

CIM THEMATIC TERM ON MATHEMATICS AND THE ENVIRONMENT

Scientific Report

## 1 Introduction

The CIM Thematic Term 2004 was about Mathematics and the Environment. The knowledge about the impact of human activities on our planet's ecosystems is nowadays more vital than ever. Increasing human population to the detriment of others, cutting and burning vast areas of forest, polluting soil, air and water, are just a few examples of how we humans are altering our environment. Within this Thematic Term, some of these issues were addressed from a mathematical and physical modelling point of view.

The first event, the School and Workshop on Dynamical Systems and Applications, was aimed at consolidating the research activities in Portugal in this area of mathematics, fundamental for the understanding of the evolution of ecological environments and the monitoring of global changes. The Workshop on Forest Fires attempted to promote the communication among researchers with an interest in theoretical modelling of forest fires, in particular in fire front propagation. The third and fourth events, the School on Atmospheric Sciences and Climate Dynamics and the School and Workshop on Oceanography, Lakes and Rivers, addressed probably the most important natural processes for the world's ecosystem, and touched on issues such as air quality, weather prediction, ocean waves and currents, estuarine dynamics, and avalanches, among others.

The activities were coordinated by Juha H. Videman (IST) and José Miguel Urbano (Univ. Coimbra).

## 2 School and Workshop on Dynamical Systems and Applications (Porto, May 3-7, 2004)

The workshop took place in the Departamento de Matemática Pura da Faculdade de Ciências da Universidade do Porto and counted as participants 11 renowned specialists as well as 25 students and junior researchers, of which 10 from Portuguese institutions.

The organizers were José Ferreira Alves (Univ. Porto) and Marcelo Viana (IMPA, Brazil).

The workshop had a strong local and national impact, contributing significantly to reinforce the cooperation between the different national groups working on Dynamical Systems and also promoting their international visibility.

The scientific programme faced the challenge of putting together specialists in a wide spectrum of topics in Dynamics, from the more fundamental research to specific applications in experimental areas, and exploring the connections between them. It is our believe, based on the active contributions of the participants, that the result was a success. The programme had two main components:

1. Two short courses (5 hours each) given by renowned specialists, both with a scientific background that combines the interest in very concrete problems with a wide knowledge of fundamental methods and results.
  - Celso Grebogi (Universidade de São Paulo, Brazil): *Chaotic dynamics and applications*. Consisted in an introduction to the notions and basic results in Dynamics and a description of several applications to concrete problems in meteorology, electrical circuits, spatial navigation, among others.
  - Carles Simó (Universidad de Barcelona, Spain): *Dynamical systems, numerical experiments and super-computing*. A presentation in full depth of the ideas and methods used in the analysis and numerical simulation of dynamical systems, widely illustrated with examples.
2. The second component of the programme consisted of around 20 talks given by specialists from several countries in a wide range of topics, from the interface with arithmetics and number theory

to applications in experimental neurology: problems of numerical computation and rigorous scientific computing (Tucker, Kim, Choe), the behaviour of conservative systems from mechanics and gas dynamics (Le Calvez, Kalisch, Lopes-Dias, Del Magno), recent fundamental progress in non-hyperbolic systems (Díaz, Gelfert, Pacífico), several aspects of the stability of dynamical systems and their models (Araújo, Elia, Viana), synchronization of systems and application in cryptography (Chembo, Cizak), algebraic and arithmetic dynamical systems (Hric, Marmi, Marzougui), neuronal systems and neuronal coding (Pakdaman).

We believe the overall balance of topics clearly illustrated the diversity of the current research directions in Dynamical Systems, also putting into perspective the relations between the various trends.

### **3 Workshop on Forest Fires (Coimbra, June 3-5, 2004)**

The event consisted of a three-day workshop with talks by invited speakers; an afternoon was reserved for young researchers to present their work in talks of 20min. The organizers were Jorge C. S. André (Univ. Coimbra) and José Miguel Urbano (Univ. Coimbra).

The main goal of the workshop was to promote the communication (i.e., mutual knowledge, criticisms, possible future synergies respecting results and, above all, strategies of research) among researchers with a common interest and competence on theoretical modelling issues of forest fires, with an emphasis on fire front propagation. The invited speakers had different backgrounds (mathematics, physics, mechanical engineering) and came from different parts of the world where wild forest fires are a threat to the environment (Mediterranean Europe, Middle-East, USA, Australia). The scientific level was very good with talks touching different aspects of forest fires research: fire ecology, convection in forest fires and numerical simulation of wild fires, for example.

Unfortunately, the attendance was rather poor.

### **4 School on Atmospheric Sciences and Climate Dynamics (Lisbon, July 12-16, 2004)**

The event consisted of five short courses of five hours each and of an afternoon session with short communications. It took place at the main auditorium of the Com-

plexo Interdisciplinar of the Instituto Superior Técnico in Lisbon. The organizers were Juha Videman (IST, Lisbon), José Miguel Urbano (Univ. Coimbra) and Didier Bresch (CNRS, LMG-Grenoble, France).

The school was intended for graduate and PhD students as well as for researchers pursuing investigation on problems related to atmospheric sciences or climate dynamics. The main goal was to broaden our understanding of the complex processes that control the climate, the chemistry of the coupled atmosphere-ocean system, and the physics of the upper atmosphere.

The courses of the invited lecturers ranged from discussions of the human influence on climate and climate forecasting (Myles Allen) to treatments of transport and mixing phenomena in atmospheric chemistry (Peter Haynes) and in atmospheric-ocean dynamics (Esterban Tabak) and to the analysis of energy balance models (Jesus Ildefonso Díaz). The speakers were excellent and the scientific quality of their lectures reached the highest possible level.

The lectures were attended most keenly by about 50 participants (40 officially registered), with 15 of them coming from 7 different foreign countries.

### **5 School and Workshop on Oceanography, Lakes and Rivers (Lisbon, July 19-24, 2004)**

This event started with a four-day Summer School including five short courses of four hours each and ended with a two-day Workshop consisting of five invited lectures and of an afternoon session with ten short communications. It took place at the main auditorium of the Complexo Interdisciplinar of the Instituto Superior Técnico in Lisbon. The organizers were Juha Videman (IST, Lisbon), José Miguel Urbano (Univ. Coimbra) and Didier Bresch (CNRS, LMG-Grenoble, France).

The main objectives of the event were to initiate and develop the communication and interactions between the specialists working on different frontiers of Oceanography and to introduce to the Portuguese students the fundamentals, as well as some of the most relevant and current problems, of Environmental and Geophysical Fluid Dynamics. The invited lecturers were chosen carefully taking into account the interdisciplinarity of this field: Joseph Pedlosky and Benoît Cushman-Roisin are world-famous physical oceanographers with strong experience in collaborating with applied mathematicians; Peter Constantin is the world's leading expert in modelling turbulent geophysical flows; Benoît Perthame is a top specialist in numerical modelling of

shallow-water equations and Emmanuel Grenier is well-known for his studies of rotating fluids. The Workshop speakers discussed a variety of challenging topics such as the mathematical and numerical treatment of the primitive equations (Francisco Guillén); thermohaline circulation (David Marshall); the modelling of avalanches (Reinhard Farwig); roughness-induced effects in large-scale geophysical systems (David Gérard Varet) and turbulence, clouds and climate models (João Teixeira).

The scientific level was superb, in fact it was unseen to see together all these people in the same event. The atmosphere was friendly and cosy which helped the students to approach the speakers in and out of the lecture room. The attendance exceeded all expectations: it rounded to almost 100 participants (80 officially registered; 30 from foreign countries including

France (11), Spain (8) Sweden (5), Italy (3), USA (3), Great Britain, Switzerland, Germany, Czech Republic, Lithuania, Croatia, Bosnia-Herzegovina, Turkey, Senegal).

As for the Portuguese participants, they came from different parts of the country (Porto, Vila Real, Aveiro, Coimbra, Évora, Faro and Lisbon) and from different Departments/Institutes (Mathematics, Geophysics, Environmental Engineering, Oceanography, Mechanical Engineering, Civil Engineering).

We think that this last event was a huge success which crowned the entire Thematic Term.

*Juha Videman and José Miguel Urbano (with Jorge André, José Ferreira Alves and Marcelo Viana)*

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## WORKSHOP ON NONSTANDARD MATHEMATICS NSM2004

### Scientific Report

This conference, aimed at emphasizing the importance of Nonstandard Analysis for Mathematics, was held in honor of its inventor, Abraham Robinson, on the thirtieth anniversary of his death. The Organizing Committee (OC) also intended to provide an opportunity for mathematicians to discuss scientific aspects as well as problems raised by teaching Nonstandard Analysis both at university and pre-university levels. The OC was much gratified by the fact that some of the participants did take the opportunity to proceed with ongoing joint projects. The web page of NSM2004 is still active at <http://www.mat.ua.pt/eventos/nsmath2004/>. A summary of the main activities, between 9:30 a.m. Monday, July the fifth and 8:00 p.m. Friday the ninth, read as follows:

- A 4.5 hours course in Analysis with Infinitesimal
- Nine plenary talks of approximately one hour
- Twenty two talks of about 25 minutes
- A closing debate of roughly one hour

There were seventy participants of varied nationality — Portuguese, English, French, North American (from the USA), Italian, German, Irish, Ukrainian, Algerian, Russian and Hungarian — together with approximately 15 professors and teaching assistants from the Mathematics Department of the University of Aveiro as well

as pre-university teachers of Mathematics, who mainly attended the course, which was actually attended by virtually all participants. Among active participants, there were four PhD students, of which two presented short talks and another co-authored; three more graduate students and an undergraduate were present too. The plenary talks ranged through Analysis and Functional Analysis, Control Theory, Differential Equations, Foundations, Perturbation Theory, Number Theory, Quantum Physics, Stochastic Analysis (herein including stochastic solutions to Navier-Stokes equations); there was also a talk of about half an hour on Nonstandard Pre-Calculus; the late José Sousa Pinto was remembered by means of a talk mainly consisting of a survey of his work on Generalized Functions.

The Scientific Board - where Robert Lutz, from the University of Haute-Alsace in France, and Francine Diner from Nice (France), who were not present at the meeting, were substituted by Tewfik Sari, from the University of Haute-Alsace – recognized the high scientific level of the meeting and therefore participants were invited to submit papers to be refereed for inclusion in the proceedings, the editors being Imme van den Berg, professor at the University of Évora and Vítor Neves, professor at the University of Aveiro.

*Vítor Neves (on behalf of the Organizing Committee)*