University of Southern California

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Mork Family Department of Chemical Engineering and Materials Science

USC Viterbi School of Engineering

Distinguished Lecture Series

Dynamical Order and Complexity in Rhythmic Chemical Systems

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Abstract

The interaction and synchronization of populations of rhythmic processes is important in a variety of fields ranging including chemistry (influence on overall rate of reaction), biology (circadian rhythm of suprachiasmatic nuclei, essential tremors), and engineering (lasers and microwave systems). A feature of such systems is that the overall, or collective, behavior can be significantly different from the dynamics of the individual components. We introduce the subject of complexity and order with a brief discussion of two examples: the sudden transition to pitting corrosion through the cooperative behavior of metastable pits and patterns of synchrony associated with epileptic seizures.

The focus of the presentation is then on experiments with arrays of electrochemical oscillators. The experiments serve as a platform with which the effects of coupling, external forcing, and feedback can be studied since rates of reaction on each electrode can be obtained and elements of the array are individually addressable. Even very weak coupling among sites can produce significant changes in the collective behavior of the system including a phase transition at a critical coupling point at which the onset of synchronization occurs. We show that mutual entrainment in interacting oscillators can be characterized using phase models developed from direct experiments with a single oscillator and sets of oscillators. We show how such phase models can be used to describe and tune complex dynamic structures to desired states; weak, non-destructive signals are employed to alter interactions among nonlinear rhythmic elements. Application is made to the generation of sequentially-visited dynamic cluster patterns similar to reproducible sequences seen in biological systems and to the design of a nonlinear anti-pacemaker for the destruction of pathological synchronization of a population of interacting oscillators.

Selected publications: Kiss, Zhai, Hudson, *Science* **296**, 1676 (2002) , Kiss and Hudson, *AIChEJ 49*, 2234 (2003). Mikhailov, Zanette, Zhai, Kiss, Hudson, *PNAS 101 (30)*, 10890 (2004). Punckt, Bolscher, Rotermund, Mikhailov, Organ,Budiansky,Scully, and udson, *Science 305*, 1133 (2004). Kiss, Rusin, Kori, and Hudson, *Science 316*, 1886 (2007).

Thursday, September 27, 2007
Seminar at 12:45 p.m. in OHE 122
Refreshments served after the seminar in HED Lobby

The Scientific Community is Cordially Invited.