EVOLUTION OF COMPLEX SYSTEMS

***Venue*: Faculty Hall, Indian Institute of Science, Bangalore**

***Date*: January 13 – 15, 2010**

PROGRAMME REPORT

TITLE **"EVOLUTION OF COMPLEX SYSTEMS"**

DATES **JANUARY 13-15, 2010**

VENUE **Faculty Hall, Indian Institute of Science, Bangalore, Karnataka**

Organizers

Chandan Dasgupta, Professor, Physics Department, Indian Institute of Science, Bangalore
cdgupta@physics.iisc.ernet.in

Raghavendra Gadagkar, Professor, Centre for Ecological Sciences, and Chairman, Centre for Contemporary Studies, Indian Institute of Science, Bangalore
ragh@ces.iisc.ernet.in

Somdatta Sinha, Scientist 'G', Centre for Cellular & Molecular Biology, Uppal Road, Hyderabad
sinha@ccmb.res.in

Organizing Committee:

Amitabh Joshi, JNCASR, Bangalore
Anurag Kumar, ECE, IISc, Bangalore
Sanjay Jain, Physics Dept, Delhi University, Delhi
Sriram Ramaswamy, Physics Dept, IISc, Bangalore

PROGRAMME

January 13, 2010

Chair: Rahul Pandit

9:15-9:30	Spenta Wadia	Opening Remarks
9:30-10:15	Sriram Ramaswamy	The complex collective dynamics of self-driven particles
10:15-11:00	Upinder Bhalla	Multiple cellular states emerge from simple chemistry and cellular traffic
	11:00-11:30 TEA	
11:30-12:15	Stefan Thurner	Darwin's daemon and a mechanistic approach to evolution dynamics
12:15-1:00	B K Chakrabarti	Statistics of the Kolkata Paise Restaurant problem
	1:00-2:30 LUNCH	

Chair: Sanjay Jain

2:45-3:30	V. Nanjundiah	The evolution of cooperation in social amoebae
	3:30-4:00 TEA	
4:00-4:45	Anindita Bhadra	The links and hubs of power in a wasp society

4:45-5:30	R E Amritkar	Synchronization of networks
5:30-6:15	Sunil Kothari	New directions in Indian dance

January 14, 2010

Chair: Ravi Mehrotra

9:30-10:15	Didier Sornette	Black swans, Dragon-kings and predictions of crises in complex systems
10:15-11:00	Vikram Soni	Consequences of sudden species loss in an evolutionary model
	11:00-11:30 TEA	
11:30-12:15	Neo Martinez	Structure, stability and robustness of complex ecological networks
12:15-1:00	Harini Nagendra	Charting the complexity of forest change in human impacted forests
	1:00-2:00 LUNCH	

Chair: Chandan Dasgupta

2:00-2:45	Priya Iyer	Theories for the evolution of the sexes
2:45-3:30	Amaresh Chakrabarti	Understanding and supporting evolution of engineering designs
	3:30- 4:00 TEA	
4:00-4:45	K Ghosh Dastidar	On some aspects of price competition in a homogeneous product market: Evolution of cooperation, existence of equilibrium and other issues
4:45-5:30	Sanjay Jain	Formalizing the notion of 'innovation' in an evolutionary model

---

January 15, 2010

Chair: Somdatta Sinha

9:30-10:15	M. Madan Babu	Structure, evolution and dynamics of transcriptional regulatory networks and its influence on genome organization
10:15-11:00	Vijay Srinivasan	Minimal metabolome: The canonical network of autotrophic metabolism and its analysis
	11:00-11:30 TEA	
11:30-12:15	Neelima Gupte	Statistical characterisers of transport in communication networks.
12:15-1:00	Alain Pumir	Quantifying complexity of genetic interactions: Theoretical analysis of invertebrate phototransduction
	1:00-2:00 LUNCH	

Chair: Karmeshu

2:00-2:45	Sumantra Chattarji	Differentiating safe from dangerous: From behavior to single neurons
2:45-3:30	G Rangarajan	Detecting functional connectivity in neuronal networks
	3:30-4:00 TEA	
4:00-4:45	Manindra Agrawal	Classifying complexity of problems algorithmically

---

SHORT REPORT

The conference on "EVOLUTION OF COMPLEX SYSTEMS" was a Satellite Meeting of the ICTS Inaugural Event held two weeks earlier in Bangalore. An ICTS programme, it was jointly organized by the Centre for Cellular & Molecular Biology (CSIR), Hyderabad, Indian Institute of Science, Bangalore, and the Santa Fe Institute (SFI), Santa Fe, USA. Being the first of its kind in India, a lot of thought was put behind planning this unique interdisciplinary meeting by the organizers and the organizing committee members. India possesses a highly developed academic community in all disciplines of science, humanities, and arts. It also is endowed with a cultural milieu encompassing classical knowledge derived over thousands of years of scientific, philosophical and artistic enquiries in one hand, and a vast array of traditional artistic and scientific knowledge developed by the magical potpourri of tribes of the Indian subcontinent. Specialized meetings are regularly held in these different areas of inquiry where experts delve into the deep details of their subject. So compartmentation of knowledge within specialized groups is a common feature. Holding a conference in an area like Complex Systems, which transcend disciplinary boundaries, was no mean task.

There has been a growing feeling that to reconstruct a system ("whole"), the parts need to interact, and cross-talk is necessary for a cohesive understanding of the evolution and maintenance of nature and life around us. It is felt that cutting across scientific disciplines, evolution of an organised structure – biological, social, economic or cultural – all require linking multiple structural and functional entities in a non-random fashion that follow certain rules and have convergent features.

Several individuals and small groups around the world have been thinking in a new way where processes and systems are studied, not in the confine of a specific disciplinary boundary, but by bringing in methods and knowledge from other disciplines to enhance the understanding in a new and holistic manner. This conference was intended to bring multi-disciplinary perspective into diverse set of processes spanning different fields of inquiry in natural and social sciences, and to amplify the synergy and convergence of the underlying processes and ideas. The ICTS had readily accepted the proposal with much enthusiasm as it falls well within their interests and activities. The speakers were chosen after much thought and all agreed to participate enthusiastically. Aptly inaugurated by Prof. Spenta Wadia, Director ICTS, the meeting had 23 talks by researchers from physics, mathematics, biological sciences, economics, computer sciences, engineering, and fine arts. The participants came from different disciplines and were composed of primarily M.Sc. and Ph.D. students, and young faculty. Many students and faculty members from the IISc also attended the talks. Few talks were also attended by school students and college teachers.

Biological systems are interesting examples of complex systems as they have highly modular organisation with a large number of interacting components. They also are products of evolution through genetic and epigenetic processes – a feature of recurrent discussion among biologists and physicists. As expected, several talks were by experimental and computational biologists, who discussed their work on systems spanning - gene networks to genome function, evolution of the minimal metabolome, integrative analysis of pathways underlying cellular trafficking, the neural basis of learning during auditory fear conditioning, social network analysis in a wasp society, evolution of cooperation in social amoebae through non-genetic interactions, ecological networks, and the complexity of forest change in human impacted forests.

A set of talks discussing theoretical analysis of models developed to understand biological systems/processes involved - study of evolution of the sexes in animals, quantifying complexity of genetic interactions in invertebrate phototransduction, detecting functional connectivity in neuronal networks, collective dynamics of self-driven particles in agent-based flocking models, mathematical characterisation of the synchronised behavior of networks of interacting dynamical systems, studying sudden species loss in a simple evolutionary model, and assessing transport in communication networks of different topologies.

Few talks dealt with general models of complex systems that discussed evolutionary dynamics in systems from biology to economics to interpret and predict extreme events, power laws, crises and systemic risk in such evolutionary systems and formalizing mathematically in structural terns the notion of 'innovation' in an evolutionary model. Classification of complexity of problems algorithmically was also discussed. Presentations were also made on the use of Game Theory and agent-based modelling in evolution of cooperation, existence of equilibrium in simultaneous move price choice games and dynamics of stochastic learning strategies to arrive at an ideal social norm. A few talks were from unusual areas. One discussed the evolution of design in engineering by describing how design-ideas evolve from the imprecise and incomplete perceived descriptions of intent to become concrete and detailed physical structures that can be implemented and utilized as intended. A multi-media talk on the evolution of Indian classical dance forms was presented with a live performer explaining the details of the specific forms and features of each type of dance, and the mixing and evolution of these forms that led to the trends in the modern dance forms (both in stage and cinema productions) were explained with video clips and analysis. This was a highly experimental talk and the speaker tried to lay down the basic robust features of the traditional form by

indicating how innovators with heterogeneous knowledge/experience have introduced variability to evolve the new forms suitable to the modern taste and socio-economic environment.

The general impression of all participants were very positive and they felt that this kind of interdisciplinary discussions can not only help one to identify one's work in a larger perspective, it also allows expanding the base of understanding specific system behaviour through learning methods and strategies from other areas. One can "see" the commonalities across diverse systems and thereby evolve a much broader appreciation to ask deeper integrative questions on the evolution and functioning of complex systems. Such an approach, by its very nature, transcend any particular field. It was felt that such meetings should be organised regularly to bring workers from different disciplines in a common ground to be able to comprehend the commonalities that link artificial, human, and natural systems. In a first meeting of this kind, the idea of convergence in thinking among multiple disciplines was appreciated. It is hoped that this would pave the way to develop similar interactions among different disciplines in India and encourage persons from all disciplines to establish vibrant groups in the area of complex systems research.

Generous funding from the ICTS enabled holding this programme. The Santa Fe Institute at Santa Fe, New Mexico, USA (www.santafe.edu), which has been a nucleus of complex systems research in the world, supported by funding the participation of three speakers from USA and Europe. The Indian Academy of Sciences and the Indian Institute of Science, Bangalore helped with much logistic support. Students and other colleagues worked tirelessly to make the conference proceed as smoothly as possible. The organizers are indebted to all for their support and interest.

List of Speakers

Manindra Agrawal
Dept. of Computer Science and Engineering, Indian Institute of Technology Kanpur, India

R E Amritkar
Physical Research Laboratory, Ahmedabad 380009, India

Anindita Bhadra
Behaviour and Ecology Lab, Dept. of Biology, Indian Institute of Science Education & Research, Mohanpur, WB, India

Upinder Bhalla
National Centre for Biological Sciences,
TIFR, Bangalore, India

Amaresh Chakrabarti
Centre for Product Design and Manufacturing, Indian Institute of Science, Bangalore, India

Bikas K Chakrabarti
Centre for Appl. Maths. & Computational Science, Saha Institute of Nuclear Physics, Kolkata, India

Sumantra Chattarji
National Centre for Biological Sciences, Bangalore, India

K. Ghosh Dastidar
Centre for Economic Studies and Planning,
School of Social Sciences,
Jawaharlal Nehru University,
New Delhi, India

Neelima M. Gupte
Department of Physics
Indian Institute of Technology,
Madras, Chennai 600 036

Priya Iyer
Indian Institute of Science Education & Research, Pune

Sanjay Jain
Physics Department, University of Delhi, Delhi, India

Sunil Kothari
School of Arts and Aesthetics, Jawaharlal Nehru University, New Delhi; Visiting Professor, Tisch School of Arts, New York University, NY, USA

M. Madan Babu,
MRC Laboratory of Molecular Biology,
University of Cambridge,
Cambridge CB2 0QH, UK

Neo Martinez
Pacific Ecoinformatics and Computational Ecology Lab, Berkeley, California, USA

Harini Nagendra,
Ashoka Trust for Research in Ecology and the Environment, Bangalore, India; Center for the Study of Institutions, Population, and Environmental Change, Indiana University, USA

V Nanjundiah,
Centre for Ecological Sciences, Indian Institute of Science, and Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore, India

Sriram Ramaswamy
Centre for Condensed Matter Theory, Department of Physics,
Indian Institute of Science, Bangalore, India

Alain Pumir
Laboratoire de Physique, Ecole Normale Supérieure de Lyon, F - 69007, Lyon, France

G Rangarajan,
Department of Mathematics, Indian Institute of Science, Bangalore, India

Vikram Soni
Centre for Theoretical Physics, Jamia Millia Islamia, New Delhi, India

Didier Sornette
Department of Management, Technology and Economics, ETH Zurich, Zurich, Switzerland

Vijay Srinivasan
Krasnow Institute for Advanced Study,
George Mason University, VA 22030, USA

Stefan Thurner
Complex Systems Research Group, Medical University of Vienna, Austria