Professor Michael Small

Complex systems, dynamical systems, nonlinear time series analysis, complex engineering systems

1. Predicting critical transitions in dynamical systems

What are the signatures of critical changes in systems dynamics that can be observed prior to transition? How do we know when the state of a system is about to cross the boundary from one basin of attraction to another? Can we predict onset of bifurcation before it occurs? In many real systems this is a critical problem. In cancer therapy we are currently working with oncologists to develop a theory of critical state transition for genetic expression data. That is, gene expression profiles are taken from mice models before, during and after treatment and we are attempting to develop tools that can use these profiles (essentially each profile is a large network of genetic interactions) to predict therapeutic outcome.

2. Robustness and fragility in engineered complex systems

A system engineered for efficiency is necessary fragile as it will lack redundancy. Robustness means a system will continue to function as designed even after failure of components. A robust system necessarily loses efficiency. By considering real engineered systems as networks of interactions and mathematical models of the design and evolution of engineered systems we aim to uncover the hallmarks of (more) efficient robustness. What small perturbations can be made to make a system more robust to failure?