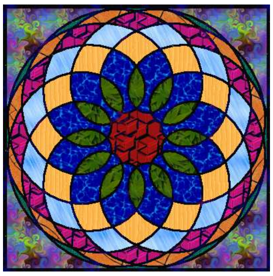

$\frac{dx}{dt} = \alpha(y - x)$
$\frac{dy}{dt} = \beta x - \varsigma xz$
$\frac{dz}{dt} = e^{xy} - \delta z$
CNSD
2015
Conference on
Nonlinear Systems
and Dynamics
at
IISER Mohali
March 13 - 15
Lecture Hall Complex
INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH MOHALI
IN PURSUIT OF KNOWLEDGE

Conference on Nonlinear Systems and Dynamics (CNSD) – 2015

Book of Abstracts



13 - 15 March 2015, IISER Mohali, India

CNSD - 2015

Contents

Invited Talks

Invited Talks

1.1 Recurrence networks and analysis of chaotic time series

G. Ambika

Indian Institute of Science Education and Research, Pune - 411 008, India.

We present a general frame work for analyzing chaotic systems using the unweighted ε - recurrence networks constructed from their time series. We propose a scheme for choosing the correct range of ε that can map the optimum information from the time series to the constructed network. Interestingly, this is dependent on the embedding dimension M and the number of nodes N. We discuss the computed characteristic measures of the constructed network like degree distribution, characteristic path length link density, clustering coefficient etc. for a number of standard low dimensional chaotic systems. We show explicitly that the degree distribution of the optimum recurrence network from a chaotic attractor is a characteristic measure of the structure of the attractor and display statistical scale invariance with respect to increase in N. The practical utility of our scheme is also made clear by applying it to a real world time series. Finally, we look at the recurrence network from a complex network perspective and compare its properties with that of scale free and Erdos-Renyi networks.

1.2 Control of stochastic processes by time-delayed feedback and its application

Hiroyasu Ando

University of Tsukuba, Japan.

We investigate an effect of time-delayed feedback control on random walks in discrete time systems. An attractor appeared by the time-delayed feedback shrinks the range of random walk. We find that diffusion processes of the controlled random walk is strongly suppressed with increasing delay time. Not only a single walker but also multiple walkers can be controlled by a combination of time-delayed feedback from each walker. In addition, an application of controlling random walks is demonstrated in numerical simulations of simple molecular dynamics.

1.3 Reduced rank, unstable space Kalman filters

Amit Apte

ICTS, Bangalore

Kalman filters have been successfully used for low dimensional state estimation problems, e.g., in engineering. One of the main reasons that make it difficult to use them in geosciences is, apart from the obvious problem of nonlinearity of the systems involved, the high dimensionality of these problems. A set of techniques collectively called ”assimilation in unstable subspace” (AUS), proposed by Trevisan et al., try to overcome this restriction by proposing a reduced rank approximation of the Kalman filter that essentially acts only in the unstable subspace which is, in many contexts, much smaller dimensional than the full system. I will introduce the AUS techniques and present a rigorous mathematical result supporting them.

1.4 New kind of deaths: Oscillation and nontrivial amplitude death in coupled oscillators

Tanmoy Banerjee

Department of Physics, University of Burdwan, Burdwan 713 104, India.
email : tbanerjee@phys.buruniv.ac.in

The quenching of oscillation is an emergent and intriguing phenomenon that has been the topic of extensive research in diverse fields such as physics, biology, and engineering. In coupled oscillators, there exist two distinct types of oscillation quenching processes, namely amplitude death (AD) and oscillation death (OD). Although, AD and OD are two structurally different phenomena, their clear distinction has been made only recently by Koseska et al [1]. In AD, all the coupled oscillators populate a common stable steady state that was unstable otherwise and thus gives rise to a stable homogeneous steady state (HSS). But, in the case of OD, due to symmetry breaking bifurcation, the oscillators populate different coupling dependent stable steady states resulting in stable inhomogeneous steady states (IHSS).

The main theme of this talk is the genesis and manifestation of AD and OD. I will discuss an important transition scenario, namely the transition from AD to OD under several coupling schemes [2], which is analogous with the Turing-type bifurcation in spatially extended systems. The first experimental observation of the transition from AD to OD will also be discussed [3]. Further, several nontrivial bi-stable HSS [4] under mean-field and direct-indirect coupling will be discussed in detail; this bi-stable steady states may have importance in the context of bi-stability arises in biology and physics.

References:

[1] A.Koseska, E.Volkov, and J.Kurths, Phy. Rev. Lett 111, 024103 (2013).

[2] T. Banerjee and D. Ghosh, Phy. Rev. E 89, 052912 (2014).

[3] T. Banerjee and D. Ghosh, Phy. Rev. E 89, 062902 (2014).

[4] D. Ghosh and T. Banerjee, Phy. Rev. E 90, 062908 (2014).

1.5 Synchronization in vectorial solid-state lasers

M. Brunel, M. Romanelli and M. Vallet

We describe the effect of a frequency-shifted feedback on the nonlinear dynamics of a dual-polarization solid-state laser, with emphasis on the synchronization mechanism. We investigate in particular experimentally and numerically a synchronization regime of frequency locking without phase locking (also known as bounded phase, phase entrainment or phase trapping), which was observed in the dual-polarization laser oscillator and afterwards in hydrodynamics and in nanomechanical oscillators. We show that the synchronization quality, supported by phase noise measurements, is not affected by the Hopf instability. Agreement with a minimal generic oscillator model shows that this feature is universal.

1.6 Synthetic Genetic Oscillators, Quorum sensing and Multistability

Syaml Kumar Dana

CSIR-Indian Institute of Chemical Biology, Jadavpur, Kolkata 700032, India

Synthetic genetic oscillator (SGN) consists of three single genes connected in a cyclic order inhibiting each other, which mimics a circadian clock. A collection of such SGN units shows diverse dynamical features under quorum sensing such as oscillatory incoherent state, inhomogeneous limit cycle, inhomogeneous steady states, homogeneous steady state. We evidence all these features in numerical simulations and also implemented the SGN with an electronic circuit analog and reproduced all the dynamical features in experiment and furthermore designed a parallel logic gate.

References:

1. Edward H. Hellen, S. K. Dana, Boris Zhurov, Evgeny Volkov, Electronic implementation of 1‘repressilator with quorum sensing feedback, PLoS ONE 8(5), e62997 (2013).

2. E.H.Hellen, S.K.Dana, J.Kurths, E.Kehler, S.Sinha, Noise-aided logic in an electronic analog of synthetic genetic networks, PLoS ONE 8(10), e76032 (2013).

3. E.H.Hellen, E.Volkov, J.Kurths, S.K.Dana, An electronic analog of synthetic genetic networks, PLoS One 6 (8), e23286 (2011).

1.7 Protein Structure and Function From Correlation Matrices and Networks

Nivedita Deo

University of Delhi

We investigate the structural organization of a protein family us- ing amino acid properties and identify residues controlling the protein functions. The method consists of entropy estimates determined by the physiochemical characteristics of amino acids which may provide greater reliability and information in the prediction of crucial sites as compared to the conventional entropy dealing with amino acids as strings. This is followed by random matrix analysis (RM) employed to cluster important positions within the protein family into 'sectors' that have biological and structural importance. On application to a protein family, the analysis (RM) shows that the smallest eigenvec- tors are highly localized containing high information content and are used to determine the different sectors. Finally a network analysis is performed which not only offers an understanding of how the posi- tions within the sectors are interacting but also unveils system level information. The proposed approach can assist in the recognition of structural motifs as shown in the enzyme family and selectively iden- tifies the crucial nodes/edges of the amino acid network for targets to deactivate the enzymatic action.

1.8 The transition to synchronisation on hierarchical lattices

Neelima Gupte

Dept. of Physics,
Indian Institute of Technology, Madras,
Chennai, 600036.
INDIA.

We study the transition to synchronisation in hierarchical lattices using the evolution of Chate Manneville maps placed on a triangular lattice. Connections are generated between the layers of the traiangular lattice assuming that each site is connected to its neighbours on the layer above with probability half. The maps are diffusively coupled, and the map parameters increase hierarchically, depending on the map parameters at the sites they are coupled to in the previous layer. The system shows a transition to synchronisation which is second order in nature, with associated critical exponents. However, the V-lattice, which is a special realisation of this lattice shows a transition to synchronisation which appears to be discontinuous. This raises the possibility of the transition belonging to the class of explosive synchronisation with the explosive nature depending on the nature of the substrate. We discuss the implications of our results.

We compare our results with those seen for explosive percolation transitions seen on these networks [1],[2] where the transition to explosive percolation has been seen on the V-lattice, with continuous transitions being seen for the usual clusters. The load bearing versions of these networks also show that the V-lattice shows power-law behaviour for the failure rates, and also for the length of the avalanches, leading to the belief that the V-lattice is the critical realisation of these networks, for these cases. We speculate on whether a similar structure can lead to critical cascading behaviour in the case of real life applications.

in collaboration with Sanjith Gopalakrishnan

[1] Transmission of packets on a hierarchical network: Statistics and explosive percolation, A.D. Kachhvah and N. Gupte, Phys. Rev. E 86, 026104 (2012).

[2] Transmission of packets on a hierarchical network: Avalanches, statistics and explosive percolation, N. Gupte and A.D. Kachhvah, Proceedings of the International Conference on Theory and Application in Nonlinear Dynamics (ICAND 2012) edited by Visarath In, Antonio Palacios, Patrick Longhini, pgs 193-202, Springer series Understanding Complex Systems, XI, Springer Switzerland (2014).

1.9 Biodiversity of plankton: non-equilibrium coexistence of competing species

Partha Sharathi Dutta[1], Bob W. Kooi[2], David Bastine[3], **Ulrike Feudel**[3]

[1] Dept. of Mathematics, IIT Ropar, India

[2] Dept. Theoretical Biology, Vrije Universiteit Amsterdam,

[3] Institute for Chemistry and Biology of the Marine Environment, University Oldenburg, Germany

Several solutions have been offered in the literature to solve the paradox of plankton which states that in equilibrium the number of coexisting species can not exceed the number of ressources. We study a competition model similar to the one introduced by Huisman and Weissing [1] who showed that coexistence of more species than ressources becomes possible in non-equilibrium states such as periodic or chaotic states. They called this phenomenon supersaturation. In contrast to the approach in [1] our model is based on the dynamic energy budget theory [2] which uses the concept of a synthezising unit. This concept is based on the mechanisms of enzyme kinetics and considers all ressources as complementary. Using this model we study the dynamics of the competing species which can exhibit competitive exclusion, heteroclinic cycles, stable coexistence in a fixed point and periodic solutions. Moreover, we find the coexistence of more species than ressources in parameter regions where periodic and chaotic solutions are possible. Hence we can show that supersaturation is possible in a model with a more realistic approach to the uptake of resources. Our study reveals the dynamical mechanism how supersaturation can occur: it is due to a transcritical bifurcation of limit cycles. Furthermore we show, how spatial heterogeneity in the distribution of nutrients promotes the coexistence of species. To this end we study the competition of different groups of phytoplankton in the wake of an island which is close to an upwelling region providing nutrients for the growth of the plankton. We show that the mesoscale hydrodynamic structures influence strongly the competition between the species resulting in localized dominance of specific species within vortices in the wake of an island. On the on hand, the mechanism of the emergence of these localized dominance patterns of species relies on the intricate interplay of hydrodynamic and biological time scales. On the other hand, the location of stable and unstable manifold of a chaotic saddle embedded in the flow is the backbone of the emergence of such dominance patterns. of the strength of vorticity and the amount of vertical upwelling of nutrients on the emergence of inhomogeneous dominance patterns of plankton groups.

REFERENCES

[1] Huisman, J. Weissing F.J.: Biodiversity of plankton by species oscillations and chaos. Nature 402: 409-410, 1999.

[2] Kooijman, S.A.L.M. : Dynamic Energy Budget theory for metabolic organisation. Cambridge University Press, Cambridge, 2010.

1.10 Origin of various patterns in real networks: An evolutionary approach

Sarika Jalan

Complex Systems Lab
IIT Indore, Indore 452017

Finding mechanisms governing the evolution of structural patterns in real world networks remains challenging in the evolutionary science. These patterns on one hand influences the functional response of the underlying system, while on the other hand may be motivated from a specific function of the system. Using the Genetic Algorithm we explain origin of various types of interaction patterns commonly observed in real world networks.

1.11 Strange Nonchaotic Stars

Vivek Kohar

Applied Chaos Lab, University of Hawaii, Manoa, Hawaii, US.

While the brightness of stars like the Sun is nearly constant, the brightness of other stars changes with time. Exploiting the unprecedented capabilities of the planet-hunting Kepler space telescope, which stared at 150 000 stars for four years, I discuss recent evidence that certain stars dim and brighten in complex patterns with fractal features. Such stars pulsate at primary and secondary frequencies whose ratios are near the famous golden mean, the most irrational number. A nonlinear system driven by an irrational ratio of frequencies is generically attracted toward a "strange" behavior that is geometrically fractal without displaying the "butterfly effect" of chaos. Strange nonchaotic attractors have been observed in laboratory experiments and a bluish white star 16 000 light years from Earth in the constellation Lyra may manifest, in the scale-free distribution of its minor frequency components, the first strange nonchaotic attractor observed in the wild. The recognition of stellar strange nonchaotic dynamics may improve the classification of these stars and refine the physical modeling of their interiors.

1.12 Basin Stability for Evaluating Large Perturbations in Power Grids

Jürgen Kurths

Potsdam Institute for Climate Impact Research and Humboldt University Berlin, Institute of Physics, Germany.
email : Juergen.Kurths@pik-potsdam.de

The human brain, power grids, arrays of coupled lasers and the Amazon rainforest are all characterized by multistability. The likelihood that these systems will remain in the most desirable of their many stable states depends on their stability against significant perturbations, particularly in a state space populated by undesirable states. Here we claim that the traditional linearization-based approach to stability is in several cases too local to adequately assess how stable a state is. Instead, we quantify it in terms of basin stability, a new measure related to the volume of the basin of attraction. Basin stability is non-local, nonlinear and easily applicable, even to high-dimensional systems. It provides a long-sought-after explanation for the surprisingly regular topologies of neural networks and power grids, which have eluded theoretical description based solely on linear stability.

Specifically, we employ a component-wise version of basin stability, a nonlinear inspection scheme, to investigate how a grid's degree of stability is influenced by certain patterns in the wiring topology. Various statistics from our ensemble simulations all support one main finding: The widespread and cheapest of all connection schemes, namely dead ends and dead trees, strongly diminish stability. For the Northern European power system we demonstrate that the inverse is also true: 'Healing' dead ends by addition of transmission lines substantially enhances stability. This indicates a crucial smart-design principle for tomorrow's sustainable power grids: add just a few more lines to avoid dead ends. Further, we analyse the particular function of certain network motifs to promote the stability of the system. Here we uncover the impact of so-called detour motifs on the appearance of nodes with a poor stability score and discuss the implications for power grid design. Moreover, basin stability enables uncovering the mechanism for explosive synchronization and understanding of evolving networks.

References:

[1] P. Menck, J. Heitzig, N. Marwan and J. Kurths, Nature Physics 9, 89 (2013).

[2] P. Menck, J. Heitzig, J. Kurths and H. Schellnhuber, Nature Communication 5, 3969 (2014).

[3] P. Schultz, J. Heitzig and J. Kurths, New Journal Physics 16, 125001 (2014).

[4] V. Kohar, P. Ji, A. Choudhary, S. Sinha and J. Kurths, Phys. Rev. E 90, 022812 (2014).

[5] Y. Zou, T. Pereira, M. Small, Z. Liu and J. Kurths, Phys. Rev. Lett. 112, 114102(2014)

1.13 Occurrence and Characterization of Chimera States in Coupled Identical Nonlinear Oscillators

M. Lakshmanan

Centre for Nonlinear Dynamics, Bharathidasan University, Tiruchirappalli - 620 024, India.

Coexisting domains of coherent and incoherent oscillations in an ensemble of identical oscillators is a novel emergent behavior, known as chimeras, which has been an area of active research in recent times. In this talk, I will discuss the significance of some of the quantitative measures which we have introduced recently, namely the strength of incoherence in both amplitude and frequency domains to distinguish amplitude and frequency chimeras and also cluster states, as well as discontinuity measure to identity multi-chimera states. In particular, different dynamical transitions to both frequency and amplitude chimeras in ensembles of nonlocal and global couplings will be analyzed and the role of symmetry breaking in the identification of chimera death states will be indicated. Further, I will also briefly discuss the emergence of chimera-like states even without any explicit coupling but with a common forcing, for example in an ensemble of Duffing oscillators with an additional common forcing.

References:

[1] I. Omelchenko, B. Riemenschneider, P. HÖvel, Y. Maistrenko, and E. Scholl, Phys. Rev. E 85, 026212 (2012)

[2] G. C. Sethia and A. Sen, Phys. Rev. Lett. 112, 144101 (2014).

[3] R. Gopal, V. K. Chandrasekar, A. Venkatesan, and M. Lakshmanan, Phys. Rev. E 89, 052914 (2014).

[4] V. K. Chandrasekar, R. Gopal, A. Venkatesan, and M. Lakshmanan, Phys. Rev. E 90, 062913 (2014).

[5] V. K. Chandrasekar, R. Suresh, D. V. Senthilkumar, and M. Lakshmanan (2015), Submitted.

1.14 Computing elements through interplay of noise and nonlinearity

K. Murali

Department of Physics, Anna University, Chennai.

We consider how to realize reliable logic elements by exploiting the interplay between nonlinearity and noise. If we drive a two-state system with two low amplitude square waves as input, the response of the system mirrors a logical output (NOR/OR) with a probability controlled by the noise level. As one increases the noise intensity, the probability of the output reflecting a NOR/OR operation increases to unity and then decreases. Also, this system allows one to morph the output into another logic operation (NAND/AND) by varying the nonlinearity. Further we review this concept of "Logical Stochastic Resonance" for emulating different computing elements including combinational and sequential logic operations.

References:

[1] K.Murali, Sudeshna Sinha, W.L.Ditto, and A.R.Bulsara, Physical Review Letters 102 (2009) 104101.

[2] K.Murali, I.Raja Mohamed, Sudeshna Sinha, W.L.Ditto, and A.R.Bulsara, Applied Physics Letters 95 (2009) 194102.

[3] D.N.Guerra, A.R.Bulsara, W.L.Ditto, Sudeshna Sinha, K.Murali and P.Mohanty, Nano Letters 10 (2010) 1168.

[4] A.R.Bulsara, A.Dari, W.L.Ditto, K.Murali and Sudeshna Sinha, Chemical Physics 375 (2010) 424.

[5] Vivek Kohar, K.Murali and Sudeshna Sinha, Communications in Nonlinear Science and Numerical Simulation 19, (2014) 2866.

1.15 Random walks on complex networks : What can we do with them

M. S. Santhanam

Indian Institute of Science Education and Research, Pune - 411 008, India.

The idea of random walk in physics is more than 100 years old. It is a fundamental model for our understanding of diffusion phenomena in physical systems. In the last decade many new applicatins of random walks have emerged especially in the context of complex networks. In the first part of this talk, we will present a brief survey of new applications of random walks on networks. Further on, we will present some of the results we had obtained on three different problems, from traffic model to extreme events, all of which involve random walk on discrete and complex lattice as the main ingredient.

1.16 Dynamics of Hedgehog Signalling Pathway and Strategy to Control Cancerous Situation

Ram Rup Sarkar

Chemical Engineering and Process Development, CSIR - National Chemical Laboratory, Pune
email: rr.sarkar@ncl.res.in / ramrup@gmail.com

The hedgehog signaling cascade generates highly diverse, fine-tuned responses in retort to the external stimulus by the sonic hedgehog protein (SHH). This is required for the flawless functioning of the cell, its development, survival and proliferation, through production of GLI and transcriptional activation of its target genes. Any change in the behavior of GLI response by ectopic expression of SHH or mutations in the core pathway components may cause serious consequences in the cell fate through rapid, uncontrolled and elevated production of GLI. Due to lack of proper understanding of the dynamics of the pathway in the ligand dependent and ligand independent scenarios and the effect of different regulations that govern differential behavior of active GLI, controlling GLI steady state levels in abnormal cells has become a serious and difficult consequence. Here, we present a simple but extensive computational model that considers the detailed reaction mechanisms involved in the signaling cascade that relay information from the extracellular ligand SHH to the nucleus and provides a detailed insight into regulation of GLI. For the first time, by explicit involvement of Suppressor of fused (SUFU) and Hedgehog-interacting protein (HHIP) reaction kinetics in the model, we try to demonstrate the temporal gradient of GLI seen in normal physiological conditions in response to SHH stimulus and the vital importance of HHIP and SUFU in maintaining the graded response of GLI. By performing parameter variations, we incorporated the ligand-dependent and ligand-independent scenarios of pathway activations observed in cancers; demonstrating an ultrasensitive switch-like response of GLI corresponding to the SUFU-deficient conditions that predispose abnormal embryonic development and the irreversible switching response of GLI that correspond to signal-independent pathway activation observed in cancers. We also perform parameter sensitivity in the signal-independent irreversible switching conditions of GLI and identify the other checkpoints in the pathway that could be used to control active GLI steady state levels in probable cancerous situations.

1.17 Mixed coupling between similar and dissimilar variables in coupled nonlinear oscillators

Manish Dev Shrimali

Department of Physics
Central University of Rajasthan

A time-varying mixed interaction between similar and dissimilar variables in coupled oscillators is studied. Mixed coupling has two types of time-dependent coupling functions: coupling between similar or dissimilar variables. This type of interaction gives rise to an interesting transition between synchronization and amplitude death states as a function of interaction time and coupling strength. Results are illustrated with Landau–Stuart (LS) and other models.

References:

1. Effect of mixed coupling on relay-coupled Rossler and Lorenz oscillators, A. Sharma, M. D. Shrimali, and K. Aihara, Physical Review E,90, 062907 (2014).

2. Time-varying interaction between similar and dissimilar variables in coupled nonlinear, M. D. Shrimali, et al, In Preperation.

Contributed Talks

Contributed Talks

2.1 Dynamical behaviours of chaotic oscillator chains

Manish Agrawal

Department of Physics, Sri Aurobindo College, University of Delhi, New Delhi - 110 017, India.

We study the manner in which the effect of an external drive is transmitted through a drive - response system by examining the phase and generalized synchronization among the drive and responses. The scalar and vector coupling schemes are used. Synchronization regimes [1] are trun- cated with the distance of response systems from external drive. The dynamical behaviours of driven systems [2] are also altered by the driving system. The results are illustrated for systems of coupled chaotic Lorentz and Rössler oscillators.

References:

[1] M. Agrawal, A. Prasad and Ram Ramaswamy, Phys. Rev. E 84, 056205 (2011).

[2] M. Agrawal, A. Prasad and Ram Ramaswamy, Phys. Rev. E 87, 042909 (2013).

2.2 Automatic Identification of Devanagri Script Texts using Complexity based Measures

Karthi Balasubramanian and Nithin Nagaraj

Department of Electronics and Communication Engg., Amrita School of Engg., Amrita Vishwa Vidyapeetham, Amritapuri Campus, Kollam, Kerala - 690 525.

Automatic script identification plays a key role in various fields like archiving multilingual documents, searching multilingual online databases, language recognition and language classification, just to name a few. An important fact to note in this aspect is that different languages may share a common script. For eg: devanagri script is used for writing Sanskrit, Marathi, Hindi, Nepali, Konkani and Sindhi while Bengali script is used for Assamese and Bengali. In this work, we deal with the problem of automatic identification of texts written in devanagri scripts from among a set of texts written in eight different scripts.

Traditionally, script identification has been done using feature extraction techniques that are generally computation intensive and not very optimal. To overcome this limitation, Benedetto et al. [1] considered this problem from an information theory perspective and used relative distance based methods using compression algorithms. We approach this problem in a similar fashion but using Lempel Ziv complexity [2] and ETC complexity measure that has been recently proposed in [3].

To ensure uniform coding for the characters in different languages, UNICODE standard coding is done for all the texts. We choose ten different languages namely Hindi, Marathi, Nepali, Malayalam, Tamil, Kannada, Urdu, Punjabi, Gujarati and Bengali out of which Hindi, Marathi and Nepali use devanagri script while the other seven use seven different scripts. Given unknown texts in all these languages, we generate minimum distance based phylogenetic tree and automatically identify the devanagari script based texts.

We show that automatic identification is possible even with the use of very short length texts. In the case of ETC measure, we are able to successfully identify unknown texts of just 12 characters long while LZ measure works only for lengths of 30 and higher.

References:

[1] Benedetto, Dario, Emanuele Caglioti, and Vittorio Loreto. “Language trees and zipping”. Physical Review Letters 88.4 (2002): 048702.

[2] Lempel, Abraham, and Jacob Ziv. “On the complexity of finite sequences”. Information Theory, IEEE Transactions on 22.1 (1976): 75-81.

[3] N Nagaraj, K Balasubramanian, S Dey, “A new complexity measure for time series analysis and classification”, The European Physical Journal Special Topics, 2013, 222(3-4), pp 847-860.

2.3 Bifurcation and control of chaos in Induction motor drives

Krishnendu Chakrabarty[1] and Urmila Kar

[1] Kalyani Government Engineering College, Kalyani - 741 235, India.

[2] National Institute of Technical Teachers Training and Research, Kolkata - 700 106, India.

Induction motor controlled by Indirect Field Oriented Control (IFOC) is known to have high performance and better stability. This paper reports the dynamical behavior of an indirect field oriented control (IFOC) induction motor drive in the light of bifurcation theory. The speed of high performance induction motor drive is controlled by IFOC method. The knowledge of qualitative change of the behavior of the motor such as equilibrium points, limit cycles and chaos with the change of motor parameters and load torque are essential for proper control of the motor. This paper provides a numerical approach to understand better the dynamical behavior of an indirect field oriented control of a current-fed induction motor. The focus is on bifurcation analysis of the IFOC motor, with a particular emphasis on the change that affects the dynamics and stability under small variations of Proportional Integral controller (PI) parameters, load torque and k, the ratio of the rotor time constant and its estimate etc. Bifurcation diagrams are computed. This paper also attempts to discuss various types of the transition to chaos in the induction motor. The results of the obtained bifurcation simulations give useful guidelines for adjusting both motor model and PI controller parameters. It is also important to ensure desired operation of the motor when the motor shows chaotic behavior. Infinite numbers of unstable periodic orbits are embedded in a chaotic attractor. Any unstable periodic orbit can be stabilized by proper control algorithm. The delayed feedback control method to control chaos has been implemented in this system.

2.4 Study of order to chaos transition in finite quantum systems of interacting particles using the ratio of consecutive level spacings

Harshal N. Deota and N. D. Chavda

Department of Applied Physics, Faculty of Technology and Engineering, The M. S. University of Baroda, Vadodara, Gujarat, India - 390 001.

A transition from order to chaos is studied here for embedded one plus two body random matrix bosonic ensembles with spin, as well as for an isolated finite chain of interacting spins-1/2. This is carried out using a recently introduced method of the ratio of consecutive level spacings. The numerical results are in good accordance with the theoretically defined distributions, which conclude that there is a rapid crossover from integrability to chaos as the strength of the chaos inducing parameter increases.

2.5 Secure Communication using Arbitrary Chaotic System

Arti Dwivedi[1], Ashok Kumar Mittal[1,2] and Suneet Dwivedi[2]

[1] Physics Department, University of Allahabad, Allahabad, UP, India - 211 002.
[2] K Banerjee Centre of Atmospheric and Ocean Studies, University of Allahabad, Allahabad, UP, India - 211 002.

This work proposes a secure communication scheme incorporating parameter adaptation and extended version of Pecora and Carroll complete replacement scheme. Here a subset of variables of an arbitrary chaotic system v, drive a system w at the transmitter end and a replica system w' at the receiver end, in such a way that the systems w and w' synchronize rapidly. The recipient is not required to know anything about the driving system v. Digital messages can be coded as additive parameters to the system w, whereas at the receiving end the corresponding parameters are treated as unknown and evolved according to suitably chosen parameter adaptation law. It is shown that the unknown parameters converge rapidly to the corresponding values at the transmitting end, allowing the recipient to decode the messages. As the synchronization process is independent of the chaotic system v, the synchronization time can be made much less than the typical oscillation time of the chaotic system leading to rapid and secure communication. This scheme is illustrated with the help of an example. In order to confuse an intruder, the chaotic system v can be varied by the transmitter at will, without having to convey this information to the recipient.

2.6 Chaotic mixing in a planar, curved channel using periodic slip

P. Garg[1], J. Picardo[2] and S. Pushpavanam[2]

[1] Department of Chemical Engineering, Indian Institute of Technology Roorkee, Roorkee - 247667, India.

[2] Department of Chemical Engineering, Indian Institute of Technology Madras, Chennai - 600 036, India.

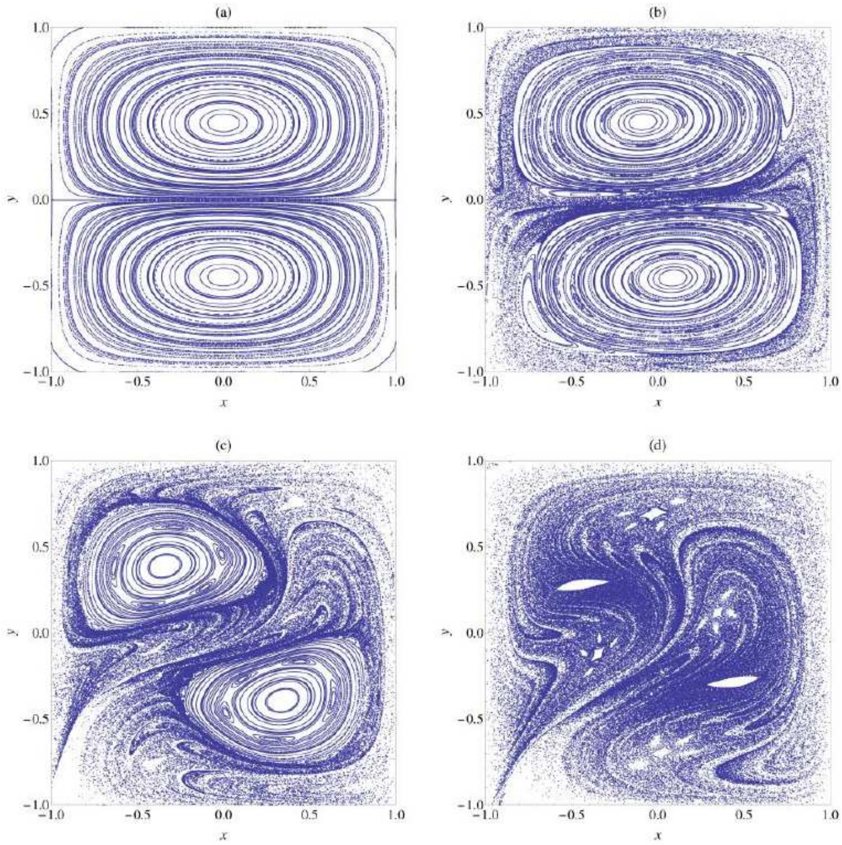


Fig 1 : Chaotic advection in a curved channel as slip is introduced alternatingly at the top and bottom walls. Poincare maps after a 1000 sections for (a) without slip (b) slip length= 0.05 (c) slip length= 0.25 (d) slip length= 0.45. Chaotic mixing occurs at low Reynolds number (=15) and curvature ratio (=0.1). Clearly, Lagrangian chaos does not exist in the absence of slip.

Relatively simple 2D, time dependent, laminar flows, or 3D steady flows, can have extremely complex particle trajectories. If the particle trajectories are chaotic, it can lead to good mixing of the fluid, despite low Reynolds numbers. Mixing via chaotic advection, first studied by Aref [1], has found important technological applications in micro-flows [2]. It also provides an interesting practical context for the study of transport in chaotic systems; here the abstract phase space is the physical space occupied by the fluid [3]. In this work, we show that laminar flow in a planar curved channel can generate chaotic trajectories, if the top and bottom walls are alternately patterned with slip surfaces [4]. Existing micro-mixers which are based on the Dean vortex flow in curved sections [5], have either complex 3D geometries, or are effective only at relatively high Reynolds numbers [2]. Both these factors limit their use in micro devices. By including slip surfaces, we overcome both these limitations. The surfaces introduce an alternating asymmetry in the size of the Dean vortices. The resultant steady flow field leads to Lagrangian chaos, which enhances mixing [6]. The associated stretching and folding of material lines/surfaces of the fluid greatly reduces the diffusion path length, thus facilitating efficient micro-mixing. An analytical solution is obtained for a simplified model of the flow, and is used to demonstrate chaotic advection using standard dynamical systems techniques. These include Poincare maps and variance calculations. Fig 1 shows a proto-typical example of the Poincare sections, as the slip length is increased. Fig 1(a) shows that the particles follow closed streamlines in the absence of slip. The introduction of the slip (Fig 1(b)-(d)) leads to the destruction of the periodic orbits; hence, the particles can now explore a greater part of the domain. Our analysis provides the foundation for a new generation of micro-mixers, which have simple geometries and are effective at micro scales. The drag reduction associated with the slip surfaces is an added benefit. Further, our design is based on recently developed Linked Twist Map theorems, and provides an incentive to extend the same to separatrix flows [6].

References

[1] Aref, H. 1984 Stirring by chaotic advection. J. Fluid Mech. 143, 1–21.

[2] Stremler, M. A., Haselton, F. R. & Aref, H. 2004 Designing for chaos: applications of chaotic advection at the microscale. Phil. Trans. R. Soc. Lond. A. 362, 1019–1036. (doi:10.1098/rsta.2003.1360)

[3] Wiggins, S. 1992 Chaotic Transport in Dynamical Systems. New York: Springer-Verlag.

[4] Tsai, P. A. 2013 Slippery interfaces for drag reduction. J. Fluid Mech. 736, 1–4.

[5] Dean, W. R. 1927 Note on the motion of fluid in a curved pipe. Phil. Mag. 7, 208–223.

2.7 Nonlinear Magnetization Dynamics in one dimensional Magnonic Crystal

D. Giridharan[1], M. Daniel[1] and P. Sabareesan[2]

[1] Center for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchi - 620 024, Tamilnadu, India.
[2] Centre for Nonlinear Science and Engineering, School of Electrical and Electronics Engineering, SASTRA University, Thanjavur - 613 401, Tamilnadu, India.

The study of nonlinear magnetic excitations in terms of solitary waves and solitons in ferromagnetic systems has attracted much interest in the past several years [1]. The results reveal that the dynamics is governed by Landau − Lifshitz (LL) equation which can be mapped to Nonlinear Schrdinger (NLS) family of equations [2]. In recent years, the study on nonlinear systems with spatial periodicity has become a great topic of interest. BEC in optical lattices, solitons in Photonic lattices and periodic magnetic systems etc., are the typical models among them [3]. Motivated by these considerations, we have investigated the nonlinear localized magnetic excitations in one dimensional magnonic crystal under periodic magnetic field. Magnonic crystal is a medium with spatially periodic variation of their magnetic properties in a definite direction [4]. The governing Landau-Lifshitz (LL) equation of magnonic crystal is transformed into variable coefficient nonlinear Schrdinger equation (VCNLS) using stereographic projection [5]. The VCNLS equation is in general nonintegrable, by using painleve analysis necessary conditions for the VCNLS equation to pass Weiss-Tabor-Carnevale (WTC) Painleve test are obtained. A sufficient integrability condition is obtained by further exploring a transformation, which can map the VCNLS equation into the well-known standard nonlinear Schrdinger equation. The transformation built a systematic connection between the solution of the standard nonlinear Schrdinger equation and VCNLS equation. The exact soliton solutions exist only when the constraint conditions on the coefficients of VCNLS equation are satisfied. The result shows that the excitation of magnetization in the form of soliton exists on the periodic background with structure similar to the form of spin Bloch waves [6]. The analytical results suggest a way to control the dynamics of magnetization in the form of solitons by an appropriate spatial modulation of the nonlinearity coefficient and (applied periodic magnetic field) potential strength in the governing VCNLS equation which is determined by the ferromagnetic materials which forms the magnonic crystal.

References:

[1] A.M. Kosevich, B.A. Ivanov, A.S. Kovalev, Physics Reports, 194, 117238 (1990).

[2] M. Daniel and J. Beula, Phys. Rev. B 77, 144416 (2008).

[3] Y. V. Kartashov, B. A. Malomed, and L. Torner, Rev. Mod. Phys. 83, 247 (2011).

[4] M.Krawczyk and H. Puszkarski, Phys. Rev.B 7, 054437 (2008).

[5] M. Daniel and R. Amuda, J. Phys. A: Math. Gen. 28, 5529 (1995).

[6] C. S. Lin, H.S. Lim, Z. K. Wang, S. C. Ng and M. H. Kuok, Appl. Phys. Lett., 98, 022504 (2011).

2.8 Sagdeev Pseudopotential and Supersolitons : A Novel Nonlinear Structure in Space Plasmas

S. S. Ghosh[1] and A. N. Sekar Iyengar[2]

[1] Indian Institute of Geomagnetism, New Panvel - 410 218, India.
[2] Saha Institute of Nuclear Physics, India.

Solitary waves are ubiquitous in the different physical systems including the plasma physics and space plasmas. The steep gradient in plasma properties at the boundary layers of the magnetosphere provides excellent free energy sources for instabilities and nonlinear wave growth leading to the generation of electrostatic solitary waves (ESWs) which in turn play crucial roles in particle accelerations and energy transports [1]. The observed ESWs are found to be comprised of monopolar, bipolar, or tripolar electric field structures. Most of the bipolar structures have so far been interpreted as ion/electron acoustic solitary waves or BGK (kinetic mode) solutions while the monopolar structures were often interpreted as corresponding double layers [2]. None of these existing theories, however, are suffice to interpret the observed tripolar structures. Recently, adopting Sagdeev pseudopotential technique [3], a novel nonlinear structure has been identified which shows a definite wiggle in its solitary potential profile [4]. The theoretical finding has been popularly named as 'supersolitons' and has rekindled the interest in studying ion and electron acoustic solitary waves for different plasma models. In the present work, we intend to study the parametric dependences of a compressive ion acoustic solitary wave in warm ion plasma comprising of two distinct populations of electrons. It has been found that the presence of a minority component of cooler electrons plays a deterministic role in the evolution of solitary waves, double layers, or the newly discovered structures called 'supersolitons'. We have explored the existence domains of the corresponding double layers and 'supersoliton' which indicates tat the latter is a transient phase between a regular solitary wave and compressive double layer. It further dissociates the overall existence domains in two distinct regime where one comprises of both compressive ion acoustic double layers and solitary waves while the other consists of only a regular solitary wave. We have also explored the possibility of applying the novel theoretical analysis in interpreting tripolar – like structures in the geospace.

References

[1] M. Temerin, K. Cerny, W. Lotko and F. S. Mozer, "Observations of solitary waves and double layers in the auroral plasma" Phys. Rev. Lett., vol. 48, pp. 1175- 1179, 1982.

[2] S. S. Ghosh and G. S. Lakhina, "Anomalous width variation of rarefactive ion acoustic solitary waves in the context of auroral plasmas" Nonlin. Process. Geophys., vol. 11, pp. 219-228, 2004.

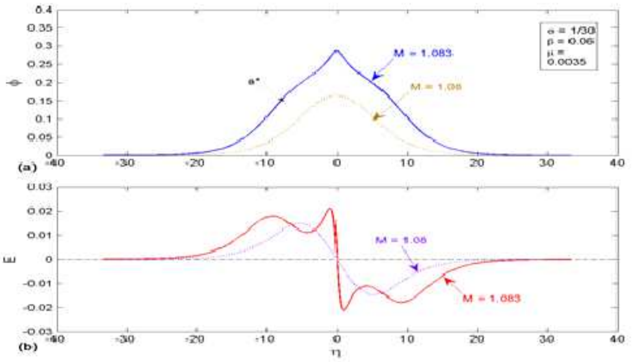


Figure 1. Compressive ion acoustic supersolitons, a) potential profile, b) electric field profile ; dotted line shows a regular solitary wave.

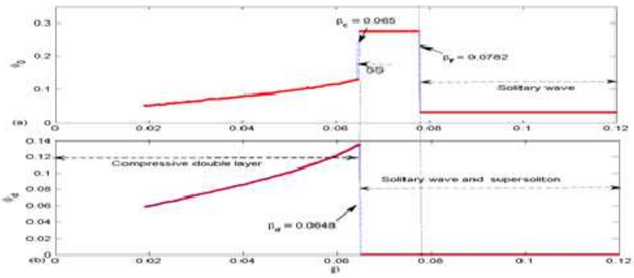


Figure 2. Comparative parametric study of the existence domains of solitary waves, double layers and supersolitons (SS) ; β is the ratio of electron temperatures.

[3] S. S. Ghosh and A. N. Sekar Iyengar, "Anomalous width variation of rarefactive ion acoustic solitary waves in the presence of warm multi-ions", J. Plasma Phys.„ vol. 67, pp. 223-233, 2002.

[4] A. E. Dubinov and D. Yu. Kolotkov, "Ion acoustic super solitary waves in dusty multi-species plasmas", IEEE TPS, vol. 40, pp. 1429-1433, 2012, doi:10.1109/TPS.2012.2189026.

2.9 Optical rogue waves in spatially modulated nonlinear waveguide

Amit Goyal[1] and C. N Kumar[2]

[1] Department of Physics, GGDSD College, Chandigarh - 160 030, India.

[2] Department of Physics, Panjab University, Chandigarh - 160 014, India.

Rogue waves are the single waves, which appear in the ocean, with amplitudes significantly larger than those of the surrounding waves. They manifest from nowhere, are extremely rare, and disappear without a trace. The dynamics of these waves has been modeled by the nonlinear Schrödinger equation. They have become a subject of intense scientific research after the experimental realization of rogue waves in various nonlinear physical systems like nonlinear optical fibers [1], plasma [2], water wave tank [3], etc. Recently, a lot of work has been done on the evolution of optical beams in nonlinear waveguides having modulated linear and nonlinear refractive indices along transverse direction [4, 5]. In this work, we study the evolution of optical rogue waves on any background beam through the spatial modulation refractive index coefficient. We consider the sech2-shaped, tanh-shaped, Bessel and Airy beams as background to study the evolution of first-order rogue waves and rogue wave triplet in graded-index waveguide. It is seen that spatial modulation of refractive index coefficients helps in the generation of more intense rogue waves in contrast to the constant coefficients. We find that the main characteristics of Peregrine rogue wave, it should be localized in both directions and have amplitude three times more than the background, are retained for spatially modulated rogue waves discuss here. Further, employing the isospectral Hamiltonian approach, one can construct one parameter family of graded-index profile to produce energetic rogue waves and to manipulate the relative distance between the successive peaks of rogue wave triplet.

References:

[1] D. R. Solli, C. Ropers, P. Koonath and B. Jalali, Nature 450 (2007) 1054.

[2] H. Bailung, S. K. Sharma and Y. Nakamura, Phys. Rev. Lett. 107(2011) 255005.

[3] A. Chabchoub, N. P. Hoffmann and N. Akhmediev, Phys. Rev. Lett. 106 (2011) 204502.

[4] W. P. Zhong, M. R. Belic and T. Huang, J. Opt. Soc. Am. B 30 (2013) 1276.

[5] K. K. De, H. Kaur, A. Goyal, C. N. Kumar and T. S. Raju, J. Mod. Opt. 62 (2015) 137.

2.10 Multiple resonance and anti-resonance in coupled Duffing Oscillators

R. Jothimurugan[1], K. Thamilmaran1, S. Rajasekar[2] and M. A. F. Sanjuan[3]

[1] Centre for Nonlinear Dynamics School of Physics, Bharathidasan University, Tiruchirappalli - 620 024, Tamilnadu, India.
[2] School of Physics, Bharathidasan University, Tiruchirappalli - 620 024, Tamilnadu, India.
[3] Nonlinear Dynamics, Chaos and Complex Systems Group Departamento de Fisica, Universidad Rey Juan Carlos, Tulipan s/n, 28933 M'ostoles Madrid, Spain.

We investigate the resonance behaviour in a system composed by n-coupled Duffing oscillators where only the first oscillator is driven by a periodic force, assuming a nearest neighbour coupling. We have derived the frequency-response equations for a system composed of two-coupled oscillators by using a theoretical approach. Interestingly, the frequency-response curve displays two resonance peaks and one anti-resonance. A theoretical prediction of the response amplitudes of two oscillators closely match with the numerically computed amplitudes. We analyse the effect of the coupling strength on the resonance and anti-resonance frequencies and the response amplitudes at these frequencies. For the n-coupled oscillators system, in general, there are n-resonant peaks and (n-1) anti-resonant peaks. For large values of n, except for the first resonance, other resonant peaks are weak due to linear damping. The resonance behaviours observed in the n-coupled Duffing oscillators are also realized in an electronic analog circuit simulation of the equations.

References:

[1] Belbasi, S., Foulaadvand, M.E., Joe, Y.S.: Anti-resonance in a one-dimensional chain of driven coupled oscillators. Am. J. Phys. 82, 32-38 (2014).

[2] Wahl, F., Schmidt, G., Forrai, L.: On the significance of antiresonance frequencies in experimental structural analysis. J. Sound & Vib. 219(3), 379-394 (1999).

2.11 Oscillation death in a system of coupled oscillators due to indirect coupling

Neeraj Kumar Kamal, Pooja Rani Sharma, Manish Dev Shrimali

Department of Physics, Central University of Rajasthan, Ajmer - 305 801, India.

We study a system of oscillators which are indirectly coupled via an environment. The environment is a exponentially decaying system with decay parameter, k. For such a system we have found that the fixed points or equilibrium states, which are either that of the uncoupled system or those evolved by the indirect coupling, are sensitively dependent on the decay parameter, k, of the environment and the coupling strength of the indirect coupling. We have also found the Chimera death state for the system of coupled oscillators without non-local coupling using this coupling scheme.

2.12 Mathematical and computational modeling of neuronal differentiation regulation by Hes1 protein

Kar, S., Sengupta, D. and Yadav, V. K.

Department of Chemistry, IIT Bombay, Powai, Mumbai - 400 076.

Development of neuroepithelial cells[1] to either neuron or astrocytes depends on the level of Hes1 protein within the cell. Hes1 acts as a transcriptional repressor of neuronal genes and it further negatively regulates its own transcription leading to an oscillatory dynamics[2] of itself with a periodicity of 2h. There were few earlier attempts[3-5] to phenomenologically model this oscillatory dynamics of Hes1 by using delay differential equations but these models lacked mechanistic insight and hence were unable to explain the developmental aspect of Hes1. Keeping this in mind, we put forward a detailed and mechanistic mathematical model for the neuronal differentiation regulation by Hes1 protein that incorporates (based on experimental literature[1,2,6-11]) the key regulators of Hes1. Our model clearly demonstrates the transition from neuroepithelial to neuronal cell in a factor dependent manner while keeping the oscillatory behavior of Hes1 intact in both neurons and astrocytes with different intensities.

References:

[1] Kageyama, R. et al., Development. Growth Differ., 50, S97 (2008)

[2] Hirata, H. et al., Science, 298, 840 (2002)

[3] Jensen, M. H. et al., FEBS Letters., 541, 176 (2003)

[4] Bernard, S. et al., Phil. Trans. R. Soc. A, 364, 1155 (2006)

[5] Momiji, H. et al., J. Theo. Biol., 254, 784 (2008)

[6] Nakagawa, N. et al., Development, 127, 4203 (2000)

[7] Jhas, S. et al., J. Neurosci., 26(43), 11061 (2006)

[8] Murai, K. et al., Plos One, 6, e27880 (2011)

[9] Gratton, M. et al., Mol. Cell. Biol., 23, 6922 (2003)

[10] Kobayashi, T. et al., Genes. Dev., 23, 1870 (2009)

[11] Imayoshi, I. et al., Development, 135, 2531 (2008)

2.13 Bi-$\mathcal{PT}$ symmetry in nonlinearly damped dynamical systems and tailoring $\mathcal{PT}$ regions with position dependent loss-gain profiles

S. Karthiga

Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirappalli - 620 024, Tamil Nadu, India.

In this talk, we discuss on the dynamics of nonlinear $\mathcal{PT}$ symmetric mechanical systems with position dependent damping. We show this position dependent damping facilitates the existence of $\mathcal{PT}$ symmetric systems even in scalar cases. By coupling two such scalar $\mathcal{PT}$ symmetric systems, we can have bi-$\mathcal{PT}$ symmetric systems with two fold $\mathcal{PT}$-symmetries. We discuss the dynamics of these systems and show how symmetry breaking occurs, that is whether the symmetry breaking of the two $\mathcal{PT}$ symmetries occurs in pair or occurs one by one. In addition, by introducing linear damping with the nonlinear damping, we show that the competition between these two dampings results in the $\mathcal{PT}$ symmetry to be broken for lower loss/gain strength and be restored by increasing the loss/gain strength. Importantly, as the boundaries of these $\mathcal{PT}$ regions are found to depend on the form of the introduced position dependent damping, these types of damping prevail the tailoring of $\mathcal{PT}$ regions in the parametric space of the system.

References

[1] S. Karthiga, V. K. Chandrasekar, M. Senthilvelan, and M. Lakshmanan, "Bi-$\mathcal{PT}$ symmetry in nonlinearly damped dynamical systems and tailoring $\mathcal{PT}$ regions with position dependent loss-gain profiles", (submitted for publication in PRA), arxiv:1412.256v1 [nlin.PS] (2014).

[2] C. M. Bender, B. K. Berntson, D. Parker, and E. Samuel, Am. J. Phys. 81 173 (2013).

[3] J. Cuevas, P. G. Kevrekidis, A. Saxena, and A. Khare, Phys. Rev. A 88 032108 (2013).

2.14 Experimental Observation of Extreme Event in a Class of Liénard type Oscillator

S. Leo Kingston[1], K.Thamilmaran[1], Pinaki Pal[2] and S. K. Dana[3]

[1] Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirappalli - 620 024, India.

[2] Department of Mathematics, National Institute of Technology, Durgapur 713209, India

[3] CSIR - Indian Institute of Chemical Biology, Jadavpur, Kolkata - 700 032, India.

Extreme event is a rare and recurrent event in which an appropriate variable exhibit an unusual behavior in several systems. This phenomenon has been studied theoretically. To the best of our knowledge, the experimental observation of extreme event has not been well studied in the literature. In this talk, I would like to present the experimental observation of extreme event in a class of Liénard type oscillator which is a second order nonautonomous system of the form $\ddot{x} + \alpha\dot{x} + \gamma x + \beta x^3 = f sin(\omega t)$. We construct real time hard ware circuit for this equation. For the particular choice of system parameter, we achieve the novel phenomena so called extreme event. This experimentally observed phenomenon is confirmed by numerical analysis which agrees well with each other.

2.15 Co-existing state of synchronization in the Mercury Beating Heart system

Pawan Kumar

Department of physics, IIT Bombay.

An abrupt transition in the star configuration of the Mercury Beating Heart system and the bistable states induces the hysteresis behaviour. The intrinsic frequency of the each oscillator have positive correlation with the number of links.The order of synchronization does not replicate as, via variable resistance changes in forward and backward direction. In the end, we show the application of the magnetic-like states of synchronization. This phenomenon has observe in the hysteresis region. Initially sytem have low order parameter state, now all oscillators have provided external frequency pacemaker, then simultaneously remove the all pacemaker. we have seen the collective dynamics of the system, permanently persist in the higher order parameter state.

2.16 Solitary Waves in a Generalized Inhomogeneous NLS Equation with Symmetric Potentials

A. Mahalingam, S. Vijayalakshmi and M. S. Manirajan

Department of Physics, Anna University, Chennai.

We have considered the optical pulse propagation inan inhomogeneous optical fiber with symmetricpotentials,which is governed by a system of Generalized Inhomogeneous NonlinearSchrödinger (GINLS) equation. Multisoliton propagation has been studied analyticallyby means of associated Lax pair and Darboux transformation. Using theobtained soliton solution, the impact of symmetric potentials on the solitondynamics is investigated.Our results shows that symmetric potentials have stronginfluence on the soliton dynamics and its behavior can be controlled by the appropriate choice of various inhomogeneous parameters and symmetric potentials.

2.17 Design of family of threshold controller nonlinearity based chaotic circuits

I. Raja Mohamed[1], M. Inbavalli[2], K. Srinivasan[3] and K. Murali[4]

[1] Department of Physics, B.S.Abdur Rahman University, Chennai - 600 048

[2] Department of Physics, Jappiar Engineering College, Chennai - 600 119

[3] Department of Physics, Nehru Memorial College, Puthanampatti - 621 007

[4] Department of Physics, Anna University, Chennai - 600 025

This work deals with designing a family of chaotic analog simulation circuits using threshold controller as the only nonlinearity. These simple circuits of both autonomous and non-autonomous types are found to exhibit ordered and chaotic phenomena. The advantage of threshold controller nonlinearity is that multi-scroll chaotic attractors can be observed by fixing different threshold levels of the nonlinearty. The dynamics of these systems is studied both numerically and experimentally.

2.18 Interplay of symmetries, null forms, Darboux polynomials, integrating factors and Jacobi last multiplier in integrable third-order nonlinear ordinary differential equations

R. Mohanasubha

Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirappalli - 620 024.

In this talk, we point out the hidden connection that exists between Prelle-Singer procedure and five other analytical methods which are used to solve the third-order nonlinear ordinary differential equations. We discuss the method of deriving Lie point symmetries, λ-symmetries, Darboux polynomials, Jacobi last multiplier and adjoint symmetries from Prelle-Singer procedure. By introducing the suitable transformations to the null forms in the Prelle-Singer method, we connect null forms with Lie point symmetries and λ-symmetries. By introducing another transformation for the integrating factor in the Prelle- Singer method, we interconnect the integrating factors with Darboux polynomials, Jacobi last multiplier and adjoint symmetries. We prove these interconnections with a specific example.

References:

[1] R. Mohanasubha, V. K. Chandrasekar, M. Senthilvelan and M. Lakshmanan, Interconnections between various analytic approaches applicable to third-order nonlinear differential equations, (Under revision in Proc. R. Soc. London. A 2015).

[2] R. Mohanasubha, V. K. Chandrasekar, M. Senthilvelan and M. Lakshmanan, Interplay of symmetries, null forms, Darboux polynomials, integrating factors and Jacobi multipliers in integrable second-order differential equations, Proc. R. Soc. A. 470, 20130656, 2014.

[3] V. K. Chandrasekar, M. Senthilvelan and M. Lakshmanan, On the complete integrability and linearization of nonlinear ordinary differential equations, Part II: Third order equations, Proc. R. Soc. A. 462, 1831-1852, 2006.

2.19 Multiple Solutions of Buoyancy-Driven Flow in a Grooved Channel

Aayush Sharma[1], Pallab S. Mahapatra[2], Nirmal K. Manna[3], Koushik Ghosh[3], **Achintya Mukhopadhyay**[3] and Pankaj Wahi[4]

[1] Department of Mechanical Engineering, Iowa State University, Ames, Iowa, USA
[2] Department of Mechanical Engineering, University of Illinois, Chicago, Illinois, USA
[3] Department of Mechanical Engineering, Jadavpur University, Kolkata, India
[4] Department of Mechanical Engineering, Indian Institute of Technology, Kanpur, India

Hydrodynamic instability analysis in a grooved channel have previously reported system solution showing interesting non-linear features like multiple stable states, bifurcation and transition to chaos. Thermal instability in a grooved channel can also attribute to such non-linear characteristics in the system solutions. We present results from computational fluid dynamic simulation of a bottom heated grooved channel undergoing natural convection in which Rayleigh number is varying from 1× 105 to 9×105. From our analysis we identify two different routes in which the solution of the system evolves along with the critical Rayleigh numbers associated with such transitions. In one route, the solution transforms from steady symmetric to chaotic while for the second route it first undergoes pitchfork bifurcation where steady symmetric solution changes to steady asymmetric followed by oscillatory or periodic solutions through Hopf bifurcation. We find from our computations that the solutions in the present system are highly dependent on the initial condition of the system, which has brought about the two distinct solution routes. It is also evident from our results that a possible route to chaos in the present system is identified; as there is a striking resemblance of the results obtained of phase plots, time series and power-spectra density to the features of a Lorenz attractor, apart from the positive largest lyapunov values reported.

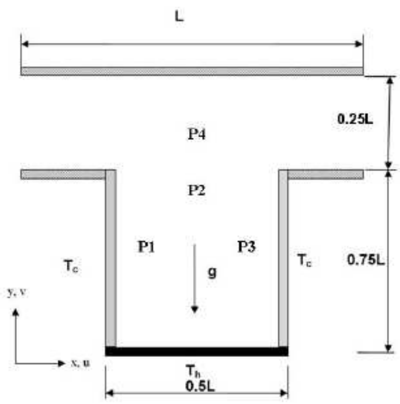


Figure 1 : Problem geometry

Figure 1 shows the problem geometry of a grooved channel in which four distinct points (P1, P2, P3 and P4) are identified within the geometry where the dynamic analysis has been carried out. Figure 2 shows the two distinct routes of the solution arising out of steady symmetric solution. Route 1, where the solution varies from steady symmetric to chaotic solution with Lorenz attractor type features observed at Rayleigh number above 2.2 ×105. Route 2, where first the solution undergoes pitchfork bifurcation followed by hopf bifurcation to oscillatory flow.

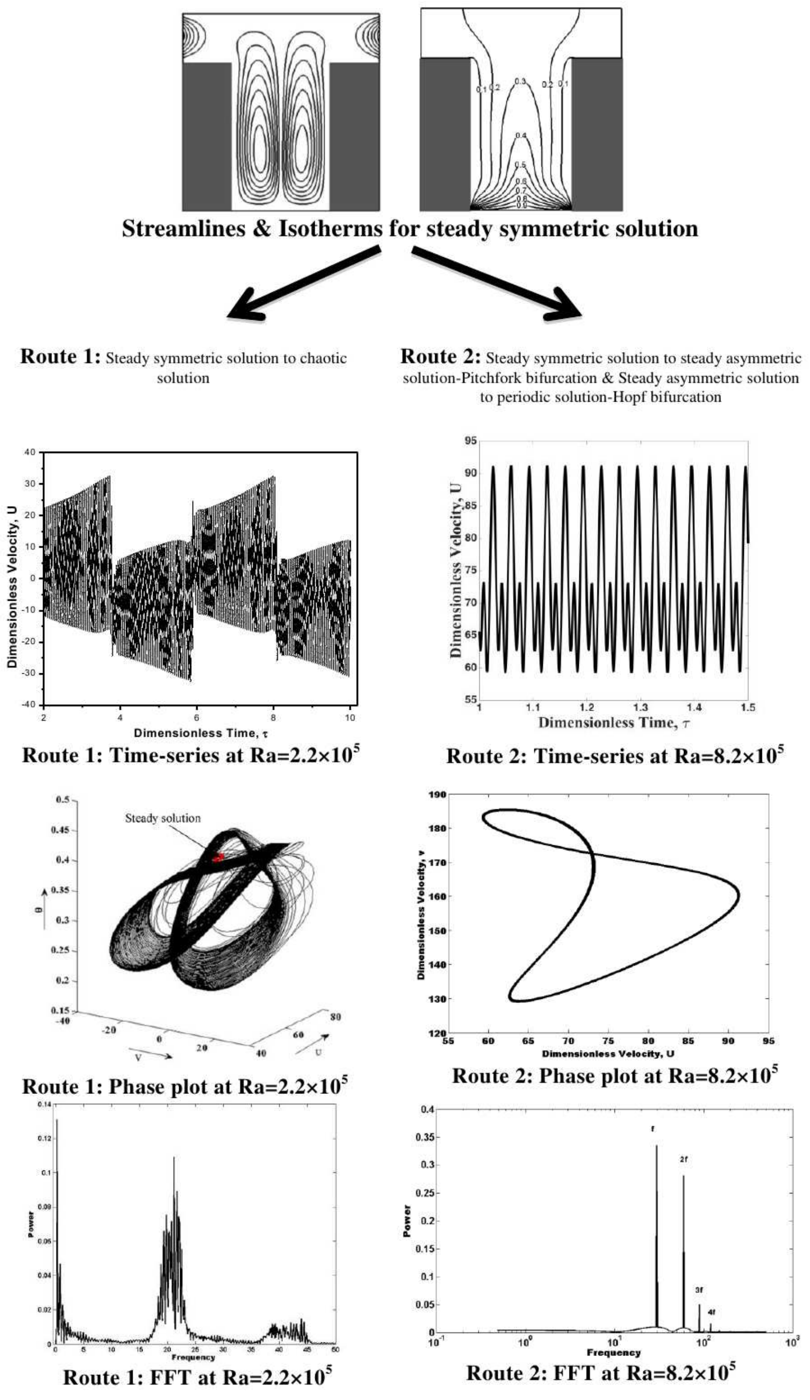


Figure 2 : Two different routes of the solution arising with change in initial condition of the system.

2.20 Effect of Prandtl number on wavy rolls in Rayleigh-Bénard convection

Pinaki Pal

Department of Mathematics, National Institute of Technology, Durgapur - 713209, India.

Rayleigh-Bénard convection (RBC) is a classical extended dissipative system. It is studied for many years to understand the basic physics of convection. Rayleigh number (Ra) and Prandtl number (Pr) are two nondimensional numbers which describe the flow in RBC. For various regimes of Ra and Pr, rich variety of instabilities, bifurcations, patterns etc. are observed which are topics of importance to many researchers in RBC. Wavy rolls is an interesting flow pattern observed in RBC. We investigate the effect of Prandtl number on wavy rolls by performing direct numerical simulations (DNS) of the three dimensional RBC. DNS shows the possibility of rich variety bifurcation structure near the onset of convection. To unfold the bifurcation structure and understand the origin of different bifurcations of the wavy rolls solution, we construct a low-dimensional dynamical system by Galerkin technique. Bifurcation analysis of the low-dimensional model shows a rich bifurcation structure involving Pitchfork, Hopf, Neimark-Sacker etc. bifurcations. Finally the results of the model are compared with that of the DNS.

2.21 Quantum dynamics in kicked Kronig-Penney system

Sanku Paul

Indian Institute of Science Education and Research, Pune - 411 008, India.

We have studied the classical and quantum dynamics of particles in one dimensional Kronig-Penney (KP) potential under the influence of time periodic kick by an external field $V(t+T) = V(t)$. This system is a Non-KAM(Kolmogorov-Arnold- Moser) system. We have found that the Non-KAM structures present in phase space leads to a sub-diffusive nature of classical average energy growth. This system displays two distinct sub-diffusive regimes due to a interplay between KAM and non-KAM type classical phase space structure. Quantum dynamics of this system is studied by using Floquet theory and observed the effect of dynamical localization in quantum average energy growth.

2.22 Dynamics of globally coupled Stuart-Landau oscilltors with symmetry broken coupling

K. Premalatha

Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirappalli - 620 024.

Chimera states ate known to occur in networks of identical oscillators in which synchronus and asynchronus oscillations are coexist. Previous studies on these states have observed in networks of nonlocally coupled phase oscillators. We observe the existence of chimera states in globally coupled networks with symmetry broken coupling. Here we find various dynamical states such as synchronized, chimera, cluster states by depending on the strength of nonisochronicity parameter. We distinguish these states by using the statistical measure such as strength of incoherence. We also report the disparate transition routes to recently observed chimera death state (coexistence of coherent and incoherent oscillation death) in the presence of symmetry breaking in the coupling.

2.23 Randomness and Preserved Patterns in the Breast Cancer Network

Aparna Rai, Pramod Shinde, Sanjiv K Dwivedi and Sarika Jalan

Complex Systems Lab, Indian Institute of Technology, Indore.

Breast cancer has been reported to account for the maximum cases among all female cancers till date. In order to gain a deeper insight into the complexities of the disease, we analyze the breast cancer network and its normal counterpart at the proteomic level through a novel mathematical tool, random matrix theory. This theory has previously been used to understand the complexities of various physical systems ranging from quantum chaos to galaxy. The random matrix analysis of the protein-protein interaction networks for both the cases reveal insightful structural patterns involving functionally important proteins and also provide an evidence towards the importance of random connections in the underlying networks. The analysis being time and cost proficient provides a benchmark for designing novel drugs and therapeutic targets which involves a subgraph instead of individual proteins.

References:

[1] Aparna Rai, A. Vipin Menon and Sarika Jalan. Randomness and preserved patterns in cancer network. Sci Rep., 4: 6368 (2014).

[2] Sarika Jalan, Aparna Rai, and Amit Kumar Pawar. ”Interaction patterns in diabetes mellitus II network: An RMT relation.” arXiv preprint arXiv:1410.2071 (2014).

2.24 Existence and Stability of Periodic Orbits in Continuous, Non-Smooth 2-D Maps

Arindam Saha and Soumitro Banerjee

Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, India.

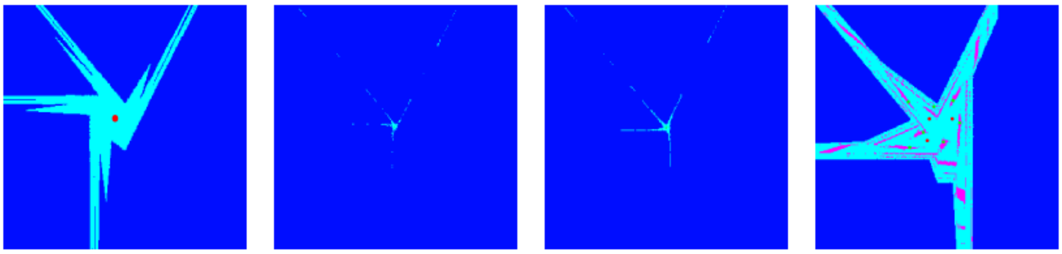


Figure 1 : Plots illustrating the changes in basin of attraction during 'dangerous bifurcation'. Here the size of the basin initially decreases to zero size before increasing again. This leads to trajectories diverging off the infinity despite the presence presence of attractors. Such a phenomenon can be explained by the changes in existence and stability of the periodic orbits.

Bifurcations in non-smooth systems have attracted wide attention among researchers due to their wide applicability in practical systems like switching circuits, impacting mechanical systems, cardiac rhythms etc. Due to the presence of non-smoothness along a manifold, many atypical bifurcations might be seen in these systems. For example, a period one orbit might directly transform into a chaotic orbit, a periodic orbit might suddenly vanish on hitting the manifold or phase space trajectories might diverge off to infinity despite the eigenvalues being inside the unit circle. At the heart of all these bifurcations lies the interplay between various periodic orbits of the system. While stable periodic orbits form the basins of attraction in the phase space; the unstable periodic orbits form the basin boundaries. Hence the appearance, disappearance or change in stability of any periodic orbit as a parameter is varied, might cause a variety of classes of bifurcations. In this talk, we describe an algorithmic approach to finding analytic conditions for the existence and stability of a class of periodic orbits in two dimensional continuous but non- smooth maps. We would also describe how the conditions obtained using these conditions might be used to predict the structure of the phase space for a certain set of parameter values.

2.25 Controlling Dynamics of Hidden Attractors

Pooja Rani Sharma

Department of Physics, Central University of Rajasthan, Ajmer - 305 801, India.

Recently, it is investigated that asymptotic trajectories of nonlinear systems not only approach to the well established self excited attractors but also stabilize towards a new class of attractors, known as hidden attractors[1]. Unlike self excited attractors, hidden attractors don't intersect with the neighborhood of any equilibrium point and therefore stabilization of these type of attractors to a fixed point state is a challenging problem. Even to locate these attractors in a given system requires propoer search methods [2]. Here, we are presenting a control scheme that can stabilize these attractors to a fixed point state by inducing amplitude death (AD). Depending on the control parameters, different route to AD such as Boundary Crises and Hopf Bifurcation are observed [3]. Note that, control scheme causes a tranisition from the initially multistable system to a monostable state prior to the amplitude death state.

References

[1] G. A. Leonov, N. V. Kuznetsov, V. I. Vagaitsev, Physica D 241 (2012) 1482.

[2] G. A. Leonov, N. V. Kuznetsov, Dokl. Math. 82 (2011) 475.

[3] P. R. Sharma, M. D. Shrimali, A. Prasad, N. V. Kuznetsov, G. A. Leonov, International Journal of Bifurcation and Chaos, In press (2015).

2.26 Dynamics of Memristor based Duffing oscillator - A case study

S. Sabarathinam and K. Thamilmaran

Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirappalli, Tamilnadu, India.

In this presentation, a four-dimensional autonomous system which is memristor based Duffing oscillator is constructed. It exhibits extremely rich dynamical behaviors, including 3-tori (triple tori), 2-tori (quasi-periodic), limit cycles (periodic), chaotic attractors. In particular, we observe 3-torus phenomena, which have been rarely reported in four-dimensional autonomous systems in the literature. With the control parameter varying in quite a wide range, the evolution process of the system begins from 3-tori, and after going through a series of periodic, quasi-periodic and chaotic attractors in so many different shapes coming into being alternately, finally it degenerates to periodic attractor. The complex dynamical behaviors of the system are further investigated by means of Lyapunov exponents spectrum, bifurcation diagram, two phase diagram, basin of attraction, Eigen value study, and time series analysis, etc,. We perform the experimental investigation to construct the realtime hardware circuit which mimic the circuit equation and obtained the results which is very much closer to the numerical predictions.

References:

[1] E B Megam Ngouonkadi, H B Fotsin and P Louodop Fotso, “Implementing a memristive Van der Pol oscillator coupled to a linear oscillator: synchronization and application to secure communication”, Phys. Scr. 89 (2014) 035201.

[2] Wenjuan Wu, Zengqiang Chen , Zhuzhi Yuan, “The evolution of a novel four-dimensional autonomous system: Among 3-torus, limit cycle, 2-torus, chaos and hyperchaos”,Chaos, Solitons and Fractals 39 (2009) 2340–2356.

[3] S. Sabarathinam and K. Thamilmaran “Transient chaos in a globally coupled system of nearly conservative Hamiltonian Duffing oscillator”, Chaos, solitons and Fractals, doi:10.1016/j.chaos.2015.0

2.27 Contact transformations and dynamical symmetries of Riccati and Abel chains

M. Senthilvelan

Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirappalli - 620 024, Tamilnadu.

In this talk, we report contact transformations that linearize the equations in the Riccati and Abel chains of nonlinear scalar and coupled ordinary differential equations. These contact transformations can be utilized to derive dynamical symmetries of the underlying nonlinear ordinary differential equations. We can also obtain the general solution of the associated nonlinear ordinary differential equations using these contact transformations. The applicability of identifying this type of contact transformations and the method of deriving dynamical symmetries, general solution of the Riccati and Abel chain of equations will be illustrated with suitable examples.

Reference

[1] R. Gladwin Pradeep, V. K. Chandrasekar, R. Mohanasubha, M. Senthilvelan and M. Lakshmanan, Order preserving contact transformations and dynamical symmetries of scalar and coupled Riccati and Abel chains, arXiv:1410.4704v1 [nlin.SI] (2014).

2.28 Transmission of Vector Solitons through Gallium-Silica Discrete Thin-film Wave guide structure

Arvind Sharma and A.K. Nagar

Department of Physics, Govt. Dungar College, Bikaner, Rajasthan - 334 001, India.

The optical pulse transmission at a symmetric thin-film gallium-silica waveguide structure is considered both analytically and numerically. Using the equivalent particle approach to solve the discrete nonlinear Schrodinger equation, we see surface waves both analytically and numerically. The dynamical analysis of the resulting discrete equations shows a series of bifurcation behavior. The stability properties of the resulting equations have been discussed.

2.29 Stochasticity and bistability in correlated environment: The case of insect outbreak

Y. Sharma[1], P. S. Dutta[1], K. C. Abbott[2] and A. K. Gupta[1]

[1] Department of Mathematics, Indian Institute of Technology Ropar, Punjab - 140 001, India.

[2] Department of Biology, Case Western Reserve University, Cleveland, OH 44106 USA.

There is a long history in ecology of using mathematical models to identify deterministic processes that may lead to dramatic population dynamic patterns like boom and bust outbreaks. Stochasticity is also well-known to have a significant influence on the dynamics of many ecological systems, but this aspect has received far less attention. Here, we study a stochastic version of a classic bistable insect outbreak model to reveal the role of stochasticity in generating outbreak dynamics. The model was originally proposed to describe spruce budworm (Choristoneura fumiferana) dynamics, but its features are quite general. We find that stochasticity has strong effects on the dynamics and that the stochastic system can behave in ways that are not easily anticipated by its deterministic counterpart. The intensity and autocorrelation of the stochastic environment are each important. Stochasticity with higher intensity (variability) generally weakens bistability, causing the dynamics to spend more time at a single state rather than jumping between alternative stable states. Which state the population tends toward depends on the noise color. High-intensity white noise causes the insect population to spend more time at low density, potentially reducing the severity or frequency of outbreaks. However, red (positively autocorrelated) noise can make the population spend more time near the high density state, intensifying outbreaks. Under neither type of noise do early warning signals reliably predict impending outbreaks or population crashes.

2.30 Mediated attachment as a growth mechanism for complex networks

Snehal M. Shekatkar and G. Ambika

Indian Institute of Science Education and Research, Pune - 411 008, India.

Complex networks have become one of the key tools in understanding the complex systems from diverse disciplines. The growth mechanisms that endow these systems with self-organizing properties have mostly looked at the preferential attachment philosophy. However, this global mechanism is incapable of providing the insight into the actual local mechanisms that result in the global properties of the networks. Here we show that the property of nodes to connect their neighbours with each other successfully reproduces the preferential attachment as well as gives rise to high clustering and hierarchical community structure. In this context, we report an important property of hubs of complex networks that is yet unexplored. We show that hubs are weaker at mediating the connections between their neighbours as compared to low degree nodes. This seems to be the property that is independent of the physical system under consideration and explains the existence of the hierarchical nature of clustering in almost all real networks. Finally, we also show how the same mechanism can give rise to assortative structure in case of social networks when mixing by age is introduced.

2.31 Synchronization using environmental coupling in Mercury Beating Heart oscillators

Tanu Singla

Department of Physics, IIT Bombay.

We report synchronization of Mercury Beating Heart (MBH) oscillators using the environmental 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 modified 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.

2.32 Experimental investigation of the onset of thermoacoustic instability in a turbulent combustor using complex networks

Meenatchidevi Murugesan and **R. I. Sujith**

Department of Aerospace Engineering, IIT Madras, Chennai.

We observe the transition from low-amplitude, seemingly random aperiodic fluctuations (combustion noise) to high-amplitude, periodic, limit cycle oscillations (thermoacoustic instability) via intermittency with increasing flow Reynolds number in a bluff-body stabilized turbulent combustor. Complex networks enable the possibility of visualizing the underlying dynamics and interaction between different components in the dynamical systems. We investigate this transition to thermoacoustic instability in a turbulent combustor using complex networks. Complex network theory is emerging very rapidly due to its applicability in a variety of fields. In this paper, unsteady pressure data which is indicative of the system dynamics in a thermoacoustic system is converted into complex networks using a visibility algorithm. We show that the complex network corresponding to combustion noise during the stable operation of the combustor exhibits scale-free behavior. The scale-free behavior of combustion noise disappears at the onset of thermoacoustic instability. We further show that thermoacoustic instability corresponds to a regular network. The transition from combustion noise to thermoacoustic instability is represented in the topology of the complex networks as a transition from complex scale-free structure to ordered regular structure. We show that during the transition to thermoacoustic instability, the topology of the complex networks undergoes structural changes and these changes can be quantified using properties of the complex networks. These network properties can be used to provide early warning for the onset of thermoacoustic instability.

2.33 Lag scenario in amplitude death of coupled oscillators

K. Suresh[1], S. Sabarathinam[1], K. Thamilmaran[1], C. R. Hens[2], Jurgen Kurths[3,4] and Syamal K. Dana[2]

[1] Center for Nonlinear Dynamics, Bharathidasan University, Trichy - 620 024, Tamilnadu, India.

[2] CSIR - Indian Institute of Chemical Biology, Kolkata - 700 032, India.

[3] Potsdam Institute of Climate Impact Research, 14473 Potsdam, Germany.

[4] Institute for Physics, Humboldt University, 12489 Berlin, Germany.

We report a lag scenario during the onset of amplitude death in two instantaneously coupled oscillators for a large parameter mismatch. In particular, we find that the coupled oscillators, due to a parameter mismatch, develop a lag or time shift via an emergent lag synchronization and ceases to oscillate for a characteristic lag at a critical coupling strength. This is analogous to amplitude death in two identical oscillators for a critical coupling delay as reported earlier [Reddy et al, PRL 80, 5109 (1998)]. We present experimental as well as numerical evidence of this lag scenario during the onset of amplitude death in two different systems, the Chua oscillator and the Bonhoffer-van der Pol system.

References:

[1] Saxena G., Prasad A. and Ramaswamy R., Phys. Rep., 521 (2012) 205

[2] Bar-Eli K., Physica D, 14 (1985) 242.

2.34 Beyond nearest neighbour spacing distribution in quantum chaos

Harshini Tekur

Department of Physics, Indian Institute of Science Education and Research Pune.

Spacing distributions of quantum spectra are known to be indicators of quantum chaos. We study the higher order spacing distributions for some of the well-known models of quantum chaos. For a mixed system like the quartic oscillator, we study the spacing distributions by separating the spacings into those that do not involve localized states and those that do. On estimating the generalized Brody parameter for the higher order spacings, it is seen that the localized states do not follow the class of Gaussian orthogonal ensemble (GOE) distributions. However, spacings not involving localized states follow the standard GOE statistics and its generalization for higher order spacings.

2.35 Analytical Study and Experimental Confirmation of SNA through Poincaré Maps in a Quasiperiodically Forced Electronic Circuit

A. Arulgnanam[1], A. Prasad[2], **K. Thamilmaran**[3] and M. Daniel[3],

[1] Department of Physics, St. John's College, Palayamkottai - 627 002, India.

[2] Department of Physics and Astrophysics, University of Delhi, Delhi - 110 007, India.

[3] Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tiruchirapalli - 620 024, India.

In this talk, we present Quasiperiodically forced series LCR circuit with simple nonlinear element in analytical and experimentally. To the best of our knowledge, this is the first time that Strange Nonchaotic Attractors (SNAs) are studied analytically. From the explicit analytical solution, the bifurcation process is shown. With a single negative conduction region of the nonlinear element two routes namely, Heagy-Hammel and fractalization routes to the birth of SNA is identified. The analytical analysis is confirmed by laboratory hardware experiments. In addition, for the first time, a detailed stroboscopic Poincaré maps are generated experimentally for two different frequencies, for the above two routes, which clearly confirm the presence of SNAs in these two routes. Also, from the experimental data of the corresponding attractors, we quantitatively confirm the presence of SNAs through singular-continuous spectrum analysis. The analytical results as well as experimental observations are characterized qualitatively interms of phase portraits, Poincaré map, power spectrum, and sensitivity dependence on initial conditions.

References:

[1] Arulgnanam, A., Thamilmaran, K., and Daniel, M., [2009] "Chaotic dynamics with high complexity in a simplified new nonautonomous nonlinear electronic circuit", Chaos, Solitons and Fractals 42, 2246 - 2253.

[2] Thamilmaran, K., Senthilkumar, D. V., Venkatesan, A. and Lakshmanan, M. [2006] "Experimental realization of strange nonchaotic attractors in a quasiperiodically forced electronic circuit", Phys. Rev. E 74, 036205-1-036205-11.

[3] Prasad, A., Negi., S. S., and Ramaswamy, R., [2001] "Strange Nonchaotic Attractors", International Journal of Bifurcation and Chaos 11 291-309.

[4] Suresh, K., Prasad, A. and Thamilmaran, K., [2013] "Birth of strange nonchaotic attractors through formation and merging of bubble in quasiperiodically forced Chua's oscillator" Physics Letters A 377, 612-621.

2.36 Mechanical Stability And History Dependence In Tetrahera Packings

N. Nirmal Tyagu

(Collaborators: M. Neudecker, and M. Schroeter, MPI-DS, Goettingen, Germany)

Department of Physics, IIT Madras, Chennai - 600 036.

Granular materials – such as cereals, powders, and sand – are the most used form of matter by human beings, next only to water. Still, the dynamics of granular media is far from understood. In this talk, I will focus on the geometry of packings of non-spherical granular materials - that of tetrahedra packings, and how the geometrical configuration of the packing influences the mechanical stability of the tetrahedra assembly. In our experiments, we use hard frictional tetrahedra particles, and employ different preparation protocols to prepare various packing configurations. This is done primarily with varying tapping intensities, and tapping times. In order to obtain the corresponding 3D geometrical configurations of these packing assemblies, we resort to 3D X-ray tomographic analysis from which we get 3D voxolized images. Results of the image analysis gives the distribution of contact types for each preparation protocol. Due to its non-spherical nature, tetrahedra show three types of contacts– Face-to-Face, Face-to-Edge, and point contacts. I will show that the most commonly used metric, the packing fraction $*\varphi*$, alone is insufficient to characterize the mechanical state of a packing configuration.

Instead, a quantity constraint number *C* derived from the contact numbers offers much better characterization of the mechanical stability. For instance, I will show that two assemblies prepared using two different protocols can have the same packing fraction but need not have the same constraint number *C*, and therefore need not have the same mechanical stability. While it is well known that granular packings are history dependent, our results show that how the preparation history determines the mechanical state of the system. Finally, I will briefly outline the implication of these results.

2.37 The Kuramoto Transition in the Mercury Beating Heart (MBH) Systems

Dinesh Verma

The ability of the Mercury Beating Heart (MBH) system to exhibit sustained mechanical and electrochemical activities simultaneously without any external agent (fluctuating or constant), has attracted the researchers for decades. The interplay of these activities could mimic the biological phenomena such as pulsating heart that occurs due to the coupled tissues exhibiting mechanical as well as electrical dynamics. In the present work, we have studied experimentally the dynamics of the population of electrically coupled autonomous MBH systems. A dynamical pulsation mode (changing radii of Hg drop), in the spherical geometry, has been chosen for the experiments. It has been observed that the redox potentials (electrical behavior) of some of quasi-identical (defined later) MBH systems in a population get synchronized at the intermediate coupling strengths (above a threshold value) whereas all of them get synchronized with a single common frequency only at large coupling strengths. Kuramoto like transitions have been observed in the population of three to sixteen quasi-MBH systems. The extent of synchrony, on an average, decreases with increasing the number of oscillators in the population for a strong coupling strength. The redox time series with the corresponding frequency distribution have been provided to demonstrate the synchronization in the systems. In addition to this, we use the order parameter r (as used by Kuramoto, discussed later) to see the extent of synchronization among the oscillators. The mechanical activities also get synchronized at strong coupling strength and its video clip would be provided as the supporting document.

Posters

Posters

3.1 Frequency Locking in Indirectly Coupled Periodic Oscillators

Priyom Adhyapok and Soumitro Banerjee

Indian Institute of Science Education and Research - Kolkata, Mohanpur Campus - 741 252, India.

Oscillators coupled indirectly through an external variable exhibit frequency measurements on synchronization which do not imitate the averaged behaviour of the original oscillator frequencies.While it has been observed that direct coupling measurements yield frequencies which stabilize around a group average and are inspired by investigation on systems like the Kuramoto oscillators [1], the quantitative dynamics for a previous system description by Katriel [2] give us different results.This work thus deals with inspecting some of the dynamic properties influenced by a global coupling in the form of an environment.Quantitative differences as calculated by FFT measurements are observed for different coupling and feedback scenarios induced in the dynamical equations.Generalized for other periodic behavior but reported specifically for the Van der Pol oscillators, synchronized frequency exceeds the higher frequency of the two oscillator values originally chosen or stands lower than the lower of the two depending on the coupling parameter and whether the coupling and feedback to the environment have been through the same dynamic variable or not. Periodic behaviour is particularly analyzed with corresponding checks by the calculation of the Lyapunov exponents and stability of the synchronous states by the Floquet multipliers.

References:

[1] S. Strogatz, From Kuramoto to Crawford: Exploring the onset of synchronization in populations of coupled oscillators, Physica D, 143 (2000).

[2] G. Katriel, Synchronization of oscillators coupled through an en- vironment, Physica D, 237(2008).

3.2 Chaotic dynamics of DC–DC converter under resonant parametric perturbation

S. Archana[1], Dr. G. Uma[1], M. Dhivya[1] and Dr. K. Murali[2]

[1] Department of Electrical Engineering, Anna University, Chennai - 600 025.

[2] Department of Physics, Anna University, Chennai - 600 025.

Chaotic dynamics of conventional Buck-Boost converter has been studied under resonant parametric perturbations. Non–linear phenomena with sinusoidal signal interference signal is observed. The effect of internal resistance of the inductor and its influence on the dynamics of the system is studied using theoretical, numerical and by experimental means.

3.3 A simple chaotic transceiver suited for Secure communications

Paul Asir

In this paper, we introduce a facile approach to synchronize chaotic systems subsumes both autonomous and non-autonomous case. Followed by this, the model is appareled to secure chaotic communication scheme and the results are verified through experiments and numerical computations. This approach includes a set of transmitter and receiver sharing common nonlinearity. On this platform, Duplex secure communication systems are modeled and checked out through Multisim simulations.

3.4 Instabilities in a Single-Phase H-Bridge Voltage Source Inverter

Aranya Bandyopadhyay, Kuntal Mandal, and Soumitro Banerjee

This paper reports the slow-timescale and fast-timescale instabilities of a single-phase full-bridge inverter with voltage-mode control which is widely used in AC power supply applications. State-space averaged model as well as Filippov's method are used to theoretically analyze both type of instabilities. From nonlinear dynamics point of view, the interaction of both the instabilities are also discussed. Moreover, the stability boundary in the parameter space was drawn to indicate the stable and unstable zone of operation. This work will also facilitate the selection of parameter range for avoiding the undesirable behavior in practical design.

3.5 Invariants for a Complex Cubic Potential in Three Dimensions

S. B. Bhardwaj[1], Ram Mehar Singh[1] and S. C. Mishra[2]

[1] Department of Physics, Ch. Devi Lal University, Sirsa - 125 055, India.

[2] Department of Physics, Kurukshetra University, Kurukshetra - 136 119, India.

With a view to obtain further insight into the theoretical understanding of the complex potentials, we construct the invariant for a complex cubic potential in three dimensions under the elegance of complex phase space approach (ECPSA) characterized by $x = x_1 + ip_4$; $y = x_2 + ip_5$; $z = x_3 + ip_6$; $p_x = p_1 + ix_4$; $p_y = p_2 + ix_5$ and $p_z = p_3 + ix_6$. For this purpose rationalization method is employed and the invariants so obtained are expected to play an important role in studying the classical aspects of a dynamical system.

3.6 Expectation values and their smooth variations of dense boson systems with one- plus two-body random matrix ensembles

N. D Chavda

Department of Applied Physics, Faculty of Technology and Engineering, Maharaja Sayajirao University of Baroda, Vadodara - 390 001, India.

Using lower order moments of the Hamiltonian for many particle systems, one can construct energy distributions fairly well. In addition to Hamiltonian, there are other interesting operators namely the number operator, the quadurpole and other electromagnetic transition operators, operators related to particle transition or a product of these operators, whose expectation values with respect to Hamiltonian eigen-values are of considerable interest. The spectral distribution methods provide smoothened forms for expectation values of such operators as a function of energy. Just like state densities, expectation values can be decomposed into smoothed (with respect to energy) and fluctuation part. In past, French and co-workers have made several attempts to derive a theory for smooth expectation values. They have developed several methods for calculating expectation values in terms of traces (moments). All moments methods for expectation values result in series expansions in terms of lower order moments of the state and expectation value densities. For isolated finite interacting many particle systems like nuclei, atoms, quantum dots, etc. many observables can be written as expectation values. In the present work, the variation of the occupancies of the single particle states and pairing Hamiltonian of interacting boson systems are studied using one-body (H1) and an embedded GOE of two-body (H2) interactions [called BEGOE(1+2)]. The BEGOE(1+2) numerical results are compared with smooth forms, calculated using the ensemble averaged moments. Moreover, the energy variation of the occupancy of single particle states, using the interpolating form of the strength function is presented. For the case of Boson systems, the ground state may show the signatures of Bose-Einstein condensation (BEC) which is an ordered structure. In order to check the nature of the ground state, one body density matrix is also studied.

3.7 Synchronization of two simple second order non-autonomous chaotic systems through threshold coupling

A. Chithra[1] and I. Raja Mohamed[2]

[1] JRF, SERB project (SR / S2 / HEP-042 / 2012), B.S.Abdur Rahman University, Chennai.

[2] Department of Physics, B.S.Abdur Rahman University, Chennai – 600 048

Synchronization is a natural phenomenon that one encounters in daily life. Though the notion of synchronization is well studied in chaotic dynamical systems, few works are carried out using the threshold nonlinearity. In this work, a method of chaos synchronization of two second order systems through threshold coupling is explored. MATLAB simulation technique and experimental electronics circuit have been considered for this study. The system exhibits complete synchronization when changing the coupling parameter, along with other types of synchronizations is also discussed.

3.8 Periodic Solutions of Fractional Differential Equations

Sangita Choudhary

Fractional Calculus deals with differentiation and integration of arbitrary orders. Frac- tional order derivatives provide a new approach for modelling many complex phenomena in Physics, Chemistry, Biology and Engineering sciences especially when dealing with memory effects. Fractional order models provide better description of underlying pro- cesses as compared to integer order models. Fractional order differential equations, there- fore have attracted attention of researchers and analysis of fractional differential equations has been studied intensively during last decade. Existence of periodic solutions is one of the important aspects of dynamical systems. In pursuance to this topic we study the ex- istence and non-existence of periodic solutions in fractional order dynamical systems. Further we analyse an autonomous fractional oscillation equation with periodic input and study the periodicity of solutions. After the detailed review of periodic solutions we investigate multi-order fractional order differential equations (FDEs) and multi-order fractional delay differential equations (FDDEs). We find Green's functions for fractional boundary value problems and then prove existence and uniqueness theorems for solutions of multi-order FDEs and FDDEs under periodic/ anti-periodic boundary conditions.

3.9 Collision Dynamics of Optical Dark Solitons in a Generalized Variable-Coefficient Higher Order Nonlinear Schrödinger System from Inhomogeneous Optical Fibers

Gifty. R[1] R. Pavithra[1], M. Vijayajayanthi [2], K. Murali[2]

[1] Laser and Electro Optical Engineering, College of Engineering, Guindy Campus.

[2] Department of Physics, Anna University, Chennai – 600 025

We consider the integrable generalized variable-coefficient single component nonlinear Schrodinger system with higher order effects such as the third-order dispersion, self-steepening and self-frequency shift, a model equation for the propagation of intense electromagnetic field in inhomogeneous optical fibers. For describing the long-distance communication, we obtain the optical multi-dark soliton using Hirota's bilinearization method. We are able to control the characteristics of optical multi-dark solitons in inhomogeneous optical fibers by choosing suitable variable-coefficient functions.

Keywords— dark solitons; generalized variable-coefficient nonlinear Schrödinger system; Hirota's bilinearization method; inhomogeneous optical fibers.

3.10 Cluster synchronization in delayed networks

Saptarshi Ghosh, Aradhana Singh and Sarika Jalan

Complex Systems Lab, Indian Institute of Technology Indore, Indore - 452 017.

We study cluster synchronization in coupled map networks with delay in information propagation and find that delay leads to enhancement in the cluster synchronization, the mechanism behind the cluster formation being dependent on the parity of delay. Furthermore, the presence of heterogeneity in delays improves the cluster formation and more heterogeneity leads to more cluster synchronizability of the network. The heterogeneity in delays may also break the robust driven clusters observed for the complete bipartite network and lead to different cluster patterns.

3.11 A Colloquium on Modulational Instability in Dispersion Decreasing Fiber Couplers with the Metamaterial Channel

M. Gunavathi[1], A. Govindaraj[2] and A. Mahalinga[1]

[1] Department of Physics, Anna University, Chennai - 600 025, India.
[2] Department of Physics, Presidency College, Chennai - 600 005, India.

We propose a dispersion decreasing fiber coupler with a negative index channel (NIM) and analyze modulational instability in the proposed DDF fiber coupler with the Metamaterial channel. We corroborated that the MI, determined by linear stability analysis, in the proposed system can support the propagation of soliton pulses. It is also observed that the MI in the dispersion decreasing fiber coupler with the Metamaterial channel is greatly influenced by the nonlinear parameters and the forward-backward ratio of the propagating wave power. Furthermore, we compared the results of the proposed system with the standard fiber couplers (SFC) in order to elucidate its cutting edge over the conventional fiber couplers.

3.12 Complex networks of slow and fast dynamical systems

Kajari Gupta and G. Ambika

Indian Institute of Science Education and Research , Pune - 411 008.

We present the different types of emergent dynamical behavior in complex networks having slow and fast dynamical systems. We explore the cases of all to all connected network and random network with varying probability of connections and present the results for stable behavior such as amplitude death, clustering etc. We also extend the work to networks having a distribution of time scales and study the emergent distribution of frequencies and amplitudes for different topologies.

3.13 Second Harmonic Generation of Cosh-Gaussian Laser Beam by Localization of Upper Hybrid Wave in Collisionless Plasma

Naveen Gupta, Arvinder Singh

National Institute of Technology Jalandhar

This paper presents a scheme of second harmonic generation (SHG) of an intense Cosh-Gaussian (ChG) laser beam in a hot collisionless plasma magnetized perpendicular to the direction of propagation of laser beam. On account of $\bigtriangledown \times B$ force, an upperhybrid wave (UHW) at pump frequency is generated. Following moment theory approach in W.K.B approximation the solution of the pump laser beam has been obtained. Filamentary structures of the laser beam are observed due to ponderomotive nonlinearity. There filaments are the regions of very high intensity and hence the UHW gets localized in these regions thereby producing steep density gradients in the trnsverse direction that in turn act as a source of S.H.G of pump beam. Numerical simulations have been carried out to have appreciation of laser filamentation and to delineate its effect on localization of UHW as well as on conversion efficiency of second harmonics. It has been observed that that decentred parameter of the laser beam and strength of static magnetic field have significant effect on localization of UHW as well as on conversion efficiency of second harmonics.

3.14 Soliton in Multi-Dimensional Alpha - Helical Proteins

K. Angelin Jeba[1], M. M. Latha[1] and Sudhir R. Jain[2]

[1] Department of Physics, Women's Christian College, Nagercoil - 629 001, India.

[2] Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400 085, India.

We propose a model Hamiltonian using the second quantized operators of quantum mechanics to explain the energy transfer through an alpha-helical protein chain. We include excitations of dipole type, nearest neighbour interactions along the X and Y directions, phonon and the phonon-exciton energies. The dynamics of the system is studied by deriving the Hamilton's equations of motion after averaging the Hamiltonian using a suitable wave function for a 2D lattice. It is found to be governed by a (2+1) dimensional perturbed nonlinear Schrödinger equation which possesses soliton solutions. The stability of soliton is analyzed for both the homogeneous and inhomogeneous lattices.

3.15 Vibrational Resonance in the Duffing Oscillator with a gamma Distributed Time-Delayed Feedback

C. Jeevarathinam[1], S. Rajasekar[1] and M. A. F. Sanjuan[2]

[1] School of Physics, Bharathidasan University, Tiruchirapalli - 620 024, Tamilnadu, India.
[2] Departamento de Física, Universidad Rey Juan Carlos, Tulipán s/n, 28933 Móstoles, Madrid, Spain.

We analyze the vibrational resonance in the Duffing oscillator system in the presence of a gamma distributed time-delayed feedback. Particularly, applying a theoretical procedure we obtain an expression for the response amplitude Q at the low-frequency of the driving biharmonic force. For both double-well potential and single-well potential cases we are able to identify the regions in parameter space where either (i) two resonances, (ii) a single resonance or (iii) no resonance occur. Theoretically predicted values of Q and the values of a control parameter at which resonance occurs are in good agreement with our numerical simulation. The analysis shows a strong influence of a gamma distributed time-delayed feedback on vibrational resonance.

References :

[1] Y.N. Kyrychko, K.B. Blyuss and E. Schöll, *Eur. Phys. J. B*, **84**, 307 (2011).

[2] C. Jeevarathinam, S. Rajasekar and M.A.F. Sanjuan, *Journal of Applied Nonlinear Dynamics* submitted (2015).

3.16 A nonlinear approach to analyse the development of Tropical disturbance using Vibrational Resonance

Jeevarekha

Vibrational resonance phenomenon was used to analyse the change in the dynamics of the convective system by having Vertical wind shear and tropical waves as external periodic forcing. The effect of the amplitude of high frequency component on the dimension of the system is also studied.

3.17 Cosh-Gaussian Solitary Wave Solution in Dissipative Laser Cavity

Baldeep Kaur[1] and Soumendu Jana[2]

School of Physics and Materials Science, Thapar University, Patiala - 147 004, India.

1–soliton travelling wave solution is obtained for the (1+1)-dimensional Complex Ginzburg Landau equation that represents dissipative laser cavity. His variational method is used to derive cosh-Gaussian solitary wave solution; a non-standard bright soliton solution.

3.18 A comprehensive mathematical model of restriction point control in mammalian cell to understand single cell experimental observations

Kompella, V. P. S. and Kar, S

Department of Chemistry, IIT BOMBAY.

Cell cycle process is an effect of robust network of reactions that are tightly regulated. Restriction point is an important event during the cell cycle after which the removal of growth factors from the medium has no effect on the subsequent cell division process[1]. It had been shown experimentally that the bi-stable nature of the Rb-E2F switch is the mechanism that governs the restriction point phenomenon [2]. Recently, Spencer et al.[3] further reported the role of p21 protein in regulating the proliferation-quiescence decision made by cells. By using the idea of multi-site phosphorylation, we proposed a mechanistic reaction network model of the restriction point control in mammalian cell, which was further used for stochastic simulations to reproduce the experimental observations at the single cell level quite efficiently. Our model makes novel predictions, that were once verified experimentally, will definitely provide new insight into the overall regulation of restriction point control.

References:

[1] Novak, B. et.al., Journal of Theoretical Biology, 230, 563 (2004).

[2] Yao, G.et.al., Nature Cell Biology, 10, 476 (2008).

[3] Spencer, S.L. et.al., Cell, 155(2) 369 (2013).

3.19 Integrability of of a coupled harmonic potential in complex phase space

Ram Mehar Singh[1], S.B.Bhardwaj[1] and S.C. Mishra[2]

[1] Department of Physics, Ch. Devi Lal University, Sirsa-125055, India

[2]Department of Physics, Kurukshetra University, Kurukshetra-136119, India

With in the frame work of extended complex phase space characterized by $x = x_1 + ip_4$; $y = x_2 + ip_5$; $z = x_3 + ip_6$; $p_x = p_1 + ix_4$; $p_y = p_2 + ix_5$ and $p_z = p_3 + ix_6$. We investigate the exact dynamical invariants for a coupled harmonic potential in three dimensions. For this purpose Lie algebraic method is employed and the invariants obtained in this work play an important role to study the stability of the solutions of differential equations, reducing the order of differential equations, solution of Cauchy system and to check the accuracy of a numerical simulation.

KEY WORDS: Exact Invariants, Complex Hamiltonian, Lie algebraic method .

3.20 Self Gravitating Granular Gases

Shikha Kumari and Syed Rashid Ahmad

Department of Physics, Jamia Millia Islamia(Central University), New Delhi, India.

Granular Materials are composed of large number of individual solid particles. They are common in nature and can be seen everywhere in the universe in all shapes and sizes, from powders to huge aster- oids. They can be considered solid, liquid or gases depending on movement of their constituting particles. They are characterized by loss of energy whenever grains collide or overlap. This inelastic behaviour causes a variety of non-equilibrium process in the system like clustering, pattern formation etc. We are studying the dynamics of such materials using computer simulations. Literature survey shows that the studies on granular gases in long-range forces are very less. The simulation of such systems is a notoriously difficult problem. We are using novel techniques to study the self gravitating granular gases. Our model aims at calculating particle-particle interaction consisting of long range gravitational interaction and short range dissipative interactions and our focus is on evolution morphology, clustering of particles in this system.

3.21 Computation of Floquet Multipliers for Fractional Order Systems

Bichitra Kumar Lenka and Soumitro Banerjee[1]

[1] Indian Institute of Science Education and Research Kolkata, Mohanpur Campus - 741 252, India.

Many real problems arising in various fields of science and engineering have drawn the attention of scientists towards fractional calculus (fractional derivative and/or integral of a function) and system models involving fractional order differential equations. Many fractional order systems have been proposed and the dynamics of the fractional order system have been investigated [1, 2]. It is observed that limit cycles are found in many fractional order nonlinear systems via numerical simulation. For example, the existence of limit cycle for fractional order Brusselator has been shown in [4]. In analysing the dynamics of such systems, one has to quantify the stability of the limit cycles. In the present work, we introduce fractional floquet system for Caputo fractional derivative. A method is proposed for computation of floquet multipliers for linearization of limit cycles of fractional order nonlinear systems. The predictor-corrector approach [3] is used to carry out numerical solution. In this paper we demonstrate why the usual approach for integer order systems cannot be applied in a straightforward way to fractional order systems, and show how the problems can be overcome. We validate the approach by successful prediction of a period doubling bifurcation.

References

[1] I.Podlubny, Fractional Differential Equations; New York: Academic press(1999).

[2] Ivo Petras, Fractional-Order Nonlinear Systems: Modeling, Analysis, Simulation, Springer, Series: Nonlinear Physical Science, 2011, ISBN 978-3-642-18100-9.

[3] K. Diethelm, N.J. Ford, A.D. Freed, A predictor–corrector approach for the numerical solution of fractional differential equations, Nonlinear Dyn. 29 (1) (2002) 3–22.

[4] Y. Wang, C. Li, Does the fractional Brusselator with effective dimension less than 1 have a limit cycle?, Physics Letters A, 363(2007), 414-419.

3.22 Bifurcation Analysis of Steady State and Limit Cycle in a Thermal Pulse Combustor Model

Sirshendu Mandal[1], Achintya Mukhopadhyay[2] and Swarnendu Sen[2]

[1] Department of Aerospace Engineering, Indian Institute of Technology Madras, Chennai - 600 036, India.

[2] Department of Mechanical Engineering, Jadavpur University, Kolkata - 700 032, India.

A bifurcation analysis of the dynamical behavior of a pulse combustor model is performed. Unlike other types of combustion systems, oscillation is desirable in pulse combustor. Hence stability analysis of steady state as well as limit cycle is performed with a lumped model of pulse combustor. As properly designed pulsations lead to improved performance like higher efficiency and lower emissions compared to steady combustors, the regime of limit cycle behavior for a particular operating condition is investigated using numerical continuation method. Bifurcation plots are obtained for the variation of wall temperature, tailpipe friction factor (f), convective heat transfer coefficient, inlet temperature and inlet fuel mass fraction. A systematic study of stability analysis is performed in present paper by continuation method using a specialized package for bifurcation analysis, MATCONT. The aim is to locate fixed point (equilibrium) and to have continuation of that fixed point, varying the parametric values. Considering the set of parametric values, right hand sides of the fourth order ODE (setting time derivatives to zero) have been numerically solved to get the fixed points.

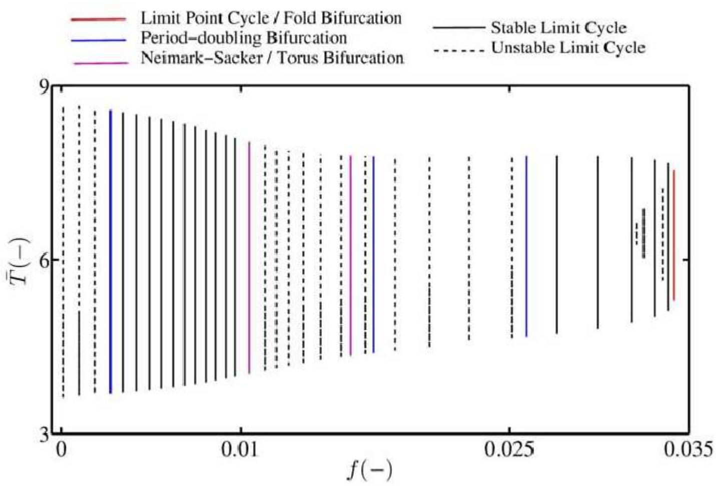


Figure 1:Continuation of limit cycle varying tailpipe friction factor

Starting from a stable fixed points, continuation of equilibrium is drawn which consists of one stable and one unstable branch. Starting from Hopf bifurcation, continuation of limit cycle is drawn and stability is examined. Fold bifurcation (limit point cycle), torus bifurcation (Neimark-Sacker) and period-doubling bifurcation are found in the continuation of limit cycle. Starting from the Hopf point at $f = 0.031975$, continuation of limit cycle in terms of dimensionless temperature (f) has been drawn in figure 1. From Hopf point, unstable limit cycle is evolved till limit point cycle (LPC) appears at $f = 0.0342$. The limit cycle manifold has a fold here and changes its stability. Stable limit cycle behavior is found up to period-doubling bifurcation at $= 0.02595$ and the limit cycle remains unstable up to second Neimark-Sacker (NS) point ($f = 0.01048$). After NS point, second stable regime of limit cycle (with higher amplitude) appears up to another period-doubling bifurcations at $f = 0.00275$. Beyond that value, all limit cycles are unstable.

On decreasing friction factor, pulsating behavior (stable limit cycle) is regained after extinction (unstable limit cycle). Phase plots are drawn in support of transition between extinction and limit cycle behavior, second stable regime of limit cycle and the onset of period doubling at $f = 0.00275$ by integrating the model numerically in figure 2. With the decrease of friction factor, a different regime periodic hot solution is achieved through aperiodic pulsation (figure 2(c)).

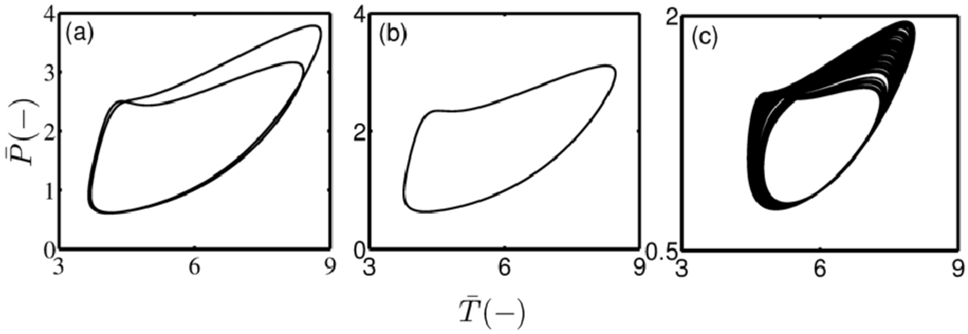


Figure 2: Phase plot with (a) f = 0.002, (b) f = 0.005, (3) f = 0.01

3.23 Persistence in Generalized Pair-Contact Process with Diffusion

Maneesh B.Matte and P. M. Gade,

PG Dept. of Physics, RTM Nagpur University, Campus, Nagpur-440033

We study persistence in Generalized Pair-Contact Process with Diffusion (GPCPD) introduced by Noh and Park (Phys. Rev. E, Vol. 69, 016122 (2004)). In this model, a new parameter which controls memory strength is introduced. We find that, at critical point local persistence shows a power-law decay. This exponent varies continuously with memory strength. We also find other related exponents in this model.

3.24 Variational method for Homoclinic snaking in VC-SEL

Gurkirpal Singh Parmar and Soumendu Jana

School of Physics and Materials Science, Thapar University, Patiala - 147 004, India.

Homoclinic snaking is a characteristic behaviour of many pattern-forming systems described by Swift-Hohenberg equation (SHE) and Complex Ginzburg-Landau Equation (CGLE). Mostly numerical analysis is adopted for the determination of the snaking profile. Variational method, an approximate analytical, has been recently used to find snaking structure in SHE, which is a real equation. To the best of the authors' knowledge no attempt has been made yet to apply variational method to find snaking in a CGLE. In the current investigation we explore the possibility of determining snaking structure in CGLE that represents a VCSEL (Vertical Cavity Surface Emitting Laser) with saturable absorber and coupled with a frequency selective feedback. The investigation is important as it attempts to handle a dissipative system using a Lagrangian based method. Rayleigh dissipative function has been used in conjugation with the variational method. The analytically obtained results have been compared with the numerical one. The influence of feedback strength and the filter band width on snaking has been elaborated.

3.25 Synchronization in a resistive and environmentally coupled electronic circuit

Mahashweta Patra and Soumitro Banerjee

This paper reports investigations on the dynamics of a couple of 555 timer circuit coupled through direct resistive coupling and environmental coupling. Independently the timers produce periodic square wave pulses of different frequencies. When they are coupled the two oscillator synchronize and produce a single frequency. We are interested in the relationship between the uncoupled frequencies of the oscillator and the coupled frequency. We show that coupled frequency lies between the uncoupled frequencies for direct coupling and outside the range for environmental coupling. We validate our result experimentally.

3.26 Effect of Electric Field on the Nonlinear Director Reorientation in Planar Nematic Cells

K. Prabakaran and M. Daniel

Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Trichy - 24.

Nematic liquid crystals have often proved advantageous for their potential applications in display and photonics for the vulnerability due to positional disorder and the unique nonlinear reorienational property they possess. Much of the studies on reorientational dynamics till date dismiss the viscous contribution from the moment of inertia on grounds that they are neglible. In this work, we have investigated the nonlinear director reorientation in planar nematic films subjected to electric field, including contribution from the rotational inertia of molecules. The resultant model equation leads to a modified sine-Gordon equation in the presence of a DC field. The director reorientation under time varying fields is much interesting and the model in this case reduces to be variable coefficient modified sine-Gordon equation. Analytical results and numerical plots depicting the director dynamics for various time varying fields such as continuous a.c field, pulsed field and rotating field have been presented here. The effect of inhomogeneity in Frank Moduli on the director dynamics is also discussed.

References:

[1] I. C. Khoo, "Liquid Crystals", Wiley-Interscience Publication, Hoboken, New Jersey, 2007.

[2] Gaetano Fiore, "Travelling-wave solutions of a modified sine-Gordon equation used in superconductivity", Waves and Stability in Continuous Media, 274-278 (2008).

[3] E. L. Aero, "Dynamic problems for the sine-Gordon equation with variable coefficients. Exact solutions", J. Appl. Maths Mechs, 66, 99(2002).

[4] L. A. Ferreira and Wojtek J. Zakrzewski , "Numerical and analytical tests of quasi- integrability in modified sine-Gordon models", Journal of High Energy Physics, 2014, 58(2014).

3.27 Experimental demonstration of delay and noise effects in parametrically driven oscillator

D. Premraj, K. Suresh and K. Thamilmaran

Center for Nonlinear Dynamics, School of Physics, Bharathidasan University, Trichy - 620 024, Tamilnadu, India.

In this poster, we investigate the slow passage through a Hopf bifurcation or delay/memory effects in Parametrically Driven Murali-Lakshmanan Chua's (PDMLC) circuit. We find the delay decreases, when the frequency of the change of controlling parameter decreases. For the Hopf bifurcation it obeys the power law and has the slope p = -1. We have included noise in the perturbation and found that, the inclusion of noise enhances the magnitude of the delay/ increases the postponement of the hopf bifurcation. We have verified these effects in real experiment and the results closely matches with each other.

References:

[1] P. Mandel, T. Erneux, J. Stat. Phys. 48, 1059-1070, 1987.

[2] S. M. Baer, T. Erneux, and J. Rinzel, SIAM J. Appl. Math. 49, 55-71, 1989.

3.28 Ghost - Vibrational Resonance

S. Rajamani[1], S. Rajasekar[1] and M. A. F. Sanjuan[2]

[1] School of Physics, Bharathidasan University, Tiruchirapalli - 620 024, Tamilnadu, India.
[2] Departamento de Física, Universidad Rey Juan Carlos, Tulipán s/n, 28933 Móstoles, Madrid, Spain.

Ghost-stochastic resonance is a noise-induced resonance at a fundamental frequency missing in the input signal. We investigate the effect of a high-frequency, instead of a noise, in a single Duffing oscillator driven by a multi-frequency signal $F(t) = \sum_{i=1}^{n} f_i \cos(\omega_i + \Delta\omega_0)t$, $\omega_i = (k + i - 1)\omega_0$, where k is an integer greater than or equal to two. We show the occurrence of a high-frequency induced resonance at the missing fundamental frequency ω_0. For the case of the two-frequency input signal, we obtain an analytical expression for the amplitude of the periodic component with the missing frequency. We present the influence of the number of forces n, the parameter k, the frequency ω_0 and the frequency shift $\Delta\omega_0$ on the response amplitude at the frequency ω_0.

References:

[1] I. Gomes, M.V.B. Vermellho and M.L. Lyra, Phys. Rev. E **85**, 056201 (2012).

[2] S. Rajamani, S. Rajasekar and M.A.F. Sanjuan, *Communications in Nonlinear Science and Numerical Simulation* (n Press).

3.29 Ultrafast All - Optical Dark Soliton Steering in As_2Se_3 Chalcogenide twin - core Photonic Crystal Fiber Couplers

M. Rajivgandhi[1], A. Govindaraj[2] and A. Mahalinga[1]

[1] Department of Physics, Anna University, Chennai - 600 025, India.

[2] Department of Physics, Presidency College, Chennai - 600 005, India.

We report the numerical investigation of all-optical dark soliton steering in a highly nonlinear As_2Se_3 chalcogenide photonic crystal fiber couplers, for the first time. A Modified Split Step Fourier Method (M-SSFM) has been developed precisely to calculate the transmittance and switching efficiency of dark solitons at 1.55 μm for 100 fs pulse width. The effect of higher order parameters such as third order dispersion (TOD), self - steepening (SS), Stimulated Raman Scatering (SRS) and cross phase modulation (XPM) have been reported. Furtermore, their outcomes have been compared with the conventional bright soliton switching.

3.30 Riccati parametrized rogue wave triplets in Bose-Einstein condensate

Ritu Pal, Shally Loomba and C. N. Kumar*

Department of Physics, Panjab University, Chandigarh 160014, India

*Email: cnkumar@pu.ac.in

Rogue waves are high amplitude waves, with amplitude approximately three times higher than the average wave crest. Recently, it was predicted that that a nth order rogue wave can be decomposed into n(n+1)/2 Peregrine breathers (PBs) called fissioned rogue waves[1]. This effect has been experimentally observed in water waves where second order rogue waves split into 3 PBs called rogue wave triplets[2]. In this work we present the coherent control of rogue wave triplets in Bose-Einstein condensate (BEC) for the parametric choices which support their occurrence experimentally. This analysis has been done for two cases involving the trapping of BEC in (i) time-dependent (ii) time-independent harmonic potential. We have found that these waves no longer lie on the apex of the equilateral triangles in the case of homogeneous system but can be manipulated by modulating the trap[3]. This enables us to control the relative distance among the three rogue wave peaks and their amplitude, for a given nonlinearity parameter. These results can be helpful to stimulate the study of rogue wave triplets experimentally in BEC.

References:

[1] A. Ankiewicz ,D. J. Kedziora and N. Akhmediev, Phys.Lett. A 375(2011) 2782.

[2] A. Chabchoub and N. Akhmediev 2013 Phys. Lett. A 377(2013) 2590.

[3] Shally Loomba, Ritu Pal and C. N. Kumar, J. Phys. B, JPHYSB-101383.R1.

3.31 Low energy dynamics of a double pendulum - role of initial conditions and rotations

J. Roy[1], S. Maiti[2], A. K. Mallick[3] and J. K. Bhattacharjee [4]

[1] UM-DAE Centre for Excellence in Basic Sciences, Mumbai.

[2] Bengal Engineering and Science University, Howrah.

[3] S. N. Bose National Centre for Basic Sciences, Kolkata.

[4] Harish-Chandra Research Institute, Allahabad.

Most studies on double pendulum have concentrated on the high energy dynamics of the system where it exhibits chaos. Here high energies refer to the energies sufficiently large enough to make the outer as well as inner pendulums rotate. In our analysis we have been able to show that the system displays non-trivial chaos even at low energies, energies by which only the outer pendulum can rotate. Carrying out a Harmonic balance and Linstedt-Poincare based perturbation analysis at large amplitudes show that while the frequency for the "in-phase" mode remains unchanged the "out-of-phase" mode changes drastically tending towards zero with the increase in amplitude. This mode softening indicates chaotic motion for the "out-of-phase" initial conditions which has been further verified by calculating the Lyapunov exponents. The interesting characteristic of this chaos is its strong dependence on initial conditions. We also investigated the effects of introducing rotation of the whole system and found chaos - quasiperiodic - chaos transition by tuning the angular speed for these particular class of initial conditions.

3.32 Investigation and quantification of nonlinearity using surrogate data in a DC glow discharge plasma

Debajyoti Saha, Pankaj Kumar Shaw , Sabuj Ghosh, M. S. Janaki and A. N. Sekar. Iyengar

Plasma Physics Division, Saha Institute of Nuclear Physics, 1/AF , Bidhan nagar Kolkata - 700 064, India.

Detection of nonlinearity has been carried out in periodic and aperiodic floating potential fluctuations of DC glow discharge plasma (GDP) by generating surrogate data using iterative amplitude adjusted Fourier transform (IAAFT) method. We introduce 'Delay vector variance' analysis (DVV) for the first time which allows reliable detection of nonlinearity and provides some easy to interpret diagram conveying information about the nature of the experimental floating potential fluctuations (FPF). The method of false nearest neighbourhood (FNN) is deployed on the FPF's to find a good embedding so as to be acquainted with the precise knowledge of m which is desirable for carrying out DVV analysis. The emergence of nonlinearity with increase in discharge voltage has been ensured by taking into consideration the total energy present in different band of frequencies excited due to nonlinear processes. Rejection of null hypothesis has been verified by performing the rank test method that confirms the presence of nonlinearity quantitatively.

3.33 Gender disparity in the society revealed through Bollywood networks

Camellia Sarkar, Alok Yadav, Sanjiv Kumar Dwivedi, Aparna Rai and Sarika Jalan

Complex Systems Lab, Indian Institute of Technology Indore, Indore, Madhya Pradesh - 452 017, India.

The glittering and glamorous world of Bollywood has largely remained aloof of the scientific world until now. But its very rapidly growing nature, and fast changing structure over the past 100 years can form the basis of studying a network in evolutionary time scales. For the first time, random matrix theory, an involved mathematical tool used in many areas of science today, was applied on Bollywood networks to understand the evolution of the society. Certain distinctive characteristics of the society which form the backbone of this industry, like gender bias, seem to have direct effects on the graph and its evolution in time. On the very onset, a proper definition of the lead female actors could not be devised as the second position of the movie star cast list was invariably occupied alternately by either female actors or supporting actors, making it difficult to extract them only based on the network data. Nodes with the highest betweenness centrality of all datasets were found to be male actors, whether lead or supporting, adumbrating the gender disparity in Bollywood. The extensive analyses of Bollywood data under network theory framework on the one hand reveals the gender disparity prevailing in the society, while on the other it unravels the gradual change in the outlook of the society towards women (documented in their success statistics), thus acting as a reflection of the society.

3.34 Numerical Analysis Of Bound Localized Pulses In Active Mode Locked Fiber Lasers

V. Satheeshkumar[1], A. Govindaraji[2] and A. Mahalingam[1]

[1] Department of Physics, Anna University, Chennai - 600 025, India.

[2] Department of Physics, Presidency College, Chennai - 600 005, India.

We numerically simulate and analyze the bound localized pulses in an active mode locked fiber laser (A-MLFL) using continuous phase modulation for wideband phase matching of the optical field circulating in the fiber ring cavity. The localized pulse-envelopes propagating in the ring laser follow the modified Ginzberg Landau equation (M-GLE). We use Symmetrized Split-Step Fourier Method (SSFM) to slove the M-GLE equation with third order global accuracy. The effects of active phase modulation and optical power can be simulated to observe the dynamics of bound localized pulses. Different operating conditions of the phase difference between bound localized pulses are also simulated.

3.35 Quantifying molecular noise accurately for a biochemical network: A comparative study between Phenomenological and Mechanistic model

Sengupta, D. and Kar, Sandip

Indian Institute of Technology Bombay, Powai, Mumbai - 400 076.

Biochemical systems modeled with phenomenological terms (Michaelis-Menten or Hill kinetics) have been found to be quite successful to model gene regulatory networks deterministically. However, how good they are to capture the stochastic behavior of a gene regulatory network in comparison to a detailed mechanistic model is still a matter of debate. Keeping this in mind, we have stochastically simulated[1] deterministically equivalent mechanistic and phenomenological models of toy systems. Our results indicate that under certain restricted parameter domain the phenomenological model can manifest the exact fluctuation of the system as adequately as mechanistic model but it often fails to do so if for example, the half lives of the mRNAs and the corresponding proteins are close to each other[2]. Based on our study we can conclude that we need mechanistic models to quantify the noise accurately for a network.

References:

[1] Gillespie, D. T., J. Computational Physics 1976, 22, 403–434.

[2] Pedraza, J. M., Paulson, J., Science 2008, 319, 339-343.

3.36 Electrodeposition by using Low Cost Versatile Data Acquisition System

Yusuf H Shaikh[1], Zakade K. R.[2], A. R. Khan[3] and Gulam Rabbani[3]

[1] Shivaji Arts, Commerce and Science College Kannad, Aurangabad.

[2] J. N. E. C. Engineering College, Aurarangabad.

[3] Dr. Rafiq Zakaria Campus, Maulana Azad College, Rauza Bagh, Aurangabad.

For use with electrodeposition setup in fractal growth the design and construction of flexible low cost user friendly data acquisition system (DAS) based on AVR microcontroller Atmega8 is presented. AVR microcontroller Atmega8 comes in 28 pin package and has built in Analogue to Digital Converter (ADC). There are six on chip analogue to digital converters (ADC's) with 10 bit resolution that amounts to a precession of one part in 1024 which is sufficiently good for regular instrumentation. Few or all of the ADC channels can be implemented in an application; in the present application two channels are used for demonstration. The Data Acquisition System (DAS) was used to record real time voltage and current during an electrodeposition experiment. The voltage sample was derived from the electrodeposition cell and the current signal was taken from a low value series resistance. Basically the DAS is designed and operated in 5V DC full scale reading mode and thus the current signal was amplified using a simple OPAMP. As the microcontroller is In System Programmable (ISP), minor modifications are extremely easy as this can be implemented with the DAS connected in a functional circuit. The data acquisition system works under program control and keeps on monitoring the signal at the analogue inputs and makes the digital equivalent available. The data transferred between microcontroller based DAS and PC is in byte (8 bit) mode and necessary multiplexing is suitably implemented. PC reads this digital input at pre-decided time intervals through controlling program. The data read by the controlling program is saved in computer files in suitable format for further use.

3.37 Evaluation of Dendritic Pattern in Electrodeposition

Pathan J.M.[1], Gulam Rabbani[1], A. R. Khan[1], **Yusuf H. Shaikh**[2]

[1] Dr Rafiq Zakria Campus, Maulana Azad College, Aurangabad, India - 431 001.

[2] Shivaji Arts, Commerce and Science College Kannad, Aurangabad, India - 431 103.

Dendritic Pattern grown in electrodeposition under suitable working conditions gives rise to fractal pattern with complexity of shape, structure and texture. Such dendritic patterns exhibit interesting characteristics and in most of the cases fractals obey scale invariance over a wide range of length scale. The study of the dendritic patterns grown in a cell with circular geometry, with a view to explore the growth rate of different electrodeposition patterns. It is found that the dendritic patterns with few branches, when closely examined exhibit microstructures that are of interest from the point of material science and newer materials with non conventional characteristics. The rate of growth is studied from the point of linear growth, volume gained and mass added as a function of time.

3.38 Study of Selfsimilarity in Biomolecules

Yusuf H Shaikh[1], Kapsae S. K.[2], Wasim Ahmed Hyderi[3] and Gulam Rabbani[4]

[1] Shivaji Arts, Commerce and Science College, Kannad.
[2] S. B. Science College, Aurangabad.
[3] Maharashtra College, Mumbai.
[4] Dr. Rafiq Zakaria Campus, Dr. Rafiq Zakaria marg, Rauza Bagh, Aurangabad.

Biomolecules have complex shapes and quantification of complex random shapes poses difficulties as they cannot be modeled using Euclidian geometry. We used box counting technique using the concept of fractals and fractal geometry for the purpose of quantification of complexity of shape and structure associated with complex shape of large biomolecules using their project in two dimensions. For this purpose two colour bitmaps of two dimensional projection of wire-frame of biomolecules is used and box counting technique is implemented for quantifying the complexity of shape and structure. It is demonstrated that the concept of fractals and fractal dimension can be used for quantification of complex structures like biomolecules of porous materials. Details are presented and findings discussed.

3.39 On transition to Checkerboard pattern in Coupled Logistic Lattice in 2-dimensions

Nitesh D. Shambharkar[1] and P. M. Gade[2]

[1] Vidya Vikas Arts, Commerce & Science College, Samudrapur. Dist - Wardha, 442 305, India.
[2] Department of Physics, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur - 440 033, India.

We study the Coupled logistic lattice in two dimensions and in particular study onset of anti-ferromagnetic order in such lattice. We observe that local persistence in such a system displays behavior which is expected from 2-d Ising model with Glauber dynamics. Given the usual non-universality in persistence exponents, this behavior is surprising. Thus these systems are in same dynamic universality class.

3.40 Intrinsic Noise Induced Coherence Resonance in a Glow discharge Plasma

Pankaj Kumar Shaw, D. Saha, S. Ghosh, M. S. Janaki and A. N. Sekar Iyengar

Plasma Physics Division, Saha Institute of Nuclear Physics, 1/AF, Bidhannagar, Kolkata - 700 064, India.

Experimental evidence of intrinsic noise induced coherence resonance in a glow discharge plasma is being reported. Initially the system is started at a discharge voltage (DV) where it exhibited fixed point dynamics, and then with the subsequent increase in the DV spikes were excited which were few in number and with further increase of DV the number of spikes as well as their regularity increased. The regularity in the interspike interval of the spikes is estimated using normalized variance (NV). Coherence resonance was determined using normalized variance curve and also corroborated by Hurst exponent and power spectrum plots. We show that the regularity of the excitable spikes in the floating potential fluctuation increases with the increase in the DV, upto a particular value of DV. Using a Wiener filter, we separated the noise component which was observed to increase with DV and hence conjectured that noise can be playing an important role in the generation of the coherence resonance. From an an harmonic oscillator equation describing ion acoustic oscillations, we have been able to obtain a FHN like model which has been used to understand the excitable dynamics of glow discharge plasma in the presence of noise. The numerical results agree quite well with the experimental results.

3.41 Extended Pathway Integral Transformer

P. S. Sehik Uduman and **Sandeep Singhal**

Department of Mathematics, B. S. Abdur Rahman University, Chennai - 600 048.

The extended pathway integral transform, which is an extension of many integral transforms, is considered. The concept of p-transforms or pathway transform is given by Kumar in 2011 using the pathway model introduced by Mathai 2005. The extensions of p-transforms with certain basic properties are obtained. The connection of extended pathway transform with the H-function is also established. The special cases of the Kernel function of extended pathway transform are the extended non-resonant thermonuclear reaction rate probability integral in the non linear thermodynamic function in astrophysics.

3.42 Hurst exponent and translation error as discriminating measures to identify the chaotic nature of an experimental time series

E. A. Gopalakrishnan, Tony John and **R. I. Sujith**

Department of Aerospace Engineering, IIT Madras, Chennai.

Identifying the existence of nonlinear structures in a time series acquired from real world systems, is necessary to distinguish chaos from correlated noise. Measures that detect temporal correlations in a time series might be insufficient to extract deterministic features from an experimental data that is contaminated with noise. Here, we employ surrogate methods to analyze experimental data obtained from an engineering system, a turbulent combustor, with Hurst exponent and translational error as discriminating measures. We conclude from the analysis that the noise level in the data could be sufficiently large to suppress the nonlinearities in the time series. Thus, the null hypothesis that the data is generated from a stochastic process cannot be rejected with sufficient confidence on a statistical basis. However, a high dimensional Mackey-Glass system also shows similar features in the presence of additive noise. Thus, we make a conjuncture that the experimental time series acquired during the stable operation in the turbulent combustor is generated from a high dimensional chaotic system contaminated with noise.

3.43 A Unified Framework To Describe Dynamics Of Thermoacoustic Instability And Blowout In A Turbulent Combustor

Vishnu R. Unni and **R. I. Sujith**

Department of Aerospace Engineering, IIT Madras, Chennai.

Thermoacoustic instability and blowout are two challenges faced while operating combustors in lean premixed conditions. Till now, the dynamics of both these phenomena are studied in very different manner. Thermoacoustic instability is seen as the loss of dynamic stability of the system and blowout is described as the loss of static stability of the system. In this paper we provide a unified description for the onset of thermoacoustic instability and the transition to blowout. We observe that in turbulent combustors, the dynamic regime prior to both onset of instability and blowout are characterized by intermittent acoustic oscillations. We also observe that the acoustic time series obtained from a turbulent combustor exhibit multifractal nature. We further characterize the multifractal nature of these oscillations and observe that while at the onset of instability the multifractal width estimated from unsteady pressure measurements reduces to zero indicating a loss of multifractality, as we approach blowout, the multifractal

width increases. Using this knowledge we describe how a single detection system can be used to forewarn about an impending instability and an impending blowout.

3.44 Lie point symmetries classification of the mixed Li enard type equation $\ddot{x} + f(x)\dot{x}^2 + g(x)\dot{x} + h(x) = 0$

Ajey K. Tiwari[a] and S. N. Pandey[b]

[a] Centre for Nonlinear Dynamics, Bharathidasan University, Tiruchirapalli-620024, India.

[b] Department of Physics, Motilal Nehru National Institute of Technology, Allahabad-211004, India.

In this paper we develop a systematic and self consistent procedure based on a set of compatibility conditions for identifying all maximal and non- maximal symmetry groups associated with the mixed Lienard type equation, $\ddot{x} + f(x)\dot{x}^2 + g(x)\dot{x} + h(x) = 0$, where $f(x)$, $g(x)$ and $h(x)$ are arbitrary functions of x. With the help of this procedure we show that a symmetry function $b(t)$ is zero for non-maximal cases whereas it is not so for the maximal case. On the basis of this result the symmetry analysis gets divided into two cases, (i) the maximal symmetry group ($b \neq 0$) and (ii) non-maximal symmetry groups ($b = 0$). We then identify the most general form of the mixed Lienard type equation in each of these cases and prove their integrability either by providing the general solution or by constructing time independent Hamiltonians.

References

[1] Ajey K. Tiwari, S. N. Pandey, M. Senthilvelan and M. Lakshmanan, arXiv:1402.3407.

[2] Ajey K. Tiwari, S. N. Pandey, V. K. Chandrasekar and M. Lakshmanan, 252 (2015) 457.

[3] Ajey K. Tiwari, S. N. Pandey, M. Senthilvelan and M. Lakshmanan, J. Math. Phys. 54 (2013) 053506; 55 (2014) 059901.

3.45 Delay - induced remote synchronization in bipartite networks of phase oscillators

Nirmal Punetha[1], **Sangeeta Rani Ujjwal**[2], Fatihcan M. Atay[3] and Ramakrishna Ramaswamy[2,4]

[1] Department of Physics and Astrophysics, University of Delhi, Delhi - 110 007, India.
[2] School of Physical Sciences, Jawaharlal Nehru University, New Delhi - 110 067, India.
[3] Max Planck Institute for Mathematics in the Sciences, Inselstr. 22, Leipzig 04103, Germany
[1] University of Hyderabad, Hyderabad - 500 046, India.

We study a system of mismatched oscillators on a bipartite topology with time–delay coupling, and analyze the synchronized states. For a range of parameters, when all oscillators lock to a common frequency, we find solutions such that systems within a partition are in complete synchrony, while there is lag synchronization between the partitions. Outside this range, such a solution does not exist and instead one observes scenarios of remote synchronization - namely, chimeras and individual synchronization, where either one or both of the partitions are synchronized independently. In the absence of time delay such states are not observed in phase oscillators.

References:

[1] N. Punetha, S. R. Ujjwal, F. M. Atay, and R. Ramaswamy, in press; and references therein.

[2] N. Punetha, R. Ramaswamy, and F. M. Atay, submitted: and references therein.

[3] A. Bergner, M. Frasca, G. Sciuto, A. Buscarino, E. J. Ngamga, L. Fortuna, and J. Kurths, Phys. Rev. E 85, 026208 (2012).

3.46 The Kuramoto Transition in the Mercury Beating Heart (MBH) Systems

Dinesh Verma

The ability of the Mercury Beating Heart (MBH) system to exhibit sustained mechanical and electrochemical activities simultaneously without any external agent (fluctuating or constant), has attracted the researchers for decades. The interplay of these activities could mimic the biological phenomena such as pulsating heart that occurs due to the coupled tissues exhibiting mechanical as well as electrical dynamics. In the present work, we have studied experimentally the dynamics of the population of electrically coupled autonomous MBH systems. A dynamical pulsation mode (changing radii of Hg drop), in the spherical geometry, has been chosen for the experiments. It has been observed that the redox potentials (electrical behavior) of some of quasi-identical (defined later) MBH systems in a population get synchronized at the intermediate coupling strengths (above a threshold value) whereas all of them get synchronized with a single common frequency only at large coupling strengths. Kuramoto like transitions have been observed in the population of three to sixteen quasi-MBH systems. The extent of synchrony, on an average, decreases with increasing the number of oscillators in the population for a strong coupling strength. The redox time series with the corresponding frequency distribution have been provided to demonstrate the synchronization in the systems. In addition to this, we use the order parameter r (as used by Kuramoto, discussed later) to see the extent of synchronization among the oscillators. The mechanical activities also get synchronized at strong coupling strength and its video clip would be provided as the supporting document.

3.47 Assortative and disassortative mixing investigated using the spectra of graphs

Alok Yadav, Camellia Sarkar and Sarika Jalan

Complex Systems Lab, Indian Institute Technology, Indore

M.E.J. Newman in 2002 (PRL 89, 208701 (2002)) introduced degree-degree Pearson correlation coefficient or popularly known as assortativity coefficient to measure the tendency of the node - node pairing. It has been used as important structural tool. We have studied numerically how this measure is related with the spectral properties of the network using the random matrix theory (RMT). We find that even though density distributions exhibit drastic changes depending on the (dis)assortative mixing and the network architecture, the short-range correlations in eigenvalues exhibit universal random matrix theory predictions. The long-range correlations turn out to be a measure of randomness in (dis)assortative networks. The analysis further provides insight into the origin of high degeneracy at the zero eigenvalue displayed by a majority of biological networks.

References

[1] Sarika Jalan and Alok Yadav, "Assortative and disassortative mixing investigated using the spectra of graphs", Physical Review E, 91(1),012813(2015).

[2] Alok Yadav and Sarika Jalan, " Origin of zero degeneracy in networks spectra" arXiv : 1412.7297 (2014). (2014).

[3] Ankit Agrawal, Camellia Sarkar, Sanjiv Kumar Dwivedi, Nitesh Dhasmana and Sarika Jalan, "Quantifying randomness in protein-protein interaction networks of different species: A random matrix approach. "Physica A 404, 359 (2014).