Miércoles, 5 de Abril

An ODE Model of the Motion of Pelagic Fish

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Abstract

A system of ordinary differential equations (ODEs) is derived from a discrete system of Vicsek, Czirók et al., describing the motion of a school of fish. Classes of linear and periodic solutions of the ODEs are found and their stability explored. The existence of toroidal solutions is also proven. Applications of the model to the migration of the capelin, a pelagic fish that undertakes an extensive migration in the North Atlantic, are dissussed and simulation presented.

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Miércoles, 20 de Septiembre

Negative Differential Conductance, Bistability, and Electric-Field Domains in Quantum-Cascade Structures

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Abstract

In undoped quantum-cascade structures (QCSs), negative differential conductance (NDC) and bistable behavior is observed in the current-density-electric-field (j-F) characteristics. While the j-F characteristic of a QCS with a single period exhibits NDC without bistability, NDC and a bistable behavior are observed for a QCS with 20 periods of the same design. Calculations using a scattering-rate model neglecting any field inhomogeneities show that the interplay of resonant tunneling between the states in the QCS with resonant scattering of longitudinal optical phonons can lead to NDC in both structures. The current-voltage characteristics of doped QCSs exhibit current plateaus with discontinuities for voltages below the lasing threshold. The number of current discontinuities is correlated with the number of periods of the QCS, suggesting the formation of electric-field domains that span the entire structure. In addition to this global field-domain formation typical for conventional superlattices, there is also a local field-domain formation within each period of the QCS. A self-consistent calculation of the conduction band profile and corresponding electronic wave functions shows that the low- and high-field domains are related to resonant tunneling between different states in the active region and injector of the cascade structure.

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Curso de Modelización en la Ciencia y en la Industria.

Noviembre de 2006.

Stochastic Processes in Agents Based Models

Prof. Vincenzo Capasso

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Abstract

Particular attention is being paid these days to the mathematical modelling of the social behaviour of individuals in a biological population. On one hand, there is an intrinsic interest in population dynamics of herds, and, on the other hand, agent based models are being used in complex optimization problems (ACO's, i.e. Ant Colony Optimization). Further decentralized/parallel computing is exploiting the capabilities of discretization of nonlinear reaction-diffusion systems by means of stochastic interacting particle systems. These systems lead to selforganization phenomena exhibiting interesting spatial patterns. As a working example, an interacting particle system modelling the social behaviour of ants is proposed. It consists of a system of stochastic differential equations driven by social aggregating/repelling ``forces". Specific reference will be made to the species ``Polyergus Rufescens" that has been observed in nature. Extensions to models of nucleation and growth, chemotaxis, such as angiogenesis related to tumor growth, will be presented. In these models, the so called organization process is driven by an underlying field that is strongly coupled with the spatial structure of the population of interacting individuals/agents/cells. Suitable ``laws of large numbers" are shown to imply convergence of the empirical spatial distributions of interacting individuals to nonlinear reaction-diffusion equations, as the total number of individuals becomes sufficiently large.

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Lunes, 13 de Noviembre

The ECMI Educational Programme Mathematics in Industry

Prof. Vincenzo Capasso

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Abstract

Mathematics, as the language of the sciences, has always played an important role in technology, and now is applied also to a variety of problems in commerce and the environment. European industry is increasingly becoming dependent on high technology and the need for mathematical expertise in both research and development can only grow. More and more companies recognise that mathematical/computer simulations may replace experiments in their product design to give both reduced costs and flexibility. These new demands on mathematics have stimulated academic interest in Industrial Mathematics and many mathematical groups world-wide are committed to interaction with industry as part of their research activities. In 1986, ten of these groups in Europe founded ECMI with the intention of offering their collective knowledge and expertise to European Industry. No single European country is likely to have sufficient expertise of mathematical knowledge to cover all possible applications of interest to industry, whereas ECMI can provide a comprehensive coverage of mathematical skills and their diverse applications. The ECMI Master Programme on Mathematics in Industry aims at educating industrial mathematicians to meet the growing demand for such experts. In modern industry, mathematical methods play an increasingly important role in research and development, production, distribution and management. These methods come not only from classical applied mathematics (mathematical physics, numerical mathematics, probability theory and statistics), but also involve e.g. operations research, control theory, signal processing and cryptography. Furthermore, mathematicians are more and more involved in the formulation, analysis and evaluation of mathematical models. Teaching centres in various European countries are providing various educational activities for this need, in addition to organising a two-year educational programme on Mathematics for Industry designed to provide new recruits for industry.