Winter 1997

Nonlinear Dynamics and Complex Systems for Applied Scientists and Engineers

Physics 620, 540, and Applied Physics 601.

This course is intended to introduce the study of nonlinear-dynamical and complex systems, and a variety of applications to several areas (condensed matter, applied physics, materials, population dynamics, etc.). It should be useful to students in physics, applied physics, biophysics, as well as engineering students (e.g., materials, mechanics, fluid dynamics). No advanced mathematical background is required (so it should be accesible to students doing experimental work).

The topics covered will provide an introduction to *nonlinear*, *complex*, and *disordered* structures, emphasizing its concepts, ideas, and applications. Nonlinearities, disorder, and collective effects often produce complex behavior, and they will be central themes underlying the course material. This complex dynamics, sometimes involving chaos, is so ubiquitous that it has become essential for workers in many disciplines to learn the basic ideas and tools of the emerging discipline of complex nonlinear systems. These tools are becoming increasingly useful not only in academia, but also for physicists working in industry and finance (e.g., nonlinear modeling of markets, weather forecast, motion of rigid bodies in fluids, computational fluid dynamics, among many other examples).

The first part of the course (about two months) will focus on basic tools of dynamical systems to study nonlinear differential and difference equations (including one-dim. and two-dim. flows, bifurcation theory, numerical algorithms, chaos, fractals; with many examples and applications). We will also use several software packages (with a good interactive interface) for the analysis of nonlinear systems and for an interactive comparison of several useful numerical techniques. Afterwards, we will present several current-research issues in complexity (cellular automata, genetic algorithms, evolutionary programming). We will also discuss spatio-temporal dynamics, collective transport in disorder systems, and instabilities, in a variety of systems (e.g., order-disorder phenomena, phase transitions, percolation theory, avalanches, chaos in Josephson junctions, superconducting networks). We will also study the complex spatio-temporal dynamics produced by a variety of types of vortex motion in superconductors with correlated and uncorrelated disorder. At the end of the course, an effort will be made to discuss research problems which are of interest to the students enrolled in the class.

Meeting Times: T-Th. 1-2:30pm

Instructor: Prof. F. Nori, Physics Department.

Texts: Several are recommended and will be on reserve. The main one (specially for the first two months) is S. H. Strogatz, *Nonlinear Dynamics and Chaos, with Applications to Physics, Biology, Chemistry, and Engineering* (Addison-Wesley, 1994).