Institute for Materials Science

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What is the Smale Paradox, Why is it Important, and How can it be Resolved

Thursday, March 31th 2022

13:00 – 14:00

Normal: Seminar Room 115, Hallwachsstr. 3 (HAL)

Pandemic version: https://tinyurl.com/nanoSeminar-GA

As he was studying an 8th-order array of two identical diffusively-coupled biological reaction cells, Stephen Smale reported an unexpected phenomenon, commonly known as Smale Paradox [1]. While, on its own, each cell was found to converge asymptotically to a silent state, irrespective of the initial conditions, the immersion of two of its copies in a dissipative medium was sufficient to wake them up, inducing the development of sustained oscillations across the resulting two-cell array. This phenomenon mesmerized Smale, since each of the two identical cells was rather expected to approach the same quiet steady state as it displayed on its own. In this presentation Local Activity and Edge of Chaos theory [2] is employed to resolve Smale paradox, using the simplest ever-reported bio-inspired memristive circuit, undergoing a similar silence-to-regular-beating transition, as object of investigation [3]. The significance of this work is two-fold. It first shows a clear example illustrating vividly how the Principle of Local Activity lies behind the emergence of complex phenomena, e.g. the diffusion-driven instabilities reported by Smale, in open physical systems. Secondly, it reveals the central role that locally-active memristors [4], operating according to similar principles as the ion channels in neuronal axon membranes [5], are expected to assume, in the years to come, to design circuits reproducing the dynamics of biological systems or implementing innovative time- and energy-efficient bio-inspired data computing paradigms (see Fig. 1).

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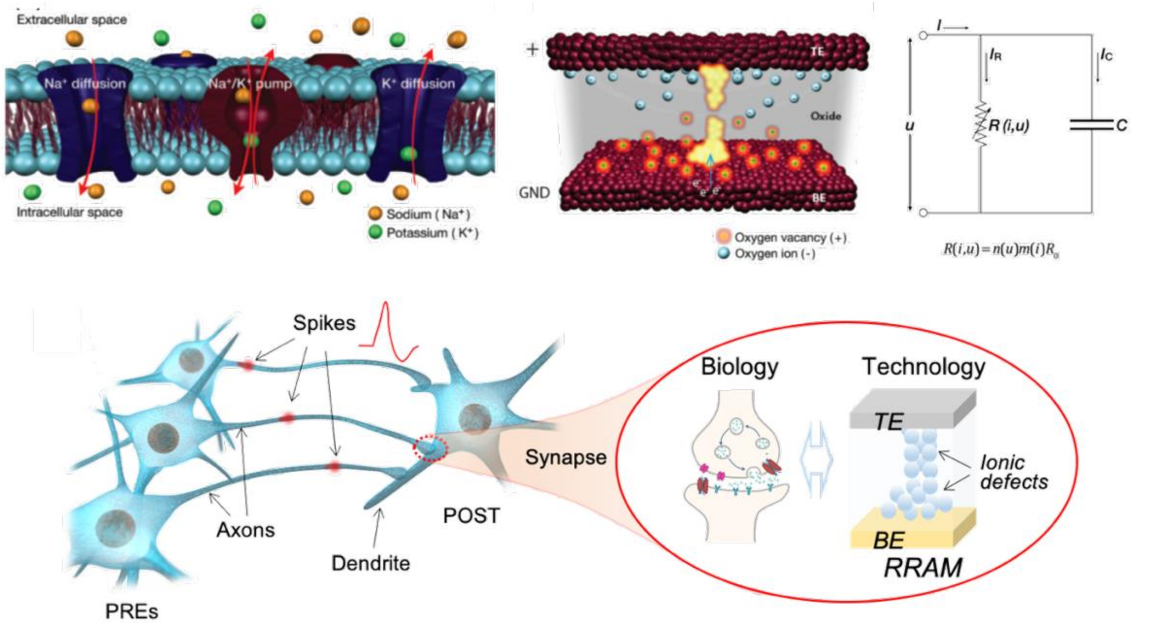

Fig. 1 Locally-Active Memristors Enable to Reproduce Emergent Phenomena in Biological Systems and to Implement Brain-Inspired Computing Paradigms (courtesy of Dr. E. Covi, NaMLab) [6]

References:

[1] S. Smale, American Mathematical Society, Lectures in Applied Mathematics, vol. 6, pp. 15-26, 1974
[2] L.O. Chua, Int. J. on Bifurcation and Chaos, vol. 15, no. 11, pp. 3435–3456, 2005
[3] A. Ascoli, A.S. Demirkol, L. Chua, and R. Tetzlaff, IEEE Trans. on Circuits and Systems-I: Regular Papers, 2022, DOI: 10.1109/TCSI.2021.3133627
[4] A. Ascoli, S. Slesazeck, H. Mähne, R. Tetzlaff, and T. Mikolajick, IEEE Trans. Circuits and Systems-I: Regular Papers, vol. 62, no. 4, pp. 1165-1174, 2015
[5] L.O. Chua, V. Sbitnev, and H. Kim, Int. J. Bifurc. Chaos, vol. 22, no. 4, 1250098 (49pp.), 2012

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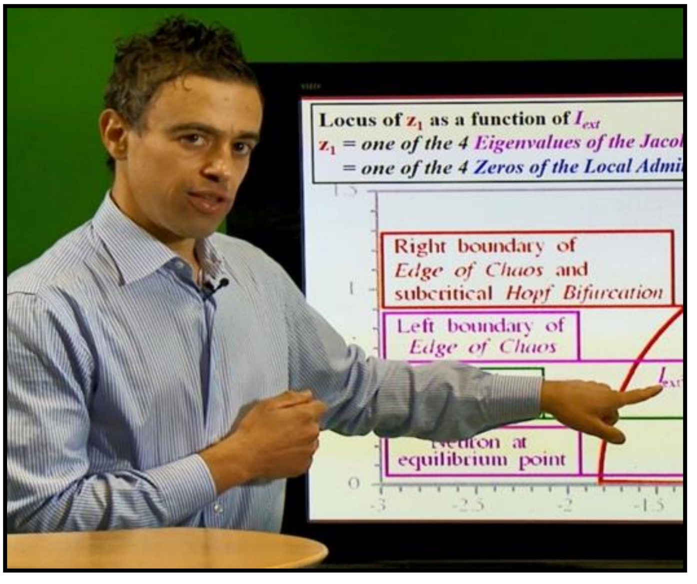

Alon Ascoli (IEEE Senior Member) received a Habilitation as Full Professor in Fundamentals of Electrical Engineering from Technische Universität Dresden (TU Dresden) in 2022, a Ph.D. Degree in Electronic Engineering from University College Dublin in 2006, and a First-Class Honours Master's Degree in Electronic Engineering from Universita' degli Studi Roma Tre in 2001. He currently holds a tenure faculty position at the Institute of Principles of Electrical and Electronic Engineering of TU Dresden. He develops system-theoretic methods for the analysis and design of bio-inspired memristive/memcapacitive circuits bound to enable progress in electronics beyond the Moore era, and to allow the plausible reproduction of complex phenomena emerging in biological systems. He was honoured with Best Paper Awards from IJCTA in 2007 and MOCAST in 2020. In April 2017 he was conferred the habilitation title as Associate Professor in Electrical Circuit Theory from the Italian Ministry of Education. He is a member of the Scientific Advisory Board of the Chua Memristor Center, and of the IEEE Nanoelectronics and Gigascale Systems Technical Committee (Nano-Giga TC). He was the Chair of the IEEE Cellular Nonlinear Networks and Array Computing (CNNAC) TC from 2019 to 2021. Since 2021 he is the Chair of the new-born IEEE Cellular Nonlinear Networks and Memristive Array Computing (CNN-MAC) TC.

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