinuity, Nonlinearity, and Complexity" and a member of the Greek Physicists Society and the Philosophy of Physics Society.

Universities of Colorado and North Carolina, USA

Title: Motion and concentration dynamics of small particles and plankton in fluid flows

Abstract: Advection and distribution of industrial impurities and biological organisms in the ocean and internal waters plays a crucial role in many ecological and biological situations. These processes have been studied for decades, but theoretical modeling of the action of currents and waves on micro-objects is limited. Even the basic equations for a particle motion in an inviscid fluid have been reconsidered several times up to the late 1980s. Here two classes of problems are outlined. The first is the complex dynamics of a particle with inertia in non-viscous fluid flows, studied both analytically and numerically. In general, the equations of such a motion are non-integrable, and we concentrate on the cases of axisymmetric flow (that is completely integrable) and a periodic cellular flow in which unbounded stochastic motions are possible. The second problem is the motion and redistribution of particles and plankton organisms under the action of currents and internal waves in the ocean. Particularly, the effect of solitary internal waves (internal solitons) which are sufficiently short to allow setting aside much slower processes such as diurnal changes of light and temperature, and internal tides. The cases of small Reynolds numbers Re when a passive particle moves with the fluid, and of large Re when its velocity can be smaller or larger than that of fluid, are considered. The dynamic of particles' concentration is also studied. Two models of vertical swimming juxtaposing with the transport by the current are considered. Specific calculations refer to the waves in a two-layer fluid and a stratified layer with a given buoyancy frequency. The results show that a wave affects the particles differently when they are initially distributed homogeneously, and when they occupy a thin layer as is rather common in the upper ocean. These results are in qualitative agreement with the available experimental data.

Bio: Prof. Lev Ostrovsky received a PhD degree and a Doctor of Science degree and the title of Full Professor in the Soviet Union. Until 1994 he was a Laboratory Head and Chief Scientist at the Institute of Applied Physics of Russian Acad., Sci. in Gorky (later Nizhny Novgorod). He also kept a part-time professorship at Gorky/Nizhny Novgorod University. From 1994 to 2016, he worked in the USA as a Senior Scientist at the University of Colorado in Boulder, then at NOAA Environmental Science Research Laboratory in Boulder. Now Lev Ostrovsky is affiliated with Universities of Colorado and North Carolina as Adjunct Professor. He also had numerous visiting positions and fellowships at universities and laboratories in the USA, Britain, France, Australia, Norway, China, and others. The scientific interests of Lev at different stages of his carrier included lasers and nonlinear optics, biophysics, nonlinear and biomedical acoustics, fluid dynamics and oceanography, and general nonlinear wave theory. He is the author and co-author of 5 books, numerous book chapters and student's workbooks, over 300 papers, 11 Invention Certificates (Russian patents), and a registered Discovery. Under his supervision, 18 students obtained a PhD degree; 12 of them were then awarded the Doctor of Science degree. He has been a plenary and invited speaker and a member of program committees at numerous scientific meetings. Among the Lev's awards are the USSR State Prize, the Mandelstam Award of the Russian Academy of Sciences, Orson Andersen Distinguished Fellowship at Los Alamos National Laboratory, and the Lagrange Award of this Conference. He is a Fellow of the Acoustical Society of America, a member of American and European Geophysical Unions, and Russian Acoustical Society. He has been a Co-Editor of professional journals, including Chaos, Acoustical Physics, Atmospheric and Oceanic Physics, and Discontinuity, Nonlinearity, and Complexity (DNC). At present, he is an Honorary Editor of the journals Chaos and DNC.

Basque Center for Applied Mathematics (BCAM – Bilbao), Spain

Title: Within-host models unravelling the dynamics of dengue reinfections

Abstract: Caused by four serotypes, dengue fever is a major public health concern worldwide. Current modeling efforts have mostly focused on primary and heterologous secondary infections, assuming that lifelong immunity prevents reinfections by the same serotype. However, recent findings challenge this assumption, prompting a reevaluation of dengue immunity dynamics. In this study, we develop a within-host modeling framework to explore different scenarios of dengue infections. Unlike previous studies, we go beyond a deterministic framework, considering individual immunological variability. Both deterministic and stochastic models are calibrated using empirical data on viral load and antibody (IgM and IgG) concentrations for all dengue serotypes, incorporating confidence intervals derived from stochastic realizations. With good agreement between the mean of the stochastic realizations and the mean field solution for each model, our approach not only successfully captures primary and heterologous secondary infection dynamics facilitated by antibody-dependent enhancement (ADE) but also provides, for the first time, insights into homotypic reinfection dynamics. Our study discusses the relevance of homotypic reinfections in dengue transmission at the population level, highlighting potential implications for disease prevention and control strategies [1].

References

[1] Anam, V., Guerrero, B.V, Srivastav A.K., Stollenwerk, N., Aguiar, M. (2024). Within-host models unravelling the dynamics of dengue reinfections. Infectious Disease Modelling, 9(2), 458-473

Bio: Dr Maíra Aguiar is a mathematical epidemiologist working on infectious disease dynamics. With a multidisciplinary research profile, is trained in dynamical systems theory, stochastic processes, nonlinear dynamics, bifurcation analysis and biostatistics and her scientific interests addresses significant mathematical and fundamental questions in biology and medicine, with special focus on public health epidemiology modeling. Dr Aguiar is a former Marie Curie Fellow at Trento University, Italy. Since 2020, Dr. Aguiar is based at the Basque Center for Applied Mathematics (BCAM – Bilbao), Spain, where she leads the Mathematical and Theoretical Biology (MTB) group as an Ikerbasque & Ramon y Cajal Researcher. More info here: https://maira-aguiar.eu

Moscow State University of Civil Engineering, Russia

Title: Mathematical modeling of viscoelastic auxetic materials via fractional calculus

Abstract: In this talk I will examine the impact response of a viscoelastic auxetic plate with fractional viscosity, where the shear operator follows a fractional derivative model. Consequently, the auxetic's Poisson's ratio shifts from negative to positive over time. The mathematical model and numerical calculations based on asymptotic solutions confirm experimental results, showing improved indentation and impact resistance in auxetic materials.

Bio: Dr Marina Shitikova is a Soros Professor and Principal Researcher at the International Center of Dynamics of Solids and Structures at Voronezh State University of Architecture and Civil Engineering in Russia. She received her MEng in Civil Engineering in 1982, a PhD degree in Structural Mechanics in 1987 from Voronezh Civil Engineering Institute, a DSc degree in Solid Mechanics in 1995 from the Institute for Problems in Mechanics, Russian Academy of Sciences and full Professorship in 1995 from Voronezh State University of Architecture and Civil Engineering. Since 1994, she has been an Associate Member of the Acoustical Society of America, since 1995 she has been a Member of the EUROMECH, GAMM, the ASME International, and Russian Association "Women in Science and Education". She has published more than 200 papers dealing with structural mechanics, vibrations, wave dynamics, acoustics, and fractional calculus viscoelasticity. In 1998 she was awarded the Russian President's Fellowship for Outstanding Young Doctors of Sciences. She is a grantee of the International Foundation, DFG, DAAD, Fulbright Foundation, and Russian Foundation for Basic Research.

Los Alamos National Laboratory, USA

Title: Modeling Hepatitis Virus Infection in the Liver

Abstract: Mathematical models of viral replication and interactions with the host have been critical in developing a dynamical understanding of viral biology. At the same time, these models represent a paradigm in applying mathematics to medicine. Hepatitis B and hepatitis C viruses both infect the liver, but have very different life cycles. However, the principles of mathematical models and the models themselves are similar and applicable to both viruses. These models have helped us understand and quantify the effects of therapy against these infections, as well as the biology of the viruses. We have been studying infection directly in the liver, using a new technique based on single cell laser capture micro-dissection. This allows us to quantify the levels of infection in hepatocytes, the primary site of replication. The insights brought by these models tell us how fast the virus replicate, the effect on killing infected cells, the virus mutation rate and how to quantify the effect of novel therapies.

Bio: Dr Ruy M. Ribeiro got his Ph.D. in Mathematical Biology at the University of Oxford, UK. He then joined Los Alamos National Laboratory (LANL) in 2000, as a Postdoctoral Researcher, later becoming a staff scientist working on viral and immune system dynamics. His main research interests are the pathogenesis of infections, and the use of quantitative modeling tools to gain insight into viral and immune system dynamics. His work has always entailed close collaborations with experimental researchers to develop proper statistical and dynamic models to analyze experimental data. His modeling work spans multiple scales from the intracellular (eg. a model of the molecular details of HCV infection) to the epidemiological (including HIV and influenza epidemics). He was Professor of Statistics at the Medical School of the University of Lisbon, while on leave from LANL, between 2017 and 2020. Ruy Ribeiro has over 140 peer-reviewed papers in this area, and he is/was the PI of several research projects funded by the National Institutes of Health, the European Union, and the Department of Energy.

University of Pisa, Italy

Title: Weak and Not so weak Mean Field Coupling regime. Invariant Measures, Convergence to Equilibrium, Linear Response

Abstract: We describe a general approach to the theory of self consistent transfer operators. These operators have been introduced as tools for the study of the statistical properties of a large number of all to all interacting dynamical systems subjected to a mean field coupling. We consider a large class of self consistent transfer operators and prove general statements about existence of invariant measures, speed of convergence to equilibrium, statistical stability and linear response. We also consider the problem of finding the optimal coupling between maps in order to change the statistical properties of the system in a prescribed way.

Bio: Stefano Galatolo is Associate Professor at Dipartimento di Matematica, University of Pisa and director of Centro Interdipartimentale per lo Studio dei Sistemi Complessi. His research focuses on dynamical systems, its statistical behavior and computational methods. He is author of about 50 papers in these fields and currently editor of Chaos Solitons and Fractals and Journal of Fixed Point Theory and Applications. More info here: http://users.dma.unipi.it/galatolo/

University of Sevilha, Spain

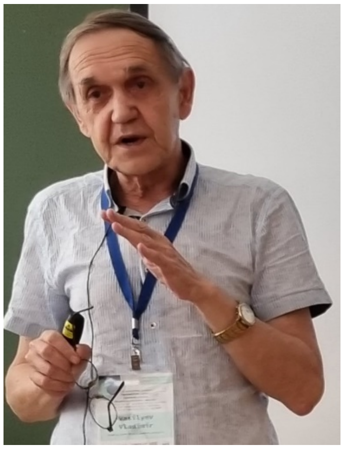
Title: Approximating the dynamics of a stochastic PDE model by using colored noise

Abstract: The theory of Random Dynamical Systems is nowadays very well developed and provides an appropriate framework to describe the pathwise dynamics of a good number of interesting stochastic PDE models from applied sciences. The main idea is to transform the stochastic problem into a random one by performing some kind of transformation (also called conjugation) which allows us to use the deterministic techniques to analyze the long time behavior of the system. However, when the noise term in the stochastic model is not linear, such conjugation is not known yet when we are dealing with a stochastic partial differential equation. Recently, a new technique is being used to approximate the stochastic problem. The idea consists in replacing the standard white noise (usually the generalized derivative of a Wiener process) but the so-called colored noise, which is a stationary stochastic process (generally an Ornstein-Uhlenbeck process) and strongly related to the Wong-Zakai approximation to the white noise. In this talk, we will analyze a problem driven by colored noise and explain the advantages of Wong-Zakai approximations, and the limitations of this alternative as well.

Bio: Dr Tomás Caraballo is Professor at the Departamento de Ecuaciones Diferenciales y Análisis Numérico of the University of Sevilla, Spain. Professor Caraballo received his Ph.D. in Mathematical Sciences from the University of Sevilla in November 1998. His research interests include deterministic and stochastic dynamical systems and applications from the applied sciences. More specifically, he was worked on stochastic partial differential equations, models with delay and memory, impulsive systems, non-autonomous and random dynamical systems, nonlocal differential equations including those of fractional time, models from biology, epidemiology, physics, population dynamics, etc He has published more than 350 papers so far, which can be seen in the web. Link: https://personal.us.es/caraball/tcgpublic.html

“Aurel Vlaicu” University of Arad, Romania

Bio: Dr Valentina E. Balas is currently Full Professor in the Department of Automatics and Applied Software at the Faculty of Engineering, “Aurel Vlaicu” University of Arad, Romania. She holds a Ph.D. Cum Laude, in Applied Electronics and Telecommunications from Polytechnic University of Timisoara. Dr. Balas is author of more than 400 research papers in refereed journals and International Conferences. Her research interests are in Intelligent Systems, Fuzzy Control, Soft Computing, Smart Sensors, Information Fusion, Modeling and Simulation. She is the Editor-in Chief to International Journal of Advanced Intelligence Paradigms (IJAIP) and to International Journal of Computational Systems Engineering (IJCSysE), member in Editorial Board member of several national and international journals and is evaluator expert for national, international projects and PhD Thesis. Dr. Balas is the Head of Intelligent Systems Research Centre in Aurel Vlaicu University of Arad and Head of the Department of International Relations in the same university. She served as General Chair of the International Workshop Soft Computing and Applications (SOFA) in ten editions organized in the interval 2005-2022 and held in Romania and Hungary. Dr. Balas participated in many international conferences as Organizer, Honorary Chair, Session Chair, member in Steering, Advisory or International Program Committees and Keynote Speaker. Recently she was working in a national project with EU funding support: BioCell-NanoART = Novel Bio-inspired Cellular Nano-Architectures – For Digital Integrated Circuits, 3M Euro from National Authority for Scientific Research and Innovation. She is a member of European Society for Fuzzy Logic and Technology (EUSFLAT), member of Society for Industrial and Applied Mathematics (SIAM) and a Senior Member IEEE, member in Technical Committee – Fuzzy Systems (IEEE Computational Intelligence Society), chair of the Task Force 14 in Technical Committee – Emergent Technologies (IEEE CIS), member in Technical Committee – Soft Computing (IEEE SMCS). She is member in the Committee of IEEE Romania Section as Volunteers Training Coordinator and vice chair of IEEE Computational Intelligence Society Chapter – CIS 11. During the interval 2021-2022 she was a member of IEEE European Public Policy Committee Working Group on ICT. From May 2023 Dr. Balas is associate member of Romanian Academy of Scientists. Dr. Balas was past Vice President (awards) of IFSA – International Fuzzy Systems Association Council (2013-2015), is a Joint Secretary of the Governing Council of Forum for Interdisciplinary Mathematics (FIM), – A Multidisciplinary Academic Body, India. She is the recipient of the “Tudor Tanasescu” Prize from the Romanian Academy for contributions in the field of soft computing methods (2019) and “Stefan Odobleja” Prize from Romanian Academy of Scientists (2023).



Belgorod State University, Russia

Title: Basic Problems in the Theory of Pseudo-Differential Equations

Abstract: A solvability problem for elliptic pseudo-differential equations in domains with a non-smooth boundary is studied. Digitization problem for these equations and certain problems related to a limit transform with a small parameter are considered also.

Bio: Professor Vladimir Vasilyev is Chair of Differential Equations, at Belgorod National Research University. More information: https://scholar.google.ru/citations?hl=en&user=NfV8TwkAAAAJ&view_op=list_works&sortby=pubdate and https://www.researchgate.net/profile/Vladimir-Vasilyev-2

Table of contents

Mathematical Model for the Dynamics of COVID-19 Pandemic Incorporating Isolation and Non-Linear Recovery Rate

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Abstract

COVID-19 has in recent times created a major health concern in both developed and developing parts of the world. In this wise, there is every need to theoretically explore ways that will provide some insights into curtailing the spread of the disease in the population. In this paper, we present a population model for COVID-19 pandemic incorporating isolation and nonlinear recovery rate. The reproduction number was obtained using the next generation method. The disease-free equilibrium (DFE) of the model (1) was found to be locally and globally asymptotically stable whenever the associated reproduction number is less than unity. Results from the sensitivity analysis of the model, using the reproduction number, R_C show that the top parameters that largely drive the dynamics of COVID-19 in the population are COVID-19 transmission rate and the proportion of individuals progressing to the class of reported symptomatic infectious individuals. Numerical simulations of the model shows that increasing the recovery rate of infected patients in the population will lead to an initial decrease in the number of hospitalized patients before subsequent increase. The reason for this could be attributed to the number of unreported symptomatic infectious individuals who are progressing to reported symptomatic infectious stage of infection for immediate isolation.

Keywords: COVID-19, reproduction number, isolation, stability, nonlinear recovery rate