BULLETIN

INTERNATIONAL CENTER FOR MATHEMATICS

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11

Contents

Coming Events

Thematic Term on Mathematics and Biology

ORGANIZERS

João A. C. Martins (IST, Lisbon, Portugal), Fernando Nogueira (University of Coimbra, Portugal), Carlota Rebelo (University of Lisbon, Portugal) and Helder C. Rodrigues (IST, Lisbon, Portugal).

DATES

June - July, 2002.

The **Thematic Term** for 2002 will be dedicated to Mathematics and Biology. The application of mathematics to biology has had considerable effect on the development of new research areas at the interface of both sciences. The development of Mathematical Biology research requires interdisciplinary teams with great expertise on several scientific areas.

This Thematic Term has the objective of acting as a seed for the development and enlargement of mathematical research applied to biological systems centered on some expertise and areas that exist already within the teams working in Portugal.

The areas covered range from Ordinary Differential Equations; Dynamical Systems, Partial Differential Equations; Optimization; Numerical Analysis; Homogenization; Calculus of Variations; Nonlinear Continuum Mechanics; to Epidemiology; Population Dynamics; Molecular Geometry; Material Science; Bone Remodeling; Numerical Analysis and Design of Bone Prosthesis and Implants; Computer Simulation of the Mechanics of Soft Tissues and Muscles and Computer Simulation of the Heart and Circulatory System.

It is expected that a large number of graduate students and researchers not only from mathematics and biology, but also from engineering, physics and chemistry, may have the opportunity of exchanging their views and knowledge in order to establish a solid and fruitful collaboration in the near future.

The programme of events is the following:

17-21 June: School and Workshop on Mathematical and Computational Modeling of Biological Systems

ORGANIZERS: João A. C. Martins and E. B. Pires (IST, Lisbon, Portugal).

AIMS

The proposed activities have the following objectives:

- to provide an updated overview of some typical models and tools used in mathematical and computational studies of biological tissues, organs and systems;
- to attract new graduate students for this area, and/or to provide them with an incentive and a learning opportunity;
- to provide an opportunity for the development of interdisciplinary collaborations between mathematicians, biologists, physicists, medical doctors and engineers that are essential for the advancement of the sciences of life and that provide important challenges and progresses in the other sciences;
- to provide an opportunity for exhibition, presentation and discussion of the work of Portuguese researchers in this area;
- to contribute for the development of strong roots of the sciences of life in a school of engineering (the I.S.T.) where a B.Sc. degree on Biomedical Engineering is expected to start in the academic year of 2001-2002.

These events will be held at IST, Lisbon.

INVITED SPEAKERS:

- Prof. Gerhard A. Holzapfel, Graz University of Technology, Institute for Structural Analysis - Computational Biomechanics, Austria (Soft tissues, atherosclerotic arteries and balloon angioplasty, Finite Element Method).

- Prof. Peter J. Hunter, Engineering Science Department, University of Auckland, New Zealand (Electro-mechanics of the Heart, Finite Element Models).

- Prof. Jacques Huyghe, Department of Biomedical Engineering, Technical University of Eindhoven, The Netherlands (Thermo-chemo-electro-mechanics of saturated porous media).

- Prof. J. L. van Leeuwen, Wageningen University, Experimental Zoology Group, Department of Animal Sciences & Wageningen Institute of Animal Sciences, The Netherlands (Dynamics of skeletal muscles, neuromuscular control).

- Prof. Clyde F. Martin, Department of Mathematics and Statistics, Texas Technical University, Lubbock, Texas, U. S. A. (Control and mechanics of human movement systems).

- Prof. Oliver E. Jensen, Division of Theoretical Mechanics, School of Mathematical Sciences, University of Nottingham, United Kingdom (Physiological Fluid Mechanics)

24-28 June: Advanced School and Workshop on Bone Mechanics - Mathematical and Mechanical Models for Analysis and Synthesis

ORGANIZERS: Helder C. Rodrigues and José M. Guedes (IST, Lisbon, Portugal).

AIMS

This event will bring together researchers from applied mathematics, mechanics, biomechanics and medicine in a course/workshop in Bone Mechanics. This event has the following objectives:

- To introduce young researchers, in applied mathematics and mechanics, into the area of bone mechanics and to its newest research developments.

- To stimulate the cooperation of the different research groups from mathematics, mechanics and medicine, focusing on the comparison of results of models and experiments and identifying areas of collaboration.

- To advance the area of biomechanics within the Portuguese research communities of applied mathematics and mechanics.

- To inspire mechanics and mathematics researchers to look at biological problems.

These events will be held at IST, Lisbon.

INVITED SPEAKERS:

- Prof. Martin P. Bendsoe, Technical University of Denmark- Mathematical Institute, Lyngby, Denmark.

- Prof. Andrej Cherkaev, Department of Mathematics, University of Utah, Salt Lake City, USA.

- Prof. Stephen C. Cowin, Department of Mechanical Engineering at City College, City University of New York, New York, USA.

- Prof. Manuel Doblaré, University of Zaragoza, Centro Politecnico Superior, Zaragoza, Spain.

- Prof. Harrie Weinans, Erasmus University Rotterdam, Erasmus Orthopaedic Research Lab, Rotterdam, The Netherlands.

27-29 June: Workshop on Molecular Geometry Optimization

ORGANIZER: Fernando Nogueira (Univ. Coimbra, Portugal).

AIMS

The workshop is intended to bring together mathematicians, chemists and physicists who work in molecular geometry optimization. Its main goal is, therefore, to allow the interchange of ideas between scientists with very different backgrounds and to provide a basepoint for the development of joint research projects. The use of high-performance computing software and hardware for performing realistic calculations of molecular structure will also be highlighted.

This event will be held at CIM, Coimbra.

INVITED SPEAKERS:

- Robert B. Schnabel, Department of Computer Science, University of Colorado at Boulder, USA.
- William E. Hart, Applied and Numerical Mathematics Department, Sandia National Laboratories, USA.
- Christodoulos A. Floudas, Department of Chemical Engineering Princeton University, USA.
- Tamar Schlick, Department of Chemistry and Mathematics, New York University, USA.
- Ron Wehrens, Laboratory of Analytical Chemistry, Catholic University of Nijmegen, The Netherlands.
- Peter Pulay, Department of Chemistry and Biochemistry, University of Arkansas, USA.
- Andrew Tuson, Department of Computing, School of Informatics, City University, London, UK.

15-19 July: Summer School on Mathematical Biology

ORGANIZERS: Alessandro Margheri (Univ. Lisbon, Portugal), Carlota Rebelo (Univ. Lisbon, Portugal) and Fabio Zanolin (Univ. Udine, Italy).

AIMS

The aim of this school is to present instances of interaction between two major disciplines, biology and mathematics, featuring recent issues from epidemiology and dynamics of populations. In this way, we expect to motivate the participants, biologists and mathematicians, to develop some future collaborations.

This event will be held at the Complexo Interdisciplinar (Univ. Lisbon).

INVITED SPEAKERS:

- Prof. Shair Ahmad, Division of Mathematics and Statistics, University of Texas at San Antonio, Texas, USA.
- Prof. Carlos Castillo-Chavez , Biometrics Unit, Cornell University, USA.
- Prof. Odo Diekmann, University of Utrecht, The Netherlands.
- Prof. M.Gabriela M. Gomes, Ecology and Epidemiology Group, Department of Biological Sciences, University of Warwick, England.

International Conference on Bounded Systems and Complexity Classes

ORGANIZER

Fernando Ferreira (Univ. Lisbon, Portugal).

DATE

28-29 June.

AIMS

To draw together people interested in bounded formal systems related to computational complexity classes in order to discuss current work and assess directions of research. If sufficient interest arises, international proceedings may be published.

This event will be held at the Complexo Interdisciplinar (Univ. Lisbon).

INVITED SPEAKERS

- Jeremy Avigad - Department of Philosophy, Carnegie-Mellon University, USA.
- Martin Hofmann - Department of Computer Science, The University of Edinburgh, United Kingdom.
- Ulrich Kohlenbach - Department of Computer Science, University of Aarhus, Denmark.
- Jan Krajícek - Mathematical Institute of the Academy of Sciences of the Czech Republic in Prague, Czech Republic.
- Thomas Strahm - Forschungsgruppe für theoretische Informatik und Logik, Institute für Informatik und angewandte Mathematik, Universität Bern, Switzerland.

For updated information on the CIM 2002 events, please visit the site

http://www.cs.math.ist.utl.pt/cim.www/cimE/eventos02.html

CIM on the WWW

Complete information about CIM and its activities can be found at the site

http://www.cim.pt

This is mirrored at

http://at.yorku.ca/cim.www/

CIM News

Balaguer Prize awarded to M. Golubitsky and I. Stewart's monograph

The Ferran Sunyer i Balaguer Prize for 2001 has been awarded by the Institut d'Estudis Catalans to Martin Golubitsky and Ian Stewart for their monograph "The Symmetry Perspective: ¿From Equilibrium to Chaos in Phase Space and Physical Space". According to the Institut, the Balaguer Prize, with a value of 10 000 Euros, "is awarded each year for a mathematical monograph of an expository nature presenting the latest developments in an active area of mathematics research in which the author has made important contributions."

Golubitsky and Stewart's book arose from lecture notes published by CIM in 2000 as no. 16 in its series of monographs. The notes corresponded to a course on "Symmetry, dynamics, bifurcations and applications" given by the authors in Coimbra in July 2000 during the School on Bifurcations, Symmetry, and Patterns organized by I. Labouriau, S. Castro and A. Dias. The School was part of the CIM Thematic term on Dynamics, Bifurcation and Biology, organized by J. Basto-Gonçalves and I. Labouriau (University of Porto). In a message to Jorge Buescu, CIM Bulletin editor, Martin Golubitsky writes that "the Coimbra Summer School was the impetus for writing 'The Symmetry Perspective'". Ian Stewart adds that "the only reason Marty and I wrote the prizewinning book was because we produced notes for the Portugal meeting." For more details on the 2000 Thematic Term see no. 8 of the CIM Bulletin.

Research in Pairs at CIM

CIM has facilities for research work in pairs and welcomes applications for their use for limited periods.

These facilities are located at Complexo do Observatório Astronómico in Coimbra and include:

- office space, computing facilities, and some secretarial support;
- access to the library of the Department of Mathematics of the University of Coimbra (30 minutes away by bus);
- lodging: a two room flat.

At least one of the researchers should be affiliated with an associate of CIM, or a participant in a CIM event.

Applicants should fill in the electronic application form

(http://www.cim.pt/cim.www/cim_app/application.htm)

Feature Article

On the Assessment of Portuguese Universities

by José Ferreira Gomes

Vice-Rector,
University of Porto

Portugal has been progressively introducing a culture of assessment in Higher education.

The change has been fast and well succeeded. The assessment of university courses started in a very tentative way around 1995 among fears of rejection by the community and a lot of suspicion. This exercise was organized by the CRUP (the Council of Rectors of Portuguese Universities) with delegated powers of the Ministry of Education. The first round was completed with a reasonably high technical quality and its success led to the extension of the process to non-university public Higher Education and to private institutions. This process of assessment is designed in a way that attempts to consider all aspects related to contents and the teaching/learning process for each particular undergraduate degree. Research performance was considered only in a very indirect way.

The Foundation for Science and Technology started in 1996 a process of re-organization of Portuguese research. This led to the setup of a network of Research Units that associate most of the active research staff in the Universities. A system of assessment was developed. It is based on a periodic peer review by international experts that ends up in a simple labelling of the Research Unit as Excellent, Very Good, Good, Fair, or Poor. The result has a direct impact on the funding of the Unit. This process has been fairly well accepted by the scientific community. The fact that the assessment is totally based on subjective expert opinions led to some difficulties but it is generally accepted that this represents a huge progress. This progress should be measured both by (i) the acceptance of a culture of assessment and (ii) an improvement of the performance of Portuguese researchers.

After this very positive appreciation of the progress attained in the last few years, the next step in the improvement of the Portuguese system should be discussed and planned.

I shall look at this from the point of view of the Higher Education Institutional assessment.

As stated above, the great success of the first round of assessment of the "Licenciaturas" at the public universities is the simple fact that it was done. The process of self-assessment within each institution,

- brought academic staff into contact with a philosophy of assessment, often for the first time;
- trained some academic staff, especially the coordinators of the self-assessment reports, in the particular methodology used;

- originated a wide reflection on the value and limitations of an assessment;
- made it clear that a permanent system of data collection within the institutions was necessary;
- identified areas where improvement was recommended.

It may be said that this assessment process played a crucial role in institutional self-knowledge. The process was designed from the beginning in a way that no immediate consequences, financial or of any other administrative type, would fall on the institution. Following the model adopted in the Netherlands, the goals are to promote quality making recommendations and following up the results. This was thought to be crucial for the process to be accepted in the first place but it created some frustration at the end, especially for the people more heavily involved. The lack of quantitative indicators was also designed from the beginning to hinder any attempt at ranking institutions or degrees. This has, however, the effect that the areas where progress can be achieved are normally fuzzy and those more clearly stressed are outside the reach or capacity of the people directly involved in the process. This limits the use of the exercise, hinders its contribution or improvement and makes it difficult to sustain such a heavy effort in a regular way in the future.

Examples abound in the world of assessment systems that employ varying sets of quantitative indicators. It is to be expected that the Portuguese system will incorporate this strategy once the current round, the first for the polytechnic and private subsystems, is complete.

To prepare this evolution, it appears appropriate that universities take the lead and start designing and testing some indicators. This requires a wide range of information that our universities do not always have readily available. For research, however, the Foundation for Science and Technology and the Observatory of Science and Technology collect and organize data on research outcomes of most university researchers. These data are organized by Research Unit. In most cases, however, universities have a different organization, the Department being typically the lowest unit responsible for teaching undergraduate students, for organizing postgraduate courses and evaluating the supervising research work at M.Sc. (Mestrado) and Ph.D. (Doutoramento) level.

The quality of advanced research training depends on the quality of the research being done in the Department. In some cases, it may be argued that the research student establishes a direct relationship with his personal supervisor. His immediate research group will have a major influence in the success of the research project but the wider atmosphere of work in related topics in the Department should not be minimized.

Making available an assessment of the research outcomes of departments would clarify the conditions of the advanced research training going on in our universities; it would put some pressure on the departments to put into practice a policy of recruitment of younger members of staff conductive to the improvement of the overall quality. In some areas the immediate introduction of this type of assessment may raise some problems. But how can we allow a department without visible research activity to accept a Ph.D. student? Can we expect this student to perform research work of international standards? And it should be clear to everybody that no other standards exist in our sphere of knowledge.

A good example in this direction appears in the Report on the Assessment of the research units that was published by the Ministry of Science and Technology in September 2001 in paper form and is also available electronically at www.fct.mct.pt/unidades/relatorio. The report for chemistry presents a table with a number of comparative indicators applying to the 19 units assessed. With the nine indicators shown, it is not easy to produce a single acceptable ranking, but this report contains food for thought and discussion among the researchers involved on how to improve their standing.

This attempt at using quantitative indicators is an example to be considered seriously. It does not substitute for the peer review exercise but gives some form of objective assessment that may suggest roads to improvement to individuals and to institutions. The Portuguese University needs it desperately to compete in the international arena. About 100 000 Europeans take the TOEFL test each year to prepare for admission to North-American universities. The number of Portuguese youngsters studying in foreign European universities is small (close to 3% in 1996/97, according to the Eurostat) but growing; it will come as no surprise that the balance of these exchanges is rather negative as Portuguese institutions attract only 0,3% of its students from aboard and mostly form traditional emigration destinations... The threat is clear even if, fortunately, with a small impact in the short term. Starting a pilot assessment along the lines outlined here may catalyse a new way of thinking, as the institutional assessment to the Universities of Gothenburg, Utrecht and Porto (see Boletim, Universidade do Porto, nº 28, Maio 1996) produced in the last decade.

Great Moments in XXth Century Mathematics

by Roger W. Carter

I have chosen for my great moment the appearance in 1976 of the paper by Deligne and Lusztig 'Representations of reductive groups over finite fields'.

This paper provided the breakthrough in understanding the characters of the irreducible representations of the finite groups of Lie type.

These groups are the analogues over finite fields of the simple Lie groups over the complex or real numbers. The classical linear, symplectic and orthogonal groups over finite fields had been studied at the beginning of the 20th century by L. E. Dickson, and Dickson also published papers on some of the exceptional groups over finite fields. However it was not until 1955 that Chevalley discovered a systematic way of constructing the finite analogues of the simple Lie groups.

The uniform description of these finite groups of Lie type, and their twisted versions due to Steinberg, Tits, Suzuki and Ree, posed the challenge of describing in a uniform manner the irreducible complex characters of such groups. The first step had been taken by J. A. Green in 1955 in a remarkable paper in which he determined the irreducible characters of the general linear groups $GL(n, q)$*. This paper was in many ways ahead of its time. It was clear that an analogous representation theory should exist for all the finite groups of Lie type. Indeed I. G. Macdonald made some famous conjectures about how such representations should behave. But these remained only conjectures until the appearance of the paper by Deligne and Lusztig. By considering the action of the group on a certain algebraic variety over a finite field and taking the* l*-adic cohomology groups, Deligne and Lusztig obtained families of irreducible characters which both proved Macdonald's conjectures and also opened the way for the determination of all the irreducible characters.*

This work was carried out by Lusztig in the years following the Deligne-Lusztig paper. Eventually the degrees of all irreducible representations were obtained, as well as much additional information about the character table. This beautiful and elaborate theory is without doubt one of the great achievements of 20th century mathematics.

Roger Carter obtained his Ph.D from Cambridge University in 1959. After spending a postdoctoral year as a Humboldt scholar at Tubingen University he spent the period 1960-5 as Lecturer in Mathematics at the University of Newcastle upon Tyne. He took up a position at Warwick University in 1965, the year in which Warwick admitted its first undergraduates, and has been a member of the Warwick department since then. He served as Chairman of the Mathematics Department for five years, and is now an Emeritus Professor.

Carter's research interests are in algebra, and include group theory, representation theory, algebraic groups and Lie theory. He is the author of a number of books on these subjects, as well as research papers. He has been involved in organising several large scale international symposia at Warwick, and one at the Isaac Newton Institute in Cambridge.

What's New in Mathematics

Geometric Quantum Computation is the topic of a "Perspectives" article in the June 1, 2001 issue of Science. The author, Seth Lloyd, of the MIT Mechanical Engineering Department, explains some recent work in quantum computation. The new research shows how holonomy, in particular the phase changes undergone by a particle moving through a tailored electromagnetic landscape, might be harnessed as the operations of quantum computation. Lloyd describes holonomy "...imagine yourself walking over a gently curving landscape ... you wind up back where you started ... to your surprise you are now facing the opposite direction." Don't try this at home, unless you live on a very small asteroid.

"Surprisingly Square" is the title of a piece by Ivars Peterson in the June 16, 2001 Science News. Peterson is reporting on recent developments in algebra that bear on the problem: how many ways can you express a number as a sum of n squares? Carl Jacobi in 1829 found simple formulas giving the number of different ways of doing it with two, four, six or eight squares, using elliptic function theory. And there the theory stood until 1996, when Stephen C. Milne of OSU came up with "powerful new formulas" to extend Jacobi's calculations to higher n. Powerful, but "hard to fathom and use," according to Peterson, Milne's formulas spurred a search for alternate routes to the same information. Recently modular forms, the same tools that helped prove Fermat's Theorem, have been brought to bear on this problem, and with success. Don Zagier (Max Planck, Bonn) used them to re-do Milne's proof of a similar formula for triangular numbers, and Ken Ono (Wisconsin-Madison) extended Zagier's work to duplicate and clarify Milne's results on squares. Elliptic functions and modular forms are two different areas of mathematics, so their convergence on the sums-of-squares problem suggests hidden connections. As Milne puts it, "Why do the two seemingly unrelated approaches give the same results?"

Is π normal? Which means, do all digit sequences of the same length appear with the same frequency in its decimal expansion? Statistical evidence favors normality. For example, in the first 200 of the 206 billion digits recently computed by Yasumasa Kanada et al. at the University of Tokyo, 7 occurred 19,999,967,594 times. This information is from a piece by Ivars Peterson in the September 1, 2001 Science News. It seems sort of obvious that there should be no incestuous relationship between π and 10, but establishing a proof is another matter. Recent progress has been made, however. It builds on a 1995 discovery by David Bailey (Lawrence Berkeley National Lab), Peter Borwein (Simon Fraser) and Simon Plouffe (University of Quebec at Montreal), who "unexpectedly found a simple formula that enables one to calculate isolated digits of π –say, the trillionth digit– without computing and keeping track of all the preceding digits." This formula only works for the base 2 and base 16 expansions, not the decimal, but it seems like a step towards determining the normality of pi in those bases. Now Bailey and Richard Crandall (Reed) have proved the equivalence between the base-2 normality of π (and $\log 2$) and the equidistribution property for the orbit of certain self-maps of the interval. Peterson tells us which map works for $\log 2$: $x_n = 2\,x_{n-1} + \frac{1}{n} \pmod 1$, and relates the pessimistic opinion of Jeff Lagarias (AT&T labs), that the new problem may be as intractable as the old. As usual, π brings out the puns: Peterson called his piece "Pi à la mode," while the Nature comment was titled "Pi shared fairly."

Drunk on fractals. A 40-year old conjecture on random walks ("drunkard's walks") has recently been solved by "an important and rigorous application of fractals to probability theory and mathematical physics." This from Ian Stewart's News and Views piece "Where drunkards hang out" in the October 18 2001 Nature. The conjecture, due to Paul Erdös and S. J. Taylor, was proved this year by Amir Dembo, Yuval Peres, Jay Rosen and Ofer Zaitouni (preprint available online) in Acta Mathematica. The conjecture involves the number of times a planar random-walking particle can be expected to revisit its most frequently visited site in the first n steps. The answer is $\frac{(\log n)^2}{\pi}$. Fractals? According to Stewart, the particle "makes frequent excusions away from the most frequently occupied disc, but keeps returning to it. These excursions occur on all length scales, which is where fractal geometry comes in."

The Gordian unknot. Alexander the Great cut the knot in 333 BC, and thereby destroyed important mathematical evidence. What was this knot that no one could untie? Keith Devlin reports in the September 13, 2001 Guardian that "A Polish physicist [Piotr Pieranski of Poznan] and a Swiss biologist [Andrzej Stasiak of Lausanne] have used computer simulation to recreate what might have been the Gordian knot." His piece is entitled "Unravelling the myth." Pieranski and Stasiak argue that the knot could not have had any free ends, so the cord was actually a circle. But if the circle had been topologically knotted, the problem would have been mathematically impossible, and therefore not a fair challenge. So the circle itself was tied into what had to be an unknot, and only the thickness of the cord made it impossible to loosen it. For example, the knot might have been tied in a wet cord which was then allowed to dry, and perhaps to shrink itself into an impossible configuration. Pieranski and Stasiak, motivated by interest in string theory and in the knotting of biological molecules, respectively, used a computer program to simulate the manipulation of such knots, and have found one so obdurate that maybe it has the structure of the original puzzle that Alexander "solved." Devlin's article is available online. Pieranski's home page has animations of the computer program in action.

The Abel prize is the name of a new "top maths prize," as Nature puts it in their September 13, 2001 "News in brief." The prize is being set up by the Norwegian government in honor of that country's greatest mathematician. The prize reportedly is aimed at bringing recognition of research achievements in mathematics up to the Nobel level. It will be given every year (starting in 2003) and the money is good: NKr 5 million (approx US$ 550,000).

Photo Solitons. Solitons are solutions to a non-linear wave equation. They have been observed in nature since 1844, when John Scott Russell chased a "solitary wave" as it sped down the Edinburgh to Glasgow canal without losing its shape. This phenomenon in another context turned out to be the key to understanding a strange phenomenon called "Fermi-Pasta-Ulam recurrence" (1953). In the computer simulation of the oscillations of a string consisting of 64 particles with non-linear interaction, the initial shape of the string dissolved as expected into a superposition of non-coherent modes, but after a certain time the modes magically reassembled into the original configuration. This was the "recurrence." In a News and Views piece ("Déjà vu in optics") in the September 20, 2001 Nature, Nail Akhmediev explains how the phenomenon was initially understood theoretically as a solitary wave in the solutions of the Korteweg-de Vries equation, the mathematical model for the original system, and how it is now understood that "essentially the Fermi-Pasta-Ulam recurrence is a periodic solution of the non-linear

Schrödinger equation." Now this phenomenon has been observed in a real physical system, using light beams in an optical fibre. The experiment was reported this year in Physical Review Letters by Van Simaeys, Emplit and Haelterman. "Because they took great care when setting up the initial conditions, the recurrence they saw was almost perfect."

Computing an Organism. The e-mail journal Science-Week for May 25 2001 picked up an item from the March 27 PNAS (98:3879): Stan Marée and Paulien Hogeweg, of the University of Utrecht, published an account of their simulation of the culmination behavior of the social amoeba ("slime mould") Dictyostelium dicsoideum. "Computing an organism" is the title of the accompanying commentary by Lee A. Segal. As the Science-Week editors note, "The D. discoideum morphogenesis cycle is one of the great puzzles of biology." Briefly, the "normal" stage of this organism is an amoeba, an independent unicellular organism. It eats bacteria and reproduces by binary fission. But when a population of these creatures is starving, they aggregate to form a slug 2 to 4 mm long which moves ("migration") as a single organism towards light. There ("culmination") the slug puts up a stalk approximately 1 cm high bearing at its tip a fruiting body containing spores, which eventually disperse over a wide area, each becoming a new "normal" amoeba. Marée and Hogeweg were able to construct a mathematical model of part of this amazing behavior, and to use it to run computer simulations of the process. Their model is a "a two-dimensional simulation using a hybrid stochastic cellular automata/partial differential equation schema" in which "individual cells are modeled as a group of connected automata: the basic scale of the model is subcellular." (...) The Science-Week editors conclude: "...viewing the simulation produced by the mathematical model of Maree and Hogeweg will no doubt startle many biologists. Perhaps the most important consideration is that this work provides evidence that computer modeling involving recognized subcellular dynamic entities may soon be used to predict (and explain) specific tissue development and tissue morphology. The implications for both basic and medical biology are profound."

Originally published by the American Mathematical Society in What's New in Mathematics, a section of e-MATH, in

http://www.ams.org/index/new-in-math/home.html

An Interview with Jean-Pierre Bourguignon

I am not familiar with the school system in France but from your CV it seems that your first degree was an Engineering one granted by l'École Polytechnique. Is that so ? What made you change your mind and realize that you wanted to be a mathematician ? An influential teacher ?

The higher education system in France is peculiar. It is split between on the one hand *Grandes Écoles* and the so-called *Classes Préparatoires* leading to them, and Universities on the other hand. Most of the *Grandes Écoles* are engineering schools, with the notable exception of the *Écoles Normales Supérieures*. The *École Polytechnique* was created right after the French Revolution to give engineers some time before studying technical subjects to get a more basic training in fundamental sciences. The school has kept this theoretical bias, and at my time its curriculum offered a substantial exposure to mathematics. Being a student at *l'École Polytechnique* was for me a formidable opportunity to meet some exceptional mathematicians : Gustave Choquet, who was my Analysis teacher there, and Laurent Schwartz, with whom I extensively discussed curriculum reform.

I date my definite attraction to mathematics from the time I was preparing the baccalauréat. The math teacher I had then suffered a poor reputation from the point of view of pedagogy but for the first time in my life I was confronted with a real (mathematical) challenge. I should probably say that in my high school years I had the great fortune of having the same (excellent) math teacher for four years out of six. He was very strict and thorough, and had the great inspiration of using quicker students to help slower ones. At no moment though, did he trigger in me the desire of becoming a mathematician, or even a scientist. At that time I was much more attracted by humanities, or even foreign languages. From this experience, I would be tempted to draw the lesson that it is very important to offer real challenges to young students. A uniform and smooth curriculum is not likely to be what will turn young minds on.

Jean-Pierre Bourguignon

You belong to the Class of 66 at l'École Polytechnique. In the middle of your degree you were caught by the May 68 events. Laurent Schwartz in his "Un mathématicien aux prises avec le siècle"refers to you in a very nice way. Let me quote partially

> "*Deux élèves de la promotion 66, Jean-Pierre Bourguignon et Yves Bamberger, jouèrent, par les initiatives comme par les contacts qu'ils établirent entre enseignants, élèves et direction de l'École, un rôle considérable pendant et après la période de mai 68.*"

Would you be willing to share with us some of your recollections of that period ?

This has indeed been a very exciting period, the campus of *l'École Polytechnique* being right in the middle of the *Quartier Latin*, which, in May 1968, became the focus of a lot of attention in France. In fact I think it is worth pointing out that already in 1967 there were signs that the very traditional (and blocked) situation the French society was in had entered a period of major crisis. The *École Polytechnique* itself had reached a stage of deterioration where it was impossible to hide the complete obsolence of its scientific management. Many professors were cut off from recent developments, and offering out of date courses. The Class of 1966 was the first that did not accept this very degraded situation, and asked for a complete revision of the curriculum. Students were fighting at the same time for more freedom in their movements (the military statute of the school forbade students to leave the school during the week for example) and in their choosing topics of study (the curriculum was uniform and quite scholastic). Students had to endure the sharp contrast between the outside image of the school, supposed to train the elite, and the very deteriorated level of the courses offered inside. This was unbearable to a number of them. The strong feeling of living the end of a world was very present before the May 1968 events, and undoubtedly led to them. Afterwards it had to be interpreted as a premonitory sign. In my opinion, this fact is too seldomly acknowledged with the proper emphasis. In the students' governing body, Yves Bamberger and myself (our duo was actually nicknamed *"le tandem Bambignon"*, as quoted by Laurent Schwartz) shared the responsibility of questions connected with teaching, both from a qualitative and a structural point of view. To set the tone, let me recall an amazing fact : in 1967, our fellow students were ready to give up a weekend of free time to put pressure on the administration to get rid of a poor teacher. Is that not an image which fully contrasts that of May 68 "baba-cools" ? Right in the agitated period, in the military environment of the school, going on strike was quickly identified as a critical step. Thanks to the very intelligent behaviour of the General heading the school, the struggle finally led to a complete restructuration of the courses for the last trimester under the supervision of voluntary professors, such as Louis Leprince-Ringuet and Laurent Schwartz who saw there an opportunity to give a big push to their vigourous claim for reform, and of students who wanted to prove the well-foundedness of their request for a new curriculum. This was of course a time of heated debates, justified fears, and finally important changes in the way some of us chose to conduct the rest of their lives.

For me, the big changes the May 68 riots brought concern the "way of life", and the consideration given to various groups of people in the society. I still vividly recall the way Yves Bamberger and myself were greeted by the President of the Board of the school in late June 1968 when, for the first time, representatives of the students chosen by them were allowed to address the Board: *"You must remember that you represent the future only biologically. Decisions will be ours"*. He resigned (or was forced to resign) in July 1968, and the General, who had so skillfully and constructively handled the crisis within the school, was transferred to an unimportant position in Bretagne (in other words sacked !). A *Commission de réforme* worked for the whole summer, and Bambignon was part of it. I must say that, from the point of view of the structure of studies, most of the students' proposals were adopted, and, for the whole academic year 1968-1969, the tandem was associated to their implementation under the supervision of a man with a strong personality, Jean Ferrandon, an engineer who had at the same time built extraordinary dams and harbours and developed a passion for rigorous mathematics. For young students in their early twenties as we were, this was an extraordinary experience, which could in some sense be put in parallel with *l'École de l'an Deux* at the time of the French Revolution.

Several of our friends accused us of being recuperated by the system. Although the question is worthy of consideration, we never accepted this view. I really believe that major changes in complex systems can only be achieved under specific circumstances, and then can go quite far without exerting much pressure after they get started, provided the pressure is exerted in the right direction. It is very important not to miss such opportunities, and in such times personal views must become secondary. The May 1968 events made possible a very successful revitalisation of the scientific life at *l'École Polytechnique*, something Louis Leprince-Ringuet and Laurent Schwartz had been fighting for more than ten years without much success.

You became Docteur ès Sciences Mathématiques having submitted a thesis with the title "Sur l'espace des structures riemanniennes d'une variété" at Paris VII in 1974. I think Marcel Berger was your thesis advisor. Let us talk about it for a while. Space in what sense ? Is it possible to give us some idea of the problems you were dealing with ?

Before answering your question per se, I would like to set the stage a little bit. I was very lucky to join the profession at a time where, in France, young researchers were given exceptional opportunities to work. I was hired by the *Centre National de la Recherche Scientifique* at age 21, before I had really done anything substantial. This gave me the possibility of considering in a long term perspective the research work I got engaged in. This contrasts with the great pressure under which young researchers are now forced to work on a short time basis.

From a disciplinary point of view, differential geometry, the domain to which Marcel Berger introduced me during long afternoons of very open and extremely informative discussions, was at that time very poorly considered in France. In fact, if you were not working in algebraic geometry, you were not doing "real" mathematics. It took me a year of stay in the US in 1972-1973 to realize that the direction in which Marcel Berger had led me was of great interest to world famous mathematicians such as Shiing Shen Chern. What was really exciting was to be able to participate in, and modestly contribute to, the emergence of a new field, namely "Global analysis", the blend of analysis and geometry that transformed differential geometry from a specialised, and very computational, subject into a hot and much more center stage topic. Marcel Berger had remarkably foreseen this transformation, and encouraged his geometry students to invest into learning more sophisticated analysis tools, something I had done under the supervision of Gustave Choquet at *l'École Polytechnique*.

A typical question that he liked to consider at this time was to find, on a given manifold, the "best" Riemannian metric. This forces one to consider all Riemannian metrics at once, and to see how one can deform a given metric into more interesting ones. One then has to worry about equivalent metrics, i.e. metrics that are exchanged by the action of a diffeomorphism, in other words by a change of variables. Equivalence classes are called "Riemannian structures", and the purpose of my thesis was to prove the space they form is stratified because of the possible presence of groups of isometries, i.e. the isotropy groups for the action of diffeomorphisms. This space plays an important role in the so-called ADM-presentation of the General Relativity, where solutions of the Einstein equation are sought as paths in the space of Riemannian metrics on a 3-dimensional spacelike hypersurface of space-time, for which one has to worry about the action of the group of diffeomorphisms. From that time on I kept interest in questions connected to deformations of metrics and the like.

From that moment on you have had a beautiful professional career. President of the European Mathematical Society from 1995 to 1998, Director of IHÉS since 1994, you probably still have some teaching to do. All these must be very time *consuming jobs. How do you still manage to find some time for mathematical research ?*

It is true that in recent years I assumed several responsibilities that have taken time away from my strictly scientific activities. In fact colleagues usually do not realize how time consuming it is to be in charge of an institute like the IHÉS which is a private foundation, i.e. a place where the director must, besides making scientific choices, cope with real managerial and financial problems.

From the scientific point of view, the a priori attractive side of such jobs is that very international research institutes, such as the IHÉS, are extraordinary observatories of the mathematical life, where one can see new tendencies coming up, and also listen to the latest news about challenging problems. Living in such an environment gives fantastic opportunities to meet extraordinary people in the society at large (and not only in the scientific community), and this is a privilege.

Since my job as director of the IHÉS is limited in time (the term is a priori 8 years, but it is now likely that I will stay a bit longer), even before taking the job, I arranged things so that I could spend three half-days a week at *l'École Polytechnique* in a small office in a remote corridor. There, I try and concentrate on my own mathematical agenda. In fact, since for me keeping contacts with students is very important, I am still teaching a course a year, and I am enjoying it very much.

As part of my duties as director, I have to keep alert on new developments, and for that purpose attend a number of conferences each year. This is an exciting part of the job. In my situation, the main difficulty is to find long enough unperturbed periods of concentration on my own research. I must confess that there are definitely moments when I do not achieve it, but I hope to be forgiven for this.

When Professor Friedrich Hirzebruch asked me whether I would be willing to run for president of the European Mathematical Society (EMS) – I was not yet in charge of the IHÉS –, I really hesitated. It was evident to me that Europe is an appropriate level to fight for science, but I still had mixed recollections of the constitutional meeting of the EMS in 1990 in Madralin (Poland), in which I took part as President of the *Société Mathématique de France*. There the attention was focused on legal and political issues, when I am much more interested in developing tools to help European colleagues getting conscious of their interdependence, and learning to work together more closely. I could only convince myself that taking on this challenge could be meaningful after I made sure that our Austrian colleague, Peter Michor, accepted to form a ticket with me and run as EMS secretary. I am proud that through the establishment of the very successful EMS server EMIS (European Mathematical Information Service) Peter was given the opportunity of putting his passion for electronic tools at work for colleagues, from Europe and elsewhere. Colleagues will judge whether the actions conducted by the EMS are successful, i.e. whether all people engaged in its committees and its actions are doing a good job. For me it was another fantastic experience, during which I was forced to understand and properly acknowledge different approaches, i.e. to face what building Europe is about. If I had one frustration, it came from the extreme slowliness with which the European Commission took up cases made by mathematicians. After some time one really gets impatient. I am very pleased to see that the new EU commissioner for Science, Philippe Busquin, succeeded in getting on its way a much more ambitious agenda, namely the construction of "a European Research Area", a programme which perfectly fits the EMS goals.

You have been making a number of interviews with great mathematicians (Chern, Hirzebruch, Thurston, Atiyah, Jacques-Louis Lions) which were considered to be of sufficient mathematical importance to be reviewed in Zentralbatt Math *and Mathematical Reviews for instance. How and why did you get started ?*

Indeed, I devoted time to make a number of interviews of mathematicians. There are some you even did not list, and also some that I could not complete, such as one by Professor Jürgen Moser. I submitted a series of questions to him, and got preliminary answers but his struggle with cancer, which ended his life untimely in December 1999, prevented him from completing them.

Here are my two main motivations : first, I feel that mathematicians do not make enough efforts to collect testimonies of eminent mathematicians ; second, the communication in our community has, in my opinion, taken a too formalized form. It now exists mainly through very carefully written articles appearing in refereed journals. Publishing interviews is a way of launching debates in the community on the basis of exchange of opinions. If I fully support the idea that published articles are the final mathematical products, we all know that doing mathematics requires going through many other steps, from identifying a promising area for research to realizing that an attempt to prove a theorem is a failure. If we want that outsiders access to a better understanding of how mathematics functions, we should therefore make also some room for all these steps. To those who fear that such an opening will lower the standards, I would say that this will not be the case if the same strict criteria are applied to this kind of articles.

Having some of these interviews reviewed in the international mathematical databases is not a sure sign of their importance. It nevertheless participates to the movement I was calling for earlier, namely making interviews a natural and significant part of the international mathematical life. You must share this view since you have been even more productive than me on this front.

Shall we talk about your videos ? You are mathematical author or co-author of two videos : "Tambour, que dis-tu ?"which won a prize at the Palaiseau International Science Film Festival in 1987 and "The New Shepherd's Lamp"which you were invited to show now in Coimbra. It seems correct to imply that you attach great importance to the popularisation of Mathematics. . .

To make a transition between your previous question and this one, the interview with Professor Shiing Shen Chern comes from a video, an idea due to an old friend, Professor Anthony Philips.

In fact I participated in two more films but the two you mention are really the ones of which I am the scientific author. Both of them were conceived with a wide public in mind. It is clear to me that mathematicians have not devoted enough attention to the question of how to communicate with the general public on their achievements and the nature of mathematics. Specialists of other disciplines have come up with useful images for all kinds of objects of importance to them. We have to do the same. This will require efforts and a lot of imagination, something that colleagues who have never been in touch with cinema activities often do not correctly appreciate. Producing movies is not only expensive. It is also time consuming !

The making of these two movies has been enlightened by encounters made on these occasions. François Tisseyre and Claire Weingarten, film directors with whom I worked for both, have become friends. What was critical for the success of the entreprise was their thoroughness in filming only a content they felt comfortable with, and this was achieved through lengthy discussions, and back and forth exchanges. As a consequence the production of *The new shepherd's lamp* has been a lengthy process during which the initial idea I had was completely transformed into a script based on a much broader historical perspective. This was also an opportunity to see how a professional writer, Romain Weingarten, could turn into a text of literary value the script of the shepherd, the character introduced by the film director structuring the whole movie.

Finding adequate projects where artists and scientists can meet and work together should be a priority in my opinion. In this way mathematicians can get a better acquaintance with the mechanisms through which the media function. Indeed producing videos does not ensure that they will be shown in TV programmes, the only way to gain greater visibility. Some mathematical videos made it, e.g. the video *The Proof* on Fermat's last theorem produced by the BBC which has been shown on the german-french channel ARTE. As far as I am concerned, I have already shown *The new shepherd's lamp* about twenty times to extremely different publics. Its length (28 minutes) allows for a short oral presentation and a debate whose content depends very much on the audience. I always find it very challenging and informative.

You were a member of the panel which in 1999 was responsible for the research assessment exercise in Portugal. I do not want to break any confidentiality which may surround that exercise but could you offer us your overall view of Portuguese mathematics at the end of the century? You do not have to be particularly kind...

First some general comments. The Portuguese higher education system is expanding rapidly. Worldwide it is now recognized that quality at this level cannot be achieved without active research teams. Therefore it is natural to try and evaluate the research to make sure that university departments are according enough attention to it. The decision to call systematically upon international teams of experts to do this job in Portugal is courageous on the part of your research agency and of your Minister of Science and Technology, but certainly wise in the long run.

The team traveled to several cities in Portugal to visit all research groups in some ten days. It was always well received, and the presentations prepared for it almost always thoroughly informative. The team was confronted with very diverse situations: some labs were already operating at an international level, others just starting to develop significant research activities. In many universities we could witness unreasonable teaching loads that make it almost impossible to pursue actively research at a good level. What makes matter worse in Portugal is the length of the academic year and the time devoted to exams. Too often university professors do not have the free time indispensable to conduct substantial research work. If the government is really serious about developing a full-fetched higher education system, it must address this issue which, from what I understand, means establishing stricter rules for students, a move which may be politically difficult. Such rules exist in almost all other countries.

From a more qualitative point of view, Portuguese research teams may not be diversified enough topically. Some important areas are not covered. In some cases, to the contrary some topics are overdevelopped, and such a situation can isolate some groups from what is happening elsewhere in the mathematical community worldwide. Again the antidote is to be open enough, to send advanced students for their PhD training outside as often as possible, and to grant active researchers the possibility of visiting other scientific institutions abroad.

The Portuguese system supports quite generously students while they are preparing their PhDs. In particular it allows them to go abroad by granting them decent support for this purpose. But the acceleration of hirings consecutive to the expansion of universities is likely to come to a hold in a not too distant future when the system will stop expanding. This could mean a major blow to the health of the research system in Portugal since younger people are indispensable for the stimulation of the research. Mechanisms should be designed to ensure that positions will remain available at a steady rate in the years to come. Many countries in Western Europe have undergone a similar phenomenon in the 70's, and negative effects consecutive to this short-sightedness have been major. If a lesson could be learned from this recent experience, Portugal may be able to achieve a smoother development of its mathematical research.

(Questions and picture by F. J. Craveiro de Carvalho)

Jean-Pierre Bourguignon was a student at the *École Polytechnique* in Paris. He went on to become *Docteur ès Sciences Mathématiques* in 1974 having written a thesis under the supervision of Marcel Berger.

Professor Bourguignon was President of the European Mathematical Society from 1995 to 1998 and since 1994 he is the Director of IHÉS - *Institut des Hautes Études Scientifiques* in Bures-sur-Yvette, near Paris.

Professor Bourguignon is also the mathematical author or co-author of the videos *Tambour, que dis-tu?*, which was awarded a prize at the Palaiseau International Science Film Festival in 1987, and *The New Shepherd's Lamp*. That very year he was awarded the *Prix Paul Langevin de l'Académie des Sciences de Paris* and in 1997 he received the *Prix du rayonnement français pour les sciences mathématiques et physiques*.

Diogo Pacheco d'Amorim

Diogo Pacheco d'Amorim, born in Monção in 1888, made his elementary and secondary studies in Monção and Braga, and after that entered the Faculty of Mathematics of the University of Coimbra. Although his original purpose had been to get a degree in military engineering, the invitation of his teachers and some disappointment with the army institution led him to change his mind.

He graduated in Mathematics, with the highest possible marks, and began to work in his doctoral dissertation during his final graduation year. In 1914 he presented his doctoral dissertation, *Elements of Probability Calculus*, whose main goal was to solve the sixth problem raised by Hilbert at the World Congress of Mathematicians in Paris, 1900: a rigorous, axiomatic construction of Probability Theory.

His very successful career at Coimbra University — in 1919 he had been appointed Full Professor — shows the general recognition of his merits.

An engaged catholic, he became a militant of the "Catholic Center", and was elected as Member of Parliament during the First Republic, playing an important role in the discussion of economic matters. During Salazar's dictatorship, after a brief period of enthusiasm with the efficiency of Parliament dealings without partisan bonds, his disagreements with internal policies led him to abandon active politics, and to focus once again his brilliance in academic life.

Apart from teaching Probability Theory, he renewed the teaching of Analytical Mechanics, using vector calculus, of Operational Calculus, and of Econometry. His cultural interests were also very broad, but unfortunately his prolific work in Political Economy, History, Philosophy and Religion is dispersed, partially unpublished, and of difficult access.

In order to put in an appropriate frame the importance of Pacheco d'Amorim's work, it is interesting to recall that, in what concerns Probability, the 19th century was a period of of troublesome discoveries.

Laplace's achievements (1812) in developing powerful analytic tools — and namely integral transforms — to broaden the scope of Applied Probability, and his justly famous preface *Essai Philosophique sur la Probabilité* to the second edition (1814) of his *Théorie Analytique des Probabilités*, where he discusses the meaning of Probability[1], started a glorious new period in the

[1] Laplace (1814,p. vij): *"Le premier de ces principes est la définition même de la probabilité qui, comme on l'a vu, est le rapport du nombre de cas favorables à celui de tous les cas possibles. Mais cela suppose les divers cas également possibles. S'ils ne le sont pas, on déterminera d'abord leurs possibilités respectives dont la juste appréciation est un des points les plus délicats de la théorie des hasards."* Laplace's observation on non-equiprobable elementary events, and his remarkable two-stage sampling design known as Laplace urns, clearly show that his deep conception of Probability is much more Bayesian than Laplacian! (Sivia, 1996). The concept of Probability is indeed shaky, and modern axiomatic constructions just take it for granted, a primitive concept of the theory.

development of Probability. As Laplace wrote, in its essence Probability is nothing but common sense reduced to calculation. How dangerous, however, this is: as Descartes writes in the opening paragraphs of *Méditations Méthaphysiques*, common sense is the thing God distributed most evenly: everyone is content with his share!

And by using common "sense" Bertrand (1888) — who did not care much either for Laplacian or Bayesian probability — arrived at several distinct probabilities for the "same" event, namely of a random chord in a circle being larger than its radius. The ambiguity arises, of course, from the subjective interpretation of what is the meaning of "choosing a chord at random". Bertrand's paradox on geometric probability stressed the fragility of 19th century Probability, and it was not surprising that Hilbert, while addressing the World Congress at the turn of the century on the major unsolved problems in Mathematics, included the axiomatic construction of Probability as a pertinent one. Plato (1994) provides much information on the early attempts to tackle this problem, and attributes the first successful results to Bernstein and to von Mises, reporting on their influence on Kolmogoroff's (1933) measure-theoretic approach.

Pacheco d'Amorim (1914) attempted a rigorous construction of Probability Theory based on the concept of "random choice" as a primitive, arguing that it has a non-ambiguous meaning for the one performing the random choice — even though communicating its meaning to anyone else is subject to ambiguity. The axiomatic development of the theory is thus performed starting from this subjective standpoint, a remarkable feat anticipating later developments. Kolmogoroff's construction is of course richer and much more far-reaching both in what regards the definition of expectation and conditioning — but Diogo Pacheco d'Amorim deserves wider international recognition for his work than he has been granted so far. It is unfortunate that at the time there was no pressure whatsoever for international publication, but it would be a valuable service to Portuguese and European culture to prepare an annotated English translation of his dissertation.

Diogo Pacheco d'Amorim

Pacheco d'Amorim did maintain his views on Probability; his course notes show that he was clearly aware of the international developments in the field, but the axiomatic that he uses is still his own.

Pacheco d'Amorim's influence in the development of Probability Theory in Portugal was of the utmost importance. An existing copy of his Course on Probability Theory (1956-7), with personal notes and improvements, is very moving, since it testifies to his commitment to his teaching duties, his drive and motivation to write a modern and "definitive" work on Probability. We can only hope that the edition that it deserves can be accomplished in the near future.

References

• Bertrand, A. (1888) *Calcul des Probabilités*, Paris.

• Fernandes de Carvalho, J. A. G. and Ribeiro Gomes, A. (1994). Diogo Pacheco de Amorim —

o Professor e o Cidadão. *Actas do II Congresso Anual da Sociedade Portuguesa de Estatística*, 49-54.

- Kolmogoroff, A. N. (1933). *Grundgebriffe der Wahrscheinlichkeitstheorie*, Ergebnisse der Mathematik. (English transl.: Kolmogoroff, A. N. (1956). *Foundations of the Theory of Probability*, Chelsea, New York.)
- Laplace, M. le Comte de (1812). *Théorie Analytique des Probabilités*, Mme Veuve Courcier, Paris.
- Pacheco d'Amorim, D. (1914). *Elementos de Cálculo das Probabilidades*, Imprensa da Universidade, Coimbra.
- Pacheco d'Amorim, D. (1956-57). *Cálculo Simbólico e das Diferenças Finitas. Cálculo das Probabilidades*, Coimbra.
- Plato, J. von (1994). *Creating Modern Probability*, Cambridge Univ. Press, Cambridge.
- Pestana, D. (1994). Diogo Pacheco de Amorim — um Vulto Maior na História da Teoria das Probabilidades. *Actas do II Congresso Anual da Sociedade Portuguesa de Estatística*, 55-63.
- Sivia, D. S. (1996). *Data Analysis. A Bayesian Tutorial*, Clarendon Press, Oxford.

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