Physics 250 - II

The Tipping Point

Nucleation and Growth in Complex System Dynamics with Numerical Applications

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Complex systems are observed to undergo sudden changes in behavior when the system "tips" from one dominant dynamical pattern to another. The transition in system dynamics is associated with the nucleation and growth of fluctuations, together with a threshold in the state space of the system. The threshold can be characterized as a "tipping point". Tipping points, or first-order transitions, can be associated with stock market crashes, earthquakes, hurricanes, and epidemics. In this course we will examine the dynamics of nucleation and growth in complex systems. We will develop the tools to understand the effects of tipping points, and how these lead to the appearance of fractals and scaling phenomena. We will examine the role of fluctuations, and how these lead to selection of new dynamical states, and we will illuminate the role of the "spinodal" the classical limit of stability of the system. Students in this course will study the dynamics of a variety of complex systems that demonstrate tipping points through the development and use of analytical and numerical methods

Structure of Classes

Classes will involve both lectures and seminar-type discussions. Grades will be based on:

Class Participation	50%
Project	30%
Homework assignments	20%

Texts and Readings:

1. Tamas Vicsek, *Fractal Growth Phenomena (Second Edition)*, World Scientific, 1992 (reprinted 1999) ISBN 981-02-0668-2.

2. W. Klein, *Lecture notes on nucleation*.

3. W. Klein, H. Gould, N Gulbahce, JB Rundle and K Tiampo, *The structure of fluctuations near mean-field critical points and spinodals, and its implication for physical processes*, preprint.

On Reserve

1. Paul Meakin, *Fractals, Scaling and Growth Far From Equilibrium*, Cambridge Nonlinear Science Series 5, Cambridge UH (1997; currently out of print). ISBN 0-521-45253-8

Approximate Course Plan (10 weeks - 20 lectures)

Introduction, Administrivia	1 lecture
Self-contained review of statistical thermodynamics, scaling, percolation theory, and ergodicity	3 lectures
Introduction to Nucleation	4 lectures
Fractals and fractal measures	2 lectures
Clusters, Growth, Self-Affine Surfaces and Aggregation	2 lectures
Classical and Spinodal Nucleation	2 lectures
Examples: Threshold Systems and Ergodicity	3 lectures
Theory of Fluctuations	3 lectures