May 18th, 3:20 PM - 3:40 PM

The Mandelbrot set for networks, templates and mutated systems

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We explore three directions extending the traditional theory of complex quadratic iterations in the family $f\,\mathbb{C} \to \mathbb{C}$, $f_c(z) = z^2 + c$. We will consider: (1) complex quadratic networks; (2) template iterations and (3) mutated iterations. These address generalizations of single map quadratic iterations to the case where multiple variables are coupled as nodes in a self-interacting network, and to the case where the iterated map is subject to temporal and spatial errors in replication. In all three cases, the system's long-term dynamics is highly non-trivial, and can be represented by asymptotic sets (extensions of the traditional Mandelbrot and Julia sets) with specific topological signatures, and with properties far beyond those described in the case of single map iterations. Understanding the complexity of these sets requires a comprehensive mathematical approach, in which analytical and computational aspects are tightly combined. In our presentation, we will introduce this framework, present some of the methods and results obtained thus far, concentrating on topological and fractal properties of the asymptotic sets in each case. We will then show how each direction can be used as a framework to address in a unified, canonical way essential open problems in neuroscience, genetics and cancer research.