Biology and Medicine Through Mathematics Conference

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Universality and synchronization in complex quadratic networks (CQNs)

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It has been long established that distinguishing between dynamic rhythms in networks of neural oscillators is an important point in neuroscience. In a brain circuit, two different asymptotic patterns (e.g., steady state versus oscillations) may reflect into different functional and cognitive outcomes and could mark differences between health and pathology. The preference for one behavior versus others depends as much on the dynamic behavior of each networked unit, as on the arrangement and strength of synaptic pathways between them. Patterns like synchronization and clustering – which reflect at a functional level the type and efficiency of network function – are also highly dependent on the network interconnectivity and architecture.

Establishing ties between connectivity and dynamics of a network is notoriously difficult. We aim to understand this relationship in a canonical framework (using complex quadratic node dynamics), and we search for universal principles. We build upon historic research in complex iterations, to define network extensions for traditional objects (like the Mandelbrot set). We use these to quantify the effects of network architecture on dynamic patterns (e.g., node "synchronization"). We harness the idea of encoding network dynamics using geometry, so that asymptotic patterns can be visualized as topological properties of fractals. We use this novel approach to analyze and classify fractals for tractography-derived brain networks.