DR. TANMOY BANERJEE

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Academic Career

2008: **Ph.D in Science, University of Burdwan, Burdwan.**
Title of the Thesis: Studies on some nonlinear dynamical problems of a class of synchronized electronic oscillators and related topics.
[Supervisor: Prof. B.C. Sarkar, University of Burdwan]

2004-2006: **CSIR funded Senior Research Fellow (SRF) in the Department of Physics, University of Burdwan.**

2002-2004: **CSIR funded Junior Research Fellow (JRF) in the Department of Physics, University of Burdwan.**

2001:

- **National Eligibility Test (NET): Council of Scientific and Industrial Research (CSIR)-University Grants Commission (UGC), India (CSIR-JRF)**
- **Graduate Aptitude Test in Engineering (GATE) (Physics)**
- **WB-SLET (State Level Eligibility Test)**

1998-2000: **M.Sc in Physics from University of Burdwan.**
Specialization: Radiophysics and Electronics.
Rank: First and recipient of the University Gold Medal.

1995-1998: B.Sc with Physics (Honours) from University of Burdwan.

1995: Higher Secondary (in Science stream) from A-Zone M.P. Boys High School, Durgapur.

1993: Secondary from A-Zone M.P. Boys High School, Durgapur.

Teaching Experience

2021 – Present : Professor of Physics, Department of Physics,
The University of Burdwan, Burdwan.
2018 – 2021 : Associate Professor of Physics, Department of Physics,
The University of Burdwan, Burdwan.
2006 – 2018 : Assistant Professor of Physics, Department of Physics,
The University of Burdwan, Burdwan.

2020-Present: Teacher-in-Charge, Department of Electronics and Communication, The University of Burdwan.

Teaching Assignments:

M.Sc Physics:
Statistical Mechanics (2 Semester course)
Nonlinear Dynamics (1 semester course)
Electronics (3 semester course)

M.Sc in Electronics and Communication:
Physics of Semiconductor Devices (1 Sem)
Numerical techniques (1 sem)

M.Tech in Electronics and Communications (Microwave):
Solidstate Microwave Devices (1 Sem)
Microwave Communication systems (1 sem)

M.Phill in Physics: Statistical Mechanics

Ph.D Course Work: Statistical Mechanics
Computer Language and plotting software, Latex, etc.

Areas of Research

Areas of research:

- **Nonlinear Science**
- **Symmetry-breaking in coupled oscillators**
- **Oscillation suppression: Amplitude Death and Oscillation Death**
- **Nonlinear Dynamics in the Quantum Regime**
- **Chaotic Dynamical Systems**
- **Nonlinear Electronic Circuits and Systems**
- **Coupled Map Lattice**
- **Mathematical Biology**

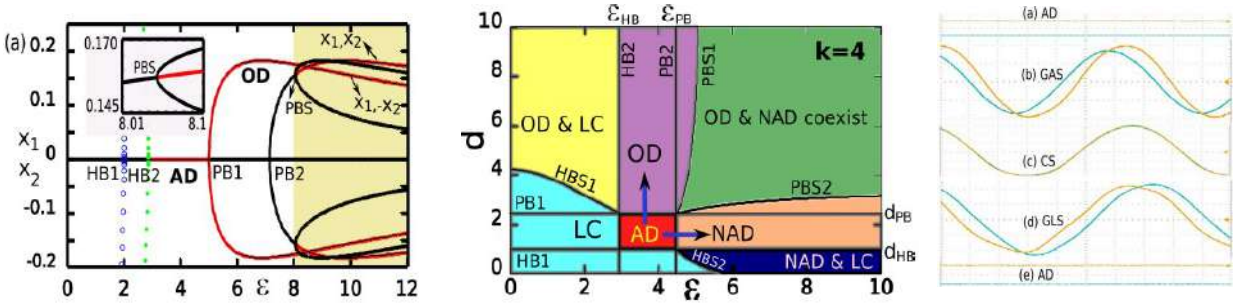
“WE BELIEVE IN CHAOS”

Brief research statement and achievements:

- **Amplitude death and Oscillation death:**

Oscillation quenching is an emergent and intriguing phenomenon that has been the topic of extensive research in diverse fields such as physics, biology, and engineering. There are two distinct types of oscillation quenching processes: amplitude death (AD) and oscillation death (OD). Although, AD and OD are two structurally different phenomena (their genesis and manifestations are different) but for many years they are (erroneously) treated in the same footing. Only recently the much needed distinctions between AD and OD has been established. In this field we have contributed some pioneering researches: examples include

- **First experimental evidence** of AD to OD transition. [**Physical Review E** 89(6), 062902, 2014]
- **Discovered a new transition scenario,** namely the one from homogeneous to inhomogeneous limit cycle. [**Phys. Rev. E**, 97, 042218, 2018]
- **Discover mixed mode oscillation suppression states.** [**Physical Review E** 92(5), 052913, 2015]
- **Discover a NEW oscillation suppression state**, namely nontrivial AD state and identify diverse routes to this type of AD. [**Physical Review E**, 89(5), 052912, 2014]
- **Discover a new transition scenario**, namely the transition from amplitude death to nontrivial *bistable* AD. [**Physical Review E**, 90(6), 062908, 2014]

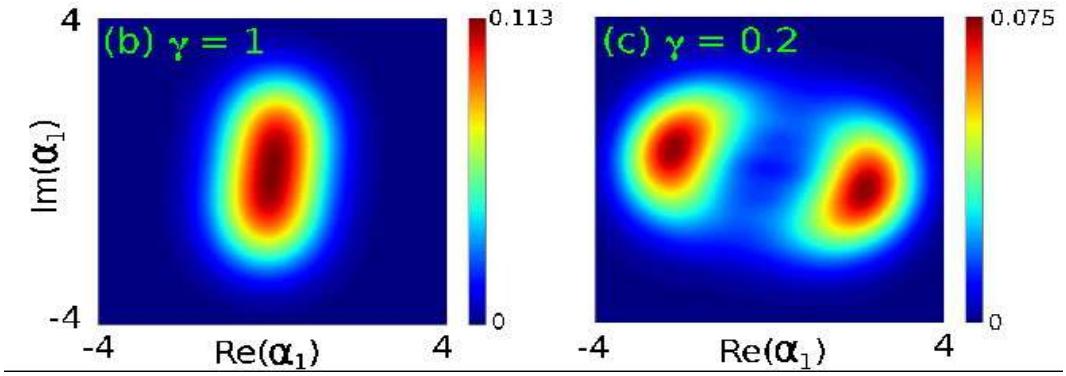


- **Nonlinear Dynamics in the Quantum Regime:**

Exploring nonlinear dynamics in the open quantum systems has gained much attention in the recent years. The well known concepts of nonlinear dynamics such as oscillation of a single unit, and emergent behaviors of coupled oscillatory units, such as synchronization have recently been explored in the quantum regime. The extension of the techniques used in the so called classical nonlinear dynamics to the quantum regime is not always straightforward. Understanding of nonlinear behavior in the quantum domain is based on the formalism of open quantum system that requires the solution of quantum master equations. Also, phase space representation of quantum system which involves quasi probability function (e.g. Wigner function) plays a crucial role in this endeavor.

We are at present exploring symmetry-breaking phenomena in quantum oscillators.

Recently we have discovered a new symmetry-breaking state in coupled quantum oscillator. [Phys. Rev. E 102, 062205, 2020 (arXiv:2009.10039).]



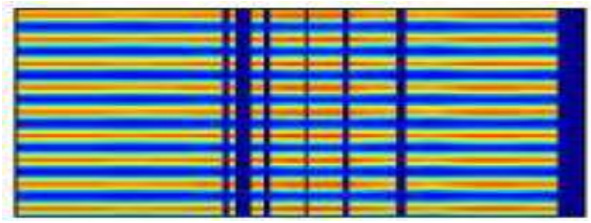
➢ **CHIMERA STATE:** The chimera state is an intriguing and counterintuitive spatiotemporal state that has been in the center of active research over the past decade. In this state the population of coupled identical oscillators spontaneously splits into two incongruous domains: In one domain the neighboring oscillators are synchronized, whereas in another domain the oscillators are desynchronized. The strong current interest in chimeras may be attributed to their possible connection with several phenomena in nature, like unihemispheric sleep of dolphins and certain migratory birds, ventricular fibrillation, and power grid networks.

My group has made some pioneering contributions towards the understanding of this state:

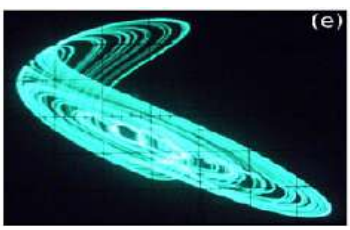
- **Discovered a new chimera state, namely** coexistence of synchronized *oscillation* and *stable steady state* (CSOD) in a network of nonlocally coupled oscillators. Unlike the chimera and chimera death state, in the CSOD state, identical oscillators are self-organized into two coexisting spatially separated domains: In one domain the neighboring oscillators show (synchronized) oscillation and in another domain the neighboring oscillators randomly populate either a (synchronized) oscillating state or a stable steady state (we refer to it as a death state). **[Phys. Rev. E, 92(4), 042919, 2015]**

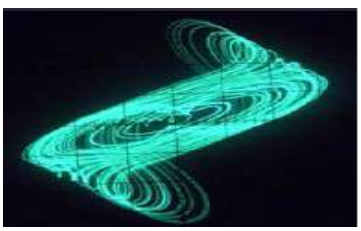
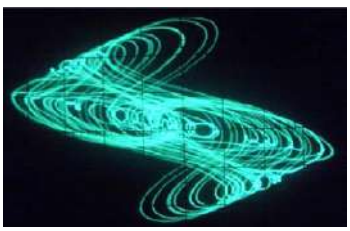
- **Discovered imperfect travelling chimera:** We discovered a new chimera pattern, namely the imperfect travelling chimera in a network of Hindmarsh-Rose neronal oscillators. **[Physical Rev. E, 94, 012215, 2016]**

- **Chimera death in mean-field coupling:** chimera death (CD) is the steady state version of amplitude chimera. I report that the CD state can be observed in mean-field coupled generic oscillators; Thus we established that the chimera death state can be induced in a system of coupled oscillators, which are not connected by a non-local coupling.**[EPL, 110, 60003, 2015]**
- **Chimera patterns under power-law coupling:** We observed several chimera patterns under distance dependent power-law type of coupling. **[Physical Rev. E, 2016, 2016, 94, 032206]**

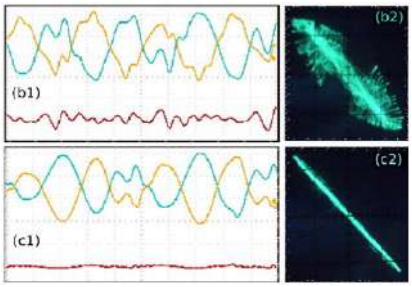


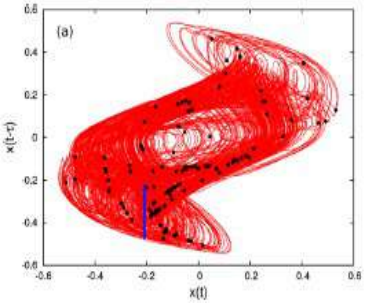

➢ **Design of chaotic & hyperchaotic delayed dynamical systems:** In our laboratory we have **invented** many delayed dynamical systems that show chaotic and hyperchaotic behavior. Those systems are implemented with off-the-shelf electronic circuits that can be controlled and synchronized for the application purposes. [**Nonlinear Dyn. (Springer)**, Vol. 70 (1), pp. 721-734 (2012), **Int. J. Bifurcation and Chaos, (World Scientific)**, 23, 1330020 (2013), **Nonlinear Dyn.** Vol. 83, pp 2331-2347, 2015]

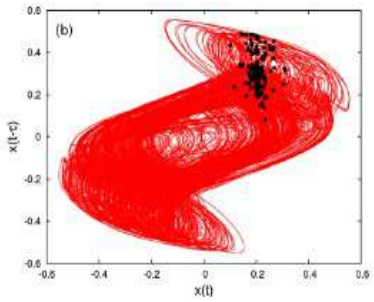


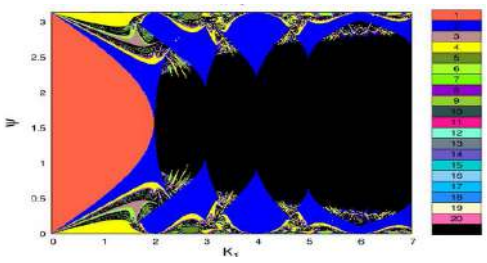
➢ **Synchronization of hyperchaotic delay dynamical systems:** Studies on different synchronization phenomena of time-delayed hyperchaotic systems. Our group reported the **FIRST** EXPERIMENTAL AND THEORETICAL observation of synchronization in chaotic and hyperchaotic time-delay systems coupled by environmental coupling. [**Nonlinear Dynamics (Springer)**, Vol. 73, pp. 2025-2048. 2013]

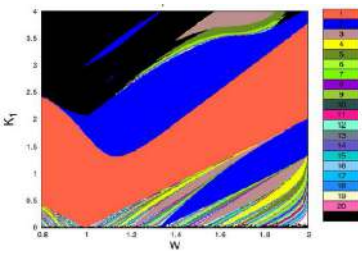


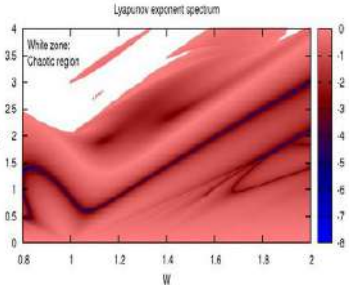




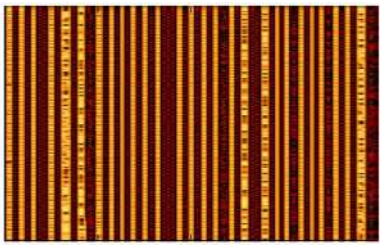
- **Design of chaotic electronic circuits:** We have **invented** some new chaotic electronic circuits, study their synchronization behavior and explore their potential for application in chaos based electronic communications. [**Nonlinear Dynamics (Springer)**, Vol.68(4), 565-573 (2012); Vol. 62(4), 859–866 (2010); **Int. J. Electron. Commun. (AEU) (Elsevier)** 66 (2012) 593– 597]
- **Nonlinear dynamics of Digital phase locked loop:** Digital phase locked loop (DPLL) is one of the basic building blocks of modern communication systems. We explore the nonlinear dynamics of DPLL in the whole parameter space and quantify its chaotic dynamics. Also, based upon the insight of the nonlinear behaviour, **we propose many modifications to the structure of DPLL** for obtaining better system response in its application potentiality. [**Int. J. Bifurcation and Chaos (World Scientific)**, Vol. 22 (12), 1230044; Vol. 23, No. 8, 2013, 1330029]

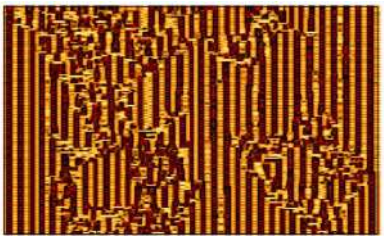


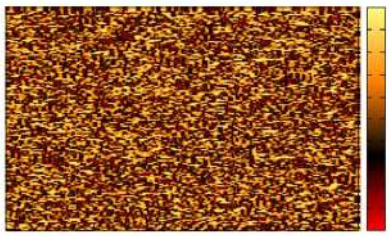




- **Spatially extended systems:** We explore the dynamics of spatially extended systems, which have practical importance from the **engineering and biological** point of view. [**CHAOS (AIP)**, Vol. 24, No.1, 013116, 2013, IJBC, 26 (5), 1650076, 2016]







- **Mathematical Biology:**
- ***Theoretical Ecology:*** ***In contrast to the general believe we show that*** the mean-field dispersion is conducive to both the spatial synchrony and dispersal induced stability even in identical patches. This simultaneous occurrence of rather conflicting phenomena is governed by the suppression of oscillation states, namely amplitude death (AD) and oscillation death (OD). For the first time we report the occurrence of OD in theoretical ecology and interpret the significance of the result. **[Physical Rev. E, 91 (5), 052919, 2015; Chaos, 25, 103121, 2015, Chaos 26, 123122, 2016]**
- ***Chimera in ecology*:** We first show that chimera state occurs in ecological network. This observation has a broad significance in the study of theoretical ecology. **[Physical Rev. E, 94, 042919, 2016]**
- ***Chimera in neuronal system*:** We observed chimera patterns in neuronal system consisting of Hindmarsh-Rose type neurons. **[Physical Rev. E, 94, 012215, 2016]**

Research Collaboration

International:

1. **Prof. Eckehard Schöll**, Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany.
2. **Prof. Juergen Kurths**, Potsdam Institute for Climate Impact Research, Germany (and Professor of Nonlinear Dynamics at the Institute of Physics at the Humboldt University, Berlin).
3. **Dr. Anna Zakharova**, Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany.

National:

1. **Dr. Partha Sarathi Dutta**, Dept. of Mathematics, IIT Ropar, Punjab.
2. **Prof. K. Thamilmaran**, Centre for Nonlinear Dynamics, School of Physics, Bharathidasan University, Tamilnadu.

Supervision of Research Scholars

Name of the research scholar	Area of research	Fellowship/ Status	Progress
Mr. Biswabibek Bandyopaghyay	***Symmetry-breaking states in coupled quantum oscillators***	**Full-time (UGC-JRF)**	**Ongoing**
Ms. Taniya Khatun	***Partial synchronization patterns: effect of noise***	**Full-time (UGC-JRF)**	**Ongoing**
Ms. Bulti Paul	***Nonlinear dynamics in the quantum regime***	**Full-time (DST-Inspire-JRF)**	**Ongoing**
Mr. Anjan Ballav	***Collective dynamics of coupled oscillators***	**Full-time (DST-Inspire-JRF)**	**Ongoing**
Mr. Nirmalendu Hui	***Oscillation quenching in nonlinear time-delayed System***	**Part time**	**Ongoing**
Dr. Meenakshi Chakraborty	**DS Kothari Post Doctoral Fellowship**		**Ongoing**
Allumni			
Dr. Debabrata Biswas	***Design of hyperchaotic time-delayed systems and studies on their synchronization problems.***	**Ph.D. Awarded (2017)**	
Dr. Debarati Ghosh	***Studies on the oscillation quenching states and their transitions in coupled oscillators.***	**Ph.D. Awarded (2018)**	
Dr. Bishwajit Paul	***Studies on controlled and spatially extended coupled digital phase-locked loops.***	**Ph.D. Awarded (2019)**	
Dr. Biswajit Karmakar	***Design and synchronization of chaotic electronic oscillators.***	**Ph.D. Awarded (2021)**	

Research Projects

1. Principal Investigator of SERB (Department of Science and Technology, India) Sponsored Core Research Grant. (2020-2022, Ongoing):
Title "Symmetry-breaking in coupled oscillators: Effects of dispersion, dissipation and noise "

2. Principal Investigator of SERB (DST) Sponsored FAST TRACK research project for the young scientists. (2014-20017, Completed) (Value: 17.28 lacs) [D.O. No. SB/FTP/PS-005/2013]:
Title "Design of autonomous time-delayed chaotic and hyperchaotic systems and studies on their synchronization problems"
Brief achievements: In this project we study the design of hyperchaotic time-delay systems and their synchronization phenomena. We will study the synchronization scenario of the proposed hyperchaotic time-delayed systems and circuits under different coupling schemes. We will explore the collective behaviour shown by the network of time-delayed oscillators. We will verify all the analytical and numerical findings through electronic circuit level experiments.

3. Principal Investigator of UGC Sponsored Minor Project. (2009-20011, completed) (Value: 0.97 lacs): Title "Studies on synchronization of chaos in electronic circuits and its applications"
Brief achievements: In this project we have designed some new chaotic electronic circuits and studied synchronization phenomena shown by these chaotic systems.

Reviewers of Journals

Total 173 reviewes (as of 20.10.2022) as per Web of Science

- **PNAS (USA)**
- **CHAOS (AIP)**
- **Europhysics Letters (EPL) (IOP)**
- **Physics Letters A**
- **Physica D**
- **Nonlinearity (IOP)**
- **Journal of the Royal Society Interface**
- **Proc. of the Royal Soc. B: Bio. Sci.**
- **Nonlinear Dynamics (Springer)**
- **Chaos, Solitons & Fractals**
- **Biosphere**
- **IEEE Trans. Circuits and Systems-I**
- **Electronics Letters (IET)**
- **Others**

Awards/Recognition/Membership in Professional bodies

- **Visiting scientist, Institute for Theoretical Physics, TECHNICAL UNIVERSITY (TU)-Berlin, Germany (14-21 Nov, 2015).**
- **Fellow of Institute for Electronics and Telecommunication Engineers (IETE), India.**
- **Trusted Reviewer award by Institute of Physics (IOP)**
- **Most Cited Author Award (India) by IOP (2018)**
- **Editorial Board Member: (i) Pramana: Journal of Physics**
  (ii) Frontiers in Network Physiology
  (iii) Frontiers in Computational Neuroscience
- **University Gold Medal (2000) for ranking first in M.Sc.**
- **National Scholarship (1998) for B.Sc result.**
- **Life member of Indian Association for Physics Teachers.**

Resource Person/Invited Talks/Delivering Lectures, etc.

(Talks in the outreach program and refreshers course of several universities are not included)

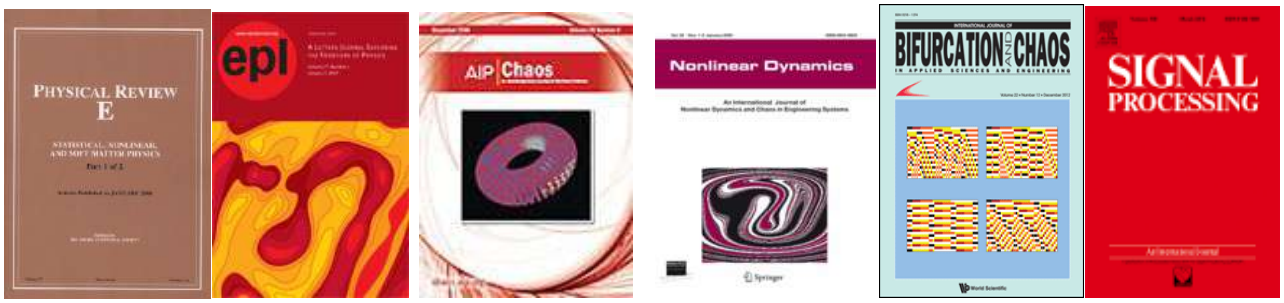
- **Invited talk on** "Nonlinear dynamics of dissipative quantum systems"**.** Sept. 28, 2022. **2022 Conference in Nonlinear Science and Complexity,** Physics Department of the Aristotle University of Thessaloniki, **Greece** (September 26-29, 2022).
- **Conference on Nonlinear Systems and Dynamics (CNSD 2021) 17-21 Dec, 2021 at Sastra University; Delivered an invited lecture (online) on "Nonlinear Dynamics In Dissipative Quantum Systems: Symmetry Breaking And More" on 18.12.2021.**
- **Chaired a session in "School and Workshop on Patterns of Synchrony: Chimera States and Beyond (smr 3286)" 6-17 May, 2019, at International Centre for Theoretical Physics (ICTP), Trieste, Italy.**
- **Invited talk** in "School and Workshop on Patterns of Synchrony: Chimera States and Beyond (smr 3286)" 6-17 May, 2019, at **International Centre for Theoretical Physics (ICTP), Trieste, Italy** (talk on 16 May).
- **Invited talk** in the **"Nonlinear Dynamics in Chemistry and Biology (NLDBC 2019)"** 8-9 April, 2019, S. N. Bose National Centre for Basic Sciences (talk on 9 April).
- **Invited talk** in the **"International Conference on Recent Development on Nonlinear Dynamics and its Applications (CRDNDA)",** March 12-13, 2019 (Organized by Durgapur Government College, West Bengal).
- **Invited talk** in the Workshop "Planning and Development of online courses with references to MOOCs" Organized by A. K. Dasgupta Centre for Planning and Development, Visva-Bharati, on 7 Feb, 2019 (5-11, Feb, 2019).
- **Invited talk** in the Workshop **"Emerging Devices Circuit and Systems (EDCS-2019)",** 21 Jan, 2019, NIT Silchar, Asaam.
- **Invited talk** in the International conference on **"Complex Dynamical Network"** held at **ISI, Kolkata** (4th-5th Oct, 2018).
- **Invited talk** in the International conference **"Dynamics Days Europe-2018"** held at **Loughborough University, UK** (2-7 Sept, 2018).
- **Invited talk** in the National conference on **"Mathematical Biology"** held at **National Institute of Technology, Patna** (7th-8th July, 2018).
- Invited lecture at the Department of Physics, **Presidency University**, Kolkata in the Wednesday Colloquium Series (24 January, 2018).
- A special invited lecture at the **Center for Nonlinear Dynamics**, School of Physics, Bharathidasan University, Tamilnadu (14 March, 2017).
- Invited talk in the National Conference On **"Nonlinear Dynamics and its Applications"** (CNDA-16) February 07-09, 2017 (Organized by Durgapur Government College, West Bengal).
- Delivered **invited talk** in the Three days seminar **"Conference on Nonlinear Systems and Dynamics (CNSD-16)" at IISER, Kolkata (16-18 December, 2016)**
- Delivered **invited talk** in TEQIP-II Sponsored SHORT TERM COURSE on Nonlinear Dynamics, Chaos and Applications (NDCA-2016) July 11-15, 2016, NIT, Durgapur.
- Delivered **invited talk** in the **Indo-UK workshop** on "Mathematics and Statistics of Biological Populations" held at Chail, Himachal Pradesh, 23-28 May, 2016. The meeting was supported by the **Department of Science and Technology (DST, India) and the International Centre for Mathematical Sciences (ICMS, UK)**, and organised by the Indian Institute of Science Education and Research (IISER) Mohali.
- Delivered **invited talk** in the **Institute for Theoretical Physics, TU-Berlin** on Chimera (17.11.2015).
- Delivered **Invited** talk and acted as a **resource person** in **"Winter School on Nonlinear Dynamics"** at **Indian Statistical Institute, Kolkata (9-18 Dec, 2015).**
- Delivered **Invited talk** and acted as **resource person in "4th SERC School on Nonlinear Dynamics"** (SERB, Department of Science and Technology, India), Physics Department,

Manipur University (18 Nov-8Dec, 2015).

- Delivered **invited talk** in the Three days seminar **"Conference on Nonlinear Systems and Dynamics (CNSD-15)" at IISER, Mohali (13-15 March, 2015)**
- **Chaired a session** in the Three days seminar **"Conference on Nonlinear Systems and Dynamics (CNSD-15)" at IISER, Mohali (13-15 March, 2015)**
- Delivered **invited talks (three)** in the Seven days School **"Hands on School on Nonlinear Dynamics"** held at **Institute of Plasma Research (IPR)**, Bhat, Gujrat (15-22 Feb., 2015)
- Delivered **invited talk** in the five days National level Workshop **"Applied Nonlinear dynamics and Chaos"** at Govt. College of Engineering and Textile Technology, Berhampore (26-31 May, 2014)
- Delivered **invited talk** in the one-day National level seminar **"Applied Nonlinear dynamics and Chaos"** at Dumkol Engineering College, Basantapur, Murshidabad (31 May, 2014)
- Delivered **invited talk** in the Two days National level seminar **"Advanced Instruments used in Current Research"** at Sri Ramakrishna Sarada Vidyamandir, Kamarpukur, Hoogly (20-21 Sept, 2013)

LIST OF PUBLICATIONS

h-index (Google Scholar): 25
i-10 index: 43
ORCID id: http://orcid.org/0000-0002-6633-3233
Author ID: 56240614500
Vidwan Expert ID : 194343 (https://vidwan.inflibnet.ac.in/profile/194343)
GoogleScholar:ZYXV8E0AAAAJ
(https://scholar.google.co.in/citations?user=ZYXV8E0AAAAJ&hl=en)
Researchgate: http://www.researchgate.net/profile/Tanmoy_Banerjee



[Impact factors 2021: Physical Review E: 2.73, CHAOS: 3.642, EPL: 2.10, Nonlinear Dynamics: 5.01, Signal Processing: 4.662, IJBC: 2.86, Chaos, Solitons& Fractals: 9.94]

Article published in Peer-reviewed

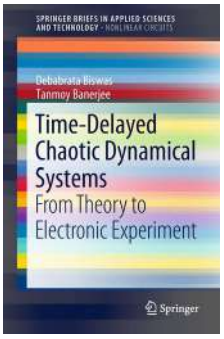
- **International Journals: 85 (Phys. Rev. E: 23, AIP Chaos: 12, NODY:10 , IJBC:6)**
- **Book: 2**
- **Book chapters: 5**

Book:

Time-Delayed Chaotic Dynamical Systems:

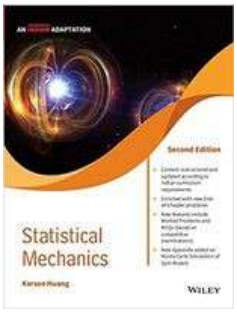
From Theory to Electronic Experiment

By Debabrata Biswas . Tanmoy Banerjee
Springer International Publishing (Springer-Nature)
ISBN: 978-3-319-70992-5.



Book Adaptation:

Statistical Mechanics, 2ed, (An Indian Adaptation), 2021



by Kerson Huang
Indian Adaptation by Analava Roy and Tanmoy Banerjee
Publisher: Wiley, ISBN-10: 9354247733, ISBN-13: 978-9354247736

Book Chapters:

1. Tanmoy Banerjee, **D. Biswas, B. C. Sarkar** (2014) "Design of *Autonomous Time-Delayed Hyperchaotic System*", **Chapter 4,** pp. 73-95, in book **"New Research Trends in Nonlinear Circuits: Design, Chaotic Phenomena and Applications"**, **Nova Science Publishers,** NY 11788-3619 (USA) [ISBN: 978-1-63321-406-4].
The picture shown in the Book Cover is from one of the figures of our book chapter.

2. Tanmoy Banerjee and B. C. Sarkar **(2016)** "*Application of Time-Delayed Feedback Control Techniques in Digital Phase-Locked Loop*"**,** "**Advances and Applications in Nonlinear Control Systems"** edited by Sundarapandian Vaidyanathan and Christos Volos, Series: Studies in Computational Intelligence (SCI). **Publisher: Springer International. [ISBN 978-3-319-30169-3]**

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