Electrochemical Oscillator Networks on Macro- and Microscales: Phase Diffusion, Synchronization, and Pacemaker Design

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Abstract: Complex chemical and biological systems exhibit dynamic self-organization with emergent properties depending on the behavior of the constituent parts and the types and extent of their interactions. The subject of chemical complexity is introduced through the use of macroscale and microscale electrochemical oscillations that occur on small networks of multi-particle electrodes.

In the presentation, electrochemical oscillations are described by using the concept of cycle phase. In small networks of three and four oscillator setups it is shown that (i) the transition to full synchronization can be predicted from eigenvalue analysis of the coupling network (ii) before transition to synchronization the precision of the period strongly deteriorates and (ii) bivariant and partial phase synchronization indices are useful tools to delineate network structure from dynamical measurements. The features of electrochemical oscillations are further characterized in microscale electrochemical cells. It is shown that these lab-on-chip devices are prone to nonlinear behavior and that strong coupling effects are expected due the large ohmic potential drops in the flow channels. Finally, it is shown that optimal waveform for entrainment of limit-cycle oscillators can designed using phase model analysis. The methodology is tested with electrochemical oscillators but applications are possible in general entrainment problems, e.g., in design of cardiac pacemakers or injection locked oscillations.

Friday, March 25, 2011
1:30 p.m.
Bryan Hall, Room 305
(Light refreshments will be served.)

Host: Dr. Jr-Shin Li

Short Bio: Istvan Kiss is an Assistant Professor in the Chemistry Department at Saint Louis University since 2007. He earned his Ph.D. degree in chemistry from the University of Debrecen (Debrecen, Hungary). From 2000-2007 he was a research scientist in the Chemical Engineering department at the University of Virginia, Charlottesville. He received the Cottrell College Science Award of Research Corporation for Science Advancement in 2008. In 2010 he received the National Science Foundation CAREER Award. He is co-author of 65 peer-reviewed publications.