Controlling Synchronization Patterns by Network Design, Connection Rewiring, and Feedback Techniques in Electrochemical Oscillator Networks

Istvan Z. Kiss[1], *Mahesh Wickramasinghe*[1], *Michael Sebek*[1]

[1]Department of Chemistry, Saint Louis University, Saint Louis, MO 63103, USA

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. An experimental design is presented with oscillatory nickel electrodissolution, in which the synchronization patterns of oscillating units are 'engineered' as network properties of coupling ('communication') between units are tuned. The coupling topology is tuned by a hybrid chemical-resistive device in which the electrodes are coupled through their electrode potential differences. Various small networks of oscillators are built (with number of units 2-20 and number of links between them is 2-150). The effects of network topology on identical synchronization, clustering, and formation of chimera states are investigated. The oscillatory networks often exhibited multistability between different types of synchronization states (e.g., between full synchrony and partial synchrony or waves with different rotation rates). However, most experimentally attainable initial conditions of the system provide a fully synchronized behavior. A combination of temporary network rewiring and global feedback is applied to attain reproducible initial conditions for a given complex synchronization pattern. The technique allows extensive study of possible pattern formation in experimental systems and sheds light on the rich dynamical structure of networks of oscillatory chemical reactions.