PONDICHERRY UNIVERSITY

School of Physical, Chemical & Applied Sciences

Deparment of Physics

Invited Lecture

On

Symbolic patterns, clusters and hierarchies in spiking systems

By

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Time : 3.00 p.m
Venue : Raman Seminar Hall, Department of Physics
Pondicherry University
Puducherry – 605014

ALL ARE WELCOME

Dr. K.V.P. Lata
(Guest lecture Co-ordinator)

16.07.2014

Dr. G. Chandrasekaran
(H.O.D Physics)

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Symbolic patterns, clusters and hierarchies in spiking systems

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Understanding the organization of recurrent patterns in sequences of spikes of stochastic excitable systems, such as neurons or cardiac cells, is a challenging task. Symbolic patterns are relevant as they often encode useful information about the system state and phase space. Here I will present experimental observations of the spiking output of a stochastic optical system, consisting of a semiconductor laser with feedback from an external reflector. The laser intensity displays sudden and irregular spikes that resemble neuronal spikes [1-3]. I will show that ordinal time-series analysis [4] allows unveiling a nontrivial organization of spike patterns, in which the pattern probabilities display a well-defined, hierarchical and clustered structure, which can be understood in terms of a simple minimal model [5]. The validity of this model can be further confirmed by analyzing the experimental spike sequence when the laser is under external periodic forcing [6]. Since the minimal model is quite generic and describes many dynamical systems, including sensory neurons, our results suggest that this method of analysis can be a powerful tool for uncovering correlations and hierarchies of patterns in other systems. Also importantly, our findings pave the way for optical neurons that could provide a controllable set up to mimic neuronal activity.

[1] J. Tiana-Alsina et al, "Quantifying the statistical complexity of low-frequency fluctuations in semiconductor lasers with optical feedback", Phys. Rev. A 82, 013819 (2010).
[2] N. Rubido et al, "Language organization and temporal correlations in the spiking activity of an excitable laser: Experiments and model comparison", Phys. Rev. E 84, 026202 (2011).
[3] A. Aragoneses et al, "Distinguishing signatures of determinism and stochasticity in spiking complex systems", Sci. Rep. 3, 1778 (2013).
[4] C. Bandt and B. Pompe, "Permutation entropy: a natural complexity measure for time series", Phys. Rev. Lett. 88, 174102 (2002).
[5] A. Aragoneses et al, "Unveiling the complex organization of recurrent patterns in spiking dynamical systems", Sci. Rep. in press (2014).
[6] A. Aragoneses et al, "Experimental and numerical study of the symbolic dynamics of a modulated external-cavity semiconductor laser", Optics Express 22, 4705 (2014).