"Dynamics Days Latin America and the Caribbean"

Puebla, México, October 24 - November 01, 2016

PROGRAM

SUNDAY 23

HOTEL COLONIAL de Puebla

REGISTRATION	11:00 - 18:00	Lobby, 1st Floor.
WELCOME RECEPTION	18:30 - 19:30	Rooftop Terrace

FYI:

The SALÓN BARROCO, SALÓN PARANINFO, SALÓN VERDE and SALÓN DE PROYECCIONES are conference rooms which are located in the CAROLINO BUILDING (EDIFICIO CAROLINO) of BUAP (See Venue).

The ROOFTOP TERRACE is located in HOTEL COLONIAL (right in front of the CAROLINO BUILDING).

MONDAY 24

WELCOME ADDRESS AND OPENING (Salón Barroco, 08:30 – 08:45)

Morning I (Salón Barroco, 08:45 – 10:45).

Chair: Bernd Krauskopf

1) Louis M. Pecora , Naval Research Laboratory, Washington, DC, USA.

"Finding and Forming Synchronized Clusters in Complex Networks of Oscillators Using Symmetries"

2) Thorsten Pöschel, Friedrich-Alexander Universität Erlangen-Nürnberg, Germany.

"History and Structure of Granular Sediments"

3) Rajarshi Roy , University of Maryland, College Park , USA.

"Amplification of Noise by Chaos and Random Number Generation"

4) Kenneth Showalter , West Virginia University, USA.

"Chimera and Chimera-Like States in Populations of Nonlocally Coupled Homogeneous and Heterogeneous Chemical Oscillators"

COFFEE-BREAK (10:45 - 11:30, Carolino Building Lobby)

Morning II a (Salón Paraninfo, 11:30 – 13:00)

Chair: Krasimira Tsaneva-Atanasova

1) Rafael A. Barrio, Instituto de Física, UNAM, D.F. México.

“Dynamical model of the function and disfunction of stem cells in colonic crypts"

2) Gustavo Martínez-Mekler, Instituto de Ciencias Físicas, UNAM, Cuernavaca, México.

“Dynamic Regime Criteria for Complex Network Reduction"

3) Enrique Peacock-López, Williams College, Williamstown MA, USA.

"The Dynamics of Chemical Self-replication"

Morning II b (Salón Verde, 11:30 – 13:00)

Chair: Hinke Osinga

1) Franco Bagnoli, University of Florence, Sesto Fiorentino (FI), Italy.

"Regional Control of Boolean Cellular Automata"

2) Marian Gidea, Yeshiva University, New York City, USA.

"A geometric mechanism of Arnold diffusion in the a priori stable case"

3) Raúl Rechtman, Instituto de Energías Renovables, UNAM, Temixco, México.

"Deterministic walks on regular lattices on the plane"

LUNCH

Afternoon I a (Salón Paraninfo, 16:00-18:00)

Minisymposium MS3

MS3. Planetary and Galactic Dynamical Astronomy

Chair: Luis Benet

1) Cristian Beauge, Univ. Córdoba, Argentina.

"Dynamics and stability of multi-planet systems"

2) Haris Skokos, University of Cape Town, South Africa.

"Investigating the dynamics of a time-dependent barred galaxy model by the Smaller (SALI) and the Generalized (GALI) Alignment Index methods of chaos detection"

3) Pablo Cincotta, Univ. Nacional La Plata, Argentina.

"Chaotic diffusion in Planetary and Galactic Systems"

4) Jorge Pérez Hernández, UNAM, México.

"The Lyapunov spectrum of the comet 1P/Halley in a Newtonian model of the Solar System"

5) Leonardo Chaves, INAOE, México.

"Stellar orbital structure in slow rotating bar models"

Afternoon I b (Salón Verde, 16:00-18:00)

Chair: Ana Amador

1) Dobromir G. Dotov , Centro de Ciencias de la Complejidad, UNAM, México.

"Chaos synchronization as an auditory-motor task for improved motor learning"

2) Konstantin E. Starkov, Instituto Politécnico Nacional, CITEDI, Tijuana, B.C., México.

"Dynamical Properties and Tumor Clearance Conditions for Multi-Dimensional Models of Bladder Cancer Immunotherapy"

3) Miguel A. Vizcardo , Universidad Nacional San Agustin, Arequipa Perú.

"Analysis of the heart rate variability (HRV) and stratification of the risk of cardiac affectation patients with Chagas' disease"

Afternoon I c (Rooftop Terrace, Hotel Colonial, 16:00-18:00)

Chair: Lennaert van Veen

1) Hinke Osinga , The University of Auckland, New Zealand.

"Intrinsic excitability and the role of saddle slow manifolds"

2) Joan Sanchez-Umbría, Universitat Politécnica de Catalunya, Barcelona, Spain.

"A software package for the continuation and bifurcation analysis of discretized partial differential equations"

3) Eusebius J. Doedel , Concordia University, Montréal, Canada.

"Some Numerical Continuation Tools in Celestial Mechanics"

4) Jorge Galán-Vioque, University of Sevilla, Spain.

"Bifurcation based mechanical diodes and amplifiers"

COFFEE 15:30--18:30 at Hotel Colonial, Salón Virreyes.

TUESDAY 25

Morning I (Salón Paraninfo, 08:45 – 10:45).

Chair: Hinke Osinga

1) Edgar Knobloch, University of California at Berkeley, USA.

"Two- and Three-Dimensional Phase Field Quasicrystals"

2) Uwe Thiele, Institut für Theoretische Physik, Universität Münster, Germany.

"Are sliding drops dissipative solitons?"

3) Lennaert van Veen, UOIT, Ontario, Canada.

"Dynamics of Large Eddy Simulation of box turbulence"

4) Michael Ward, University of British Columbia, Vancouver, BC, Canada.

"Asymptotic Analysis of Quorum-Sensing Behavior for a Coupled Cell Bulk-Diffusion Model in 2-D"

COFFEE-BREAK (10:45 - 11:30, Carolino Building Lobby & Hotel Colonial)

Morning II a (Salón Paraninfo , 11:30 – 13:00)

Chair: Murilo da Silva Baptista

1) Mario Chávez, Hôpital de La Pitié-Salpêtrière, Paris, France.

“New Challenges for Complex Brain Networks"

2) Markus Franziskus Müller, Centro de Investigación en Ciencias, UAEM, Cuernavaca, México.

"How to orchestrate a soccer team - Generalized synchronization promoted by rhythmic acoustic stimuli-"

3) Nicolás Rubido, Universidad de la República, Montevideo, Uruguay.

“Dynamical Detection of Network Communities"

Morning II b (Salón Verde , 11:30 – 13:00)

Chair: Kenneth Showalter

1) Marcus J. B. Hauser, University of Magdeburg, Magdeburg, Germany.

"Laminar mixing in tubular networks of plasmodial slime moulds"

2) Marta Net , Universitat Politécnica de Catalunya, Barcelona, Spain.

"Periodic orbits in tall laterally heated rectangular cavities"

3) Desiderio Vásquez, Indiana University-Purdue University, Fort Wayne, USA.

"Effects of convection on thin reaction fronts"

LUNCH

Afternoon I a (Salón Paraninfo, 16:00-18:00)

Chair: Miguel A. F. Sanjuan

1) Anastasios (Tassos) Bountis , Nazarbayev University, Astana, Republic of Kazakhstan.

"Dynamics and Statistics of the Fpu B -Model with Different Ranges of Interactions"

2) Andre L. P. Livorati , Universidade Estadual Paulista - UNESP - Rio Claro -SP Brazil.

"Anomalous transport and diffusion analysis of a non-dissipative Fermi-Ulam model"

3) Reinout (G.R.W.) Quispel, La Trobe University, Melbourne, Australia.

"Geometric Numerical Integration: How to Discretize Differential Equations While Preserving Their Physical Properties"

4) Hiroki Takahasi , Keio University, Yokohama, Ko-hoku, Hiyoshi, Japan.

"Flatness-Induced Phase Transition in Lyapunov Spectrum for Unimodal Maps"

Afternoon I b (Salón Verde, 16:00-18:00)

Chair: Rajarshi Roy

1) Roberto Bernal Jaquez, UAM- CUAJIMALPA, Distrito Federal, México.

“Dynamics and control for virus propagation in complex networks in the frame a a discrete time Markov process for the case of SIS epidemic model"

2) Gabriela G.I.D. De Petri, Instituto de Física - Universidade de São Paulo, São Paulo – Brazil.

“The complex scenario to collective behaviour in complex networks"

3) Takaaki Ohnishi, The University of Tokyo, Bunkyo-ku, Tokyo, Japan.

“Scaling relations between population and number of facilities"

4) Tanu Singla, Instituto de Ciencias Físicas, UNAM, Cuernavaca, Morelos, México.

“Synchronization using environmental coupling in Mercury Beating Heart oscillators"

Afternoon I c (Rooftop Terrace, Hotel Colonial, 16:00-18:00)

Minisymposium MS5 – I

“MS5. Dynamics, from Theory to Computation”

Chair: Arturo Olvera

1) Pablo Cincotta, Univ. Nacional La Plata, Argentina

"Characterization of diffusion in N > 2 conservative dynamical systems"

2) Carlos García-Azpeitia, Facultad de Ciencias, UNAM, México

"Choreographies and symmetric Lyapunov families arising from a n-gon of bodies"

3) Jean-Philippe Lessard, Université Laval, Canada

"Halo periodic orbits in the spatial circular restricted four body problem: a computer-assisted proof"

4) Renato Calleja, IIMAS, UNAM, México

"Domains of analyticity of KAM tori in mechanical systems with friction"

Afternoon I d (Salón de Proyecciones, 16:00-18:00)

Chair: Joan Sánchez Umbría

1) Hirdesh Kumar Pharasi , Instituto de Ciencias Físicas, UNAM, Cuernavaca, México.

   “Heat flux spectrum of rotating Rayleigh-Bénard convection"

2) Nicolás Perinet , DFI-FCFM, Universidad de Chile, Chile.

   "Hysteric Faraday waves"

3) Ilias Sibgatullin, Moscow State University (MGU), Moscow, Russia.

   “Cascades of Triadic Resonance Instabilities in Internal Waves Attractors"

4) Yuzuru Sato, Hokkaido University, Sapporo, Japan

   “Anomalous diffusion in random dynamical systems"

COFFEE 15:30--18:30 at Hotel Colonial, Salón Virreyes.

CONFERENCE DINNER 19:30--21:30,

at Complejo Cultural Universitario BUAP, Centro de Convenciones (restaurant), address: Vía Atlixcáyotl 2299, Puebla.

WEDNESDAY 26

Morning I (Salón Barroco, 08:45 – 10:45)

Chair: Alberto Robledo

1) Sumiyoshi Abe, Mie University, Kurimamachiya-cho Tsu city, Japan.

“Anomalous diffusion of volcanic seismicity"

2) Imre M. Jánosi, Eötvös Loránd University, Budapest, Hungary.

“The Story of the Ozone Hole"

3) Cristina Masoller , Universitat Politècnica de Catalunya., Barcelona, Spain.

“Inferring the connectivity and the community structure of a complex systems from observed data"

4) Miguel A. F. Sanjuán, Universidad Rey Juan Carlos, Madrid, Spain.

“Basin Entropy: A new tool to explore uncertainty in dynamical systems"

COFFEE-BREAK (10:45 - 11:30, Carolino Building Lobby & Hotel Colonial)

Morning II a (Salón Paraninfo, 11:30 – 13:00)

Chair: Yuzuru Sato

1) Jan Awrejcewicz, The Lodz University of Technology, Lodz, Poland.

“Wavelet-based analysis of regular and chaotic dynamics of interacting structural members under white noise"

2) Thanos Manos, Research Center Juelich, Institute of Neuroscience and Medicine,Germany.

“Improving long lasting anti-kindling effects via coordinated reset stimulation frequency mild modulation"

3) Ricardo Mansilla, CEIICH-UNAM, DF, México.

“Description of heart disease and other medical conditions using visibility graphs and random matrix theory"

Morning II b (Salón Verde, 11:30 – 13:00)

Chair: Nicolás Rubido

1) Murilo S. Baptista, University of Aberdeen, King's College, Aberdeen, UK.

"The space-time nature of causality"

2) Arturo C. Martí, Facultad de Ciencias, Universidad de la Republica, Montevideo, Uruguay.

"Inference of direct links in complex networks from real experimental data"

3) Gabriel Ramos-Fernández, CIIDIR Unidad Oaxaca, IPN; CCC C3, UNAM, México.

"Measuring social flexibility using information theory"

LUNCH

FREE AFTERNOON (Tour to Cholula & its Pyramid at 14:00 at Hotel San Leonardo)

THURSDAY 27

Morning I (Salón Barroco, 08:45 – 10:45).

Chair: Elbert Macau

1) Ana Amador, Universidad de Buenos Aires, C.U., CABA, Argentina.

“Integrating motor and neural control in songbirds"

2) Bernd Krauskopf, The University of Auckland, New Zealand.

“Slow-fast dynamics: interacting manifolds and mixed-mode oscillations"

3) Alberto Robledo, Universidad Nacional Autónoma de México, D. F., México.

“Manifestations of the onset of chaos in condensed matter and complex systems"

4) Sebastian Wieczorek , University College Cork, Cork, Ireland.

“Global Stability of Lasers: Effects of Light Shear and Active-Medium Polarisation Dynamics"

COFFEE-BREAK (10:45 - 11:30, Carolino Building Lobby & Hotel Colonial)

Morning II (Salón Paraninfo, 11:30-13:00)

Chair: Tassos Bountis

1) Andrey Shilnikov, Georgia State University, Atlanta, USA.

"Homoclinic Chaos Painted"

2) Charalampos (Haris) Skokos, University of Cape Town, South Africa.

“Chaos in disordered nonlinear lattices"

3) Krasimira Tsaneva-Atanasova, University of Exeter, Devon, UK.

“Mathematical modelling and analysis of transient escapes for network dynamics"

LUNCH

Afternoon I a (Salón Paraninfo, 16:00-18:00)

Minisymposium MS8

- **"MS8. Homenaje al Dr. Eduardo Piña Garza POR SUS CONTRIBUCIONES A LA TEORÍA DEL CAOS Y LA DINÁMICA HAMILTONIANA EN MÉXICO"**

Chair: José-Rubén Luévano

1) Eduardo Piña-Garza, UAM, Unidad Iztapalapa, México.

"Función de Distribución de Mapeos"

2) José-Rubén Luévano, UAM, Unidad Azcapotzalco, México.

"The work of Eduardo Piña on chaos"

3) Álvaro Salas Brito, UAM, Unidad Azcapotzalco, México.

"Classical motions under the inverse square potential"

4) José Luis del Río, UAM, Unidad Iztapalapa, México.

"Boltzmann y los Multifractales"

Afternoon I b (Salón Verde, 16:00-18:00)

Chair: Arturo Martí

1) Hilda A. Cerdeira, Instituto de Física Teórica, UNESP, São Paulo, Brazil

“Collective cohesive motion of chaotic attractors with applications to a flock of starlings"

2) Johann H. Martínez, Universidad de los Andes de Colombia, Bogotá, Colombia.

"The Role of Connector Links for Functional Centrality Distribution in Brain Hemispheres"

3) Osvaldo Rosso, Instituto Tecnológico de Buenos Aires (ITBA), Argentina

“Classification and Verification of Handwritten Signatures with Time Causal Information Theory Quantifiers"

4) Patrick H. Louodop Fotso, Instituto do Fisica Teorica, UNESP, São Paulo, Brazil

“Transitions and dynamics of bidirectionally coupled chaotic systems"

Afternoon I c (Rooftop Terrace, Hotel Colonial, 16:00-18:00)

Minisymposium MS5 – II

"MS5. Dynamics, from Theory to Computation"

Chair: Renato Calleja

1) Umberto Hryniewicz, Universidad Federal de Rio de Janeiro, Brazil

"Genus zero global surfaces of section"

2) David Martínez del Río, IIMAS, UNAM, México

"Critical global transport in a non-autonomous periodic standard map"

3) Rosa María Vargas Magaña, IIMAS, UNAM, México.

"A Whitham-Boussinesq long-wave model for variable topography"

4) Arturo Olvera, IIMAS, UNAM, México.

"Resurgence of rational invariant circles in area preserving twist maps"

Afternoon I d (Salón de Proyecciones, 16:00-18:00)

Minisymposium MS9

"MS9. Nonlinear Time Series in Complex Systems"

Chair: Lev Guzmán

1) Lev Guzmán, Laboratorio de Sistemas Complejos, UPIITA, IPN, México.

"The approximate entropy of natural language"

2) Ricardo Páez, UAM, Unidad Azcapotzalco, México.

"Local Stability analysis for a simplified model of calcium flow between the cytoplasm and the sarcoplasmic reticulum."

3) Alejandro Ramírez, UAM, Unidad Azcapotzalco, México.

"Multifractal analysis of anomalies observed in geoelectric time series"

4) Jenifer Pérez, ESFM, IPN, México.

“La sismicidad como un fenómeno críticamente autoorganizado”

COFFEE 15:30--18:30 at Hotel Colonial, Salón Virreyes.

POSTER SESSION (Edificio Carolino Lobby, 18:30 - 19:30)

FRIDAY 28

Morning I (Salón Barroco, 08:45 – 10:45).

Chair: Edgar Knobloch

1) Zhigang Chen, San Francisco State University, SF, CA, USA.

   “**Nonlinear dynamics in soft-matter and biological suspensions”**

2) Sergej Flach, Institute for Basic Science, Daejeon, Korea.

   “Designing and perturbing flatband networks"

3) Boris A. Malomed, Tel Aviv University, Israel.

   “Fundamental nonlinear equations in physics and their fundamental solutions"

4) Fedor M. Mitschke, Universität Rostock, Rostock, Germany.

   "Fiber-Optic Solitons in a Nonintegrable Environment"

COFFEE-BREAK (10:45 - 11:30, Carolino Building Lobby & Hotel Colonial)

Morning II (Salón Paraninfo, 11:30-13:00)

Chair: Louis M. Pecora

1) Tomasz Kapitaniak, Technical University of Lodz, Poland.

   “Chimera States for Coupled Pendula"

2) José Luis Mateos, Universidad Nacional Autónoma de México, CDMX, México

   “Emergence of Anomalous Diffusion and Long Range Navigation on Complex Networks"

3) Sergej Flach, Institute for Basic Science, Daejeon, Korea.

   “An Intermittent Dynamics of Equipartitioned Many-Body Interacting Systems"

LUNCH

Afternoon I a (Salón Paraninfo, 16:00-18:00)

Minisymposium MS1

"MS1. Synchronization and Extreme Events in Complex Systems".

Chair: Cristina Masoller

1) Istvan Z. Kiss, Saint Louis University, USA,

"Synchronization in Electrochemical Oscillations"

2) Andreas Daffertshofer, Vrije Universiteit, Belgium

"Scale-freeness or partial synchronization in neural mass phase oscillator networks: pick one of two?"

3) Oleh Omel'chenko, Weierstrass Institute, Germany

"On the limitations of the Kuramoto model"

4) Jordi Soriano Fradera, Universitat de Barcelona, Barcelona, Spain.

"Experiments in clustered neuronal networks: complex dynamics and resilience in a dish"

Afternoon I b (Salón Verde, 16:00-18:00)

Minisymposium MS6

"**MS6. Nonlinear dynamics, chaos and complex networks: from concept to application".**

Chair: Jesús Manuel Muñoz Pacheco

1) Jesús Gómez Gardenes, Universidad de Zaragoza, España.

"Explosive Synchronization of Complex Networks with phase oscillators and chaotic systems".

2) Eric Campos Cantón, IPICYT, México, and Houston University, USA.

"Generation of nonlinear dynamics by using PWL systems"

3) Rider Jaimes-Reategui, Universidad de Guadalajara, Lagos de Moreno, México.

"Study of the deterministic coherence resonance in a network of chaotic oscillators with frequency mismatch"

4) Eduardo Jonathan Torres Herrera, Benemérita Universidad Autónoma de Puebla, Puebla, México.

"The ergodic to many-body localization phase transition: static and dynamical properties"

Afternoon I c (Rooftop Terrace, Hotel Colonial, 16:00-18:00)

Minisymposium MS2 - I

"MS2. Applications of dynamical systems in biology".

Chair: Víctor Breña

1) Pablo Aguirre, Departamento de Matemáticas, Universidad Técnica Federico, Santa Maria Campus Valparaíso

"On the search for separatrices and basins of attraction in biological systems"

2) Andrus A. Giraldo, Department of Mathematics-The University of Auckland. Auckland, New Zealand.

"Cascade of Saddle Periodic Orbits and their Manifolds Close to a Homoclinic Flip Bifurcation".

3) Till D. Frank, Department of Psychology and Department of Physics, University of Connecticut.

"Amplitude equations describing human perception and performance under adaptation"

Afternoon I d (Salón de Proyecciones, 16:00-18:00)

Talks by Students - I

Chair: Gustavo Martínez-Mekler

1) Daniel A. Priego-Espinosa, Instituto de Ciencias Físicas, UNAM, Cuernavaca, Morelos, 62210, Mexico

" Dissecting the molecular mechanisms that underlie the temporal organization and envelope of $Ca2+$ -spike trains in sea urchin sperm flagellum"

2) Daniel Aguilar-Velázquez, UPIITA-IPN, CDMX, México

"Correlations and synchronization in interacting small-world networks"

3) Rogelio Basurto-Flores, UPIITA-IPN, CDMX, México

"A drug-disease complex network analysis"

4) Iván Fernández- Rosales, ESFM, UPIITA-IPN, CDMX, México

"Co-occurrence Networks of Complex Time Series"

5) Paul A. Valle, CITEDI, Av. del IPN, Tijuana, B.C., México

"Persistence and tumor clearance conditions on a cancer chemotherapy system"

COFFEE 15:30-18:30 at Hotel Colonial, Salón Virreyes.

MONDAY 31

Morning I (Salón Paraninfo, 09:00 – 10:30).

Chair: Jordi Soriano

1) Jesús Gómez Gardeñes, Universidad de Zaragoza, Zaragoza, Spain.

“Epidemic Spreading in Multiplex Metapopulations"

2) Elbert E. N. Macau (Instituto Nacional de Pesquisas Espaciais - INPE, SP, Brasil)

“Synchronization Effects Related to Neighborhood Similarity in a Complex Network of Non-Identical Oscillators"

3) Guillermo Fernández Anaya, Universidad Iberoamericana, CDMX, México.

"Lyapunov direct method for fractional order nonlinear time-varying systems"

COFFEE-BREAK (10:30-11:00, Salón Virreyes, Hotel Colonial)

Morning II a (Salón Paraninfo, 11:00-13:00)

Minisymposium MS4 – I

“MS4. New methods in Celestial Mechanics”

Chair: Ernesto Pérez-Chavela

1) Zhifu Xie, University of Southern Mississippi, USA

"Variational Method with Structural Prescribed Boundary Conditions and N-body Problem"

2) Abimael Bengochea, UAM-Iztapalapa, México

“Exchange orbits in the problem of N bodies”

3) Claudio Vidal, Universidad del Bío, Bío, Chile

"Stability of equilibrium points in Hamiltonians systems under the existence of an invariant ray"

Morning II b (Salón Verde, 11:00-13:00)

Minisymposium MS7 – I

"MS7. Dynamics of nonlinear lattices and graphs".

Chair: Luis Cisneros Ake

1) H. Skokos, University of Cape Town, South Africa.

"Efficient integration techniques for the long time simulation of the disordered discrete nonlinear Schrödinger equation"

2) F. Martínez-Farias, Univ. Aut. Est. Hidalgo, Apan, México.

"Inhomogeneous FPU models for weakly nonlinear protein vibrations"

3) C. García-Azpeitia, Fac. Ciencias, UNAM, México.

"Global bifurcation of traveling waves in discrete nonlinear Schrödinger equations"

LUNCH

Afternoon I a (Salón Paraninfo, 16:00-18:00)

Minisymposium MS7 – II

"MS7. Dynamics of nonlinear lattices and graphs".

Chair: Francisco Martínez Farias

1) L. Cisneros Ake, ESFM, Inst. Politécnico Nacional, México.

"Variety of solutions in anharmonic Davydov's type equations"

2) R. Martínez-Galicia, Fac. Química, UNAM, México.

"Quantum coherent states and breathers in a discrete NLS"

3) F. Bustamante-Castañeda, IIMAS, UNAM.

"Anclaje en la ecuación discreta de Nagumo"

4) P. Panayotaros, IIMAS, UNAM, México.

"Breathers ansd shelf solutions in a nonlocal DNLS equation"

Afternoon I b (Salón Verde, 16:00-18:00)

Minisymposium MS4 – II

"MS4. New methods in Celestial Mechanics"

Chair: Ernesto Pérez-Chavela

1) Eduardo Leandro, Universidad Federal de Pernambuco, Brasil.

"Factorization Of The Stability Polynomials Of Ring Systems"

2) Yohanna P. Martínez, Universidad del Bío Bío, Chile.

"**Classification of global phase portraits and bifurcation diagrams of Hamiltonian systems with rational potential"**

3) Reynaldo Castaneira, IM, UNAM, México

"**Continuous Choreographies as Limiting Solutions of the N-Body Problem"**

Afternoon I c (Rooftop Terrace, Hotel Colonial, 16:00-18:00)

Minisymposium MS2 - II

"MS2. Applications of dynamical systems in biology"

Chair: Pablo Aguirre

1) Víctor F. Breña Medina, Centro de Ciencias Matemáticas, UNAM Campus Morelia

"Spot Dynamics in a 2D Root Hair Plant Initiation Model"

2) Saeed Farjami, Department of Mathematics, Faculty of Science, The University of Auckland, NZ

"Approximating Stable Manifolds of a Saddle Slow Manifold in a Bursting Model"

3) Ramón Plaza, Departamento de Matemáticas y Mecánica, IIMAS, UNAM

"On the spectral stability of traveling fronts for reaction Diffusion-degenerate equations"

4) Alessio Franci, Departamento de Matemáticas, Facultad de Ciencias, UNAM

"A qualitative feedback theory for multiscale spatio-temporal Behaviors"

Afternoon I d (Salón de Proyecciones, 16:00-18:00)

Talks by Students – II

Chair: Hilda Cerdeira

1) Alvaro Díaz-Ruelas,

Instituto de Física, UNAM, CDMX, México

"Sums of positions at Feigenbaum and Misiurewicz points"

2) Candelario-Hernández-Gómez , and Lev Guzmán Vargas,

ESFM, UPIITA, IPN, CDMX, México

"Calculating the approximate entropy of natural language"

3) Fabián Reyes-Manzano, and Lev Guzmán Vargas,

UPIITA-IPN, CDMX, México

"Detecting Correlations in traffic-volume fluctuations in Mexico City"

4) L. Rebeca Moreno-Torres,

Departamento de Ciencias Básicas, UAM-Azcapotzalco, México D.F., México.

"Fractal properties of photon sequences obtained from Dynamical Light Scattering experiments for a polymeric gel"

5) Ángel Lareo , Grupo de Neurocomputación Biológica, Departamento de Ingeniería Informática, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Madrid, Spain.

"**Sequential information processing in electroreception: A modelling approach"**

COFFEE 15:30-18:30 at Hotel Colonial, Salón Virreyes.

TUESDAY 01

Morning I (Salón Colonia , Hotel del Portal, 09:00-10:30)

Chair: Sebastian Wieczorek

1) Gerardo García Naumis, Universidad Nacional Autónoma de México, CDMX, México.

"Topological properties of the Quantum Hall effect and mechanically deformed graphene"

2) Felipe Pacheco, Benemérita Universidad Autónoma de Puebla, Puebla, México.

"Leiden frost phenomenon on conical surfaces"

3) Edgardo Ugalde, Universidad Autónoma de San Luis Potosí, SLP, México

"**Piecewise contractions as models of regulatory networks"**

COFFEE-BREAK (10:30-11:00, Hotel del Portal)

Morning II a (Salón Colonia , Hotel del Portal, 11:00-13:00)

Minisymposium MS4 - III

"MS4. New methods in Celestial Mechanics"

Chair: Ernesto Pérez-Chavela

1) Dan Offin, Queens University, Canada

"Stability of periodic orbits by Conley-Zehnder index theory"

2) Jaime Andrade, Universidad del Bío, Bío, Chile

"On a Circular Restricted Three Body Problem on the Sphere"

3) Luis Franco, UAM-Iztapalapa, México

"Symmetry in trapezoid central configurations: numeric and analytic results"

4) Juan Sánchez, UAM-Iztapalapa, México

"On the stability of Relative Equilibria of the three body problem on S^2 and H^2"

Morning II b (Salón de Conferencias, Hotel del Portal, 11:00-13:00)

Talks by Students – III

Chair: Marcus J. B. Hauser

1) Jesús Andrés Arzola Flores,

Instituto de Física. Benemérita Universidad Autónoma de Puebla, Puebla, México.

"A new model of Oregonator"

2) Shunashi G. Castillo,

Instituto de Física. Benemérita Universidad Autónoma de Puebla, Puebla, México.

"Toward a spectral classification of fractal billiards"

3) Tania Contreras-Uribe,

UPIITA-IPN, CDMX, México

"Evaluation of scaling behavior in electrogastric signals"

4) Nicolás-Carlock, J.R.,

Instituto de Física. Benemérita Universidad Autónoma de Puebla, Puebla, México.

"Universality in morphological transitions of fractal growth processes"

CLOSING REMARKS 13:00

ABSTRACTS OF INVITED AND CONTRIBUTED TALKS

MONDAY 24/10

MORNING I

Finding and Forming Synchronized Clusters in Complex Networks of Oscillators Using Symmetries

Louis M. Pecora

Naval Research Lab, 3903 Keller Ave., Alexandria, VA 22302, US

Many networks are observed to produce patterns of synchronized clusters, but it has been difficult to predict these clusters in general or understand the conditions for their formation. We show the intimate connection between network symmetry and cluster synchronization. We apply computational group theory to reveal the clusters and determine their stability. In complex networks the symmetries can number in the millions, billions, and more. The connection between symmetry and cluster synchronization is experimentally explored using an electro-optic network. In networks with Laplacian coupling clusters are possible which do not directly result from symmetries; however, it is possible to construct all possible synchronized clusters starting from the symmetry clusters. We show how to do this using the computational group theory as an aid and how to derive the variational equations for all the clusters.

History and Structure of Granular Sediments

Thorsten Pöschel

Institute for Multiscale Simulation, Friedrich-Alexander Universität, Erlangen-Nürnberg, Germany

We consider the sedimentation of monodisperse granular particles under the in infuence of gravity. The history of the process is described by the surface of the sediment as a function of time. We show that the resulting structure of the sediment, characterized by the field of contact number is intimately related to the process of sedimentation such that the history of the process, can be completely deduced from the time-independent field of contact number of the sediment. We show that the structural features of a sediment arising from the specific process of sedimentation may be quantified by Minkowski tensors.

Ref:

N. Topic, F. Schaller, G. Schröder-Turk, T. Pöschel: "The microscopic structure of mono-disperse granular heaps and sediments of particles on inclined surfaces" Soft Matter Vol. 12, 3184 (2016).

N. Topic, J. Gallas, T. Pöschel: "Nonuniformities in the angle of repose and packing fraction of large heaps of particles" Physical Review Letters Vol. 109, 128001 (2012)

Amplification of Noise by Chaos and Random Number Generation

Rajarshi Roy

University of Maryland, College Park

Random number generation is essential for encryption of information and Monte Carlo simulations. We examine sources of noise and signatures of randomness and determinism in optoelectronic nonlinear dynamical systems. Measures of entropy production and dependence on observational precision and time resolution are described. The amplification of noise by chaos and applications of optoelectronic systems to physical random number generation and assessment are explored. State-of-the-art techniques will be discussed.

Chimera and Chimera-Like States in Populations of Nonlocally Coupled Homogeneous and Heterogeneous Chemical Oscillators

Kenneth Showalter

West Virginia University

kshowalt@wvu.edu

We have studied chimera and chimera-like states in populations of photochemically coupled Belousov-Zhabotinsky (BZ) oscillators. Simple chimeras and chimera states with multiple and traveling phase clusters, phase-slip behavior, and chimera-like states with phase waves are described. Simulations with a realistic model of the discrete BZ system of populations of homogeneous and heterogeneous oscillators are compared with each other and with experimental behavior.

References:

A. F. Taylor et al., Angewandte Chemie Int. Ed. **50**, 10161 (2011);

M. R. Tinsley et al., Nature Physics **8**, 662 (2012);

S. Nkomo et al., Phys. Rev. Lett. **110**, 244102 (2013);

J. F. Totz et al., Phys. Rev. E **92**, 022819 (2015).

MORNING II a

Dynamical model of the function and disfunction of stem cells in colonic crypts.

Rafael A. Barrio

Instituto de Física, UNAM

We present a theoretical and computational framework to model the colonic crypt organisation in the human intestine. This model is based on a Using a theoretical and computational framework to model the colonic crypt behaviour we addressed how the disregulation in their functioning can lead to tumour masses and cancer.

Dynamic Regime Criteria for Complex Network Reduction.

Gustavo Martinez-Mekler[1,2], Daniel Priego[1], Jesús Espinal[3], Alejandro Aguado[1], Alberto Darszon[4].

[1]Instituto de Ciencias Físicas Universidad Nacional Autónoma de México (UNAM), [2]Centro de Ciencias de la Complejidad (UNAM), [3]Instituto Nacional de Medicina Genómica, México, [4]Instituto de Biotecnología (UNAM)

The structure and dynamics of complex phenomena are often modeled by means of networks. In their study, the possibility of node reduction is commonly sought for. Here we present a strategy for such a reduction in terms of a discrete time attractor landscape analysis in conjunction with dynamical regime criteria. In doing so, we address issues such as robustness, redundancy, degeneracy, plasticity and criticality. As an exemplification, we analyze a signaling network for sea urchin flagellum calcium oscillations that controls sperm swimming during fertilization [1-3]. The recurrence of a critical dynamical regime after node deletions is challenging in evolutionary terms. A comparative study of the spread of initial condition perturbations as network nodes are deleted, by means of a modified version of the Derrida plot [4,5], identifies expansive (chaotic), contractive (regular) and marginal (critical) relative dynamics. This classification provides information that complements the attractor landscape analysis. Coincidence of the reduced network with an alternative continuous time formulation is encouraging. The reduction method is applicable to general logical networks.

[1]Espinal, J., Aldana, M., Guerrero, A., Wood, C. D., Darszon, A., and Martínez-Mekler, G. (2011). Discrete dynamics model for the speract-activated Ca2+ signaling network relevant to sperm motility. PloS ONE 6(8): e22619.

[2] Guerrero, A., Espinal, J., Wood, C.D., Rendón, J.M., Carneiro, J., Martínez-Mekler, G., Darszon, A., Niflumic acid disrupts marine spermatozoan chemotaxis without impairing the spatiotemporal detection of chemoattractant gradients (2013) Journal of Cell Science 126(6): 1477.

[3] Espinal J, Darszon, A., Wood, C., Guerreo A, Martínez- Mekler G, (2014) In silico determination of the effect of multi- target drugs on sea urchin spermatozoa motility. PLoS ONE 9(8): e104451

[4]Derrida, B. and Pomeau Y (1986) Random Networks of Automata: A Simple Annealed Approximation. Europhys. Lett., 1(2):45

[5] Simone Gupta, Siddharth S Bisht, Ritushree Kukreti, Sanjeev Jain, and Samir K Brahmachari (2007). Boolean network analysis of a neurotransmitter signaling pathway. J. Theor. Biol., 244(3):463.

The Dynamics of Chemical Self-replication

Enrique Peacock-López

Williams College; 47 Lab Campus Lab; Williamstown MA 01267, USA

For many years it has been recognized that autocatalysis is necessary element for complex chemical oscillation. Chemical self-replication is one of the simplest cases of autocatalysis, and it has been experimentally studied for the lat twenty years, using organic compounds, nucleotides, ribozymes, and peptides. In most cases the experiments considered closed systems and were more interested in established possible chemical paths related to the origins of Life.

In parallel to the experimental analysis, we have proposed simple models of self-replication and analyzed its dynamics in open systems. In particular, we have analyzed Joyce's rybozyme experimental model and considered extension of self and cross-catalytic self-replication via a single template mechanism. In this case the dynamic behavior in open systems include chemical spatio-temporal patterns, but the limitation to a singlet catalytic species reduces he dynamic options and avoids complex catalytic self-replicating networks.

In contrast the formation of catalytic duplexes open up a myriad of possibilities in both closed and open systems. So far only peptide can be manipulated experimentally to select or design chemical self-replication via a catalytic active duplex. On the one hand, potentially, DNA may be able to self-replicate forming a triple helix, but experimental evidence of this mechanism is absent.

On the other hand, artificial peptide networks have been synthesize and experimentally studied in batch reactors.

In our present work, we considered the dynamic analysis of self-replicating peptide systems that can use a singlet or a duplex as catalytic templates. In the case of open systems, we analyzed the coexistence of competitive self-replicating simple networks. Finally, we also consider the dynamics of recombinant peptides in artificial peptide networks.

MORNING II b

Regional Control of Boolean Cellular Automata

Franco Bagnoli

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An interesting problem in extended physical systems is that of the regional control, i.e., how to add a suitable control at the boundary or inside a region of interest so that the state of such region is near to a desired one. Many physical problems are modelled by means of cellular automata. It is therefore important to port control concepts to this discrete world. In this talk we address the problem of regional controllability of cellular automata and similar discrete systems via boundary actions, i.e., we investigate which are the characteristic of a cellular automaton rule so that it can be controlled inside a given region only acting on the value of sites at its boundaries.

A geometric mechanism of Arnold diffusion in the a priori stable case

Marian Gidea

Yeshiva University, new York City, USA

We consider the a priori stable case of the Arnold diffusion problem, for nearly integrable, 3-degrees of freedom Hamiltonian systems. The unperturbed Hamiltonian is assumed to be convex and superlinear, and the perturbation is assumed to be from a cusp-residual set. The diffusion problem is concerned with the existence of trajectories that follow prescribed sequences of simple resonances.

Earlier work by J.-P. Marco shows that there are chains of 3-dimensional normally hyperbolic invariant cylinders with boundary, along the simple resonances, which admit homoclinic and heteroclinic connections.

Here we prove the existence of diffusing orbits drifting along such chains, under precise conditions on the dynamics on the cylinders, and on their homoclinic/heteroclinic structures. Our approach is based on geometric/topological methods that allow for an algorithmic construction of diffusing orbits. The mechanism outlined here is in agreement with numerical experiments by Gelfresich, Simo, and Vieiro. This is joint work with J.-P. Marco.

Deterministic walks on regular lattices on the plane

Ana Rechtman (1), <u>Raúl Rechtman (2)</u>

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(2) Instituto de Energías Renovables, UNAM,
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We consider walks in square, triangular, and hexagonal two dimensional lattices. In each case, there is a scatterer at every site that can be in one of two states that force the walker to turn either to his/her right or left. After the walker passes, the scatterer changes state. We call a lattice with an arrangement of scatterers an environment. In the three types of lattices, there are only two types of scatterers for which the walks are reversible, mirrors or rotators. The initial state of the environment and the initial position and velocity of the walker determine the outcome of the walk. For walks in a hexagonal lattice, Webb and Cohen1 showed that given an initial environment of scatterers, mirrors or rotators, there is an initial environment of the other type of scatterers, such that both trajectories are equivalent in the sense that the same sites are visited at the same time steps. We extend this result to walks in square and hexagonal lattices.

If p is the initial fraction of randomly placed obstacles in state 1 when the walk starts and we consider an ensemble of initial environments with the same value of p, we and anomalous diffusion for some values of p for environments with mirrors or rotators.

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AFTERNOON I a

SEE MS3 IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I b

Chaos synchronization as an auditory-motor task for improved motor learning

Dobromir Dotov

Centro de Ciencias de la Complejidad, UNAM, México

Convergent evidence confirms the potential of movement variability for improving the efficacy of motor rehabilitation. It is less known, however, in what exactly constitutes beneficial variability. One way of characterizing variability is in terms of the process of its generation. Nonlinear dynamical instabilities constitute a biologically plausible and computationally frugal mechanism for useful and constrained variability; nature uses chaos to generate "effective randomness" on the cheap. A long-standing and recently revived hypothesis is that the brain explores the opportunities to expand its perceptual and motor skill by using the sensitivity to initial conditions inherent in nonlinear dynamical instabilities. This also allows variability to be generated by the same dynamical mechanism that also produces orderly behaviour. This idea has found support in robotics. Chaotic central pattern generators (CPGs) can flexibly use environmental feedback to adapt a robot's movement pattern. The variability and adaptation inherent to chaotic systems make this possible. On the one hand, chaotic systems can contain an infinite number of unstable periodic orbits (UPOs). On the other hand, chaos can be controlled or entrained by an external signal that stabilizes a given UPO. I seek to develop an experimental paradigm for motor learning that encourages variability by asking healthy participants to learn to entrain a chaotic dynamical system. The paradigm is to rely on movement sonification, i.e. real-time mapping of a variable extracted from limb motion to the pitch of a sound synthesizer. Coupling scenarios using four chaotic CPGs (Chua circuit, Lorenz attractor, Circle map, and Logistic map) were explored.

Preliminary data is presented for an auditory-motor synchronization task where hand motion is sonified in the one channel of the headphones while a driven chaotic CPG receiving the hand motion as a driving signal is sonified in the other channel.

Dynamical Properties and Tumor Clearance Conditions for Multi-Dimensional Models of Bladder Cancer Immunotherapy

Konstantin E. Starkov, Instituto Politecnico Nacional, CITEDI, Avenida IPN N 1310, Nueva Tijuana, Tijuana 22435, B.C., Mexico, konst@citedi.mx, kstarkov@ipn.mx and

Svetlana Bunimovich-Mendrazitsky, Department of Computer Science and Mathematics, Ariel University, Ariel 40700, Israel, svetlanabu@ariel.ac.il

Understanding the global interaction dynamics between tumor and the immune system plays a key role in the advancement of cancer therapy. In papers [1, 2] various bladder cancer models of 4- and 9- dimensions were derived. Two types of therapy: Bacillus Calmette-Guérin (BCG) and interleukin-2 (IL-2) were applied in these models. Using the localization method of compact invariant sets, [3], and stability theory we derive ultimate upper and lower bounds for all densities of cells populations and concentration of treatments involved into these models. Further, we prove dissipativity property in the sense of Levinson and describe global asymptotic tumor clearance conditions. Results which will be reported in this work are based on papers [4, 5]. Our method may be exploited for a prediction of the cells populations dynamics involved into these models.

The work of the first author is supported by the CONACYT project N 219614 "Análisis de sistemas con dinámica compleja en las áreas de medicina matemática y física utilizando los métodos de localización de conjuntos compactos invariantes", Mexico.

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3. A.P. Krishchenko and K.E. Starkov, Localization of compact invariant sets of the Lorenz system, Phys. Lett. A 353 (2006) 383--388.

4. K.E. Starkov and D. Gamboa, Localization of compact invariant sets and global stability in analysis of one tumor growth model, Mathematical Methods in the Applied Sciences, 37 (2014) 2854-63.

5. K.E. Starkov and S. Bunimovich-Mendrazitsky, Dynamical properties and tumor clearance conditions for nine-dimensional model of bladder cancer immunotherapy, submitted to Mathematical Biosciences and Engineering

Analysis of the heart rate variability (HRV) and stratification of the risk of cardiac affectation patients with Chagas' disease

Miguel A. Vizcardo

Universidad Nacional San Agustin, Calle Santa Catalina Nº 117, Arequipa Perú

According to the World-wide Organization of the Health, the number of people infected with the Tripanosoma Cruzi is considered between 16 and 18 million, causal agent of the Chagas' disease, and in 100 million the people exposed to the affectation risk. When concluding in 1983 a study longitudinal epidemiologist in patients with the disease evaluated every 3 years, the cardiac affectation: chronic Chagasic myocarditis (MCHC) increased from a 17% at the beginning of the study to a 49,4% after 15 years. Previous studies of the variability of cardiac frequency in patients with the Chagas' disease, show alterations in the spectral indices of the HRV.

We analyze the 24-hour heart rate by Holter recordings in 62 patients with ECG alterations (CH2), 32 patients without ECG alterations (CH1) who had positive serological findings for disease of Chagas' and 36 healthy subjects (Control) matched for sex and age.

We find a orthogonal base that is able to discriminate the groups from circadian profiles, Control and CH2, and stratify the groups CH1.

AFTERNOON I c

Intrinsic excitability and the role of saddle slow manifolds

Hinke M. Osinga

Department of Mathematics, The University of Auckland,

Private Bag 92019, Auckland 1142, New Zealand

Excitable cells, such as neurons, exhibit complex oscillations in response to external input, e.g., from other neurons in a network. We consider the effect of a brief stimulation from the rest state of a minimal neuronal model with multiple time scales. The transient dynamics arising from such short current injections brings out the intrinsic bursting capabilities of the system. We focus on transient bursts, that is, the transient generation of one or more spikes, and use a simple polynomial model to illustrate our analysis. We take a geometric approach to explain how spikes arise and how their number changes as parameters are varied. We discuss how the onset of new spikes is controlled by stable manifolds of a slow manifold of saddle type. We give a precise definition of such a stable manifold and use numerical continuation of suitable two-point boundary value problems to approximate them.

Joint work with: Krasimira Tsaneva-Atanasova (University of Exeter), Vivien Kirk and Saeed Farjami (both University of Auckland)

A software package for the continuation and bifurcation analysis of discretized partial differential equation

Joan Sánchez-Umbría

Universitat Politécnica de Catalunya, Barcelona, Spain.

A first version of a software package for the continuation and stability analysis of equilibria and periodic orbits of systems of parabolic partial differential equations will be presented.

The currently implemented features include the continuation of both kinds of invariant objects and the study of their stability. The methods used will be described is some detail together with simple one-dimensional application examples used to aid the development of the codes. In a near future the detection and branch switching modules for codimension-one bifurcations will be implemented.

Some Numerical Continuation Tools in Celestial Mechanics.

Eusebius Doedel

Concordia University, Montreal, Canada

A collection of Python scripts has been developed for the numerical bifurcation analysis of several problems in Celestial Mechanics.

These scripts control the boundary value software AUTO to carry out the necessary calculations. The talk will focus on some of the more basic capabilities, one of these being the computation of families of periodic solutions for the restricted n-body problem in the Maxwell configuration. Also considered is the full n-body problem in Maxwell configuration, for which generalized choreographies are determined in a systematic manner. This is joint work with Renato Calleja and Carlos Garcia Azpeitia of UNAM.

Bifurcation based mechanical diodes and amplifiers

Jorge Galan-Vioque

University of Sevilla, Spain.

In the last decade there has been a significant interest in the modeling and design of micro electronic mechanical systems (MEMS) for energy harvesting and structure monitoring. In this talk we will study the possibility to construct two of those mechanical devices that play the analogous role of the diodes and amplifiers in traditional circuits. In one case the vibrations have a preferred direction of transmission whereas in the other we will seek the conversion of small amplitude and low frequency to large amplitude and high frequency oscillations.
We will see that resonances and bifurcations are essential to understand the dynamical mechanism.

TUESDAY 25/10

MORNING I

Two- and Three-Dimensional Phase Field Quasicrystals

E. Knobloch

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We investigate the formation and stability of quasicrystalline structures using a dynamic phase field crystal model in both two [1,2] and three [3] dimensions. Nonlinear interactions between density waves at two length scales lead to metastable 12-fold quasicrystals in two dimensions but stable icosahedral quasicrystals in three dimensions. We determine the phase diagram in both two and three dimensions and the parameter values required for the three-dimensional quasicrystal to be the global minimum free energy state. The results lead to insight into the conditions that favor the formation of soft matter quasicrystals in both two and three dimensions.

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This is joint work with P. Subramanian and A. M. Rucklidge (Department of Applied Mathematics, University of Leeds, UK) and A. J. Archer (Department of Mathematical Sciences, Loughborough University, UK)

Are sliding drops dissipative solitons?

Uwe Thiele, Sebastian Engelnkemper, Markus Wilczek and Svetlana Gurevich

Institute for Theoretical Physics, WWU Muenster, 48149, Muenster, Germany

Abstract: We study the dynamics of liquids drops on a solid substrate [1] employing a long-wave evolution equation for partially wetting liquids of small equilibrium contact angles. After a brief introduction of the modelling of capillarity and wettability in a mesoscopic hydrodynamic theory we focus on the case where lateral driving forces, e.g., gravity for an inclined substrate results in sliding ridges (two-dimensional drops) [2] and three-dimensional drops [3].

First, we analyse periodic trains of stationary sliding droplets and the transformations of their individual droplets in dependence of the driving force employing continuation techniques [4]. We show that a number of shape transitions of stationary sliding droplets occur at saddle-node bifurcations. Further there is a global bifurcation that results in dynamic states where a main sliding droplet emits small satellite droplets at its rear (pearling instability) that subsequently coalesce with the next main droplet. These pearling states show the period-doubling route to chaos.

Second, we conduct direct numerical simulations on a large spatial domain and examine the interaction of many sliding drops. As the sliding velocity of the drops depends on their volume, larger drops overtake smaller drops and merge with them. The ongoing merging and pearling behavior results in a stationary distribution of drop sizes, whose shape depends on the inclination angle of the substrate and the overall volume of liquid in the system. We illustrate that aspects of the steady long-time drop size distribution may be deduced from the bifurcation diagrams for individual drops.

Finally, we return to the pearling-coalescence cycles and pose the question whether the illustrated droplet interactions indicate that sliding droplets may actually be considered as another type of dissipative solitons.

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[4] Using PDE2PATH, see H. Uecker, D. Wetzel and J.D.M Rademacher, Numer. Math.-Theory Methods Appl. 7, 58-106 (2014).

Dynamics of Large Eddy Simulation of box turbulence

Lennaert van Veen

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Since the pioneering work by Kawahara and Kida (2001) on weakly turbulent Couette flow, many attempts have been made to study the dynamics of turbulence through Unstable Periodic Orbits. From a mathematical point of view, UPOs are the building blocks of a high-dimensional chaotic attractor; they are expected to exist in abundance and have properties similar to those of turbulent, non-periodic motion. From a physical point of view, UPOs can be regarded as coherent structures in terms of which
the turbulent dynamics could be decomposed. The central difficulty is the computation of UPOs. In three-dimensional flows with periodic boundary conditions, i.e. box turbulence, the number of degrees of freedom runs in the millions even for marginally turbulent motion. Even with the extensive use of parallel computing and the most suitable numerical algorithms, accurately solving for periodic orbits is next to impossible. Several strategies can be tried to bring the number of degrees of freedom down, such as imposing spatial symmetried on the UPOs. In this presentation, we will explore a different approach, namely that of Large Eddy Simulation (LES). This approach allows us to resolve only the spatial scales on which we expect to see the most interesting dynamics, while modelling the effect of the smallest scales. We will show, that LES of box turbulence with simple external forcing gives rise to various UPOs and investigate their dependence on the range of resolved spatial scales and the LES modelling parameters.

Joint work with Tatsuya Yasuda (Imperial College) and Genta Kawahara (Osaka University).

Asymptotic Analysis of Quorum-Sensing Behavior for a Coupled Cell Bulk-Diffusion Model in 2-D

Michael Ward

Dept. of Mathematics, University of British Columbia, Vancouver, BC, V6T 1Z2, Canada

We formulate and analyze a class of coupled cell-bulk PDE models in 2-D bounded domains. Our class of models, related to the study of quorum sensing, consists of m small cells with multi-component intracellular dynamics that are coupled together by a diffusion field that undergoes constant bulk decay. We assume that the cells can release a specific signaling molecule into the bulk region exterior to the cells, and that this secretion is regulated by both the extracellular concentration of the molecule together with its number density inside the cells. By first constructing the steady-state solution, and then studying the associated linear stability problem, we show for several specific cell kinetics that the communication between the small cells through the diffusive medium leads, in certain parameter regimes, to the triggering of synchronized oscillations that otherwise would not be present in the absence of any cell-bulk coupling.

Moreover, in the well-mixed limit of very large bulk diffusion, we show that the coupled cell-bulk PDE-ODE model can be reduced to a finite dimensional system of nonlinear ODEs with global coupling, that exhibits quorum-sensing behavior, whereby a collective oscillation occurs only if the number of cells exceeds a threshold. The analytical and numerical study of these limiting ODEs reveals the existence of globally stable time-periodic solution branches that are intrinsically due to the cell-bulk coupling.

Joint work with Jia Gou (UBC, UMinnesota)

MORNING II a

New Challenges for Complex Brain Networks

Mario Chávez

Hôpital de La Pitié-Salpêtrière, Paris, France

Understanding brain connectivity has become one of the most important issues in neuroscience. But connectivity data can reflect either the functional relationships of the brain activities or the anatomical properties between brain areas. Although one should expect a clear relationship between both representations, this is not straightforward. In this talk I'll discuss this relationship between anatomical and functional connectivity. In previous studies, the correspondence of these networks has been often assessed by their difference in an Euclidean space of vectors containing connectivity measures such as the clustering coefficient, shortest path length, degree distribution, etc. Nevertheless radically different framework have been recently proposed for studying brain connectivity differences. Instead of extracting a vector of features for each layer (anatomical or functional), one can embed all of them in a common metric space that allows straightforward comparisons. This methodologies can be used not only to compare multimodal networks but also to extract statistically significant aggregated networks of a set of subjects. I'll illustrate one this procedures to compare a set of functional networks from different subjects with the structural layer. The comparison of the multilayer brain network reveals some features that are not observed when the analysis is done on single networks.

How to orchestrate a soccer team
Generalized synchronization promoted by rhythmic acoustic stimuli-

Manfred A. Müller[1], Alfred O. Effenberg[2], Armin Friedrich[1], Ignacio Garcia-Madrid[3], Matthias Hornschuh[4], Gerd Schmitz[2], Markus F. Müller[1,5,6,*]

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[3]Posgrado en Ciencias Cognitivas, Universidad Autónoma del Estado de Morelos, 62209 Cuernavaca, Morelos, México

[4]Stiftung Universität Hildesheim, Institut für Musik und Musikwissenschaft, Kulturcampus Domäne Marienburg, Universitätsplatz 1, 31141 Hildesheim

[5]Centro de Investigaciones en Ciencias, Universidad Autónoma del Estado de Morelos, 62209 Cuernavaca, Morelos, México

[6]Centro de Ciencias de la Complejidad, Universidad Nacional Autónoma de México, CU, DF, México

Team sport implies Teamwork. This requires precise interpersonal coordination on a common time frame, oftentimes with scarce or even without any verbal communication. Prominent examples of such generalized synchronization are orchestras or team sports. However, musicians benefit continuously from the score, the acoustic feedback of the whole ensemble and the external driving of the conductor, while the coupling between teammates is much weaker and reduced to the actions perceived from a limited visual sector and a restricted acoustic radius. On the other hand, it is widely accepted that an orderly time structure provided by rhythmic acoustic stimuli promotes motor control even in case of patients with severe motor disorders. Also nonverbal communication between individuals, probably the driving force of self-organized team management, displays a rhythmic time structure of interactions between the protagonists. However, whether a common rhythmic acoustic time frame also promotes interpersonal coordination is unknown so far. Here we show, by using soccer teams as a testing ground, that acoustic stimuli may improve significantly the interplay between teammates. We provide quantitative evidence that the collectivity as well as scoring rate of male soccer teams improves significantly when playing under the influence of an appropriate acoustic environment. Considering that Rhythmic Auditory Stimulation (RAS) in other contexts has shown long term effects embolden us to hypothesize that the present study may also conduct to new, efficient training methods in team sport like soccer. Unexpectedly, female teams do not show any improvement under the same experimental conditions.

The effect is not due to motor entrainment, as we could show by a follow up experiment. Instead we argue that the rhythmic acoustic stimuli modulate the attention level of the protagonists such that the marked gender difference can be explained by a kind of (nonlinear) resonance effect.

Dynamical Detection of Network Communities

Nicolás Rubido (1,2),

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Trophic networks, where nodes are species in an ecosystem and edges can be predator-prey relationships, or the Internet, where nodes are web-pages and edges can be links between them, are just two examples of networks showing modular structures, namely, communities. Communities are subsets of nodes, species, or web-pages, that are clustered in a densely connected way, as it so happens to a group of users in Facebook that are densely connected by their mutual friendship and are sparsely connected to other users. Among the many advantages of identifying communities in networks, is the understanding of how the networks grow/shrink and which dynamical behaviors can arise. However, community detection is a nontrivial task. Specially, since real-world networks, as Facebook, evolve in time by adding/removing nodes (users) and/or including/excluding edges (friendships). Our work [1] presents an approach to detect communities in networks that succeeds in both scenarios: static and time-varying topologies. It is based on mapping the nodes of the network to a set of interacting particles, where the interactions between particles are either attractive, when the nodes share a link, or repulsive, when the link is missing. Consequently, the system of particles promptly converges to a clustered state, which corresponds to the different communities in the network. We highlight that the choice for the interaction force between particles is flexible, easy to implement, and mathematically tractable, giving our approach a remarkable advantage over several state-of-the-art methods. Moreover, it can also deal with overlapping communities.

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MORNING II b

Laminar mixing in tubular networks of plasmodial slime moulds

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The plasmodium of the unicellular slime mould *Physarum polycephalum* forms an extended vascular network, which is used for transportation of protoplasm through the giant cell. The transport is driven by pressure gradients generated by peristaltic pumping, leading to a flow that reverses its direction periodically. Although the flow in the veins of *P. polycephalum* is always parabolic, protoplasm and particles suspended in it are effectively and rapidly distributed within the cell. To elucidate how an effective mixing is achieved in such a microfluidic system with Poiseuille flow (at low Reynolds and Womersley numbers), we performed micro-PIV experiments and advect virtual tracers in the determined time-dependent flow fields. Flow splitting and flow reversals at branchings of veins, as well as small fluctuations in the flow patterns at the branchings of veins play key roles in providing for an efficient mixing of protoplasm in the cell.

Periodic orbits in tall laterally heated rectangular cavities

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The usefulness and advantages of computing periodic solutions of dissipative PDEs by means of Newton-Krylov continuation methods [1, 2, 3] will be illustrated in the presentation

with the application of the method to the calculation of the periodic flows arising in a tall rectangular cavity laterally heated. This problem has long been studied because of its relevance in industrial applications, for instance, in the successful growth of single liquid crystals, the design of large-scale laser systems, or the optimal heating or cooling and isolation of buildings.

It was known that in this problem there are multiple stable periodic and quasiperiodic orbits coexisting in the same range of parameters, which origin was assumed in [4] from the comparison of the critical eigenfunction of the steady solutions at the bifurcating points and the spatial and temporal structure of the periodic orbits. Here it is shown that the orbits detected previously by time evolution (and other branches calculated only by continuation techniques) arise directly from the basic steady flow without intermediate turning points or symmetry-breaking bifurcations. The Neimark-Sacker points on the branches of periodic solutions have been determined with precision for a long range of Rayleigh numbers.

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Effects of convection on thin reaction fronts

Desiderio Vásquez

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Fluid motion affects the propagation of chemical reaction fronts in liquids. Changes in surface tension or density gradients across the front may generate convection. The resulting fluid motion increases the speed and changes the shape of fronts as observed in the iodate-arsenous acid reaction. We calculate these effects using a thin front approximation, where the reaction front is modeled by an abrupt discontinuity between reacted and unreacted substances. We analyze the propagation of reaction fronts of small curvature. In this case the front propagation equation becomes the deterministic Kardar-Parisi-Zhang (KPZ) equation with the addition of fluid flow. These results are compared to calculations based on a set of reaction-diffusion-convection equations.

AFTERNOON I a

DYNAMICS AND STATISTICS OF THE FPU β –MODEL WITH DIFFERENT RANGES OF INTERACTIONS

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In a recent study of the one-dimensional N particle Fermi-Pasta-Ulam (FPU) β-model [1], we introduced in the quartic interactions a coupling constant that decays with particle distance r as $1/r^{\alpha}$ ($\alpha \geq 0$), which recovers the nearest neighbor classical FPU model in the limit $\alpha \to \infty$, and showed that in the *long range interaction* case (LRI) $0 \leq \alpha \leq 1$: (i) the maximal Lyapunov exponent *decreases* as N increases, indicating a kind of "weaker chaos", and ii) the probability density function (pdf) of time-averaged velocities is described by a q (>1)-Gaussian, while for $\alpha > 1$ we recover the well – known Gaussian (q=1) of Boltzmann-Gibbs (BG) statistics and "strong chaos" [2]. In the present work [3], we study the FPU – β model introducing LRI to both the quadratic and quartic parts of the potential, through $1/r^{\alpha}$ couplings depending on two exponents α_1 and α_2 respectively. Our results demonstrate that "weak chaos", in the sense of decreasing Lyapunov exponents and q – Gaussian pdfs of sums of the momenta, occurs *only when LRI are included in the quartic part*. More importantly, for $0 \leq \alpha_2 < 1$, we obtain extrapolated values of $q > 1$, as $N \to \infty$, suggesting that a type of Tsallis q – statistics *persists in the thermodynamic limit*. On the other hand, when LRI are imposed *only on the quadratic part*, "strong chaos" and purely Gaussian pdfs of BG thermodynamics are always observed.

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Anomalous transport and diffusion analysis of a non-dissipative Fermi-Ulam model

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We study the dynamics of an ensemble of non interacting particles moving constrained by two infinitely heavy walls, where one of then is moving eriodically in time and the other is fixed. The system presents mixed dynamics, where the accessible region for the particle to diffuse chaotically is bordered by an invariant spanning curve. Statistical analysis for the root mean square velocity, lead different velocity ensembles to the same steady state plateau. We defined a hole as a predefined subset of the phase space, and measured the probability of an orbit does not escape through

it as function of the number of collisions, where the escape rate decays changes according the ensemble. Starting with low initial velocity, we have typical exponential decays, as for the higher one, bumps and successive stretched exponential decays followed by power laws tails, indicate delays and stickiness influence to the dynamics.

Transport analysis via escape basins, frequency histograms and step-size averages, reveal that high velocity orbits prefer to stay trapped near the invariant curve, causing anomalous transport and diffusion. Also, the stable manifolds play the role of a preferential path for faster escape rates in both ensembles.

Geometric Numerical Integration: How to Discretize Differential Equations While Preserving Their Physical Properties

GRW QUISPEL

LA TROBE UNIVERSITY, MELBOURNE , AUSTRALIA

In this talk we give a survey of geometric numerical integration, i.e. the numerical solution of differential equations while preserving one or more of their physical properties exactly, i.e. up to round-off error.

Properties that can be preserved include symplectic structure, energy and other first integrals, phase space volume, symmetries, dissipation, etc.

Flatness-Induced Phase Transition in Lyapunov Spectrum for Unimodal Maps

HIROKI TAKAHASI

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For a class of Misiurewicz *S*-unimodal maps with at critical points, we study the occurrence of phase transitions, i.e., the lack of analyticity in their Lyapunov spectra.
Combining a description of the Hausdorff dimension for Lyapunov exponents and the thermodynamic formalism by Dobbs & Todd for maps with at critical points, we show that the Lyapunov spectrum is not real-analytic if the absolutely continuous invariant measure (a.c.i.m. for short) is a finite measure. On the other hand, we treat an *S*-unimodal map which behaves, near its critical point *x* = *c*, like *abs(x-c)**((abs(x-c))**(-p))* , *p* >= 1 and therefore the a.c.i.m. is an infinite measure. Adapting the parameter exclusion argument of Benedicks & Carleson to a phase-space analysis, and then using a large deviation upper bound inspired from the work of Chung, we show that the Lyapunov spectrum is not real-analytic also in this case. This reveals a contrast to the classical result of Nakaishi for interval maps with parabolic _xed points which shows that the Lyapunov spectrum is real-analytic if and only if the a.c.i.m. is an infinite measure.

AFTERNOON I b

Dynamics and control for virus propagation in complex networks in the frame a a discrete time Markov process for the case of SIS epidemic model

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In this work, the dynamics of virus propagations in complex networks of arbitrary topology have been studied in the framework of discrete time Markov process dynamical systems for the case of the SIS epidemics model. This studies have yielding conditions for extinction in terms of the transitions probabilities and the largest eigenvalue of the conectivity matrix. Based on these results we stablish a method for controlling the network, in order to reach extiction, using a

reduced number of nodes without modifying the structure of the net. Besides, our method provides the criteria to select the nodes that have to be controlled to reach the extinction state.

Simulation results are presented which show the performance of the designed control scheme for large scale-free networks and that corroborate our theoretical findings.

The complex scenario to collective behaviour in complex networks

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4Institute for Complex Systems and Mathematical Biology, SUPA, University of Aberdeen, Aberdeen, AB24 3UE, UK

Regular behaviour can emerge inside chaotic regions of the parameter space of a dynamic system, organized in periodic windows surrounded by chaos, also known in the literature as \shrimps", due to their geometrical shape. These windows are self-similar: their size depend on their periodicity, following scaling laws, but their geometrical shape is a dynamical invariant. Moreover, they present accumulation property: they occur in an in_nite number of self similar windows arranged along a particular direction.

In this work we address the occurrence of these periodic windows in the pa-rameter space of the Chua circuit, determinig how their behaviour change when we couple two or more circuits. The developed approach can be generalized to predict the occurrence of collective behaviour in complex networks of arbitrary
dimensions.

Scaling relations between population and number of facilities

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The University of Tokyo, Japan
Takayuki Mizuno, National Institute of Informatics, Japan
Tsutomu Watanabe, The University of Tokyo, Japan

How different urban properties such as number of hospitals, shops, patents, and crimes depend on city size? It has been demonstrated that most urban properties Y follow the allometric scaling law: Y is proportional to N^b, where N and b are population size of a city and the scaling exponent. Urban infrastructure has been shown to scale sub-linearly (b<1) reflecting large cities don't need large infrastructure, whereas output and income have been shown to scale super-linearly (b>1) reflecting high per capita in large cities. Here we empirically analyze urban scaling observed in Japanese phone directory (Yellow Pages) data on a nationwide scale collected from Telepoint provided by Zenrin Co., Ltd. This data contains comprehensive individual listings of about 7 million facilities (nearly all shops, firms, hospitals, schools, parks, etc). Name, address, latitude and longitude, phone number, and industrial sector of the facility are also included. Because no consensus exists on how cities should be defined, we define cities as municipalities. Then we count the number of facilities in each municipality. The industrial sector is divided into 39 categories. Each category is further divided into 731 subcategories. This allows us to study and discuss systematically the scaling exponent that are associated with various aspects of urban agglomeration. We show that obtained scaling exponents help to characterize urban properties.

Synchronization using environmental coupling in Mercury Beating Heart oscillators

Tanu Singla

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We report synchronization of Mercury Beating Heart (MBH) oscillators using the environmen-tal coupling mechanism. This mechanism involves interaction of the oscillators with a common medium/environment such that the oscillators do not interact among themselves. In the present work, we chose a modi_ed MBH system, as the common environment. In the absence of coupling, this modified system does not exhibit self sustained oscillations. It was observed that, as a result of the coupling of the MBH oscillators with this common environment, the electrical and the mechanical activities of both the oscillators synchronized simultaneously. Experimental results indicate the emergence of both lag and the complete synchronization in the MBH oscillators.

AFTERNOON I c

SEE MS5 IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I d

Heat flux spectrum of rotating Rayleigh-Bénard convection

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Turbulence studies on stratified flow focused their primary attention on the scaling of energy and entropy spectra. Much debate has centered on whether the scaling of the spectra are of the Kolmogorov (K41) [1] type or Bolgiano-Obhukhov (BO) [2] type. Scaling of convective turbulence is quiet unclear despite of several experimental and numerical efforts [3]. In Rayleigh-Bénard convection, where a thin fluid layer confined between two conducting plates is uniformly heated from below and cooled from above, the frequency spectra of heat flux shows power-law behavior [4]. The study of heat flux spectra in wave number space has been investigated before [5]. However, the effect of rotation on the heat flux spectra is sparse. We present the scaling of the heat flux in the wave number space for rotating Rayleigh-Bénard convection using direct numerical simulations. We have used a thin layer of fluid with Prandtl number Pr = 0.5 rotating uniformly with free-slip and conducting boundary conditions. The spectra of the convective heat flux H(k) are defined as $Nu-1= \int H(k)dk$, where the Nusselt number Nu scales with the wave number k as $k^{-\delta}$ with $\delta \approx 2$ for higher values of the reduced Rayleigh number $r = Ra/Ra_c$ ($> 10^3$). It is the same universal scaling of the Rayleigh number regime, where Nu scales with Ra approximately as $Ra^{2/7}$ [6]. The scaling results are independent of Taylor number Ta and Prandtl number Pr. However, for smaller values of r ($<10^3$) the exponent δ shows Ta and Pr dependence. The value varies in the range of $2.0 \leq \delta \leq 2.8$.

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Hysteric Faraday waves

Nicolas Perinet, Claudio Falcon

DFI-FCFM-Universidad de Chile,

SEUNGWON SHIN, Hongik University,
JALEL CHERGUI, DAMIR JURIC, LIMSI-CNRS.

The Faraday instability consists in vibrating vertically a recipient containing two fluids separated by an interface. When the amplitude of the vibration overcomes a threshold, waves appear at the interface initially planar. These stationary waves organize to form a huge variety of patterns.
We are simulating numerically Faraday waves in a two-dimensional channel with two immiscible and incompressible fluids. Far after the primary threshold, a further instability is observed, giving rise to a new state, still composed of stationary waves, but whose amplitude is around twice that of the original pattern. In addition, the bifurcation presents an hysteresis. We explain this secondary instability and the related hysteresis by means of a simple shear stress balance. The model gives predictions in agreement with the results of our numerical simulations.

Cascades of Triadic Resonance Instabilities in Internal Waves Attractors

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Laboratoire de Physique, ENS de Lyon, France
Lavrentyev Institute of Hydrodynamics, Novosibirsk, Russia

In contrast to the atmosphere of the Earth, the driving force of the Ocean is not a heat engine. Vertical mechanisms of energy transfer due to thermal processes and wind play significant role mostly in the vicinity of the surface of the Ocean. Meanwhile the global dynamics of the Ocean is also greatly affected by deep water processes and mixing. It means that now one of the most important questions in the dynamics of the oceans is related to the cascade of mechanical energy in the abyss and its contribution to mixing. Here, we propose internal-wave attractors in the large-amplitude regime as a unique self-consistent experimental and numerical setup that models a cascade of triadic interactions transferring energy from large-scale monochromatic input to multi-scale internal-wave motion. We also provide signatures of a discrete wave turbulence framework for internal waves. Beyond this regime, we have a clear transition to a regime of small-scale high-vorticity events which induce mixing. Also we have studied mixing due to boundary interaction and wave attractors formed from 3D sources of monochromatic waves in trapezoidal geometry.

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Anomalous diffusion in random dynamical systems

Yuzuru Sato

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Diffusion based on stochastic chaos in random dynamical systems is studied. There exist anomalous diffusion and ageing in a spatially extended random dynamical systems, where the unperturbed version is a well-established model for deterministic diffusion. The power-law exponents for the mean square displacement and the waiting time distribution match to predictions by continuous time random walk theory. When we fix a particular noise realisation for all trajectories, we find noise-induced synchronization of jump times and breaking of self-averaging, which is similar to weak ergodicity breaking in weakly chaotic systems. Universality of this phenomenon is discussed as well. This is a joint work with Prof. Rainer Klages at Queen Mary University of London.

WEDNESDAY 26/10

MORNING I

Anomalous diffusion of volcanic seismicity

Sumiyoshi Abe

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Although volcanic seismicity is a phenomenon of complex dynamics on complex architecture, it turns out to be characterized by a set of simple empirical laws concerning its spatio-temporal behaviors. Here, a comparative study is developed for volcanic seismicities at Mt. Etna in Italy and Mt.Eyjafjallajokull in Iceland. It is shown for both of the volcanoes that the spatial distance between two successive earthquakes obey the exponential distribution, whereas the waiting time distribution is of the power law. Spatial spreading of earthquakes exhibits subdiffusion also at both volcanoes. These properties are examined in view of the theories of anomalous diffusion, including continuous-time random walks and fractional Brownian motion. Existence of aging and non-Markovianity show that standard theoretical approaches to anomalous diffusion are not satisfactory. Thus, volcanic seismicity is highly challenging for science of complex systems.

The Story of the Ozone Hole

Imre M. Jánosi

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"The discovery of the Antarctic ozone hole was one of the most dramatic scientific findings of modern times." - begins Nature's Web Focus on the subject. Since it exists for some thirty years, the public interest is somewhat moderate nowadays, nevertheless scientific investigations incessantly going on. One recent focus topic is that the ozone hole is on the mend, owing to the 1987 Montreal Protocol which bans chlorofluorocarbons used as refrigerants in products such as fridges and air conditioners.

In my talk, I will give a short overview on the milestones of discovery and understanding of key processes, then some details on the evidences of healing. Besides globally coupled atmospheric modeling, time series analysis of measured total column ozone data provides also indications of trend reversal. There are two main "schools" of evaluating the noisy and gappy records (there is scarce data during the polar night periods): the first attempts to fit data by incorporating several explanatory variables such as poleward heat flux, quasi-biennial oscillations, equivalent effective stratospheric chlorine concentration, etc., in rather complex models, the second methodology uses minimal pretreatments and fits time series to locate statistically significant breakpoints. I will shortly report on our results, which is motivated by level-crossing statistics, where subsets of the records above or below particular threshold levels are evaluated. The observed trend reversal in the total column ozone time series is consistent with the temporal development of the stratospheric halogen loading.

Inferring the connectivity and the community structure of a complex systems from observed data

Cristina Masoller

Universitat Politècnica de Catalunya., Barcelona, Spain.

Systems composed by interacting dynamical elements are ubiquitous in nature. In many situations, such systems are modeled as complex networks with modular structure, where the nodes represent the individual units and the links represent the interactions among them. The interactions are often unknown and a popular inference method is based on a statistical similarity analysis of the time-series collected from the dynamics of the nodes. In the first part of the presentation I will discuss our recent work on inferring network connectivity from observed data. I will present results obtained with synthetic data (simulations of Kuramoto phase oscillators) and with empirical data (Rössler electronic chaotic circuits), which are coupled with known network topology [1]. I will show that, under adequate conditions, the structural network can be perfectly inferred, i.e., no mistakes are made regarding the presence or absence of links.

In the second part of the presentation, I will discuss a practical application by considering empirical climatological data. I will demonstrate two methods for inferring the underlying community structure of the climate system, which uncover geographical regions with similar climate statistical properties (climate communities) [2].

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[2] G. Tirabassi and C. Masoller "Unravelling the community structure of the climate system by using lags and symbolic time-series analysis", Sci. Rep. 6 29804 (2016). www.nature.com/articles/srep29804

Basin Entropy: A new tool to explore uncertainty in dynamical system"

Miguel A. F. Sanjuán

Universidad Rey Juan Carlos, Madrid, Spain.

In nonlinear dynamics, basins of attraction link a given set of initial conditions to its corresponding final states. This notion appears in a broad range of applications where several outcomes are possible, which is a common situation in neuroscience, economy, astronomy, ecology and many other disciplines. Depending on the nature of the basins, prediction can be difficult even in systems that evolve under deterministic rules. From this respect, a proper classification of this unpredictability is clearly required. To address this issue, we introduce the basin entropy, a measure to quantify this uncertainty. Its application is illustrated with several paradigmatic examples that allow us to identify the ingredients that hinder the prediction of the final state. The basin entropy provides an efficient method to probe the behavior of a system when different parameters are varied. Additionally, we provide a sufficient condition for the existence of fractal basin boundaries: when the basin entropy of the boundaries is larger than *log 2*, the basin is fractal. This is joint work with Alvar Daza, Alexandre Wagemakers, Bertrand Georgeot and David Guéry-Odelin.

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MORNING II a

Wavelet-based analysis of regular and chaotic dynamics of interacting structural members under white noise

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In recent years, an increase in interest in understanding and analysis of interaction between deterministic and noisy dynamics of structural members has been observed. In particular, a special case of excitations, i.e. so-called additive white Gauss noise has been employed in numerous studies in various branches of science. In general, the employed white noise plays a crucial role in vibrating structural members. White Gaussian noise is characterized by uniform spectral density and normally distributed amplitude value, as well as by an adaptive action on a signal. The used term 'additive' means that the noise is summed with a given signal. On the contrary, multiplicative noise acts on a given signal as a multiplication factor. On the other hand, either deterministic chaos or white noise is a source of difficulties in monitoring predictions of the structural members' material, since it is difficult to detect the exact/reliable stress-strain time-dependent relations while modelling their non-linear effects in a noisy field. Notice that non-linear problems exhibiting chaotic dynamics are highly sensitive to the initial conditions, and hence any prediction of their dynamical behavior can be difficult and often impossible, even when a periodic excitation is applied.

In this work we study PDEs governing beam dynamics under the Timoshenko hypotheses as well as the initial and boundary conditions which are yielded by the Hamilton's variational principle. The analyzed beam is subjected to both uniform transversal harmonic load and additive white Gaussian noise. The PDEs are reduced to ODEs by means of the finite difference method employing the finite differences of the second-order accuracy, and then they are solved using the 4th and 6th order Runge-Kutta methods. The numerical results are validated with the applied nodes of the beam partition. The so-called charts of the beam vibration kinds are constructed versus the amplitude and frequency of harmonic excitation as well as the white noise intensity. Analysis of numerical results is carried out based on a theoretical background on non-linear dynamical systems, with the help of time series, phase portraits, Poincaré maps, power spectra, Lyapunov exponents, as well as using different wavelet-based studies.

Novel transition scenarios from regular to chaotic dynamics and vice versa are illustrated and discussed. It is shown, among other, how an action of white noise decreases the threshold for transition into spatial-temporal chaotic dynamics and how it significantly reduces occurrence of periodic vibrations. It is illustrated through numerical simulations that a scenario of transition into chaos of the studied mechanical interacting objects essentially depends on the control parameters, and it can be different in different zones of the constructed charts of vibration kinds regarding two control parameters (amplitude and frequency of the periodic load excitation for different values of the amplitude of white noise intensity). Furthermore, two interesting non-linear phenomena are detected and discussed. The first one is associated with increase of the noise intensity, which yields the vibrational characteristics without influence of noisy effect. Namely, chaos is destroyed by noise and windows of periodicity appear. The second one deals with a loss of symmetry of the previously symmetric dynamical regime caused by an action of the white noise.

Acknowledgments
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Improving long lasting anti-kindling effects via coordinated reset stimulation frequency mild modulation

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Several brain diseases are characterized by abnormally strong neuronal synchrony. Coordinated Reset (CR) stimulation [1,2] was computationally designed to specifically counteract abnormal neuronal synchronization processes by desynchronization. In the presence of spike timing-dependent plasticity (STDP) [3] this leads to a decrease of synaptic weights and ultimately to an anti-kindling [4], i.e. unlearning of abnormal synaptic connectivity and abnormal neuronal synchrony. The long-lasting desynchronizing impact of CR stimulation has been verified in pre-clinical and clinical proof of concept studies (e.g. [5]). However, as yet it is unclear how to optimally choose the CR stimulation frequency, i.e. the repetition rate at which the CR stimuli are delivered. This work presents a first computational study on the dependence of the long-term outcome on the CR stimulation frequency in neuronal networks with STDP. From a clinical standpoint it is desirable to achieve an anti-kindling already with stimulation durations as small as possible. For this reason and due to CPU time constraints we have chosen a certain range of stimulation durations, where we were able to achieve a reasonable success rate (i.e. anti-kindling) at least for suitable stimulation frequencies. For a representative stimulation duration of this kind, we have thoroughly varied the stimulation frequency while we have preliminary evidence that even for longer stimulation durations the picture does not change much. For this purpose, CR stimulation was applied with Rapidly Varying Sequences (RVS) [4] in a wide range of stimulation frequencies and intensities. A similar survey was also performed with a different type of CR signal, i.e. the Slowly Varying Sequences (SVS) [6]. We show that when comparing the two different CR signals, the RVS turn out to be more robust against stimulation frequencies; however, the SVS can obtain stronger anti-kindling effects [7]. In cases where the initial combination of CR intensity and frequency did not perform efficiently for the majority of different network initializations, we implement three plausible therapy-like stimulation protocols, which aim to ameliorate the long-lasting effects. The first one prolongs the CR on period before ceasing it completely, the second one consists of repetition of CR on and off trial-periods with the same fixed CR frequency while the third one incorporates a control mechanism monitoring the degree of synchronization at the end of the CR off period and adjust CR's period for the following trials via a mild modulation. When comparing these three approaches, the last one not only manages to induce global (for all networks) desynchronization but also shows very good robustness among different signals and network dependent variations [8]. These findings can be implemented into stimulation protocols for first in man and proof of concept studies aiming at further improvement of CR stimulation.

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Description of heart disease and other medical conditions using visibility graphs and random matrix theory

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Although that Takens' Embedding Theorem has helped to the understanding of the complexity of some physiological time series, the classification of different ailments has not been possible therefrom. In this paper we use the concept of visibility graph to translate physiological time series of patients and use the random matrix theory to obtain a classification of adjacency matrix of different ailments.

MORNING II b

The space-time nature of causality

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In a causal world the direction of the time arrow dictates how past causal events produce future effects. The determination of the direction and the intensity of the arrow of influence, causality, is one of the first questions one tries to answer in order to model a system. Given the relevance of the topic, several methods have been developed in the last decades to study causality. Among then, there are the approaches that access causality based on informational quantities. They are sustained by the fundamental idea if X causes an effect in Y, then uncertainty about future states of Y is reduced by considering the past of Y and the past of X, a hypothesis that implicitly adopts the Granger causal idea that observations in the past of both X (causing system) and Y (where the effect is produced) can be used to predict the future state of Y. This work aims at unifying the Granger definition of causality defined in terms of predictability with those based on information quantities by studying the dynamical fundamental of causality. We will show that a system X causes an effect in a system Y, if solely observations in Y can be used to predict the past states of the system X, an observation that will lead us to propose a new informational theoretic quantity to determine the direction of causal events that we name Causal Mutual Information. Along the way to demonstrate this fundamental intrinsic dynamical property of causality, we will show that causality has space and time signatures, and each signature can be advantageously explored to study the direction of influence in systems that are being observed with different space-time resolutions, for example, time-series data of the environment or historical medical data of

patients. Moreover, we will show that our quantity allows for a simple and less computational demanding approach, but rigorous, quantification of causality, and will illustrate its applicability by commenting on our currently developments to understanding causality in different natural, biological, and complex systems that our approach is being applied to.

Inference of direct links in complex networks from real experimental data

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The inference of the underlying network that interconnects the units composing a complex system from observed data is of great interest nowadays. For example, network inference applied to brain fMRI scans or climate data allows for the reconstruction of a functional connectivity network, which has helped scientists to understand better the emerging behaviors in these systems. These networks are usually constructed by analyzing time-series observed at different points and establishing links between them depending on how similar the observations are. However, network inference of real-world systems is still not fully understood. Here, we conjecture that, when a complex system exhibits a type of incoherent collective behavior, retrieving the underlying network is possible. We sustain this conjecture by measuring time-series of experimentally designed coupled maps and critically comparing the pair-wise similarity results obtained from using Pearson Cross-Correlation, Mutual Information (using ordinal patterns), and Granger Causality. These statistical methods are classified in terms of their efficiency, robustness, and reliability to obtain the underlying network when we have different time-series lengths, noise levels, parameter heterogeneities, and coupling configurations. Shockingly, we show that there is a persistent collective behavior where an exact network inference is achieved for all methods and all coupling configurations.

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Measuring social flexibility using information theory

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Groups of animals or humans often show flexible grouping patterns, in which temporary aggregations or subgroups come together and split, changing composition in short scales of time. Here we develop and validate a method to measure the flexibility in composition of these subgroups using Shannon's entropy, which shows how predictable is the composition of a given subgroup over time. We formulate null expectations of entropy that consider subgroup size variation and sample size, against which the observed entropy can be compared. Using the theory of set partitioning, we also develop a method to estimate the number of subgroups that the group is likely to be divided into, based on the composition and size of the observed subgroups. We use this method to analyze the composition of spider monkey and chimpanzee subgroups, species which show a high flexibility in their grouping patterns. Our results show that this measure can be used to evaluate how flexible grouping patterns are in different species, and can also be interpreted as the degree of social uncertainty faced by individual members of a given group.

THURSDAY 27/10

MORNING I

Integrating motor and neural control in songbirds

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Birdsong is a complex motor activity that emerges from the interaction between the peripheral system, the central nervous system and the environment. The similarities to human speech, both in production and learning, have positioned songbirds as unique animal models for studying this learned motor skill.

In this work, we developed a low dimensional dynamical system model of the vocal apparatus in which inputs could be related to physiological variables, being the output a synthetic song (SYN) that could be compared with the recorded birdsong (BOS). To go beyond sound comparison, we measured neural activity highly tuned to BOS and found that the patterns of response to BOS and SYN were remarkable similar. This work allowed to relate motor gestures and neural activity, making specific predictions on the timing. To study the dynamical emergence of this feature, we developed a neural model in which the variables were the average activities of different neural populations within the nuclei of the song system. This model was capable of reproducing the measured respiratory patterns and matched the specific predictions on the timing of the neural activity during their production. These results suggest that vocal production is controlled by a distributed recurrent network rather than by a top-down architecture.

Slow-fast dynamics: interacting manifolds and mixed-mode oscillations

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In many systems arising in application, inlcuding single neurons, electronic circuits, semiconductor lasers and chemical reactions, one finds dynamics that features a combination of slow and of fast episodes. The geometric theory of slow-fast systems aims at explaining such overall dynamcis from the knowledge of the limiting slow and fast subsystems. Key objects are the attracting and repelling slow manifolds and their intersections known as canard orbits. These objects organise the dynamics in phase space and, in particular, the occurence and nature of mixed-mode oscillations (MMOs) with a mix of small and large oscillations.

The talk will focus on systems with two slow and one fast variable, when the slow manifolds are surfaces in three dimensions. After a brief introduction of the underlying theory and our numerical approach to computing slow manifolds and their intersection curves, the focus will be on a new phenomenon: a tangency between the repelling slow manifold and the two-dimensional unstable manifold of a saddle-focus equilibrium. We show how this interaction shapes both of these surfaces locally and globally. The ensuing geometry in phase space can be interpreted as a global return mechanism that generates large oscillations of MMOs.

This is joint work with Jose Mujica and Hinke Osinga, University of Auckland.

Manifestations of the onset of chaos in condensed matter and complex systems

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We indicate the occurrence of the patterns of the onset of chaos in low-dimensional dissipative systems in leading topics of condensed matter physics and complex systems of various disciplines. We consider the dynamics in and towards the attractors at period-doubling accumulation points and at tangent bifurcations to describe features of glassy dynamics, critical fluctuations and localization transitions. We provide an analytical framework to reproduce rank distributions of large classes of data (including Zipf's law), and mimic the evolution of high-dimensional ecological models. Finally, we extend the discussion to point out a common circumstance of drastic contraction of configuration space and generalized entropic concepts.

Global Stability of Lasers: Effects of Light Shear and Active-Medium Polarisation Dynamics

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Recent technological advances in semiconductor lasers give reason for revisiting the effects of active medium polarization dynamics on laser stability. We use Maxwell-Bloch equations to examine transition between class B and class C conditions, when the active-medium polarisation changes from a fast dynamical variable that can be adiabatically eliminated (class B lasers) to a regular dynamical variable that evolves on a similar timescale as the active-medium population inversion and light intensity (class C lasers). Firstly, we introduce relative stability difference and show that class C conditions can locally stabilise or destabilise a laser. Secondly, we introduce geometrical concept of shear in the laser phase space, demonstrate robust and global stabilising

effects of class C conditions, and explain why conventional semiconductor lasers exhibit such a wealth of instabilities and chaos. The counterintuitive stabilising effect is illustrated using examples of external optical injection and time-delayed optical feedback, where, rather surprisingly, externally induced instabilities and chaos found for class B conditions disappear for class C conditions. The results give insight into stability of new generation of semiconductor emitters, such as quantum-dot lasers, quantum-cascade lasers, polariton lasers and nanolasers, being developed for applications in optical interconnects and quantum information.
This work demonstrates that new-generation semiconductor lasers may be dynamically more stable than conventional lasers in spite of having more degrees of freedom.

[S. Wieczorek, K. Synnott and Weng W. Chow "Stability of new-generation semiconductor lasers", SPIE Newsroom; http://dx.doi.org/10.1117/2.1201606.006551]

MORNING II

Homoclinic Chaos Painted

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We explore self-similar organizations of heteroclinic and homoclinic bifurcations of saddle singularities in the parameter space of several exemplary models with deterministic chaos, including the Lorenz attractor and the Shilnikov saddle-focus. We demonstrate how the original computational technique, based on the symbolic description and kneading invariants, can disclose the complexity and universality of parametric structures and their connections with nonlocal bifurcations in such systems.

Chaos in disordered nonlinear lattices

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We analyze mechanisms and regimes of wave packet spreading in nonlinear disordered media, where all linear modes are exponentially localized by disorder. Due to chaotic nonlinear interactions the initial localization is destroyed and wave packets eventually spread subdiffusively for small or moderate nonlinearities. In our study we consider the disordered variants of two typical one-dimensional Hamiltonian lattice models: the Klein-Gordon (KG) oscillator chain, and the discrete nonlinear Schrödinger equation (DNLS). Performing extensive numerical simulations for different initial wave packet profiles, disorder strengths and nonlinearities, we determine the characteristics of the wave packet spreading. In addition, we compute the time dependence of the maximum Lyapunov exponent and the distribution of the associated deviation vector. We find a slowing down of chaotic dynamics, which does not cross over into regular dynamics up to the largest observed time scales. Nevertheless, chaos is still fast enough to allow the thermalization of the spreading wave packet. Our findings confirm that nonequilibrium chaos persists, fueling the prediction of a complete delocalization. We also refer to the use of symplectic methods for the integration of both the Hamilton equations of motion and the variational equations needed for the evaluation of Lyapunov exponents.

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Mathematical modelling and analysis of transient escapes for network dynamics

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Mathematical models of excitable cells, such as neurones, are often characterised by different dynamic regimes, such as alternating excited and rest states. The transient dynamics responsible for the transition between dynamic states are often overlooked. It is well known that the addition of noise in a multi-stable system can induce random transitions between stable states where the rate of transition can be characterised in terms of the properties of the noise-free system and the added noise: for potential systems in the presence of asymptotically low noise the well-known Kramers' escape time gives an expression for the mean escape time. We focus on the case of sequential escapes: we assume that one of the stable states is only marginally stable and we start with all nodes in the marginally stable state. After escape, we assume that the transitions back are astronomically large by comparison and there will typically be a sequence of noise-induced escapes that we try to quantify and characterise here. Specifically, we build small dynamically perturbed motif networks and consider the effect of network structure, noise and coupling strength on the exit (escape)-time problem. Using dynamical systems analysis and numerical simulations we investigate emergent transient dynamics of this model.

AFTERNOON I a

SEE MS8 IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I b

Collective cohesive motion of chaotic attractors with applications to a flock of starlings

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We report a simple model of two drive-response type coupled chaotic oscillators where the response system copies the nonlinearity of the driver system. It leads to a coherent motion of the coupled systems, however, it establishes a separating distance, constant in time, between the driver and response attractors that depends upon the initial state. The coupled system responds to external obstacles, modelled by a short-duration pulses acting either on the driver or the response system, by a coherent shifting of the distance and, readjust their distance as and when necessary by talking to each other via a mutual exchange of feedback information. We provide numerical confirmation in a Jerk system and extend the results to a collection of oscillators to produce a cohesive motion. We apply the system to describe the flight of a flock of starlings.

The Role of Connector Links for Functional Centrality Distribution in Brain Hemispheres

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In the last decade, complex networks theory has led to a paradigm shift in the neuroscience as a powerful tool to characterise brain organisation underlying cognitive processes and diseases [1]. The fact that brain networks are spatially embedded and each brain node has a precise spatial position results in useful information that it is not always accessible in other kind of real networks. In particular, the human brain consists of two large modules (i.e. the hemispheres), which usually exhibit different but complementary functions. To better understand the role of the functional interaction between the brain hemispheres, we adopted a network approach aimed to evaluate if and to what extent they engage a competitive behaviour in terms of centrality distribution or, conversely, they are close to a trade-off solution.

Specifically, we studied the brain as a system composed of two sub-networks, i.e. the left (L) and right (R) hemispheres, which vie to maximise centrality of their nodes. Centrality C, i.e., the importance of the network nodes, was quantified by means of the eigenvector associated to the largest eigenvalue of the connection matrix [2], which is known as the eigenvector centrality. Resting brain activity of 54 healthy adults was recorded by means of electroencephalography (EEG). The imaginary coherence was used to construct the functional links between 48 cortical regions (24 in the left hemisphere and 24 in the right one) in the theta (4-7 Hz), alpha (8-13 Hz), beta (14-29 Hz) and gamma (30-40 Hz) frequency bands. We differentiated between intra-links (inside each hemisphere) and inter-links (between hemispheres) and analysed their distribution. We then allowed both networks to modulate their centrality through a rewiring mechanism in the connection between hemispheres. The extent to which each hemisphere maximised its centrality during the rewiring process was quantified through a competition parameter Î©. Different rewiring strategies could be defined according to the distribution of the inter-hemispheric links. Our results show that, even at rest, hemispheres are characterised by dynamical asymmetry, and by different connection patterns (See Fig. 1). These results open the way to a new characterisation of the interactions between the two hemispheres that can be used to better understand organisational mechanisms in healthy and diseased brain networks.

Classification and Verification of Handwritten Signatures with Time Causal Information Theory Quantifiers

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We present a new approach for handwritten signature classification and verification based on descriptors stemming from time causal Information Theory. The proposal uses the Shannon Entropy, the Statistical Complexity, and the Fisher Information evaluated over the Bandt and Pompe symbolization of the horizontal and vertical coordinates of signatures. These six features are easy and fast to compute, and they are the input to an One-Class Support Vector Machine classifier. The results produced surpass state-of-theart online techniques that employ higher-dimensional feature spaces which often require specialized software and hardware. We assess the consistency of our proposal with respect to the size of the training sample, and we also use it to classify the signatures into meaningful groups.

Transitions and dynamics of bidirectionally coupled chaotic systems

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We investigate the dynamics of two bidirectionally coupled chaotic systems. The couplings are made such that the systems could achieve simultaneously Synchronization and nonlinear amplifica-tion. We found that the ampli_cation parameter leads us in many different types of synchronization such as phase, period synchronization and complete synchronization. Many transitions are observed such as transition between two types of Synchronization.

AFTERNOON I c

SEE MS5-II IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I d

SEE MS9 IN "ABSTRACTS OF MINISYMPOSIA"

FRIDAY 28/10

MORNING I

Nonlinear dynamics in soft-matter and biological suspensions

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In the past decade, the development of artificial materials exhibiting novel optical properties has become one of the major scientific endeavors. Of particular interest are soft-matter systems, which play a central role in numerous fields ranging from life sciences to chemistry and physics. In this talk, I will present a brief overview of our work on a few types of soft-matter systems with tunable optical nonlinearities, including self-trapping of light in dielectric colloidal suspensions with negative polarizability and plasmonic resonant solitons. I will then focus on discussion about our recent work on nonlinear beam dynamics in biological suspensions, including those with marine bacteria and human red blood cells. In all these systems, we observed deep penetration of light through the colloids. Our findings may bring about solutions to overcome large scattering loss in various soft matter systems, promising for applications in optical trapping and manipulation as well as control of chemical and biological processes.

Designing and perturbing flatband networks

Sergej Flach

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I will review recent progress in designing and perturbing flatband networks - tight binding lattices which host macroscopically degenerate flat spectral bands. Their origin is rooted in local symmetries of the lattice, with destructive interference leading to the existence of compact localized eigenstates. Recent studies of one- and two-dimensional lattices [1-6] showed that weak diagonal disorder hybridizes compact eigenstates with dispersive bands, leading to Fano resonances, Cauchy-tailed effective disorder potentials, and singular mobility edges, among others. The perturbation-induced hybridization between flatbands and dispersive bands leads to unusual transport processes consisting of ballistic flights between compact localized states which are mediated by dispersive states, and trapping events in a compact localized state. I will further discuss recent results on designing flatbands using a local symmetry construction method, and time permitting will also touch upon many body interactions in flatband systems.

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Fundamental nonlinear equations in physics and their fundamental solutions

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A brief overview of universal equations, which govern the propagation of nonlinear waves in various physical media (both classical – such as optical fibers - and macroscopic quantum media, such as Bose-Einsten condensates, BECs), will be given. The survey will include the nonlinear Schroedinger (NLS)/Gross-Pitaevskii equations, the sine-Gordon (SG) equation, the Korteweg - de Vries (KdV) equation, the Kadomtsev - Petviashvili (KP) equations, and some others (the KP equations are two-dimensional models). All the above-mentioned equations, in their ideal form, share the fascinating property of the exact integrability, by means of a mathematical technique known as "the inverse-scattering transform".

Not only are these equations ubiquitous and universal, but also their fundamental solutions - first of all, solitons, i.e., solitary waves - play a profoundly important role in all physical settings to which the model equations apply. In the case when the model contains additional terms breaking the exact integrability, and efficient perturbation theory for solitons may be developed, predicting many nontrivial effects which are not possible in the integrable systems. Solitons have been predicted in a great variety of physical systems, and one-dimensional solitons were observed and/or created experimentally in nonlinear optics, BEC, long Josephson junctions (superconductivity), fluid flows, plasmas and many other settings. A great challenge to the experiment is to produce stable two- and three-dimensional solitons, which have been predicted by a more recent theoretical analysis.

Fiber-Optic Solitons in a Nonintegrable Environment

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Nonlinear propagation of light in optical fiber is usually described by using the Nonlinear Schrödinger equation. Soliton solutions are of special interest due to their remarkable properties; they have been investigated for many years. Other solutions include Akhmediev Breathers; these have attracted attention only quite recently. An integrable equation has the benefit of allowing exact analytical solutions. In a real-world situation, however, there are perturbations like attenuation and others; strictly speaking, an integrable equation is then not applicable. Usually one treats such cases in an approximate way, or relies on numerical simulations.

It turns out that it is possible to describe analytically the evolution of solitons in a fiber with loss or gain, localized or distributed, or with changes of fiber parameters, by making only a few well-motivated assumptions. This allows, among other things, to describe the long-term fate of a soliton, an inherently nonlinear entity, when energy is constantly drained from it in a lossy fiber. The procedure also allows to draw inspiring analogies between solitons propagating in fibers with changing parameters on one hand, and living organisms adjusting to a fluctuating environment on the other. We will also give a status report about our attempts to generalize this concept to the case of Akhmediev Breathers which is much more complex.

MORNING II

Chimera States for Coupled Pendula

Tomasz Kapitaniak

Division of Dynamics, Lodz University of Technology, Lodz, Poland

Chimera states correspond to the spatiotemporal patterns in which synchronized and phase locked oscillators coexist with desynchronized and incoherent ones. These patterns have been reported both in simulations and experiments of the large networks of coupled oscillators with a variety of topologies. Recently Ashwin and Burylko defined a *weak* chimera state as one referring to a trajectory in which two or more oscillators are frequency synchronized and one or more oscillators drift in phase and frequency with respect to the synchronized group. It has been found that these states can be observed in small networks as few as 4 phase oscillators.

Up to now weak chimera states in small networks have been reported in simulation and theory of coupled phase oscillators. Here, we show that they can be observed experimentally in small networks of more general oscillators. As a proof of concept, we use two networks of: (i) four coupled externally excited double pendula, (ii) three coupled self-excited pendula (metronomes) In In the first experiment each pendulum is characterized by the coexistence of rotational or oscillatory periodic solutions of different frequencies. In the second one each uncoupled pendulum can exhibit limit cycle oscillation or stay in equilibrium We argue that such multistability implies the occurrence of the chimera states and present evidence that they can persist for a positive measure set of coupling strength.

Emergence of Anomalous Diffusion and Long Range Navigation on Complex Networks

José Luis Mateos

IFUNAM, Universidad Nacional Autónoma de México, CDMX, México

We analyze the mobility, searching and navigation of random walkers on networks using a long-range dynamics. We discuss the efficiency of searching using Lévy flights, in comparison with normal random walks, and the possibility that scale-free mobility emerges from the interaction with a complex environment. The dynamical effect of using the Lévy flight searching strategies is to transform a large-world network into a small world. We motivate the problem with examples from foraging of primates in behavioral ecology and human mobility. Our exact results provide a general framework that connects two important fields: Lévy navigation strategies and dynamics on complex networks.
See *Phys. Rev. E* **86** (2012) 056110 and *Phys. Rev. E* **90** (2014) 032809

An Intermittent Dynamics of Equipartitioned Many-Body Interacting Systems

Sergej Flach

Center for Theoretical Physics of Complex Systems, Institute for Basic Science, Daejeon, South Korea

The equilibrium value of an observable defines a manifold in the phase space of an ergodic and equipartitioned many-body interacting system. In the ergodic regime, a trajectory pierces that manifold infinitely many times. We use these piercings to measure both the relaxation time of the lowest frequency eigenmode of the Fermi-Pasta-Ulam chain, as well as the fluctuations of the subsequent dynamics in equilibrium. The subsequent dynamics in equilibrium is characterized by a power law
distribution of excursion times far off equilibrium, with a diverging variance. These excursions are shown to arise from the stickiness near regular orbits that live on sets, which are most probably of measure zero.

AFTERNOON I a

SEE MS1 IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I b

SEE MS6 IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I c

SEE MS2-I IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I d

SEE also Poster Presentations.

MONDAY 31/10

MORNING I

Epidemic Spreading in Multiplex Metapopulations

Jesús Gómez Gardeñes

Department of Condensed Matter Physics and Institute for Biocomputation and the Physics of Complex Systems (BIFI). University of Zaragoza, 50009 Zaragoza (Spain).

In this talk we propose a framework for the analytical computation of the epidemic spreading incidence of metapopulations models in complex networks. The framework is a generalization of the so-called Microscopic Markov Chain Approach MMCA in complex networks. First we will analyze the classical susceptibleinfected-susceptible (SIS) and the susceptible-infected-removed (SIR) on metapopulations for single layer networks. Then, we will show its validity in more complex scenarios such as multilayer networks. In particular, we apply the methodology to assess the epidemic spreading on a real sample of a socially stratified populations where different mobility patterns (corresponding to each socioeconomic class) coexist.

Synchronization Effects Related to Neighborhood Similarity in a Complex Network of Non-Identical Oscillators

E**lbert. E. N. Macau**

Instituto Nacional de Pesquisas Espaciais - INPE – São José dos Campos – SP

We explore in this talk a complex network structure of non-identical oscillators. More specifically, we focus on the impact of Similar or Dissimilar neighborhoods over synchronization measures. Maybe contrary to the intuitive idea, our numerical simulations show that the more homogeneous is a network, the higher tend to be the coupling strength required to phase-lock. In addition, more heterogeneous networks exhibits larger values of order parameter, which means that the fixed phase synchronization is closer to full synchronization.

Lyapunov direct method for fractional order nonlinear time-varying systems

Guillermo Fernández-Anaya

Departamento de Física y Matemáticas, Universidad Iberoamericana,
Ciudad de México, México

In recent years, nonlinear systems of fractional order have appeared in multiple fields, problems of heat transfer modeling of electrical and mechanical systems, in design of controllers of fractional order, among others, by allowing modeling a wide range of nonlinear systems, nonlinear systems including nonlinear systems of integer order. An important aspect in the study is its asymptotic behavior, which can be analyzed by studying its stability. In this talk, we present recent results on the Lyapunov direct method for the study of stability and asymptotic stability of nonlinear fractional order systems. This method is an extension of the classical results for nonlinear systems integer order. The Lyapunov direct method is a sufficient condition to show the stability of systems, which is widely used in several fields of the science and the engineering. In particular this is important in the study of the synchronization of chaotic fractional nonlinear systems.

MORNING II a

SEE MS4-I IN "ABSTRACTS OF MINISYMPOSIA"

MORNING II b

SEE MS7-I IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I a

SEE MS7-II IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I b

SEE MS4-II IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I c

SEE MS2-II IN "ABSTRACTS OF MINISYMPOSIA"

AFTERNOON I d

SEE also Poster Presentations

TUESDAY 01/11

MORNING I

Topological properties of the Quantum Hall effect and mechanically deformed graphene

Gerardo García Naumis

Instituto de Fisica, UNAM. Cto. Exterior s/n, Mexico DF, México.

In this Quantum Hall spectrum is a quantum fractal with a highly complex nested set of gaps, where each gap represents a state whose quantized conductivity is characterized by topological invariants known as the Chern numbers. We show that such properties can be derived from a projection from a higher dimensional space, resulting in a dynamical map and symbolic sequences. We also discuss how these features are relevant for the understanding of strained graphene and other two dimensional materials.

Leiden frost phenomenon on conical surfaces

Felipe Pacheco

Instituto de Física,
Benemérita Universidad Autónoma de Puebla
Puebla, Puebla, México

The Leidenfrost state is typically studied by placing droplets on flat or slightly curved surfaces. Here this phenomenon is investigated by depositing water in hot conical bowls. We found that this phase exists even for large amounts of liquid in very narrow cones without considerable effect of the confinement on the Leidenfrost transition temperature TL. At a fixed temperature, T>TL, the total evaporation time τ has a non-monotonic dependence on the angle of confinement θ: for large volumes(~20 ml) on flat surfaces (θ~0∘), vapor chimneys appear and accelerate the evaporation rate, their frequency diminishes as θ augments and becomes zero at a certain angle θc, at which τ reaches its maximum value; then, τ decreases again at larger angles because the vapor layer holding up the water becomes thinner due to the increase of hydrostatic pressure and because the geometry facilitates the vapor expulsion along the conical wall. For small volumes (~1 ml), surface tension mainly determines the drop curvature and the lifetime is practically independent of θ. Different chimney regimes and oscillation patterns were observed and summarized in a phase diagram. Finally, we developed a simple model to decipher the shape adopted by the liquid volume and its evolution as a function of time, and the predictions are in good agreement with the experimental results.

Piecewise contractions as models of regulatory networks

Edgardo Ugalde

Universidad Autónoma de San Luis Potosí, SLP, México

Background Genetic regulatory networks are usually modeled by systems of coupled differential equations, and more particularly by systems of piecewise affine differential equations. Finite state models, better known as logical networks, are also used (see [1] and references therein). During the last years we have been studying a class of models, which can be situated in the middle of the spectrum; they present both discrete and continuous aspects. They consist of a network of units, whose states are quantified by a continuous real variable. The state of each of these units evolves according to a contractive transformation chosen from a finite collection. The particular transformation chosen at each time step depends on the state of the neighboring units. In this way, we obtain a network of coupled contractions. In this talk I will present some of the our theoretical results and biological applications which I groupe in two cathegories as follows.

Dominant Vertices The dissipative and interdependent nature of the regulatory dynamics allows a size reduction of the system which we have studied in [4]. In that work we show that the knowledge of a trajectory on well chosen subcolections of vertices allows to determine the asymptotic dynamics of the whole network. We call the nodes in these distiguished subcollections, dominant vertices, and we completely characterize them from combinatorial grounds.

We also propose an heuristic algorithm to compute those subcolletions of nodes, which we call dominant sets. Dominant sets have been used as a tool to clasify biological networks [5], and in principle could be used as strategic control sites.

Modularity In [2] we determine conditions under which the restriction of the dynamic on a subnetwork is equivalent to the dynamics one would observe in the subnetwork considered as an autonomous dynamical systems. We also have studied [3] the dynamical response of a small subnetwork subject to the action of the rest of the system, considering the former one as an open system under external inputs. Those two studies constitute a first rigorous approach to the notion of dynamical modularity.

Our work opens several interesting lines of theoretical and applied research that I will point out in this talk.

Keywords: Regulatory networks, dynamical complexity, symbolic dynamics.

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MORNING II a

SEE MS4-III IN "ABSTRACTS OF MINISYMPOSIA"

MORNING II b

SEE also Poster Presentations

MS1. Synchronization and Extreme Events in Complex Systems.

- **Organizers:**
  - **Cristina Masoller, Universitat Politécnica de Catalunya, Barcelona, Spain.**
  - **Jordi Soriano Fradera, Universitat de Barcelona, Barcelona, Spain.**

Synchronization in Electrochemical Oscillations

- **Istvan Z Kiss, Department of Chemistry, Saint Louis University, St Louis, MO, USA.**

When electrochemical reactions take place on electrode arrays, a network can form through the potential drop among the elements. The goal of the presentation is to show how synchronization and network theories can be applied to describe the dynamic features of the oscillatory chemical reaction system.

In the presentation, we consider synchronization pattern in a ring network of electrochemical oscillators to explore the effect of random cross-connections and nonisochronicity of the interactions on the pattern formation. Without cross-connection, we show the existence of various simple rotating wave states and develop an experimental technique to obtain patterns, whose basin of attraction is very small. Experimental confirmation is given to show that a few additional cross-links facilitate the emergence of the fully synchronized state. With large nonisochronicity, complex rotating waves or persistent irregular phase dynamics can derail the convergence to global synchronization. Depending on the sign of nonisochronicity either the sinks or the sources of the complex rotating waves are pinned to end points of the cross-connections in the network. At increased nonisochronicity the variability in the phase differences in a phase locked state decreases until synchronization is no longer possible and persistent, or very long transient phase dynamics occurs. The observed long transients of irregular phase dynamics exemplify the possibility of a sudden onset of hypersynchronous behavior without any external stimulus or network reorganization. The experimental results are further confirmed with supporting phase model calculations that predict the presence of complex rotating waves and long transients in small random networks with sufficiently nonisochronous oscillations.

Scale-freeness or partial synchronization in neural mass phase oscillator networks: pick one of two?

- **Andreas Daffertshofer, MOVE Research Institute Amsterdam, Faculty of Behavioural and Movement Sciences, VU University Amsterdam, The Netherlands.**

To get more insight into the complex dynamics of cortical activity, networks of Wilson-Cowan firing rate models will be compared with networks of voltage-based Freeman models. The resulting dynamics are expected to differ qualitatively due to an attractive coupling in the first and a repulsive coupling in the latter case. This theoretical finding will be linked to experimental data from encephalographic recordings by using empirical structural connectivity matrices when constructing the network models. Specific focus will be on two pivotal dynamical features: (i) a partial phase synchrony with a possibility of a transition towards either a desynchronized or the fully synchronized state; (ii) long-term autocorrelations indicative for a scale-free temporal dynamics of phase synchronization, i.e. a power law. Interestingly, only the phase dynamics of the Freeman model obeys a power law and exhibits the experimentally found scale-free behavior. Its repulsive coupling, however, lets the individual phases disperse and does not allow for a transition into a (partially) synchronized state in disagreement with the empirical findings. The Wilson-Cowan-based phase model, by contrast, can switch into a synchronized state, but it does not generate long-term correlations although it is located close to the onset of synchronization, i.e. in its critical regime. Taken together, the models can display one of two dynamical features (i) or (ii), but not both together. That is, neither of these seminal models can capture the full dynamical spectrum observed in cortical activity.

On the limitations of the Kuramoto model

- **Oleh Omel'chenko, Weierstrass Institute, Mohrenstr. 39, 10117 Berlin, Germany.**

Systems of coupled oscillators play an important role in various fields. Collective rhythmical behavior can be found in biology, where examples include cycles in the metabolism of cells, spiking of neurons, and behavior of whole organisms or populations, as well as in mechanical systems, electrochemistry, and economics.

Global coupling through a common mean field, as in the classical Kuramoto model, is a particularly simple interaction structure and in this case the fundamental dynamical phenomenon is that in a population of oscillators with slightly varying natural frequencies a coupling above a certain strength can introduce a synchronous behavior. In the emerging partially synchronized state the oscillators with natural frequencies close to the maximum of the distribution are entrained, while those with more detuned natural frequencies still oscillate independently. For further increasing coupling strength more and more oscillators become synchronized.

In this talk, we present examples of the Kuramoto-type models which, contrary to common belief, show unusual synchronization transitions, where synchrony can decay with increasing coupling, incoherence can regain stability for increasing coupling, or multistability between partially synchronized states and/or the incoherent state can appear.

These examples reveal that the classical Kuramoto model is singular in the sense that already arbitrarily small structural perturbations might induce qualitative changes to its dynamics.

Experiments in clustered neuronal networks: complex dynamics and resilience in a dish

- **Sara Teller, Jordi Soriano, Department of Condensed Matter Physics, University of Barcelona.**

Uncovering the interplay activity-connectivity is a major challenge in neuroscience. To deepen in the understanding of how a neuronal circuit shapes network dynamics, we present a model experimental system consisting in an ensemble of interconnected clusters of neurons. Using calcium fluorescence imaging to monitor spontaneous activity in these clustered neuronal networks, we were able to draw functional maps and reveal their topological features. We observed that these networks exhibit a hierarchical modular dynamics, in which clusters fire in small groups that shape characteristic communities in the network. The structure and stability of these communities are sensitive to chemical or physical action, and therefore their analysis serves as a proxy for network health. Indeed, the combination of all these approaches is helping to develop models to quantify damage upon network degradation, with promising applications for the study of neurological disorders in vitro.

MS2. Applications of dynamical systems in biology

Organizers:

- **Pablo Aguirre, Departamento de Matemáticas, Universidad Técnica Federico, Santa Maria Campus Valparaíso**
- **Víctor F. Breña Medina, Centro de Ciencias Matemáticas, UNAM Campus Morelia**

Mathematics and biology have travelled similar interacting paths over the last decades. Indeed, many biological phenomena in nature can be readily modelled and analyzed with a plethora of mathematical theories. Equivalently, different areas of mathematics have drawn inspiration from progresses in cellular and molecular biology, genetics, population dynamics, neuroscience, physiology, systems biology, among other biological areas. This mini-symposium aims to provide a glimpse on current research performed in several topics in biology with advanced tools from dynamical systems theory.

SESSION I

On the search for separatrices and basins of attraction in biological systems

- **Pablo Aguirre, Departamento de Matemáticas, Universidad Técnica Federico, Santa Maria Campus Valparaíso**

Many biological systems can be modelled as dynamical systems given as sets of differential equations or iterations of a map. Often one is interested in finding the stable equilibrium states and periodic solutions of the system.

Most of the standard techniques for this type of problems involve the analysis of local properties of the equations such as to study the linealisation of system near the object of interest. However, typically very little is said about the (global) basins of attraction of the stable objects. Their basin boundaries are formed by the global stable manifolds of equilibria and/or periodic orbits.

Moreover, these global manifolds may change both topologically and geometrically under suitable perturbations of the model parameters at bifurcations, transforming the properties of the basins of attraction they separate.

While in general, one cannot find analytical expressions for global invariant manifolds, there is a number of accurate, reliable, and fast numerical techniques that have surfaced in the last decade. In this talk I will present how the computation of global invariant manifolds shed light on the role of these global objects in the organization of the dynamics in biologically inspired systems, specially in the presence of bifurcations. I will focus on two examples: a predator-prey model with Allee effect, and a laser system showing excitable dynamics which mimics different types of neuron pulsing.

A qualitative feedback theory for multiscale spatio-temporal Behaviors

- **Alessio Franci, Departamento de Matemáticas, Facultad de Ciencias, UNAM.**

Background. Biology exhibits an enormous variety of spatial and temporal behaviors. We can easily recognize and name these behaviors because, beside quantitative differences, only qualitative properties matter. As an example, we can discern whether a neuron is "bursting" or not regardless the brain area, or even the animal, to which it belongs to, and regardless quantitative details of the recorded voltage trace. Many experimental questions are also qualitative in nature: will a molecule let a neuron burst? or will it silent it? Life itself is insensitive to (most) quantitative details: how could it be robust if (all) details matter?

The use of quantitative theories to attack qualitative questions leads to interpretation problems that hamper a successful collaboration between theory and experiments. Mainly because of parameter redundancy, two different quantitative theories can both succeed in explaining the same experimental result, yet, with contradictory explanations. This is a common scientific situation, in particular in biology.

Feedback theory and other qualitative mathematical theories, like singularity theory, can jointly be used to extract the key elements governing biological behaviors. This approach is particularly fruitful in the presence of multiple spatial and temporal scales: multiscale behaviors can be dissected into simpler feedback subsystems, each living in a characteristic scale, organized by a specific singularity, and exhibiting a specific behavior.

Contributions. I will illustrate these ideas on the qualitative modeling of a biologically relevant class of spatio- temporal behaviors (multiscale traveling and standing waves), and their modulation. These behaviors can be studied in a three-scale feedback motif organized by the winged-cusp singularity. In the language of Rene Thom, this singularity is the organizing center for this class of behaviors. The importance of an organizing center is that it determines all the possible robust behaviors, as well as the necessary and sufficient number of parameters to (qualitatively) model those behaviors. It is exactly this property that allows to extract the key elements governing a given behavior, both in experiments and in mathematical modeling. I will briefly conclude with a couple of examples of successful application of the illustrated theory in the fields of neuro-modulation and bio-inspired engineering. Time permitting, I will run a live cognitive experiment to test a prediction of our theory.
Preprint: https://drive.google.com/open?id=0B5moU9obcfsbcUlrSHJGZDQ1TGc.

Amplitude equations describing human perception and performance under adaptation

- **Till D. Frank, Department of Psychology and Department of Physics, University of Connecticut.**

In recent years, a community of researchers has discussed the working hypothesis that human perception and performance can be understood from the perspective of dynamical systems theory. In particular, it has been suggested to describe human perceptual experiences and human behaviors by means of suitably defined patterns (e.g. patterns of neural brain activity) that are assumed to emerge at via self-organization. The build-up and vanishing of these patterns at bifurcation points is then determined by amplitude equations. The talk focuses on the special case when human perception and performance is subjected to adaptation. To account for adaptation a two-layered dynamical system approach is suggested featuring a slowly evolving parameter dynamics in addition to the aforementioned amplitude equations.

The theoretical framework that has been referred to as quasi-attractor theory (Haken) or extended synergetics (Frank) will be presented. Examples from human perception, decision making, and human behavior will be given.

SESSION II

Spot Dynamics in a 2D Root Hair Plant Initiation Model

- **Víctor F. Breña Medina, Centro de Ciencias Matemáticas, UNAM Campus Morelia, México**

Patch location dynamics of an initiation process in a plant root hair cell at a sub-cellular is thoroughly analyzed. An earlier model proposed by Payne and Grierson captures key features of an interacting small G-protein family so-called Rho of Plants (ROPs). These proteins are in charge of promoting certain protuberances on root hair cells, which are crucial for nutrients uptake from the soil and anchorage, for instance. Auxins are a class of hormones that are known to take part on the morphogenesis of plants. As experimental observations show that a fast auxin flow is heterogeneously distributed along the cell at the ROPs diffusive scale, auxin catalysis is modelled as a spatially dependent coefficient controlling dominant cubic terms. Such a model consists of a generalized two-component Schnakenberg reaction-diffusion system, which is set up in a non-homogeneous domain. Upon considering a more realistic cell geometry, a two-dimensional root hair cell gathers the essential ingredients that allows to rigorously analyze whether shape and form are relevant for patch location dynamics. Numerical bifurcation analysis, as well as time numerical simulations, and the theory of semi-strong interactions are performed in order to shed light on the understanding of dynamical root hair morphogenesis.

Approximating Stable Manifolds of a Saddle Slow Manifold in a Bursting Model

- **Saeed Farjami, Department of Mathematics, Faculty of Science, The University of Auckland, NZ.**

Many models of neuronal activity exhibit complex oscillations in re-sponse to an input from a stimulus or other neurons in a network.
We consider an ordinary di_erential equation model with two timescales that exhibits dynamics qualitatively similar to neuronal burst-ing. Without an external stimulus, the model is at rest, that is, at a globally attracting equilibrium. We are interested in understand- ing its intrinsic excitability, particularly the number of spikes in the transient response caused by applying a short stimulus. We _nd that the transient response is organised by a separatrix associated with a saddle slow manifold of the system. Based on manifold theory, geo- metric singular perturbation theory, and the theory of nonautonomous systems, we give a precise de_nition for this separatrix and design an algorithm to compute it; our computational method is formulated as a two-point boundary value problem and uses continuation to compute the manifold.

In a different parameter regime, the separatrix that determines the transient response is the stable manifold of a saddle-type equilibrium; methods for computing such manifolds are well established. We com- pare the separatrices and how they organise the transient responses for both cases.

On the spectral stability of traveling fronts for reaction Diffusion-degenerate equations

- **Ramón Plaza, Departamento de Matemáticas y Mecánica, IIMAS, UNAM.**

Motivated by biological applications (e.g. spatial ecology, bacterial aggregation), several reaction-diffusion models consider density-dependent diffusion coefficients which, in addition, are degenerate in one (or more) equilibrium points of the reaction. These degenerate diffusions describe, for example, the avoidance of crowded areas by individuals of certain biological populations. In this talk I present new results and techniques in the study of spectral stability of traveling fronts for reaction-diffusion equations with degenerate diffusion. I will explain the two main ideas to control, on one hand, the essential spectrum and, on the other hand, the point spectrum of the linearized operator around the wave. Both techniques are designed to overcome the degeneracy of the diffusion at the end point. This is joint work with J. Francisco Leyva.

MS3. Planetary and Galactic Dynamical Astronomy

Organizers:

- **Luis Benet, Instituto de Ciencias Físicas, UNAM.**
- **Bárbara Pichardo, Instituto de Astronomía, UNAM.**

In this minisymposium we shall focus on topics of particle dynamical systems going from planetary to galactic scales. In particular, we will address the stability of multi-planetary systems, the relevance of diffusion and chaotic mixing, time-dependent models of barred galaxies and dynamics of Halley's comet, including tools to address different dynamical aspects.

Dynamics and stability of multi-planet systems

- **Cristian Beauge, Observatorio Astronómico, Universidad Nacional de Córdoba, Argentina.**

Exoplanetary systems are characterized by very diverse dynamical configurations. In contrast with our own Solar System, many of our extra-solar neighbors have high-eccentricities, large mutual inclinations and may have been the outcome of catastrophic scattering. Mean-motion resonances also abound, from classical two-body commensurabilities up to multiple resonances involving 3 or 4 planets.

In this talk we review several dynamics properties of these systems, from simple secular models to more complex multi-resonant motion. We analyze what information can be gathered on the origin of these bodies from their current configurations, and how orbital stability criteria my aid us in this endeavor.

Investigating the dynamics of a time-dependent barred galaxy model by the Smaller (SALI) and the Generalized (GALI) Alignment Index methods of chaos detection

- **Haris Skokos, University of Cape Town, South Africa.**

Determining the chaotic or regular nature of orbits of dynamical systems is a fundamental problem of nonlinear dynamics, having applications to various scientific fields. The most commonly employed method for distinguishing between regular and chaotic behavior is the evaluation of the maximum Lyapunov exponent (MLE), because if MLE>0 the orbit is chaotic [1 and references therein]. The main problem of using this chaos indicator is that its numerical evaluation may take a long -and not known a priori- amount of time to provide a reliable estimation of the MLE's actual value.

In this talk we will focus our attention on two other efficient methods of chaos detection: the Smaller (SALI) and the Generalized (GALI) Alignment Index techniques [2-8]. We will first recall the definitions of the SALI and the GALI and will briefly discuss the behavior of these indices for conservative Hamiltonian systems. Note that these methods are based on the evolution of more than one deviation vectors from the studied orbit, in contrast to the computation of the MLE where only one deviation vector is needed.

Then, we will explain how one can use these methods to investigate the dynamics of time-dependent Hamiltonians by considering a barred galaxy model whose parameters evolve in time [9]. We will show that the SALI/GALI is as a reliable criterion to estimate the relative fraction of chaotic versus regular orbits in such time-dependent potentials, which proves to be much more efficient than the computation of the MLE. In particular, we will demonstrate that these indices are able to capture subtle changes in the nature of an orbit (or ensemble of orbits) even for relatively small time intervals; a property which makes them ideal for detecting dynamical transitions in time-dependent systems.

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Chaotic diffusion in Planetary and Galactic Systems

- **Pablo Cincotta, Universidad Nacional La Plata, Argentina.**

In this talk I will discuss the relevance of chaotic mixing in two different scenarios. First, we investigate the dynamical structure of the (1,-3,2) Laplace resonance in the planetary system Gliese 876 by means of diffusion experiments. The results show that there are two main regions in the surroundings of the Laplace resonance: the inner resonant region is characterized by large Lyapunov times and very slow diffusion. This multi-resonant configuration seems to be responsible for its long-term stability. The outer resonant region is dominated by a extremely chaotic dynamics, exhibiting a fast diffusion. Although these results correspond to a specific planetary system, it seems reasonable that the main characteristics of any system representing similar multi-resonant configurations could share all these main features. In the second part of this talk is focused on the relevance of chaos for halo stars in the solar neighborhood. Using a very realistic potential for the DM halo (Aquarius project), and by means of diffusion numerical experiments we find that chaotic mixing, although non-negligible, is not a significant factor in erasing for instance, local signatures of accretion events at least within a physically meaningful timescale in the Solar Neighborhood.

The Lyapunov spectrum of the comet 1P/Halley in a Newtonian model of the Solar System

- **Jorge Pérez Hernández, Universidad Nacional Autónoma de México, México.**

In this talk, I present some results regarding the dynamics of comet 1P/Halley; namely, the Lyapunov spectrum of its orbit, for a Newtonian model of the Solar System, i.e., neglecting relativistic as well as non-gravitational accelerations. Our approach consists of using the variational equations in order to compute the time evolution of first-order variations in Halley's comet orbit. We took initial conditions from JPL's HORIZON system, and integrated simultaneously both this model of the Solar System and the associated variational equations during 10,000 years. We find that the Lyapunov time (i.e., the inverse of the maximal element of the Lyapunov spectrum) of Halley's comet orbit is about 200 yr.

Stellar orbital structure in slow rotating bar models

- **Leonardo Chaves Velasquez, Ivânio Puerari, P.A. Patsis, Instituto Nacional de Astrofísica, Óptica y Electrónica, México.**

Orbits are the fundamental building blocks of any galactic structure. The orbital stellar dynamics gives important insights to understand the formation and evolution of such structures (Binney \& Tremaine, 1987). It is now known that the large structures in galaxies are formed by both regular and chaotic orbits.

In this work we are investigating the regular and chaotic nature of stars that orbit a galactic potential given by models from Manos \& Machado (2013) consisting in disk, halo and bar. In order to understand such nature we have implemented the so-called GALI2 index which is a powerful tool to detect chaos/stability in dynamical systems. We are building the characteristic curves of these models by using the shooting method to find closed orbits, and the GALI2 index to detect their stability. We have found that the main family is transformed from the X1 family to the X2 family in all models. The behavior we are finding agrees with the bi-stability scenario found in Tsigaridi \& Patsis (2015) for slow rotating bars.

MS4. New methods in Celestial Mechanics

Organizers:

- **Ernesto Pérez-Chavela, Instituto Tecnológico Autónomo de México (ITAM).**
- **Marian Gidea, Yeshiva University, New York, USA.**

SESSION I

Variational Method with Structural Prescribed Boundary Conditions and N-body Problem

- **Tiancheng Ouyang, Zhifu Xie, Duokui Yan, Department of Mathematics, University of Southern Mississippi, Hattiesburg, MS 39401.**

Variational Method with Structural Prescribed Boundary Conditions (SPBC) has been used to study periodic solutions in N-body problem in recent years. Some interesting new periodic solutions have been discovered for planar three and four body problem. In this talk, the frame work of the variational method with SPBC and its applications will be presented. Some challenge in using this method will be discussed.

Exchange orbits in the problem of N bodies

- **Abimael Bengochea, UAM-Iztapalapa, México.**

Abstract: In this talk we present some particular solutions of the 2n+1 body problem, namely exchange orbits. We discuss some properties of these orbits, for instance, they are closely related with homographic solutions, and how to determine numerically these orbits by means of using a boundary value problem which is solved with AUTO. We present numerical results for n= 2, 3, 4.

Stability of equilibrium points in Hamiltonians systems under the existence of an invariant ray.

- **Claudio Vidal, Universidad del Bío, Bío, Chile.**

In this talk we consider an autonomous Hamiltonian systems with n-degrees of freedom with a single resonance, and we prove the instability of the equilibrium point under the existence of an invariant ray.

SESSION II

FACTORIZATION OF THE STABILITY POLYNOMIALS OF RING SYSTEMS

- **Eduardo Leandro, Universidad Federal de Pernambuco, Brasil.**

Let D_n be the dihedral group with 2n elements. We call ring system a finite D_n-symmetric set of points in R^2 with or without an additional point at the barycenter of the set. Ring systems have been used as models for planets surrounded by rings, and may be seen as relative equilibria of the N-body or the N-vortex problem. We study the factorization of the linear stability polynomials of arbitrary ring systems by systematically exploiting their symmetry through representation theory of finite groups. Our results generalize contribution by J. C. Maxwell from mid-XIX century until contemporary authors such as J. Palmore and R. Moeckel, among others.

Classification of global phase portraits and bifurcation diagrams of Hamiltonian systems with rational potential

- **<u>Yohanna P. Martínez</u>, Claudio Vidal, Universidad del Bío Bío, Chile.**

In this work we study the global dynamics of the Hamiltonian systems x'=Hy(x,y), y'=Hx(x,y) where the Hamiltonian function H has the particular form H(x,y)=y2/2+P(x)/Q(x), where P(x) and Q(x) are polynomials, in particular H is the sum of the kinetic and a rational potential energy. Firstly, we provide the normal forms by suitable □-symplectic change of variables.

Then, the global topological classification of the phase portraits of these systems having canonical forms in the Poincaré disk in the case where degree(P)=0,1,2 and degree(Q)=1,2 are studied as a function of the parameters that define each polynomial. We use blow-up technique for finite equilibrium points and in the Poincaré compactification for the infinite equilibrium points. Finally, we present some applications.

CONTINUOUS CHOREOGRAPHIES AS LIMITING SOLUTIONS OF THE N-BODY PROBLEM

- **Reynaldo Castaneira, IM, UNAM, México.**

It is well known that the planar regular N-gon relative equilibrium is a solution of the equations of motion for the Newtonian N-body problem with $N \geq 3$ and equal mass bodies.

We consider the N-body problem with equal masses in R^d, $d \geq 2$, with $-\sigma$-homogeneous potential, $0 < \sigma < 1$, and study the resulting equation of motion when $N \to +\infty$, which we will refer to as continuous system, as well as a particular type of solutions which we call continuous choreographies using a variational approach. We can roughly say that a continuous choreography is a limiting configuration of classical choreographies when the number of particles grows without limit and indeed the circle turns out to be the continuous choreography associated to regular N-gons on the plane.

Joint work with P. Padilla-Longoria and H. Sanchez-Morgado.

SESSION III

Stability of periodic orbits by Conley-Zehnder index theory

- **Dan Offin, Queens University, Canada.**

Roughly speaking, the Conley-Zehnder index measures the number of half windings of a fundamental solution for a periodic linear Hamiltonian system. This index, and its closely re-
lated cousin the Morse index for the equivariant action functional, can be used to give non perturbative arguments for linearized stability and instability for families of periodic orbits in Hamiltonian systems. We will give several examples of this from the setting of parametric resonance in parameterized families, to minimum distance lines in kinetic plus potential systems. Using a necessary and suficient condition for elliptic stability of periodic orbits in two degree of freedom systems, we ouline the global argument for families of hyperbolic orbits in the Henon-Heiles system.

ON A CIRCULAR RETRICTED THREE BODY PROBLEM ON THE SPHERE

- **Jaime Andrade, Universidad del Bío, Bío, Chile.**

Using the model given by F. Diacu and coworkers for the N- body problem in spaces with constant curvature, we consider a restricted three-body problem on the sphere S2. The primaries correspond to a circular relaitve equilibrium of the two-body problem on S2 with equal masses, where the particles move on a fixed latitude and on opposite sides. We study some aspects of the dynamics such as existence of relative equilibrium solutions and periodic orbits.

Symmetry in trapezoid central configurations: numeric and analytic results.

- **Luis Franco, UAM-Iztapalapa, México.**

In the four body problem, if two bodies with equal mass are on the opposite vertices in a quadrilateral conforming a non-collinear convex central configuration , then there exists an axis of symmetry. In fact, this configuration must be of kite type. The other case, that is if the pair of equal masses are located at adjacent vertices of a trapezoid, conforming a central configuration, the existence of a symmetry axis is not clear, unless the remaining pair of masses were equal too. In this talk we show some analytic and numeric results in this direction.

On the stability of Relative Equilibria of the three body problem on S^2 and H^2.

- **Juan Sánchez, UAM-Iztapalapa, México.**

We consider three point particles moving on S^2 and H^2 under the cotangent potential. In this talk we show the analysis for the stability of some families of relative equilibria. On S^2 we give a complete classification of the spectral stability for the colineal relative equilibria. On H^2 we prove that these families are unstable, except for a degenerate case when two masses are negligible.

MS5. Dynamics, from Theory to Computation

Organizers:

- **Renato C. Calleja, Department of Mathematics and Mechanics,IIMAS, UNAM, México.**
- **Arturo Olvera, Department of Mathematics and Mechanics,IIMAS, UNAM, México.**
- **Jason Mireles-James, Department of Mathematical Sciences, Florida Atlantic University, USA.**

The session's focus is on computational and theoretical methods for analyzing invariant/coherent structures in discrete and continuous time dynamical systems, and applications of such methods. The session will bring together experienced as well as young researchers to exchange ideas and explore recent developments.

SESSION I

Characterization of difusion in N > 2 conservative dynamical systems

- **Pablo Cincotta, Univ. Nacional La Plata, Argentina.**

We characterize diffusion in a 2.5 degrees of freedom Hamiltonian system and a 4D simplectic map. We show the the usual approximation of free or normal diffusion fails and therefore, any attempt to derive a reliable diffusion coefficient should take into account phase correlations, the latter being still a completely open problem. The diffusion is clearly inhomogeneous and anisotropic, several dynamical objects in phase space seriously affect its rate, such as Cantor sets or those that lead to the well known stickiness phenomena. All these results will be illustrated and discussed with several numerical experiments. Anyway, we argue that diffusion experiments would help us to guess about stability/instability within chaotic domains over finite (or physical) timescales.

Choreographies and symmetric Lyapunov families arising from a n-gon of bodies

- **Carlos García-Azpeitia, Facultad de Ciencias, UNAM, Mexico.**

We continue numerically global Lyapunov families appearing from n-gons of bodies in a rotating frame of reference. The Lyapunov orbits are periodic solutions in the inertial frame when the frequencies of the Lyapunov families and the rotating frame maintain a rational relation. We prove that a dense set of Lyapunov orbits with frequencies satisfying a Diophantine equation are choreographies. We present and discuss a sample of choreographies along the Lyapunov families for n=4,...,9.

Halo periodic orbits in the spatial circular restricted four body problem: a computer-assisted proof

- **Jean-Philippe Lessard, Université Laval, Canada.**

The complete understanding of the well known N-body problem has proven to be one of the most challenging and interesting problem since the pioneer work of Newton. Since then, many approaches have been developed to study one of the "simplest" and important class of solutions in the problem, namely the periodic orbits. In the 19th century, Poincar developed powerful mathematical machineries to study periodic orbits in differential equations, and in particular in its celebrated restricted three body problem (R3BP). In the R3BP the motion of two massive bodies (called the primaries) is given by a periodic solution of the Kepler problem, and a massless particle moves under the gravitational inuence of such primaries.

Several decades after the work of Poincar, many extensions of the R3BP have been proposed, and studying periodic orbits has remained an important problem, especially since they have important implications in the design of space missions. One important extension is the restricted four-body problem, which consists in considering a special solution of the three body problem and then considering a massless particle interacting with these three bodies.

In this talk, we introduce a rigorous numerical method to prove, in a constructive way, existence of periodic orbits in the circular restricted four body problem (CR4BP). The first step is to use tricks from automatic di_erentiation and transform the CR4BP into a 9D polynomial (quintic) vector _eld. The study of a periodic orbit is then turned into that of a fixed point of a Newton-like operator de_ned on a Banach space of fast decaying Fourier (or Chebyshev) coe_cients. Combining analytic estimates and the contraction mapping theorem yields the existence of a unique fixed point (i.e. a periodic orbit) nearby an approximate solution. We apply this method to show existence of several periodic orbits in the CR4BP. Some interesting periodic orbits we can prove are the so-called "halo orbits. This is joint work with Jaime Burgos (ITAM, México) and J.D. Mireles James (FAU, USA).

Domains of analyticity of KAM tori in mechanical systems with friction

- **Renato Calleja, IIMAS, UNAM, Mexico.**

Many problems in Celestial Mechanics are described by conformally symplectic systems (e.g. mechanical systems with a friction proportional to the velocity). I will present a study of the limit of small dissipation in conformally symplectic systems. The Lindstedt series of the parametrization of quasi-periodic orbits with Diophantine frequency depend on a small dissipative parameter epsilon for which epsilon = 0 corresponds to the symplectic case. We study the domains of analyticity of the parametrization of invariant tori close to the epsilon= 0 limit.

I will present a conjecture about the geometry of the domains and numerical computations that support it. This is joint work with Alessandra Celletti, Rafael de la Llave, and Adrián P. Bustamante.

SESSION II

Genus zero global surfaces of section

- **Umberto Hryniewicz, Universidade Federal do Rio de Janeiro, Brazil**

In this talk we will discuss the problem of constructing genus zero global surfaces of section for three-dimensional Reeb ows, with prescribed binding orbits. We focus on the case of SO(3), and state a theorem which generalizes the classical result of Birkhoff asserting that Birkhoff annuli associated to simple closed geodesics are global surfaces of section of geodesic ows of positvely curved metrics on the 2-sphere. We provide applications to the planar restricted three-body problem. This is joint work with Pedro Salomao and Kris Wysocki.

Critical global transport in a non-autonomous periodic standard map

- **David Martínez del Río, IIMAS, UNAM, México.**

In this talk I will present some the results derived from a particular definition of a non-autonomous standard map (NASM) and the study of its properties. The definition of the map is inspired from a simplified model of self-consistent transport in marginally stable systems including vorticity mixing in strong shear ows and electron dynamics in plasmas, known as the self-consistent map model or single wave map model. The numerical simulations of this map for a particular kind of initial conditions shows the existence of coherent structures, which leaded to the introduction a bidimensional map model that could mimic the asymptotic behavior and shed light on the effects of an external oscillatory field over an uncoupled system, the NASM. This kind of map has been studied before in the literature under different approaches to study different kind of structures. From all the possible variations of perturbation parameter of the standard map, the study focus on the periodic case, starting with the period-two because the evidence of the non trivial change of behavior it introduces. It is of particular interest to find the critical set of values of the parameters that causes the NASM to no longer have invariant circles (not homotopic to a point), i.e. the system displays global transport. To do so, symmetries and reduced cases of the natural autonomous realization of the map are found and two different approaches are used to characterize the critical global transport: direct simulation with values of the parameters taken from a systematic sweep of the parameter space and the parameterization method to study the critical breaking of particular invariant circles. The findings of both methods lead to a very particular symmetric star shape in the parameters space that separates the bounded evolution from numerical global diffusion in the two-periodic case of the NASM.

A Whitham-Boussinesq long-wave model for variable topography

- **Rosa María Vargas Magaña, IIMAS, UNAM, México.**

In this talk we propose a Hamiltonian Whitham-Boussinesq model for the study of the propagation of water waves in a channel with large bottom deformations, using the long wave asymptotic regime. This formulation is inspired on the work of Craig et. al. who introduced the non-local Dirichlet-Neumann operator explicitly in the Hamiltonian, and due to the complexity of the expressions of the asymptotic expansion associated with this operator in the presence of a non-trivial bottom topography. We perform an ad-hoc modification of these terms using a Pseudo Differential Operator (PDO) associated with the bottom topography. We will introduce an accurate and eficient numerical method that has been developed to compute this PDO.We present the results for the normal modes and eigenfrequencies of the linearized problem for families of different topographies. We also present some experiments of the evolution of some initial wave profiles over different topographies.

Due to the ad-hoc nature of this simplified model we present some comparisons between the full expression of the asymptotic expansion given by Craig et. al. and our PDO approach for some specific topographies.

MS6. Nonlinear dynamics, chaos and complex networks: from concept to application.

Organizers:

- **Jesús Manuel Muñoz Pacheco, BUAP, México.**
- **Luz Del Carmen Gómez Pavón, BUAP, México.**
- **Arnulfo Luis Ramos, BUAP, México.**

Explosive synchronization of complex networks with phase oscillators and chaotic systems.

- **Jesús Gómez Gardenes, Departamento de Física de la Materia Condensada, Facultad de Ciencias, Universidad de Zaragoza Zaragoza, España.**

In this talk we will address a topic that has attracted a lot of attention in the field of statistical physics and nonlinear dynamics of complex networks: explosive phase transitions. In particular we will address this topic in the context of the synchronization of both (Kuramoto) phase oscillators and chaotic Rossler systems. The phase transitions associated to the latter well-known models are known to be of second order, i.e., they show a smooth and continuous transition of the degree of synchronization from their respective onsets. However we will show that, by taking advantage of the interplay between network topology and the dynamical properties of the oscillators, it is possible to delay such onsets and, as a byproduct, to obtain explosive (abrupt) transitions in which the systems pass from a completely incoherent state to an almost fully synchronized one as soon as the coupling between units reaches its critical value. Interestingly, this abrupt transition display hysteresis cycles, thus pointing out a parametric region in which bistability (of the incoherent and synchronized solutions) exists.

Generation of nonlinear dynamics by using PWL systems

- **Eric Campos Cantón, División de Matemáticas Aplicadas, IPICYT, San Luis Potosí, México.**

In this talk we present the electronic circuit known as chaotic generator and its mathematical model. The circuit is comprised by a nonlinear element, a resonator circuit and a low pass filter. This mathematical model is the onset of a class of piecewise linear systems that presents chaotic behavior. Thus we present an approach to generate multi-scroll chaotic attractors based on piecewise linear systems. This class of systems is constructed with a switching control law by changing the equilibrium point of a dissipative system with unstable dynamics, named Unstable Dissipative System (UDS). The switching control law that governs the position of the equilibrium point changes according to the number of scrolls that is displayed in the attractor. Switched systems have been widely used in many different areas in science and engineering. There is some interest in generating chaotic or hyperchaotic attractors with multiple scroll with this kind of systems. We present a generalized theory that is capable of explaining different approaches as saturation, threshold and step functions in R3. This class of systems is constructed with ``unstable dissipative systems" (UDS) and a control law to display various multi-scroll strange attractors in different grids (1D, 2D, 3D). Interesting phenomena have been observed with these multi-scroll strange attractors, for example, multistability via master-slave synchronization and by means of change the stable and unstable manifolds of one system, generation of deterministic Brownian motion by a deterministic system based on the Langevin equation. Actually we are interested in generating chaotic attractors without equilibria based on piecewise linear systems. These attractors fulfill the definition of hidden attractors.

Study of the deterministic coherence resonance in a network of chaotic oscillators with frequency mismatch

- **<u>Rider Jaimes-Reátegui</u> 1, Xochilt A. Cedillo-Padilla1, N. Pisarchik2, 3, Carlos E. Castañeda-Hernandez1, M. A. García-Vellisca2 and Juan H. Garcia-Lopez1,**
  1Centro Universitario de los Lagos, Universidad de Guadalajara, Enrique Díaz de León, Paseos de la Montaña, Lagos de Moreno, Jalisco 47460, México.
  2Center for Biomedical Technology, Technical University of Madrid, Campus Montegancedo, 28223 Pozuelo de Alarcon, Madrid, Spain.
  3Centro de Investigaciones en Óptica, Loma del Bosque 115, 37150 León, Guanajuato, México

We present the evidence of deterministic coherence resonance in a small network of unidirectionally coupled chaotic Rössler oscillators with mismatch between their natural frequencies. The regularity in both the amplitude and the phase of chaotic fluctuations is proven by the analyses of normalized standard deviations of the peak amplitude and interpeak interval. The resonant chaos suppression appears when the coupling strength is increased and the oscillators are in phase synchronization. This surprising phenomenon resembles self-stabilization of chaotic systems when a small parameter mismatch makes the collective dynamics more regular.

The ergodic to many-body localization phase transition: static and dynamical properties

- **Eduardo Jonathan Torres Herrera, Benemérita Universidad Autónoma de Puebla, Puebla, México.**

We present results on static and dynamical properties of a finite one-dimensional system with onsite random disorder. The long-time dynamics is particularly sensitive to changes in the spectrum and in the structures of the eigenstates. The study of the evolution of the survival probability, Shannon information entropy, and von Neumann entanglement entropy enables the distinction between the chaotic region, an intermediate region and the many-body localization regime.

MS7. Dynamics of nonlinear lattices and graphs.

Organizers:

- **Panayotis Panayotaros.**

SESSION I

Efficient integration techniques for the long time simulation of the disordered discrete nonlinear Schroedinger equation

- **Haris Skokos, Department of Mathematics and Applied Mathematics, University of Cape Town Rondebosch, 7701, Cape Town, South Africa**

Symplectic integration methods based on operator splitting are well established techniques for the integration of the Hamilton equation equations of motion and the so-called 'variational equations' needed for the computation of chaos indicators like the Lyapunov exponents [1, 2, 3, and references therein]. In this talk we present several methods based on two and three part operator splitting, for the numerical integration of the disordered, discrete nonlinear Schrödinger equation, and compare their efficiency [4, 5]. Our results suggest that the most suitable methods for the very long time integration of this one-dimensional Hamiltonian lattice model with many degrees of freedom (of the order of a few hundreds) are the ones based on three part splits of the system's Hamiltonian.

Two part split techniques can be preferred for relatively small lattices having up to about 70 sites. An advantage of the latter methods is the better conservation of the system's second integral, i.e. the wave packet's norm.

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Inhomogeneous FPU models for weakly nonlinear protein vibrations

- **Francisco Martínez-Farías, Univ. Autónoma del Estado de Hidalgo, Apan, México.**

We study spatially localized oscillations in inhomogeneous nonlinear Fermi-Pasta-Ulam (FPU) lattices from phenomenological nonlinear elastic network models of protein vibrations. In the FPU lattices we consider the number of interacting neighbors varies from site to site, and we see numerically that this spatial inhomogeneity leads to spatially localized normal modes in the linearized problem.

This property is seen in 1-D toy models and in a 3-D model with a geometries obtained from protein data. The spectral analysis of these examples suggest the existence of invariant subspaces of spatially localized solutions in quartic Birkhoff normal forms of the FPU systems.
The invariant subspaces have a global pahse symmetry that simplifies the computation of periodic orbits of the quartic normal form. The theoretical results on these approximate solutions are compared with numerical integrations for some protein models.

Global bifurcation of traveling waves in discrete nonlinear Schroedinger equations

- **Carlos García-Azpeitia, Departamento de Matemáticas, Facultad de Ciencias, Universidad Nacional Autónoma de México, 04510 Ciudad de México, México.**

The discrete nonlinear Schroedinger equations of n sites are studied with periodic boundary conditions. These equations have n branches of standing waves that bifurcate from zero. Traveling waves appear as a symmetry-breaking from the standing waves for different amplitudes. The bifurcation is proved using the global Rabinowitz alternative in subspaces of symmetric functions.

SESSION II

Variety of solutions in anharmonic Davydov´s type equations

- **Luis A. Cisneros Ake, ESFM, Instituto Politecnico Nacional, México.**

We consider cubic lattice anharmonicities in Davydov´s type interactions. One directional wave propagation in the continuum limit suggest a variety of solutions, which are sought in the corresponding discrete limit through variational and numerical means.

Quantum coherent states and breathers in a discrete NLS

- **Ricardo Martinez-Galicia, Depto. de Matematicas, Facultad de Quimica, Universidad Nacional Autonoma de Mexico, Mexico.**

We compare quantum states obtained from the integration of exact and approximate evolution equations for a quantized discrete nonlinear Schroedinger system (DNLS) with three (trimer) and five lattice sites. The initial conditions are Glauber coherent states, and their projections to subspaces with a definite number of particles, and we are especially interested in coherent states that correspond to classical states that are in the neighborhood of breather solutions of the classical system.

The two evolution equations give converging results in the subspaces with an increasing number of particles. This is no longer the case for normalized projections of Glauber states, where we see that the distance between the quantum states obtained by the exact and approximate equations shows recurrence phenomena that depend on the number of quanta and on the dynamical properties of the classical trajectory.

Anclaje en la ecuación discreta de Nagumo

- **José Fernando Bustamante Castañeda, IIMAS, UNAM, México.**

La ecuación de Nagumo discreta en una dimensión ha sido ampliamente estudiada y se sabe que en ella se da el anclaje (pinning) o propagación fallida de frentes de onda. Dicho anclaje consiste en la existencia de un intervalo de valores del coeficiente de difusión para el cual el frente de onda no puede propagarse, esto como una consecuencia del carácter discreto de la ecaución. En esta charla se mostraran alguna simulaciones que ejemplifican este comportamiento en una y dos dimensiones espaciales.

También se mostrarán algunos cálculos asintóticos basados en la suma de Poisson para delimitar la zona de anclaje y la zona de propagación.

Breathers and shelf solutions in a nonlocal DNLS equation

- **Panayotis Panayotaros, Depto. Matematicas y Mecanica, IIMAS, Universidad Nacional Autonoma de Mexico , Cd. Mexico, Mexico.**

We present recent results on breather solutions of a discrete NLS equation with nonlocal, Hartee-type nonlinearity arising in the study of liquid crystal optical wavequide arrays.
Nonlocal effects include non-monotonic front profiles, and the presence of more internal modes in space decaying solutions.

We also present recent results on discrete versions of dispersive shocks for local and nonlocal DNLS equations.

MS8. HOMENAJE AL DR. EDUARDO PIÑA GARZA POR SUS CONTRIBUCIONES A LA TEORÍA DEL CAOS Y LA DINÁMICA HAMILTONIANA EN MÉXICO

Organizer:

- **José-Rubén Luévano, Department of Basic Sciences, Universidad Autónoma Metropolitana, Unidad Azcapotzalco, México**

Función de Distribución de Mapeos

- **Eduardo Piña Garza, Departamento de Física, Universidad Autónoma Metropolitana, Unidad Iztapalapa, México.**

En esta plática presento algunas ideas fundamentales de experimentos donde se relacionan mapeos numéricos con un número enorme de iteraciones y conceptos básicos de estadística. La idea subyacente es la hipótesis de perder la condición inicial y alcanzar situaciones estacionarias, por una mezcla del gran número de iteraciones y de las imperfecciones de exactitud de computaciones numéricas. Al mismo tiempo, en cada iteración numérica conservamos la ley dinámica rígida dada por el mapeo. Se tiene pues una dinámica estadística de origen matemático, pero con posibilidades abiertas a las aplicaciones físicas que apadrinen el mapeo.

The work of Eduardo Piña on chaos

- **José-Rubén Luévano, Department of Basic Sciences, Universidad Autónoma Metropolitana, Unidad Azcapotzalco, México.**

We describe the early work by Eduardo Piña on chaos. Comments about his papers on symbolic dynamics, maps of an interval, and the Schröder equation are given.

Classical motions under the inverse square potential

- **E. Guillaumín, A.L. Salas-Brito, Departamento de Ciencias Básicas, Universidad Autónoma Metropolitana, Unidad Azcapotzalco.**
- **H.N. Núñez-Yépez, Departamento de Física, Unidad Iztapalapa, Universidad Autónoma Metropolitana.**

We show that the classical motions under a inverse square potential k/r^2, k a real number, are canonically equivalent to free motion on a noncompact manifold. The result is analogous to the one proved by J. Moser for the Coulomb potential that has found useful as an starting point for developing computational methods in quantum mechanics. As a consequence we corroborate the non existence of bound states with negative energy in the quantum problem nor of bound orbits in the classical one.

Boltzmann y los Multifractales

- **José-Luis del-Río-Correa, UAM, Unidad Iztapalapa, México.**

We extend the Boltzmann´s ideas for describe the evolution to the equilibrium of a many body systems to the characterization of the statistical multifractals with the singularity spectrum in terms of the Holder exponent, with this goal in mind we follow the following steps:

1.-We establish a relationship between the Hausdorff dimension and Shannon entropy through the Eggleston´s theorem; it takes the place of the relation between entropy and probability in Boltzmann treatment.

2.-We use the Billingsley´s result for obtain the Hausdorff dimension of the statistical multifractal; it is similar to assert that in the equilibrium state the entropy is maximum.

3.-We find the multifractal singularity spectrum in terms of the Holder exponent using an extremal principle equivalent to the Boltzmann way for find the fundamental relationship for an ideal gas in the entropic representation.

4.-We show that the Legrende transform of the singularity spectrum, contains information about the condensation set of the multifractal Legrende transform of the singularity spectrum, contains information about the condensation set of the multifractal when the escort distribution is used to generate a multiplicative cascade.

MS9. Nonlinear Time Series in Complex Systems.

Organizer:

- **José-Rubén Luévano, Department of Basic Sciences, Universidad Autónoma Metropolitana, Unidad Azcapotzalco, México**

The approximate entropy of natural language

- **Candelario Hernández-Gómez, and Lev Guzmán-Vargas, Laboratorio de Sistemas Complejos, Unidad Profesional Interdisciplinaria en Ingeniería y Tecnologías Avanzadas, Instituto Politécnico Nacional, Av. IPN 2580, G. A. Madero, Ciudad de México, México.**

The natural language can be considered as a complex system with permanent changes, and when dealing with written texts, it is possible to treat it as a time series for a convenient analysis. Recent studies have reported the use of different methods to calculate the entropy of natural language considering it as composed by binary symbolic sequences (Papadimitriou, et al. Physica A 389(2010) 3260), bits per word (Montemurro, et al. Plos One 6 (2011)) and part per speech (Kalimeri, et al., Journal of Quantitative Linguistic 22(2015) 101). In this work, we propose a modified version of the algorithm proposed by Pincus (Pincus, Proc. Natl. Acad. Sci. 88 (1991) 2297) to calculate the Approximate Entropy of natural language from five different linguistic families (Germanic,Romance,Slavic,Asian and Amerindian) and two synthetic languages (Esperanto and Interlingua) and a random text. We found differences between the different linguistic families and our method consistently distinguishes between natural and synthetic as well as randomized texts.

Local Stability analysis for a simplified model of calcium flow between the cytoplasm and the sarcoplasmic reticulum.

- **Ricardo Páez Hernández, Área de Física de Procesos Irreversibles. Departamento de Ciencias Básicas, Universidad Autónoma Metropolitana, Azcapotzalco, Cd. De México.**
- **Norma Sánchez Salas, Departamento de Física, ESFM, Instituto Politécnico Nacional Edif. 9 2o Piso, U.P. Zacatenco, Ciudad de México, México**
- **Moisés Santillán, Centro de Investigación y Estudios Avanzados del IPN, Unidad Monterrey, Parque de Innovación Tecnológica, 66600 Apodaca NL., México.**

The sarcoplasmic reticulum (SR) constitutes the main intracellular calcium store in striated muscle and plays an important role in the regulation of excitation-contraction- coupling (ECC) and of intracellular calcium concentrations during contraction and relaxation.

The process of Ca2+ release from sarcoplasmic reticulum(SR) comprises 4 phases in smooth muscle cells. Phase 1 is characterized by a large increase of the intracellular Ca2+ concentration ([Ca2+]i) with a minimal reduction of the free luminal SR [Ca2+] ([Ca2+]FSR). Importantly, active SR Ca2+ ATPases (SERCA pumps) are necessary for phase 1 to occur. This situation cannot be explained by the standard kinetics that involves a fixed amount of luminal Ca2+binding sites. A new mathematical model was developed that assumes an increasing SR Ca2+ buffering capacity in response to an increase of the luminal SR [Ca2+] that is called Kinetics-on- Demand (KonD) model. This approach can explain both phase 1 and the refractory period associated with a recovered [Ca2+]FSR.

Additionally, our data suggest that active SERCA pumps are a requisite for KonD to be functional; otherwise luminal SR Ca2+ binding proteins switch to standard kinetics. The importance of KonD Ca2+ binding properties is twofold: a more efficient Ca2+ release process and that [Ca2+]FSR and Ca2+ -bound to SR proteins ([Ca2+]BSR) can be regulated separately allowing for Ca2+ release to occur (provided by Ca2+-bound to luminal Ca2+ binding proteins) without an initial reduction of the [Ca2+]FSR.

In this work is presented an analysis of local stability for a Kinetics-on- Demand (KonD) model, which consists of three calcium fluxes in the cell, the flow all mechanism that remove calcium from the cytoplasm except the SERCA pumps, is calcium flux from the reticulum to the cytoplasm via the RyR receptors present are included in reticular membrane and is calcium flux from the cytoplasm to the reticulum by the SERCA pumps also located in the reticular membrane. From the local stability we find that the called Kinetics-on-Demand (KonD) model, has a stable point, which confirm that model explains the process in the sarcoplasmic reticulum.

Multifractal analysis of anomalies observed in geoelectric time series.

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- **Luciano Telesca, National Research Council, Institute of Methodologies for Environmental Analysis, C. da S. Loja, 85050 Tito (PZ) , Italy.**

As it is well known, the electrical activity of the ground can shows fluctuations in the electrical self-potential due to perturbations produced by big mechanical sources like earthquakes. In a steady state, the electric activity of the ground behaves as an uncorrelated noise like white noise; nevertheless, prior to occurrence of earthquakes, it has been detected that this electrical signal became to a correlated one. It has been observed that some geoelectrical signals display particular anomalies, named Signals Electro Seismic (SES), showing bimodal features. This kind of behavior has been considered as possible precursory signals of earthquakes. SES has been observed in geolectrical time series monitored in seismic zones of Greece, Japan and Mexico and have appeared before some EQ´s, such that have also been considered as precursory of EQ´s. Up to now, SES observed in geoelectric time series monitored in the Mexican seismic region and have been studied by means of natural time domain showing statistical properties like reported for SES in Greece an Japan. In this work we characterize SES before an EQ occurred in Mexico by means of the multifractal spectra. Our findings display differences in the Hausdorff dimension, and other dynamical features that identify sequences of the time series in steady state from the anomalous SES.

La sismicidad como un fenómeno críticamente autoorganizado

- **Jennifer Pérez Oregón (1), Alejandro Muñoz Diosdado (2), Fernando Angulo Brown (1). (1)Escuela Superior de Física y Matemáticas, IPN, México, (2)UPIBI, IPN, México**

La sismicidad ocurre en la corteza terrestre. La corteza es un sistema abierto que recibe energía desde el manto terrestre y disipa energía a través de la sismicidad. La corteza está constituida por una jerarquía de formas y tamaños en diferentes escalas que van desde las micras hasta 10 3 kilómetros. La corteza es un sistema con geometría fractal. La distribución del número de sismos en términos de su magnitud está dada por la famosa relación de Gutenberg-Richter. Tanto la fractalidad espacial de la corteza como la distribución temporal de los sismos son típicas leyes de potencia. Las leyes de potencia de la sismología fueron establecidas empíricamente desde principios del siglo XX. Fue hasta alrededor de 1987 que las leyes de potencia empíricas de la sismología fueron explicadas como el resultado de concebir a la corteza como un sistema críticamente autoorganizado (SOC, por sus siglas en inglés). El primer modelo SOC para reproducir algunas propiedades generales de la sismología fue el modelo resorte-bloque propuesto por Olami, Feder y Christensen en 1992. En esta plática se establecen nuevas conexiones entre la sismicidad real y la sismicidad sintética proveniente de un modelo SOC resorte-bloque.

Poster Sessions

P. 78 A. Ángel Lareo , Francisco B Rodriguez,
"Sequential information processing in electroreception: A modelling approach"
Grupo de Neurocomputación Biológica, Departamento de Ingeniería Informática, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Madrid, Spain

P. 79, A. Puga , B.N. Miller,
"Escape in The Strong Quantum Regime"
Unidad Académica de Física | Universidad Autónoma de Zacatecas, Mexico

ORAL AND POSTER PRESENTATIONS BY STUDENTS

P1 Daniel A. Priego-Espinosa, A.Guerrero† , A.Darszon† , G.Martnez-Mekler∗‡ and J.Carneiro§	**Dissecting the molecular mechanisms that underlie the temporal organization and envelope of Ca^{2+} -spike trains in sea urchin sperm flagellum**	∗ Instituto de Ciencias Físicas, UNAM, Cuernavaca, Morelos, 62210, Mexico; † Instituto de Biotecnolog´ıa, UNAM, Cuernavaca, Morelos, 62210, Mexico; ‡Centro de Ciencias de la Complejidad UNAM, México; and § Instituto Gulbenkian de Ciência, Rua da Quinta Grande 6, 2780-156, Oeiras, Portugal
P2 Paul A. Valle, and Konstantin E. Starkov,	**Persistence and tumor clearance conditions on a cancer chemotherapy system**	CITEDI, Av. del IPN, Tijuana, B.C., México
P3 Iván Fernández- Rosales, and L. Guzman-Vargas,	**Co-occurrence Networks of Complex Time Series.**	ESFM, UPIITA-IPN, CDMX, México
P4 Rogelio Basurto-Flores, F. C. Reyes-Manzano, L. Guzman-Vargas,	**A drug-disease complex network analysis.**	UPIITA-IPN, CDMX, México
P5 Daniel Aguilar-Velázquez, L. Guzman-Vargas,	**Correlations and synchronization in interacting small-world networks.**	UPIITA-IPN, CDMX, México
P6 Alvaro Díaz-Ruelas (1), Miguel Fuentes (2), Alberto Robledo (1)	**Sums of positions at Feigenbaum and Misiurewicz points**	(1) Instituto de Física, UNAM, CDMX, México (2) Centro Atómico Bariloche, Instituto Balseiro and CONICET, Bariloche, Argentina
P7 Candelario-Hernández-Gómez , and Lev Guzmán Vargas	**Calculating the approximate entropy of natural language**	ESFM, UPIITA, IPN, CDMX, México
P8 Fabián Reyes-Manzano, and Lev Guzmán Vargas,	**Detecting Correlations in traffic-volume fluctuations in Mexico City.**	UPIITA-IPN, CDMX, México

P9 L. Rebeca Moreno-Torres[1]**, Catalina Haro-Pérez[1] , Luciano Telesca[2], Alejandro Ramirez-Rojas[1]	**Fractal properties of photon sequences obtained from Dynamical Light Scattering experiments for a polymeric gel.**	[1] Departamento de Ciencias Básicas, Universidad Autónoma Metropolitana-Azcapotzalco, Av. San Pablo 180, 02200 México D.F., Mexico. [2] National Research Council, Institute of Methodologies for Environmental Analysis, C.da S. Loja, 85050 Tito (PZ) Italy.
P10 Jesús Andrés Arzola Flores	**A new model of Oregonator**	Instituto de Física. Benemérita Universidad Autónoma de Puebla, Puebla, México.
P11 S. Castillo , and E. Sadurní	**Toward a spectral classification of fractal billiards**	Instituto de Física. Benemérita Universidad Autónoma de Puebla, Puebla, México.
P12 Tania Contreras-Uribe, and Lev Guzmán Vargas,	**Evaluation of scaling behavior in electrogastric signals**	UPIITA-IPN, CDMX, México
P13 Nicolás-Carlock, J.R., Carrillo-Estrada, J.L., and Dossetti, V.	**Universality in morphological transitions of fractal growth processes**	Instituto de Física. Benemérita Universidad Autónoma de Puebla, Puebla, México.

POSTER PRESENTATIONS

CAROLINO BUILDING LOBBY

- **P. 14, Lilia Rodríguez-Barragán, A.L Salas-Brito, and Aquiles Ilarraza-Lomelí**
  "Inducing order in a diffusor using "probabilistic forces"
  Departamento de Ciencias Básicas, UAM-Azcapotzalco, Mexico

- **P. 15, Andrea Montiel Perez, J. Fernando Rojas Rodríguez**
  "Dynamics of two vegetables specie's in cuasi-homogeneous media"
  BUAP, Puebla, México

- **P. 16, Cristian C. Pérez A., J. Fernando Rojas R.**
  "Mechano-chemical model of cancer tumor growth"
  FCFM, BUAP, Puebla, Mexico

- **P. 17, Durán Meza Grabriela, Del Rio Correa José Luis**
  "Halsey's measure and condensation set"
  Universidad Autónoma Metropolitana-Iztapalapa, Mexico

- **P. 18, Diogo Ricardo (D. R.) da Costa**
  "Oval or elliptic billiards with a dispersing mechanism"
  Departamento de Física, UNESP-Univ Estadual Paulista, Av. 24A, 1515, 13506-900 Rio Claro, SP, Brazil

- **P. 19, J. Ramirez-Hernández**
  "The effects of mismatching for the bilayer model with Balanced Loss/Gain"
  IFUAP, BUAP, Puebla, Mexico

- **P. 20, de Oliveira Juliano A.**
  "Decay to the stationary state in one-dimensional discrete map"
  UNESP - Univ Estadual Paulista, Departamento de Fisica - Rio Claro - SP – Brazil
  UNESP - Univ Estadual Paulista - Joao da Boa Vista - SP – Brazil

- **P. 21, Barranco Díaz Jhoana L.**
  "A New Mechano-Chemical Model For Wound Healing Process"
  Facultad De Ciencias Fisico Matematicas, Buap, Puebla, México

- **P. 22, Salas-Brito A.L.**
  "Monodromía en un modelo del péndulo extensible"
  Departamento de Ciencias Básicas, Universidad Autónoma Metropolitana, Unidad Iztapalapa, DF, México

- **P. 23, Carlos Carrizales-Velazquez1**
  "Time evolution of the Gutenberg-Richter coefficients for some Mexican seismic regions"
  1Escuela Superior de Física y Matemáticas-Instituto Politécnico Nacional
  2Unidad Profeasional Interdisciplinaria en Ingeniería y Tecnologías Avanzadas-Instituto Politécnico Nacional

- **P. 24, Matheus Hansen, R. Egydio de Carvalho and Edson D. Leonel**
  "Statistical properties of open billiards"
  Instituto de Física da Universidade de São Paulo, Rua do Matão, Travessa R 187, Cidade Universitária, 05314-970 São Paulo, SP – Brazil

- **P. 25, Rodrigo A. García,1, Federico Abellá,1 Arturo C. Martí,1 and Nicolás Rubido1,2**
  "Few inter-links suffice for optimal diffusion in regular multiplex networks"
  1) Instituto de Física, Facultad de Ciencias, Universidad de la República - Iguá 4225, Montevideo, 11400, Uruguay
  2) Institute for Complex Systems and Mathematical Biology, University of Aberdeen, King's College AB24 3UE , Aberdeen, UK, EU

- **P. 26, Naranjo Mayorga Fernando**
  "Vector Borne Diseases in Metapopulations Zika case"
  Universidad Pedagógica y Tecnológica de Colombia, Colombia

- **P. 27, Alvarez Llamoza, Orlando**
  "Inner synchronization of chaos in systems with dual interactions"
  Universidad Católica de Puebla 010150. Cuenca, Ecuador.

- **P. 28, Carlos Bonazzola, Alejandro Hnilo, Marcelo Kovalsky and Jorge Tredicce**
  "Extreme events in an all-solid-state laser with saturable absorber"
  CITEDEF , Buenos Aires, Argentina

- **P. 29, Núñez-Yépez Hilda Noemí**
  "Geometrization of the motion in a 1/q^2 potential"
  UAM-Iztapalapa, Departamento Física, Iztapalapa D F, México

- **P. 30, Johann H. Martínez (1,2), Javier M. Buldú (2,3,4), José Luis Herrera (5,6)**
  "Symbolic Networks of Diseases Outbreaks"
  1. Universidad del Rosario de Colombia. Bogotá, Colombia
  2. Grupo Interdisciplinar de Sistemas Complejos de Madrid (GISC). Madrid, Spain
  3. Laboratory of Biological Networks, Center for Biomedical Technology Universidad Politécnica de Madrid, Madrid, Spain
  4. Universidad Rey Juan Carlos, Móstoles, Spain
  5. Grupo de Caos y Sistemas Complejos, Universidad de Los Andes, Mérida – Venezuela
  6. Department of Integrative Biology, University of Texas at Austin, USA

- **P. 31, Arellano Ceballos Nahúm**
  "Solución general de sistemas discretos"
  FCE, BUAP, México

- **P. 32, Arias Méndez Nelson Edgardo**
  "Máquina de Toma de Muestras"
  FCE, BUAP México

- **P. 33, Centeno Bautista Manuel Alejandro**
  "Controlabilidad"
  FCE, BUAP México

- **P. 34, Córdova Gutiérrez Erick Javier**
  "Sistemas de segundo orden en Arduino"
  FCE, BUAP México

- **P. 35, Duran Santos Martin**
  "Análisis en tiempo cortó a través de la función de energía"
  FCE, BUAP México

- **P. 36, Martínez de la Cruz Dany Iván**
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- **P. 37, Mota Martínez Mizantha Concepsión**
  "Diagramas de Bode"
  FCE, BUAP México

- **P. 38, Ortega Cortés Esteban Roberto**
  "Modelo de espacio de estados en tiempo discreto"
  FCE, BUAP México

- **P. 39, Pellico Sánchez Oscar Isaid**
  "Polos y ceros"
  FCE, BUAP México

- **P. 40, Reyes Reyes Erik**
  "Estabilidad de Lyapunov de un sistema de segundo orden"
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- **P. 41, Romero Michihua José Carlos**
  "Filtrado y estimadores de servomecanismos"
  FCE, BUAP México

- **P. 42, Solórzano Caballero Luis Irán**
  "Simulación de sistemas dinámicos lineales discretos"
  FCE, BUAP México

- **P. 45, Vargas García Tomas Miguel**
  "Simulación de sistemas dinámicos lineales discretos en sistemas embebidos"
  FCE, BUAP México

- **P. 46, Tepal Nieto Oswaldo**
  "Design an implementation of a control program for control algorithms on a three freedom degrees direct drive robot (ROTRADI)"
  FCE, BUAP México

- **P. 47, Mayoral Arzaba Edgar Hugo**
  "Implementación de algoritmo de aprendizaje automático para identificación de tarjetas electrónicas"
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- **P. 48, Reyes Rodríguez José Manuel**
  "Modelo dinámico de un sistema subactuado de 4 grados de libertad"
  FCE, BUAP México

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  "Disorder effects in isolated quantum many-body systems"
  IFUAP, BUAP México

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  "Phase transitions in tumor growth"
  University of Havana, Havana 10400 Cuba

- **P. 51, Nieto-Villar José Manuel**
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  Instituto de Investigación en Ciencias Básicas y Aplicadas, Universidad Autónoma del Estado de Morelos (UAEM), Cuernavaca Morelos, México

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- **P. 73, Lilia Rodríguez-Barragán, A.L Salas-Brito and Aquiles Ilarraza-Lomelí**
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- **P. 74, Estrada-González Vicente**
  "Is There a Visual Mozart Effect?"
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