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in honour of Mauricio Peixoto and David Rand

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Mauricio Peixoto

Academic Career

1953	together with Leopoldo Nachbin helped to found IMPA (Instituto de Nacional de Matematica Pura e Aplicada), to which has been associated ever since and is a Emeritus Researcher at the present;
1957-1958	visited Princeton and met S. Lefschetz and later S. Smale who in 1960 spent six months at IMPA and did there pioneering work of fundamental importance;
1964-1968	Professor at Brown University, Providence, R.I., U.S.A.;
1972-1978	Professor at University of Sao Paulo, Brazil.

Awards and Honors

1969	Moinho Santista Prize for Mathematics;
1975-1977	President of the Brazilian Mathematical Society;
1979-1980	President of the National Research Council;
1981-1991	President of the Brazilian Academy of Sciences;
1987	received the Third World Academy of Science Award in Mathematics;

Main Research Achievements

Roughly speaking most of his work his concerned with the global theory of ordinary differential equations. The best known part of this work corresponds to the papers [15], [17], [19] and this is nowadays referred to as Peixoto's Theorem. In [40] Peixoto found find a careful presentation of how it came about and how it was instrumental in putting the qualitative theory of flows on differentiable manifolds on a solid set-theoretical basis with reasonably well defined goals and problems exhibiting a certain unity.

The gist of his contribution here is: (i) the introduction of the space of all flows; (ii) the modification of the original definition of structural stability by Andronov - Pontrjagin freeing it from the requirement of a small, ? - homeomorphism; (iii) the recognition of the importance and of the difficulty of the differentiable "closing lemma". Concerning (ii) it should be remarked that this modified non ϵ - definition of structural stability was introduced in 1959, [15, p. 201] and is nowadays the usual definition of structural stability. We remark that as late as 1986, Anosov in a survey article about structural stability [Structurally stable systems, Proc. Steklov Inst.

Math., issue 4, pp. 61-95] still refers to this usual definition as "structural stability in the sense of Peixoto".

The above Theorem was the starting point for the setting up of a high dimension qualitative theory of flows and diffeomorphisms on manifolds that was undertaken by Smale and his school in the sixties and seventies and continues to this day.

If we add to this the remarkable contributions of Kolmogorov, Arnold, Moser and others who look at these problems from a somewhat different, more metric point of view we get a vast body of knowledge that constitutes what is called nowadays Dynamical Systems. Thanks to the immense progress of computation techniques these theoretical concepts became more and more amenable to applications in the physical sciences. This seems to be the reason why the above Theorem is finding its place in many text books of applied mathematics even at the undergraduate level. A final comment about the above Theorem is that a natural complement to it is found in [28] where it is given a complete classification of structurally stable flows (i. e. Morse-Smale) on compact surfaces. This is done by means of "distinguished graphs" associated to such flows. In a recent paper by X. Wang [Ergod. Th. & Dynam. Sys. (1990), 10, 565-597] a close relationship is shown to exist between these graphs and the C^*- algebra of the corresponding flows. This approach offers a kind of algebraic substratum to the distinguished graphs of [28] and ties up nicely the above classification with modern algebraic trends. We now turn to another aspect of Peixoto's list of Publications. I wish to point out to a string of some 12 papers starting at my very first contribution [1] and eleven of the last ones ([34] - [36], [39], [40] and [42] - [47]). They are all somehow connected with the 2-point boundary value problem for a second order ordinary differential equation and more precisely to the problem of counting how many solutions do pass through the end points. In the case where only one such solution exists the subject relates naturally to the concept of generalized convexity with respect to the family of solutions of the equation $y'' = F(x, y, y')$. In particular I proved the following characterization theorem [7]: a function g(x) is convex with respect to the family of solutions of the above equation if and only if $g'' > F(x, g, g')$. This theorem generalizes the classical result that $g''(x) > 0$ is a necessary and sufficient condition for ordinary convexity of g. Ordinary convexity ammounts to generalized convexity with respect to the solutions of the equation $y''(x) = 0$. An application of our theorem to a mechanical problem was made in [11, pp. 102-108]. Giving up the very special case where the 2-point problem has always a unique solution, Peixoto came back to this problem in [25] with the knowledge I had acquired in dynamical system theory and put some genericity into the picture. So [25] is some kind of Kupka - Smale theorem (Kupka thesis at IMPA) in the context of the 2-point problem. What takes the places of the stable and unstable manifolds of the K-S theorem are the "lifted manifolds" at each point i.e. at each point Peixoto makes a blow up in 3-space of the totality of the trajectories through the point. We now come to [34] where Peixoto introduced the concept of focal decomposition (originally called sigma-decomposition) associated to the 2-point problem. Given a second order equation $x'' = F(t, x, x')$ and fixing a point $A_0(t_0, x_0)$, each other point (t, x) is labeled by an integer i, the number of solutions i of the equation through (t0, x0) and (t,x). We then call ?i the totallity of points (t,x) to which the index i has been assigned. The fundamental problem then is: to study the nature of the sets σ_i and of the decomposition of the plane determined by them. In [35,36], joint work with R. Thom Peixoto generalized the above problem letting the base point vary also so that we get a sigma decomposition of R^4 into sets Σ_i . They then show the existence of a certain 4-dimensional manifold $\Omega \subset R^6$ and of a projection $\Pi : R^6 \to R^4$ such that $(t_1, x_1, t_2, x_2) \in \Sigma_i$ if and only if the cardinality of $(\Pi|\Omega)^{-1}(t_1, x_1, t_2, x_2)$ is i. From this and from results of Hironaka and Thom, it follows that when the differential equation is analytic and the projection $(\Pi|\Omega)$ is proper, then calling δ the diagonal $t_1 = t_2$ in $R_4(t_1, x_1, t_2, x_2)$ we have that there is a Whitney stratification of $R^4 - \delta$ such that each $\Sigma_i - \delta$ is the union of strata. In [35] we construct the focal decomposition associated to the pendulum equation $x'' + sinx = 0$. It exhibits non empty σ_i for all indices i. In [38], in collaboration with A. R. Silva, Peixoto showed that some results of S. Bernstein fit nicely

with the results of [34, 35]. In [39], joint work with Kupka, Peixoto extended focal decomposition to the case of geodesics. In the case of the flat torus the corresponding focal decomposition, Fig. 1 of [39], is a most fascinating object, identical with the extension of the equation $x_2 + y_2 = N$ to the whole plane (in a natural sense) and to the Brillouin zones of a cubic crystal.

Spontaneous commentarys from other authors

Steve Smale, in the book "The Mathematics of Time" (Springer Verlag 1980), selects six of his papers on Dynamical Systems and Economy and among them, the article "What is global analysis?" (Am. Math. Monthly vol. 76 ,1969, pp.4-9) is essentially Peixoto's theorem. In the same book he gives the following testimony: "It was around 1958 that I first met Mauricio Peixoto. We were introduced by Lima who was finishing his Ph.D. at that time with Ed Spanier. Through Lefschetz, Peixoto had become interested in structural stability and he showed me his own results on structural stability on the disk D2 (in a paper that was to appear in the Annals of Mathematics, 1959). I was immediately enthusiastic, not only about what he was doing but with the possibility that, using my topology background, I could extend his work to n dimensions. "Peixoto told me that he had met Pontryagin, who said that he did not believe in structural stability in dimensions greater than two, but that only increased the challenge." René Thom in the article "The role of qualitative dynamics in applied sciences" ("Geometric dynamics", edited by Jacob Palis, Lecture Notes in Mathematics, number 1007, Springer Verlag, 1983, pp. 784-788), wrote:

"Now the global theory of topological stability of flows, originated by Poincaré, and developed by him for the study of the 3 - body problem (discovery of homoclinic, heteroclinic points) found its first major development with G.D. Birkhoff (1920), who introduced the fundamental notions of wandering, and non-wandering points. The second decisive progress came from the Soviet School, when Andronov-Pontrjagin, introduced the notion of structural stability of flows (1930). The third decisive progress came with the results of S. Smale and M.M. Peixoto, e.g. the density of stable flows on surfaces."

List of publications

1. Sobre las soluciones de la ecuación $yy" = \phi(y')$ que pasan por dos puntos del semi-plano y ¿ 0. Revista de la Union Matemática Argentina, Vol. XI, 1946, p. 84-91.

2. Sistemas não holônomos; 68 pages, Rio de Janeiro, 1947.

3. Princípios variacionais de Hamilton e da menor acão; 55 pages, Rio de Janeiro, 1947.

4. Uma desigualdade entre números positivos. Gazeta de Matemática, Vol. 9, 1948, p. 19-20.

5. On the existence of derivative of generalized convex functions. Summa Brasiliensis Mathematicae, Vol. 2, 1948, p. 35-42.

6. Convexidade das curvas. 66 pages. Notas de Matemática number 6, Rio de Janeiro, 1948.

7. Generalized convex functions and second order differential inequalities. Bulletin of the American Mathematical Society, Vol. 55, number 6, 1949, p. 563-572.

8. On convexity. Anais da Academia Brasileira de Ciências, Vol. XXI, 1949, p. 291-302.

9. Note on uniform continuity. Proceedings of the International Congress of Mathematicians, Vol. 1, 1950, p. 385. (in collaboration with A.A. Monteiro).

Le Nombre de Lebesgue et la continuita uniforme. Portugaliae Mathematica, Vol. 10, 1951, p. 105-113. (in collaboration with A.A. Monteiro).

11. Equacões gerais da dinâmica; 110 pages, Rio de Janeiro,1951.

12. Note on structurally stable systems. Anais da Academia Brasileira de Ciências, Vol. 27, 1955, p. 35.

13. On integral invariants. Anais da Academia Brasileira de Ciências, Vol. 38, 1956, p. XXV.

14. On structural stability. International Congress of Mathematicians, Edinburgh, 1958. Abstract of Short Communications, p. 86.

15. On structural stability. Annals of Math. Vol. 69, 1959, pp. 199-222.

16. Some examples on n-dimensional structural stability. Proc. Nat. Acad. Sci. Vol. 45, 1959, pp. 633-636.

17. Structural stability in the plane with enlarged boundary conditions. Anais da Academia Brasileira de Ciências, Vol. 31, 1959, pp. 135-160. (in collaboration with M.C. Peixoto).

18. Structural stability on two-dimensional manifolds. Boletin de la Sociedad Matemática Mexicana, 1960, pp. 188-189.

19. Structural stability on two-dimensional manifolds. Topology, Vol. 1, 1962, pp. 101-120.

20. Sobre o problema fundamental da teoria das equacões diferenciais. Atas of the 3rd Colóquio Brasileiro de Matemática, pp. 190-194. Fortaleza, 1961.

21. Structural stability on two-dimensional manifolds - a further remark. Topology, Vol. 2, 1963, pp. 179 -180.

22. On an approximation theorem of Kupka and Smale. Journal of Differential Equations, Vol. 3, 1967, pp. 214 - 227.

23. Qualitative theory of differential equations and structural stability. Proceedings of the International Symposium of differential equations and dynamical systems, Puerto Rico, 1965. Academic Press 1967, pp. 469-480. J. Hale and J.P. La Salle, ed.

24. Structurally stable systems on open manifolds are never dense. Annals of Mathematics, Vol. 87, 1968, pp. 423 - 430. (in collaboration with C.C. Pugh).

25. On a generic theory of end point boundary value problems. Anais da Academia Brasileira de Ciências, Vol. 41, 1969 pp. 1-6.

26. Sobre a classificacão das equacões diferenciais. Atas of the 6th Colóquio Brasileiro de Matemática, pp. 15-17. São Paulo, 1970.

27. Sur la classification des équations différentielles. C.R. Acad. Sc. Paris, Vol. 272, 1971, pp. 262-265.

28. Teoria geométrica das equacões diferenciais, 75 páginas. 7th Colóquio Brasileiro de Matemática, 1971.

29. On the classification of flows on 2 - manifolds. Proceedings of the International Symposium of Dynamical Systems. Salvador, Bahia, 1971. Academic Press, 1973, pp. 389-419.

30. Dynamical systems. Proceedings of the International Symposium of Dynamical Systems. Salvador, Bahia, 1971. Academic Press, 1973. (Editor of book and author of introductory chapter).

31. There is a simple arc joining two Morse-Smale flows. Société Mathématique de France, Astérisque, Vol. 31, 1976, pp. 16-41. (in collaboration with S. Newhouse).

32. On bifurcations of dynamical systems. Proceedings of the International Congress of Mathematicians, Vol. 2, 1975, pp. 315-319, Vancouver. Invited lecture.

33. Generic properties of ordinary differential equations. Math. Assoc. of America Studies in Mathematics, Vol. 14 1977, pp. 52-92, J. Hale, ed.

34. On end-point boundary value problems. Journal of Differential Equations, Vol. 44, 1982, pp. 273-280.

35. Le point de vue énumératif dans les problemes aux limites pour les équations différentielles ordinaires. I Quelques exemples. C.R. Acad. Sc. Paris, Vol. 303, Série I, number 13, 1986, pp. 629-633. Erratum, Vol. 307, 1988, pp. 197-198. (in collaboration with René Thom).

36. Le point de vue énumératif dans les problemes aux limites pour les équations différentielles ordinaires. II. Le théoreme. C.R. Acad. Sc. Paris, Vol. 303, Série I, number 14, 1986, pp. 693-698. (in collaboration with René Thom).

37. Acceptance speech for the TWAS 1986 Award in Mathematics (Beijing, 1987). From the volume: The future of Science in China and the Third World - Proceedings of the Second General

Conference Organized by the Third World Academy of Sciences, pp. 600-614. World Scientific, 1989.

38. Uma demonstracão do teorema do índice de Poincaré para superfícies. Matemática Universitária, Vol. 9/10, 1989, pp. 145 -151.

39. Enumerative two-point boundary value problems and a theorem of S. Bernstein. Anais da Academia Brasileira de Ciências, Vol. 62, 1990, pp. 321-327. (in collaboration with A.R. da Silva).

40. On the enumerative geometry of geodesics, in "From Topology to Computation" - Proceedings of the Smalefest, Springer Verlag, ed. M.W. Hirsch, J. E. Marsden & M. Shub, 1993, pp. 243-253. (in collaboration with I. Kupka).

41. "Some recollections on the early work of Steve Smale", in "From Topology to Computation" - Proceedings of the Smalefest, Springer Verlag, ed. M. W. Hirsch, J. E. Marsden & M. Shub, 1993, pp. 73-75. The above is a dinner speech delivered on August 6, 1990 at Berkeley on occasion of the cellebration of the sixtieth aniversary of Stephen Smale.

42. Sigma décomposition et arithmétique de quelques formes quadratiques définies positives. Published in the Festschrift de R. Thom: Passion des Formes. Editado por M. Porte, ENS Editions Fonteny-St.Cloud, 1994, pp. 455-479.

43. Focal decomposition in Geometry, Arithmetic and Physics. In Geometry, Topology and Physics. Eds. Apanasov / Bradlow / Rodrigues / Uhlenbeck, Berlin, Walter de Gruyter, 1997, pp. 213-232.

David Rand

Academic Career

2006-2011	EPSRC Senior Research Fellow
2006-present	Associate Director Systems Biology Doctoral Training Centre
2005-2008	Co-director, Systems Biology Centre, University of Warwick
2003-2007	Associate Director MOAC Doctoral Training Centre
2000-2005	Chair, Mathematics Institute, University of Warwick.
1996-2000	Director, MIR@W (Mathematical Interdisciplinary Research at Warwick).
1986-1998	Director, Nonlinear Systems Laboratory, University of Warwick.
1986-present	Professor of Mathematics, University of Warwick.

Awards and Honors

1986	Whitehead Prize of the London Mathematical Society.
1988	Wolfson Research Award.
1988	Founding editor of Nonlinearity
2004	Fellow, Institute of Mathematics and Its Applications (by invitation)
2005	Britten Lecturer. McMaster University
2006	EPSRC Senior Research Fellowship

Main Research Achievements

David Rand has made lasting contributions to pure and applied dynamical systems, and also to theoretical physics, fluid dynamics, ecology and epidemiology, immunology and circadian rhythms. His most recent work is on the interface between mathematics and systems biology.

David Rand did foundational work on dynamics and symmetry [15,16] using the symmetries to predict the space-time structure of flows in systems with S1 and O(2) symmetry and their bifurcations with applications to rotating fluids. These two papers have approximately 166 and 77 citations respectively.

David Rand and L. Jonker discovered and proved the topological-dynamical structure of 1-dimensional unimodal maps (see [12, 13, 14]).

The papers [17,18] opened up a substantial area in dynamical systems by discovering the universal fine-scale structure of the transition from quasi-periodic dynamics to chaotic behaviour in circle maps and the breakdown of invariant circles in dissipative systems, and also explaining this in terms of a renormalisation transformation with a conjectured hyperbolic structure. These papers have received over 500 citations.

In [20], David Rand and his coauthors uncovered the detailed scaling and fractal structure of quasiperiodic Schrodinger operators, particularly at the boundary of extended states.

The papers [22] and [27] contain the first non-heuristic and rigorous formulation of the thermodynamic formalism for multifractal invariants such as $f(\alpha)$ relating geometric, ergodic, dynamical and fractal properties of attractors and repellers. These papers are highly cited (approximately 166 and 77).

David Rand and his coauthors developed new general dynamical theory of evolutionary stability and coevolution [39,40,54,55]. This puts Darwinian evolution in such mean-field models of complex dynamical ecologies onto a firm mathematical basis.

David Rand and his coauthors developed pair approximations and correlation equation methods for spatial ecologies and infection [51,54,55,58].

In [30], Rand and Wilson introduced the notion of chaotic stochasticity. This paper has been influential and has received over 110 citations.

David Rand and Alberto A. Pinto have developed an extensive theory characterising the flexibility and rigidity of one and two dimensional hyperbolic dynamical systems and have constructing Teichmüller spaces for them, in particular for their C^{1+} conjugacy classes. This work that has appeared in a number of papers (e.g. [44,59,61,63,66,71,96]) has been collected into a monograph that is to be published by Springer in 2008.

In [6], David Rand published a dynamical game based on Cournot duopoly and showed that under rather natural conditions this game would have chaotic trajectories.

David Rand, Hugo van den Berg and Nigel Burroughs developed a new approach to one of the central questions of immunology: how can the exquisite antigen specificity of T cells be reconciled with the low affinity of the binding between the T cell receptor (TCR) and the MHC/peptide complex and how can this lead to an effective and safe immune response.

In chronobiology, David Rand has addressed two centrally important current problems: (a) To determine how the structure of the genetic network allows it to accommodate multiple, possibly conflicting goals, and to characterise these goals [65,70]. (b) To understand why circadian clocks have multiple intertwined regulatory loops and complex genetic control at the core of the clock mechanism even though a single feedback loop with a very simple structure will produce robust oscillations [65,76,77]. This work is part of a larger project to develop analytical tools that will aid in the understanding of regulatory and signaling networks. In particular, Rand has worked on: infinitesimal response curves (IRCs) (see [65,70]); mapping sensitivity (see [77]); flexibility (see [65,70]); experimental optimization (see [65,89]); statistical estimation of regulatory and signaling networks (see [73]).

Other areas where David Rand has contributed include: game theory and economics, the evolution of altruism and cooperation, bifurcation theory, nonlinear oscillations, the topological classification of Lorenz attractors, singularity theory and eikonal equations, local adaptive Galerkin bases, mechanisms for localised turbulence, turbulent transport, vortex dynamics, turbulence and linear stability in Ginzburg-Landau models, spatio-temporal chaos, patterns in spatially-extended ecologies, epidemics on dynamic networks, the timing of flowering, temperature compensation in circadian clocks. Several of the papers in these other areas have significant citations.

Spontaneous commentaries from other authors

A chapter in a recent book "Oligopoly Dynamics: Models and Tools, Tönu Puu and Irina Sushko (Eds.)" is devoted to a review of this work and that which followed it up. To quote from a review of this book in the Journal of Economic Behavior & Organization: "The second chapter, by J. Barkley Rosser, surveys the recent literature on nonlinear oligopoly dynamics that followed the seminal work of David Rand from 1978. Using the Cournot duopoly model, Rand was the first to make a thorough study of nonlinear dynamics in an economic framework."

David Rand and Hugo van den Berg and Nigel Burroughs developed a new approach to one of the central questions of immunology: how can the exquisite antigen specificity of T cells be reconciled with the low affinity of the binding between the T cell receptor (TCR) and the MHC/peptide complex and how can this lead to an effective and safe immune response? Their approach is the subject of an invited review in Immunological Reviews [72].

List of publications

1. D. A. Rand, Non-unitary valuation subalgebras. Proc. Lond. Math. Soc. 24 485-501 (1974).

2. D. Kirby & D. A. Rand, Regular rings and valuation ideals. Oxford Quarterly J. of Mathematics 25 329-340 (1974).

3. D. A. Rand, A space of valuation subalgebras. Oxford Quarterly J. of Mathematics 26 263-267 (1975).

4. D. A. Rand, Thresholds in Pareto sets. J. Math. Econ. 3 139-154 (1976).

5. D. A. Rand, The bifurcations of Duffing's equation. Journal of Sound and Vibration 44 237-253 (1976).

6. D. A. Rand, Exotic phenomena in games and duopoly models. J. of Math. Economics. 5 173-184 (1978).

7. D. A. Rand, The Topological classification of Lorenz attractors. Math. Proc. Camb. Phil. Soc. 83 451-460 (1978). (Reprinted in: Strange Attractors, editors Y Sinai and A Kolmogorov, (1981) (in Russian)).

8. P. Holmes & D. A. Rand, Bifurcation of the forced Van der Pol equation. Quart. Applied Math. 50 495-509 (1978).

9. L. Jonker & D. A. Rand, Une bourne inferieure pour l'entropie de certaines applications de l'interval. C.R. Acad. Sci. Paris 287 (1978).

10. D. A. Rand, On the stability of wave fronts defined by eikonal equations. Proc. Royal Soc. of Edinurgh. 85A 195-232 (1980).

11. P. Holmes & D. A. Rand, Phase portraits and bifurcations of a nonlinear oscillator. Int. J. Nonlinear Mechanics 15 (6) 449-458 (1980).

12. L. Jonker & D. A. Rand, The periodic orbits and entropy of certain maps of the unit interval. J. Lond. Math. Soc. 22 175–181 (1980).

13. L. Jonker & D. A. Rand, Bifurcations in one-dimension. I. The nonwandering set. Inventiones Matematicae 62 347-365 (1981).

14. L. Jonker & D. A. Rand, Bifurcations in one-dimension. II. A versal model for bifurcations. Inventiones Matematicae 63 1–15 (1981).

15. M. Gorman, D. A. Rand & H. Swinney, Doubly-periodic circular Couette flow: experiments compared with predictions from dynamics and symmetry. Phys. Rev. Letters, 46 (15) 992-995 (1981).

16. D. A. Rand, Dynamics and symmetry. Predictions for modulated waves in rotating fluids. Archive for Rational Mechanics and Analysis, 79(1) 1–37 (1982).

17. D. A. Rand, S. Ostlund, J. Sethna and E. Siggia, Universal transition from quasiperiodicity to chaos in dissipative systems. Phys. Rev. Letters 49(2) 132-135 (1982).

18. S. Ostlund D. A. Rand, J. Sethna and E. Siggia, Universal properties of the transition from quasi-periodicity to chaos. Physica D, 8 1-54 (1983).

19. L. Jonker & D. A. Rand, Universal properties of maps of the circle with ?-singularities. Comm. Math. Phys. 90 273-292 (1983).

20. S. Ostlund, R. Pandit, D. A. Rand, H. Schellnhuber and E. Siggia, The 1-dimensional Schrodinger equation with an almost-periodic potential. Phys. Rev. Letts. 50 1873-1876 (1983).

21. D. A. Rand, Fractal bifurcation sets, renormalization strange sets and their universal invariants. Proc. R. Soc. Lond. A 413 45-61 (1987). Proceedings of the Royal Society Discussion Meeting on Dynamical Chaos. December, 1986.

22. D. A. Rand & T. Bohr, The entropy function for characteristic exponents. Physica D 25 387-398 (1987).

23. D. A. Rand, Universality and renormalisation in dynamical systems. In New Directions in Dynamical Systems (ed. T. Bedford and J. Swift) 1-56, (1988), CUP.

24. D. A. Rand, Global universality, smooth conjugacies and renormalisation. I: The C^{1+} case. Nonlinearity 1 181-202 (1988).

25. A. C. Newell, D. A. Rand and D. Russell, Turbulent transport and the random occurrence of coherent events. Physica D, 33 (1988) 281-303.

26. A. C. Newell, D. A. Rand and D. Russell, Turbulent dissipation rates and the random occurrence of coherent events. Physics Letters A D, 132 (1988) 112-123.

27. D. A. Rand, The singularity spectrum $f(\alpha)$ for cookie-cutters. Ergodic Theory and Dynamical Systems 9 527-541 (1989).

28. T. Bohr & D. A. Rand, A mechanism for localised turbulence. Physica D 52 (1991) 532-543.

29. D. Broomhead, R. Indik, A. C. Newell & D. A. Rand,, Local adaptive Galerkin bases for large-dimensional dynamical systems. Nonlinearity 4 (1991) 159-197.

30. D. A. Rand & H. Wilson, Chaotic stochasticity: A ubiquitous source of unpredictability in epidemics. Proc. Roy. Soc. B. 246 (1991) 179-184. [See J J Sidorowich, Repellors attract attention. Nature 355 (1992) 584-585 News and Views for a review.]

31. A. A. Pinto & D. A. Rand, Global phase space universality, smooth conjugacies and renormalisation: 2. The C^{k+} case using rapid convergence of Markov families. Nonlinearity 4 (1992) 49-79.

32. D. A. Rand, Existence, non-existence and universal breakdown of dissipative golden invariant tori. I: Golden critical circle maps. Nonlinearity 5 (3) (1992) 639-662.

33. D. A. Rand, Existence, non-existence and universal breakdown of dissipative golden invariant tori. II. Convergence of renormalisation for mappings of the annulus. Nonlinearity 5 (3) (1992) 663- 680.

34. D. A. Rand, Existence, non-existence and universal breakdown of dissipative golden invariant tori. III. Invariant circles for mappings of the annulus. Nonlinearity 5 (3) (1992) 681-706.

35. V. M. Gundlach & D. A. Rand, Spatio-temporal chaos. 1. Hyperbolicity, structural stability, spatio- temporal shadowing and symbolic dynamics. Nonlinearity 6 (1993) 165-200.

36. V. M. Gundlach & D. A. Rand, Spatio-temporal chaos. 2. Unique Gibbs states for higher-dimensional symbolic systems. Nonlinearity 6 (1993) 201-213.

37. V. M. Gundlach & D. A. Rand, Spatio-temporal chaos. 3. Natural spatio-temporal measures for weakly- coupled map lattices defined by circle maps. Nonlinearity. 6 (1993) 215-230.

38. H. Wilson & D. A. Rand, Detecting chaos in noisy dynamical systems. Proc. Roy. Soc. B 253 (1993) 239-244.

39. H. Wilson & D. A. Rand, Evolutionary catastophes, punctuated equilibria and gradualism in ecosystem evolution. Proc. Roy. Soc. B 253 (1993) 137-141.

40. D. A. Rand, H. Wilson and J. M. McGlade, Dynamics and evolution: Evolutionarily stable attractors, invasion exponents and phenotype dynamics. Phil. Trans. R. Soc. Lond. 343 (1994) 261-283.

41. D. A. Rand, Measuring and characterising spatial patterns, dynamics and chaos in spatially-extended dynamical systems and ecologies. Phil. Trans. R. Soc. Lond. A 348 (1994) 497-514.

42. D. A. Rand, Expanded version of [41] in Chaos and Forecasting: Proceedings of the Royal Society Discussion Meeting (ed. H. Tong) World Scientific, 1995.

43. D. A. Rand & H. Wilson, Using spatio-temporal chaos and intermediate-scale determinism to quantify spatially-extended ecosystems. Proc. R. Soc. Lond. B (1995) 259, 111-117.

44. A. A. Pinto & D. A. Rand, Classifying C1+ structures on dynamical fractals: 1. The moduli space of solenoid functions for Markov maps on train tracks. Ergodic Theory and Dynamical Systems. 15 (1995) 697-734.

45. A. A. Pinto & D. A. Rand, Classifying C1+ structures on dynamical fractals: 2. Embedded trees. Ergodic Theory and Dynamical Systems. 15 (1995) 969-992.

46. D. A. Rand, M. Keeling and H. Wilson, Invasion, stability and evolution to criticality in spatially extended host-pathogen systems. Proc. R. Soc. Lond. B (1995) 259, 55-63.

47. M. Keeling & D. A. Rand, A spatial mechanism for the evolution and maintenance of sexual reproduction. Oikos 74 (1995) 414-424.

48. V. M. Gundlach & D. A. Rand, Spatio-temporal chaos. Corrigendum. Nonlinearity. 9 (1996) 605-606.

49. M. J. Keeling, R.J. Hendry, J. M. McGlade & D. A. Rand, Characteristic Length Scales of Discrete Spatial Models in Ecology. Phil. Trans. Roy. Soc. B. 352 (1997) 1589-1601.

50. H. Wilson & D. A. Rand, Reconstructing the dynamics of unobserved variables in spatially extended systems. Phil. Trans. Roy. Soc. B. 264 (1997) 625-630.

51. M. Keeling, A. Morris & D. A. Rand, Correlation models for childhood epidemics. Proc. R. Soc. B 264 (1997) 1149-1156.

52. N. J. Burroughs & D. A. Rand, Complex dynamics of cytoxic T-cell antagonism enhances virus survival. Proc. R. Soc. B 265 (1998) 529-535.

53. N. J. Burroughs, D Mutimer, D. A. Rand, E. Elias & D.Pillay, The consequences of quasi-species heterogeneity and within-host ecology for anti-viral therapy in HBV. In Therapies for Viral Hepatitis (ed. Schinazi, Sommadossi & Thomas) International Medical Press (1998) pp. 335-343.

54. M. van Baalen & D. A. Rand, The evolution of altruism in viscous populations. J. Theor. Biol. 193 (1998) 631-648.

55. D. A. Rand, Correlation equations and pair approximations for spatial ecologies. In Advanced Ecological Theory. Principles and Applications (ed. J. McGlade), pp. 100-142, Blackwell Science, 1999.

56. D. Mutimer,, D. Pillay., E. Dragon, H. Tang M. Ahmed, K. O'Donnell, J. Shaw, N. J. Burroughs, D. A. Rand, P. Cane, B. Martin, S. Buchan, E. Boxall, S. Barmat, K. Gutekunst, P. McMaster, & E. Elias, High pre-treatment serum hepatitis B virus titre predicts failure of lamivudine prophylaxis and graft re-infection after liver transplantation. J. Hepatology. 30, (1999) 715-721.

57. G. Cooper, N. Burroughs, D. A. Rand, D. C. Rubinstein and W. Amos, Markov Chain Monte Carlo analysis of human Y chromosome microsatellites provides evidence of biased mutation. PNAS 96 (1999) 11916-11921.

58. C. Bauch & D. A. Rand, A Moment Closure Model for STD Transmission Through a Concurrent Partnership Network. Proc. R. Soc. series B. 269 (2000) 2019-2027.

59. A. A. Pinto & D. A. Rand, Existence, uniqueness and ratio decomposition for Gibbs states via duality. Ergodic Theory & Dynamical Systems 21 (2) (2001) 533-544.

60. H. A. van den Berg & N. J. Burroughs & D. A. Rand, A reliable and safe T cell repertoire based on low-affinity receptors. J. Theor. Biol. 209 (2001) 465-486.

61. A. A. Pinto & D. A. Rand, Smoothness of holonomies for codimension 1 hyperbolic dynamics.. Bull. London Mathematical Society 34 (2002) 341-352.

62. H van den Berg, N J Burroughs & D. A. Rand, Quantifying the strength of ligand antagonism in TCR triggering. Bull. Math. Biol. 64 (2002) 781-808.

63. A. A. Pinto & D. A. Rand, Teichmüller spaces and HR structures for hyperbolic surface dynamics. Ergodic Theory and Dynamical Systems 22(6) (2002) 1905-1931.

64. H van den Berg & D. A. Rand, Antigen presentation as a diversity filter that enhances immune efficacy. J. Theor. Biol. 224(2) (2003) 249-267.

65. D. A. Rand , B. V. Shulgin, D. Salazar , A. J. Millar, Design principles underlying circadian clocks. Journal of The Royal Society, Interface 1 (2004) online at DOI: 10.1098/rsif.2004.0014

66. A. A. Pinto & D. A. Rand, Rigidity of hyperbolic surface dynamics. J. Lond. Math. Soc. 71(2) (2004) 481-502.

67. H. A. van den Berg & D. A. Rand, Dynamics of T cell activation threshold tuning. J. Theor. Biol. 228 (2004) 397-416.

68. H. van den Berg & D. A. Rand, Foreigness as a matter of degree: The relative immunogenicity of peptide/MHC ligands. J. Theor. Biol. 231 (2004) 535-548.

69. B. F. Finkenstadt, A Morton & D. A. Rand, Measuring antigenic drift and surge in Influenza: statistical inference on immunity loss. Statistics in Medicine. 24(22) (2005) 3447-3461.

70. D. A. Rand, B.V. Shulgin, J.D. Salazar and A.J. Millar Uncovering the design principles of circadian clocks: Mathematical analysis of flexibility and evolutionary goals. Journal of Theoretical Biology, 238(3) (2006) 616-635.

71. A. A. Pinto & D. A. Rand, Solenoid functions for hyperbolic sets on surfaces. In: Dynamics, Ergodic Theory, and Geometry: Dedicated to Anatole Katok (ed. Boris Hasselblatt). Mathematical Sciences Research Institute Publications, Cambridge University Press (2007) 145-178.

72. H. van den Berg & D. A. Rand, Quantitative theories of T cell responsiveness. Immunological Reviews. 216(1) (2007) 81-92.

73. E. Heron, B. Finkenstadt, D. Rand, Statistical inference for delayed transcriptional gene regulation, an application to the Hes1 system,. Bioinformatics. doi: 10.1093/bioinformatics/btm367

74. A. A. Pinto, D. A. Rand & F. Ferreira, Hausdorff dimension bounds for smoothness of holonomies for codimension one hyperbolic dynamics. Journal of Differential Equations 243(2) (2007) 168-178.

75. A. A. Pinto, D. A. Rand & F. Ferreira, Cantor exchange systems and renormalization. Journal of Differential Equations 243(2) (2007) 593-616.

76. O. E. Akman, J.C.W. Locke, S. Tang, I. Carré, A. J. Millar & D. A. Rand, Global temperature compensation and extended functionality for the Neurospora crassa circadian clock. Molecular Systems Biology. 4
http://www.nature.com/doifinder/4100210 on 12/02/08 doi: 4100210

77. D. A. Rand, Mapping the global sensitivity of cellular network dynamics: Sensitivity heat maps and a global summation law. J. R. Soc. Interface (2008) doi:10.1098/rsif.2008.0084.focus

Homage Session	Session in Homage to Professors Mauricio Peixoto and David Rand Musical moment organised by the undergraduate degree in musics Short presentation of the homaged by Professor Alberto Adrego Pinto The homaged will receive the Medal of the University given by the Vice-Reitor of University of Minho The homaged will receive a commemorative plate given by the Vice-Reitor of IMPA
Date	September 8th (Monday), 18:45-19:15 (subject to confirmation).
Location	Salão Nobre dos Congregados

Social Program	A short visit to Bom-Jesus, in Braga, followed by a trip to Guimarães. The Sanctuary of Bom-Jesus (14th century) is a hilltop pilgrimage site known by its impressive granite staircase with zigzag shape and a baroque church at the top. It represents an important touristic attraction in Minho. Guimarães is a medieval town recognized as being one of the most interesting places in Portugal whose history is strongly connected to the foundation of the Portuguese Nation. In Guimarães we will visit the Palace of the Dukes of Braganza (15th century) which is classified as a National Monument and shows a great influence of the manorial architecture of the Northern Europe. It is also possible to visit the Castle (10th century) and the Historic Centre of the city (world heritage classified area) with the ancient Squares of Oliveira and Santiago and the Old Town Council Chambers.
Date	September 10th (Wednesday).
Fare	30 € per person.
Meals	Dinner included (traditional Portuguese food)
Tour Highlights	Bom-Jesus (Braga); Palace of the Dukes of Braganza, Castle and Historic Centre (Guimarães)
Itinerary	14h00 - Departure from Av. Central (Braga) to Bom-Jesus 15h30 - Departure to Guimarães 16h30 - Visit to the Palace of the Dukes of Braganza 18h00 - Trip to the Castle or to the Guimarães Historic Centre 20h00 - Dinner in Guimarães in honour of Maurício Peixoto and David Rand 23h00 - Return to Braga (Av. Central)

To apply, please, send an email to dynappl2008@math.uminho.pt.

Schedule & Programme

CHEE-Complexity of Human Excellence and Expertise, pp 49
DB-Dynamics and Biology, pp 29, 51
DBHPU- Dynamics and BHP Universality, pp 43
DE-Differential Equations, pp 53
DFTA- Dynamic Field Theory and Applications, pp 25, 31, 34, 39
DIO- Dynamics and Industrial Organization, pp 54
DS- Dynamical Systems, pp 26, 37, 56
DSG- Dynamical Systems in Gravitation, pp 32, 38
FC- Fractional Calculus, pp 58, 59
GTE- Game Theory and Economics, pp 46
HDA- Hamiltonian Dynamics and Applications, pp 62
IOE- Industrial organization and economics, pp 63
IPS- Interacting Particle Systems, pp 41, 48
KTA- Kinetic Theory and Applications, pp 27
SDAE- Stochastics, Dynamics and Applications in Economics, pp 42

	MON 8/Sep	TUE 9/Sep	WED 10/Sep	THU 11/Sep	FRI 12/Sep
9.00h	D. Rand	W. de Melo	S. Elaydi	C. Landim	Y. Jiang
9.50h	break	break	break	break	break
10.00h	DFTA1,DS1,KTA	DFTA3,DS2,DSG2	A.Yannacopoulos	L. Bevilacqua DBHPU,GTE	DIO,DS3,FC1
10.50h			V. Pinheiro	A.R. Silva IPS2	
11.30h	break	break	Lunch	break	break
11.40h	A. Pinto	E. Faria	free afternoon	N. Banik	A. de Carvalho
12.30h	Lunch	Lunch		Lunch	Lunch
15.00h	C. Bernardin	G. Schütz		M.J. Pacifico	S. Strien
15.50h	break	break		break	break
16.00h	DB1,DFTA2,DSG1	DFTA4,IPS1,SDAE	see the social programme	CHEE,DB2, DE	FC2,HDA,IOE
16.50h					
17.30h	break	break		break	break
17.40h	S.Wu	E. Pujals		L. Flaminio	M. Peixoto
18.45h	Homage Session				

Programme

Monday, September 8

Plenary Session 1

Speaker: David Rand (Warwick, UK), pp. 17

Time: 09:00-09:50

Location: Anfiteatro

Coffee Break
Time: 09:50-10:00

Dynamic Field Theory and Applications 1 — Room 2.58

10:00 Stephen Coombes (U. Nottingham, UK)
Bumps, Breathers, and waves in a neural network with threshold accomodation, pp. 25

10:45 John Wyller (Norwegian University of Life Sciences, Norway)
Bumps in a two - population neuronal field model, pp. 26

Dynamical Systems 1 — Room Anfiteatro

10:00 Mike Todd (FCUP, Portugal)
Multifractal analysis for multimodal maps, pp 26

10:20 Alejandro Kocsard (IMPA, Brasil)
First cohomology group and invariant distributions, pp 27

10:40 Ana Cristina Moreira (FEP, Portugal)
Statistical properties of the maximum for non-uniformly hyperbolic dynamics, pp 27

11:00 Ana Margarida Rodrigues (IUPUI Indianapolis, USA)
pp 27

Kinetic Theory and Applications — Room 2.57

10:00 Simone Calogero (U. Granada, Spain)
The relativistic Fokker-Planck equation, pp. 27

10:20 Manuel Portilheiro (U. Autónoma de Madrid, Spain)
A Fourier transform method for relaxation of kinetic equations, pp. 28

10:40 Fabio Chalub (U. Nova de Lisboa, Portugal)
Continuous models for genetic evolution in large populations, pp. 28

11:00 Filipe Oliveira (U. Nova de Lisboa, Portugal)
An H-Theorem for Chemically Reacting Gases, pp. 28

11:20 Ana Jacinta Soares (U. Minho, Portugal)
Kinetic theory for chemical reactions without a barrier, pp. 29

Coffee Break
Time: 11:30-11:40

Plenary Session 2

Speaker: Alberto Pinto, pp. 17

Time: 11:40-12:30

Location: Anfiteatro

Lunch
Time: 12:30-15:00

Plenary Session 3

Speaker: Cedric Bernardin (ENS Lyon, France), pp. 17

Time: 15:00-15:50

Location: Anfiteatro

Coffee Break
Time: 15:50-16:00

Dynamics and Biology 1 — Room 2.56

16:00 Bruno Oliveira (U. Porto, Portugal)
Stability analysis of a model of local immune responses with regulatory T cells, pp. 29

16:20 José Martins (U. Minho, Polytechnic Institute of Leiria, Portugal)
Stable equilibria in moment closure and stochastically quasi-stable equilibria in SIS model, pp. 30

16:40 Gabriela Gomes (I. Gulbenkian, Portugal)
Prospects for malaria eradication in sub-Saharan Africa, pp. 31

17:00 Gabriela Gomes (I. Gulbenkian, Portugal)
Variant surface antigen repertoire of Plasmodium falciparium shaped by two-level, pp. 31

Dynamic Field Theory and Applications 2 — Room Anfiteatro

16:00 Nicolas Rougier (INRIA Lorraine, France)
Syncronous and Asyncronous Integration of Dynamic Neural Fields, pp. 32

16:45 Anwar Hussein (U. Minho, Portugal)
Traveling pulse solutions in a neural field model with asymmetric connectivity functions, pp. 32

Dynamical Systems in Gravitation 1 — Room 2.57

16:00 Ana Nunes (U. Lisboa, Portugal)
The set of planar orbits of second species, pp. 33

16:30 Simone Calogero (U. Granada, Spain)
Dynamical Systems in Cosmology, pp 33

17:00 José Pedro Mimoso (FCUL Lisboa, Portugal)
The Dynamics of Scalar Fields in Cosmology, pp. 33

Poster: Dulce Pinto (Univ. Minho, Portugal)
Numerical stability of Polydeuces, pp. 33

Coffee Break
Time: 17:30-17:40

Plenary Session 4

Speaker: Si Wu (Sussex, UK), pp. 17

Time: 17:40-18:30

Location: Anfiteatro

Tuesday, September 9

Plenary Session 5

Speaker: Welington de Melo (IMPA, Brasil), pp. 18

Time: 09:00-09:50

Location: Anfiteatro

Coffee Break
Time: 09:50-10:00

Dynamic Field Theory and Applications 3 — Room 2.58

10:00 Gregor Schöner (Bochum, Germany)
Dynamic Field Theory as a conceptual framework for understanding embodied cognition, pp. 34

10:45 Raymond Cuijpers (NICI Nijmegen, The Netherlands)
Bayesian decision making using neural fields, pp. 34

11:40 Jorge Ibañez (UAM, Spain)
Towards a dynamic field model of inhibition of return, pp. 35

12:05 Alexander Gepperth (Honda Research Institute, Germany)
Neuro-dynamic systems for real-world computation, pp. 36

Dynamical Systems 2 — Room Anfiteatro

10:00 Vitor Araujo (UFRJ, Brasil)
Multidimensional Rovella-like singular attractors, pp 37

10:20 João Paulo Pais de Almeida (U. Minho, Portugal)
Golden Tilings, pp 37

10:40 Jorge Milhazes Freitas (FCUP, Portugal)
Statistical stability for equilibrium states, pp 38

11:00 Miguel Mendes (FEUP, Portugal)
Codings of trajectories in certain discontinuous maps, pp 38

Dynamical Systems in Gravitation 2 — Room 2.57

10:00 Tiago Charters (CFCT e ISEL Lisboa, Portugal)
Post-inflationary scalar field phase dynamics, pp 38

10:30 Irene Brito (DMCT U. Minho, Portugal)
General Relativistic Elasticity - Statics and Dynamics of Spherically Symmetric Metrics, pp.39

11:00 Estelita Vaz (DMCT U. Minho, Portugal)
Relating material and space-time metrics within relativistic elasticity: a dynamical example, pp. 39

Coffee Break
Time: 11:30-11:40

Plenary Session 6

Speaker: Edson de Faria (USP, Brasil), pp. 18

Time: 11:40-12:30

Location: Anfiteatro

Lunch
Time: 12:30-15:00

Plenary Session 7

Speaker: Gunter M. Schütz (IFF Jülich, Germany), pp. 18

Time: 15:00-15:50

Location: Anfiteatro

Coffee Break
Time: 15:50-16:00

Dynamic Field Theory and Applications 4 — Room Anfiteatro

16:00 Phillipe Gaussier (Cergy-Pointoise, France)
Dynamic fields and interactive systems, pp. 39

16:45 Estela Bicho (U. Minho, Portugal)
A dynamic neural field architecture for flexible and fluent human-robot interaction, pp. 40

Interacting Particle Systems 1 — Room 2.58

16:00 Patrícia Gonçalves (U. Minho, Portugal)
Hydrodynamic Limit for a Particle System with degenerate rates, pp 41

16:20 Augusto Teixeira (ETH Zürich, Switzerland)
Random walk trajectories and Random Interlacements, pp 41

16:40 Eric Gautier (ENSAE, France)
Exit time and persistence of solitons for stochastic Korteweg-de Vries equations, pp 42

Stochastics, Dynamics and Applications in Economics — Room 2.57

16:00 A.N. Yannacopoulos (Athens, Greece)
Convergence to Walrasian prices in random matching Edgeworthian economies, pp. 42

16:20 D. Kravvaritis (National Technical University of Athens, Greece)
Similarity solutions for a replicator dynamic equation, pp. 42

16:40 Filipe Mena (U. Minho, Portugal)
Forecasting interest rate curves by local states reconstruction, pp. 43

17:00 Joaquim Baião (U. Minho, Portugal)
Location Choices and Partial Price Discrimination, pp. 43

Coffee Break
Time: 17:30-17:40

Plenary Session 8

Speaker: Enrique R. Pujals (IMPA, Brasil), pp. 19

Time: 17:40-18:30

Location: Anfiteatro

Wednesday, September 10

Plenary Session 9

Speaker: Saber Elaydi (Trinity U., USA), pp. 19

Time: 09:00-09:50

Location: Anfiteatro

Coffee Break
Time: 09:50-10:00

Plenary Session 10

Speaker: Athanasios Yannacopoulos (Athens, Greece), pp. 19

Time: 10:00-10:50

Location: Anfiteatro

Plenary Session 11

Speaker: Vilton Pinheiro (Salvador, Brasil), pp. 19

Time: 10:50-11:30

Location: Anfiteatro

Lunch
Time: 11:30-14:00

Thursday, September 11

Plenary Session 12

Speaker: Claudio Landim (IMPA, Brasil), pp. 20

Time: 09:00-09:50

Location: Anfiteatro

Coffee Break
Time: 09:50-10:00

Plenary Session 13

Speaker: Luiz Bevilacqua (UFABC, Brasil), pp. 20

Time: 10:00-10:50

Location: Anfiteatro

Plenary Session 14

Speaker: Antônio Roberto da Silva (UFRJ, Brasil), pp. 21

Time: 10:50-11:30

Location: Anfiteatro

Dynamics and BHP Universality — Room 2.56

10:00 Luís Vieira (FEUP, Portugal)
Difference equations and the spectra of a family of strongly regular graphs, pp. 43

10:20 Mário Basto (IPCA, Portugal)
Dynamics on spectral solutions of forced Burgers equation, pp. 44

10:50 Rui Gonçalves (U. Porto, Portugal)
Dynamics and Universal fluctuations of the Wolf's sunspot numbers, pp. 43

11:10 Silvio Gama (FCUP, Portugal)
Generation of magnetic field from a dynamical system point of view, pp. 43

Game Theory and Economics — Room 2.57

10:00 Fernanda Ferreira (IPP Vila do Conde, Portugal)
Leadership and demand uncertainty, pp. 46

10:20 Marta Faias (U. Nova de Lisboa, Portugal)
Tourism Choice with Crowding Types, pp. 47

10:50 Miguel Ferreira (U. Minho, Portugal)
Patents in new technologies,pp. 48

11:10 Nuno Azevedo (U. Porto, Portugal)
Using wavelets to decompose the time-frequency effects of monetary policy, pp. 48

Interacting Particle Systems 2 — Room 2.58

10:00 Milton Jara (U. Catholique de Louvain, Belgique)
Hydrodynamic limit for a zero-range process in the Sierpinski gasket, pp 48

10:20 Iesus C. Diniz (IME USP, Brasil)
Poissonian Tree Constructed from Independent Poisson Point Processes, pp 49

Coffee Break
Time: 11:30-11:40

Plenary Session 15

Speaker: Nilanjan Banik (CAFS, India), pp. 21

Time: 11:40-12:30

Location: Anfiteatro

Lunch
Time: 12:30-15:00

Plenary Session 16

Speaker: Maria José Pacifico (UFRJ, Brasil), pp. 21

Time: 15:00-15:50

Location: Anfiteatro

Coffee Break
Time: 15:50-16:00

Complexity of Human Excellence and Expertise — Room 2.58

16:00 Alberto A. Pinto (U. Minho, Portugal)
Bayesian-Nash Equilibria in the Theory of Planned Action, pp. 49

16:40 Helena Ferreira (U. Minho, Portugal)
Hysteresis in Theoretical Comportamental Games, pp. 49

17:00 José Fernando Silva Azevedo Cruz (U. Minho, Portugal)
Psychological processes, stability and uncertainty, pp. 50

Dynamics and Biology 2 — Room 2.56

16:00 Sandra M. Aleixo (ISEL, Portugal)
Dynamics of Populational Growth Models with Allee Effect, pp 51

16:30 Jorge Carneiro (Instituto Gulbenkian, Portugal), pp 52

17:00 Nico Stollenwerk (U. Lisboa, Portugal)
Rich dynamics in multi-strain epidemiological models: evolution towards criticality in accidental pathogens, reinfection threshold, and new dengue chaotic attractors, pp 52

Differential Equations — Room Anfiteatro

16:00 Carlos Rocha (IST Lisboa, Portugal)
Morse-Smale Attractors for Semilinear Parabolic Equations on the Circle, pp. 53

16:20 Henrique Oliveira (IST Lisboa, Portugal)
Bifurcations for non autonomous interval maps, pp. 53

16:40 Rafael Luís (IST Lisboa, Portugal)
Non-autonomous periodic systems with Allee effect, pp. 53

17:00 Rui Ralha (U. Minho, Portugal)
Numerical issues in the stability analysis of linear dynamical systems, pp 54

Coffee Break
Time: 17:30-17:40

Plenary Session 17

Speaker: Livio Flaminio (U. Lille, France), pp. 22

Time: 17:40-18:30

Location: Anfiteatro

Friday, September 12

Plenary Session 18

Speaker: Yunping Jiang (CUNY, USA), pp. 22

Time: 09:00-09:50

Location: Anfiteatro

Coffee Break
Time: 09:50-10:00

Dynamics and Industrial Organization — Room 2.56

10:00 Flávio Ferreira (ESEIG, Portugal)
Signalling to the home policymaker, pp. 54

10:20 Diogo Pinheiro (U. Porto, Portugal)
Behavioural scenarios for contingent claims valuation in incomplete markets, pp 55

10:20 Telmo Parreira (U. Porto, Portugal)
A Hotelling Network, pp. 55

11:00 Vivaldo Mendes (ISCTE Lisbon, Portugal)
Learning to play Nash in deterministic uncoupled dynamics, pp. 56

Dynamical Systems 3 — Room Anfiteatro

10:00 Luís Silva (U. Évora, Portugal)
Invariants of templates, knots and links generated by renormalizable Lorenz maps, pp 56

10:20 Nuno Franco (CIMA - U. Évora, Portugal)
Effective computation of the multivariable Alexander polynomial, genus and trip number of Lorenz links, pp 56

10:40 Acilina Caneco (ISEl and CIMA, U. Évora, Portugal)
On the relationship between the synchronizability of a network and some graph invariants, pp 56

11:00 Pawel Pilarczyk (U. Minho, Portugal)
Computational-topological approach to the classification of global dynamics of multiparameter systems, pp 57

11:20 Sara Fernandes (CIMA - U. Évora, Portugal)
Analysis of long time behaviour using symbolic dynamics, pp 57

Fractional Calculus 1 — Room 2.58

10:00 J. Tenreiro Machado (IPP, Portugal)
Fractional Calculus, pp. 58

10:45 Ramiro S. Barbosa (IPP, Portugal)
Fractional Control of Dynamic Systems, pp. 59

Coffee Break
Time: 11:30-11:40

Plenary Session 19

Speaker: Aragão de Carvalho (FRJ, Brasil), pp. 22

Time: 11:40-12:30

Location: Anfiteatro

Lunch
Time: 12:30-15:00

Plenary Session 20

Speaker: Sebastian van Strien, pp. 23

Time: 15:00-15:50

Location: Anfiteatro

Coffee Break
Time: 15:50-16:00

Fractional Calculus 2 — Room 2.58

16:00 Manuel S. Silva (IPP, Portugal)
Fractional Control of Legged Robots, pp. 59

16:25 Lino Figueiredo (IPP, Portugal)
Fractional Analysis of Traffic Dynamics, pp. 60

16:50 Cecília Reis (ISEP, IPP, Portugal)
Fitness Function Evaluation using Fractional Calculus, pp. 60

17:15 Isabel S. Jesus (ISEP, IPP, Portugal)
Implementation of Fractional Electromagnetic Potential Through a Genetic Algorithm, pp. 61

Hamiltonian Dynamics and Applications — Room Anfiteatro

16:00 Diogo Pinheiro (UT Lisboa, Portugal)
Asymptotic universality of non-isochronous potentials, pp. 62

16:20 João Lopes Dias (UT Lisboa, Portugal)
Renormalization of quasiperiodic dynamics, pp. 62

16:50 Mário Bessa (FCUP, Portugal)
Hamiltonian elliptic dynamics on symplectic 4-manifolds, pp. 62

17:10 Pedro Duarte (CMAF/DM-FCUL, Portugal)
Hamiltonian systems on polyhedra, pp. 63

Industrial Organization and Economics — Room 2.56

16:00 Cristina Januário (ISEL, Portugal)
Topological entropy and the controlled motion of profits in a chaotic economic model, pp. 63

16:20 Fernando Alexandre (U. Minho, Portugal)
Optimal monetary policy, pp. 63

16:40 Luís Aguiar-Conraria (U. Minho, Portugal)
Energy Cartel Pricing and Macroeconomic Dynamics, pp. 63

17:00 Orlando Gomes (Escola Superior de Comunicação Social, IPL, Lisbon, Portugal)
The Dynamics of Learning in Optimal Monetary Policy, pp. 64

17:20 Rosa Branca Esteves (U. Minho, Portugal)
Price Discrimination with Private and Imperfect Information, pp. 63

Coffee Break
Time: 17:30-17:40

Plenary Session 21

Speaker: Mauricio Peixoto (IMPA, Brasil), pp. 23

Time: 17:40-18:30

Location: Anfiteatro

Plenary Sessions

Plenary Session 1.

Date: Monday, 9h00

Speaker: David Rand (University of Warwick)

Title: Some Mathematical Challenges from Systems Biology

Abstract: I will review some challenges for dynamical systems that arise from Systems Biology.

Keywords: systems biology

References: [1] D. A. Rand. Mapping the global sensitivity of cellular network dynamics: Sensitivity heat maps and a global summation law. J. R. Soc. Interface (2008) doi:10.1098/rsif.2008.0084.focus

Plenary Session 2.

Date: Monday, 11h40

Speaker: Alberto Pinto (U. Minho, Portugal)

Title: Fine Structures of Hyperbolic Diffeomorphisms

Abstract: The study of hyperbolic systems is one of the core themes of modern dynamical systems. For dynamics on surfaces, I will present a very complete and elegant description of the fine-scale structure of hyperbolic invariant sets and the measures they support.

Plenary Session 3.

Date: Monday, 15h00

Speaker: Cedric Bernardin (ENS Lyon, France)

Title: Microscopic models for thermal conductivity

Abstract: I will review some recent work on the macroscopic non-equilibrium behavior of the Hamiltonian dynamics of chains of oscillators perturbed by a conservative noise. The stochastic perturbation is given by hypoelliptic diffusions on the momentum of particles, such that total energy, and eventually total momentum, is conserved. I will discuss existence or not of thermal conductivity for these models and compare them to the purely Hamiltonian dynamics where very little is known. These are joint works with G. Basile and S. Olla.

Plenary Session 4.

Date: Monday , 17h40

Speaker: Si Wu (Department of Informatics, Sussex University, Brighton, BN1 9QH, UK)

Title: Tracking Dynamics of Neural Networks with Continuous Attractors

Abstract: Understanding how the dynamics of a neural network is shaped by the network structure, and consequently facilitates the functions implemented by the neural system, is at the core of using mathematic models to elucidate brain functions. The present study investigates the tracking dynamics of continuous attractor neural networks (CANNs).Due to the traslational-invariance of neuronal recurrent interactions, CANNs can hold a continuous family of stationary states. They form a continuous manifold in which the neural system is neutrally stable.

We systematically explore how this property facilitates the tracking performance of a CANN, which is believed to have wide applications in brain functions. By using the wave functions of the quantum harmonics oscillator as the basis, we demonstrate how the dynamics of a CANN is decomposed into different motion modes, corresponding to, respectively, the changes in amplitude, position, width or skewness of the network state. We then develop a perturbative approach that utilizes the dominating movement of the network stationary states in the state space. This method allows us to approximate the network dynamics up to an arbitrary accuracy depending on the order of perturbation used. We obtain results on the maximum speed for a moving stimulus to be trackable, and the reaction time for the network to catch up an abrupt change in stimulus.

Plenary Session 5.

Date: Tuesday, 9h00

Speaker: Welington de Melo (IMPA, Brasil)

Title: Renormalization in dynamics

Abstract: We discuss the renormalization operator in the space of unimodal smooth interval maps and its impact on the understanding of one dimensional dynamical systems. At the end we eill describe a recent joint work with V.V.M.S. Chandramouli, M. Martens and C. P. Tresser where we prove that the Feigenbaum fixed point is no longer hyperbolic in the space of C^2 maps.

Plenary Session 6.

Date: Tuesday, 11h40

Speaker: Edson de Faria (USP, Brasil)

Title: Thompson group's action on Asymptotic Teichmüller Spaces

Abstract: This talk is based on joint work with Frederick Gardiner and William Harvey.
Richard Thompson's groups are rather ubiquitous objects, appearing in many branches of Mathematics, from Logic to Topology. We construct two actions, one dynamical and the other non-dynamical, for Thompson's F-group as mapping class groups on certain asymptotic Teichmüller spaces. The study involves Cantor sets of bounded geometric type and their fine-scale structure. New ideas introduced include the construction of dual dynamical Riemann surfaces and the use of scaling functions to monitor the group action. We also hint at generalizations to actions of Thompson-like groups on Teichmüller spaces of more general Cantor repellers.

Plenary Session 7.

Date: Tuesday, 15h00

Speaker: Gunter M. Schütz (Institut für Festkörperforshung, Forschungszentrum Jülich, D-52425 Jülich, Germany)

Title: Exact solution of the Bernoulli matching model of sequence alignment

Abstract: We consider the Bernoulli matching model of sequence alignment. We map this problem to the discrete-time totally asymmetric exclusion process with backward sequential update and step function initial condition. Using earlier results obtained from Bethe ansatz allows us to derive the exact distribution of the length of the longest common subsequence of two sequences of finite lengths X, Y. Asymptotic analysis adapted from random matrix theory allows us to derive the thermodynamic limit directly from the finite-size result.

Plenary Session 8.

Date: Tuesday, 17h40

Speaker: Enrique R. Pujals (IMPA Rio de Janeiro, Brasil)

Title: Hyperbolicity versus homoclinic bifurcation

Abstract: We show that any $f \in \mathrm{Diff}^1(M^n)$ can be C^1 approximated by other diffeomorphisms exhibiting a homoclinic bifurcation (tangencies or heterodimensional cycle) or by one which is essentially hyperbolic (it has a finite number of hyperbolic attractors with open and dense basin of attraction). This is joint work with Sylvain Crovisier.

Plenary Session 9.

Date: Wednesday, 9h00

Speaker: Saber Elaydi (Trinity U., USA)

Plenary Session 10.

Date: Wednesday, 10h00

Speaker: A. N. Yannacopoulos (Athens University of Economics and Business, Department of Statistics, Greece)

Title: The effect of expectations in economic dynamic

Abstract: In economic models it is very common that expectations concerning the future states of the economy drive today's actions of the economic agents and thus determine today's state of the economy. A key example of that is the theory of rational expectations, one of the cornerstones of the new classical macroeconomics. The dependence on expectations introduces a forward-backward in time structure for the dynamical system. When uncertainty is present, this introduces several complications related mainly to the need of compatibility of the solutions for the system with the information structure dictated by the flow of uncertainty. We present a general introduction concerning how expectations affect importantly economic dynamics and then provide a rigorous mathematical formulation of a general class of such systems using the theory of forward-backward stochastic differential equations. This theory provides conditions on the well-posedeness of such models as well as constructive algorithms for determining the equilibrium paths. The general theory is illustrated using concrete examples from macroeconomic theory.

Plenary Session 11.

Date: Wednesday, 10h50

Speaker: Vilton Pinheiro (Universidade Federal de Bahia, Brazil)

Title: Expanding Measures

Abstract: We prove that any $C^{1+\alpha}$ transformation, possibly with a (non-flat) critical or singular region, admits an invariant probability measure absolutely continuous with respect to any expanding measure whose Jacobian satisfies a mild distortion condition. This is an extension to arbitrary dimension of a famous theorem of Keller [1] for maps of the interval with negative Schwarzian derivative. We also show how to construct an induced Markov map F adapted to any expanding probability, solving the problem of lifting an invariant expanding measure to an induced Markov map. Furthermore, the induced time R of F is bounded by the first moment of good expansion (for instance, the first hyperbolic time) and F can be used to construct the Young towers, permitting the study of decay of correlations and related statistical properties for general expanding measures.

Keywords: Liftable measures; Expanding measures;

References: [1] G. Keller, Exponents, attractors and Hopf decompositions for interval maps. Ergod. Th. & Dynam. Sys. 10, 717-744 (1990)

Plenary Session 12.

Date: Thursday, 9h00

Speaker: Claudio Landim (IMPA - Rio de Janeiro, Brasil and CNRS - Rouen, France)

Title: Macroscopic fluctuation theory for stationary non equilibrium states

Abstract: We formulate a dynamical fluctuation theory for stationary non equilibrium states (SNS) which is tested explicitly in stochastic models of interacting particles. In our theory a crucial role is played by the time reversed dynamics. Within this theory we derive the following results: the modification of the Onsager-Machlup theory in the SNS; a general Hamilton-Jacobi equation for the macroscopic entropy; a non equilibrium, non linear fluctuation dissipation relation valid for a wide class of systems; an H theorem for the entropy.

Plenary Session 13.

Date: Thursday, 10h00

Speaker: Luiz Bevilacqua (Universidade Federal do ABC) and Marcelo Barros and Augusto C.N. Galeão (Laboratório Nacional de Computação Científica)

Title: Dynamical Characterization of Fractal Curves

Abstract: Diverging from the classical approaches the technique presented here explores a different way to determine the fractal dimension of one-dimensional structures. The fundamental idea is: given a geometric structure find an appropriate physical experiment that can identify whether the given geometry is fractal or not and additionally what is the associated fractal dimension. This paper deals with fractal curves and the dynamical response of associated simple oscillators. Using the same technique it is also possible to find out if a given curve belongs to a fractal sequence. The dynamical characterization can generate more than one 'dynamical fractal dimension' due to the multiple degrees of freedom of the oscillators. This property far from being a drawback is rich in information and due to this fact it is possible to identify, at least for curves of the Koch family, the randomness of a generation process. A new class of fractal curves was also introduced and analyzed that we have called 'mixed fractals'. These curves separate into two groups one is fractal the other is quasi-fractal sequence.

Keywords: fractal curves, dynamical dimension, mixed fractals.

Plenary Session 14.

Date: Thursday, 10h50

Speaker: Antônio Roberto da Silva (Universidade Federal do Rio de Janeiro, Brasil)

Title: The graph of 1-dim foliations and the 2-point boundary value problem

Abstract: In our talk we present a concise survey of the role that the concept of graph of a foliation, introduced by René Thom in the early sixties, plays in the Peixoto-Thom theory for the 2-point boundary value problem. Further, following Alain Connes, we show that attached to the foliation groupoid induced by the graph there is a natural C^*-algebra allowing us to present an alternative formulation of Peixoto's classification of Morse-Smale fields on two-dimensional manifolds.

Plenary Session 15.

Date: Thursday, 11h40

Speaker: Nilanjan Banik (Center for Advance Financial Studies, Institute for Financial Management and Research, Chennai - 600034, India)

Title: Reciprocal Dumping under Antidumping Enforcement and Uncertain Technology

Abstract: In recent years antidumping measures has earned the dubious distinction of being the most widely used non-tariff barrier (NTB). However, they may also be the cause of large trade distortions, the very problem that these instruments were designed to solve. This paper is built on these two premises. The first aspect relates to NTB aspect of dumping. We examine the loopholes in the present antidumping agreement which makes it easier for a nation to impose antidumping measures. The second aspect relates to the economic argument of dumping - as to what might be the factors, besides predatory pricing strategy, that will motivate a firm to dump in the foreign market. In our model, which is a dynamic extension of the reciprocal dumping approach, oligopolistic firms producing imperfect substitutes use the carrot and stick strategy to enforce non-dumping (cooperative) behavior.

When dumping occurs, firms lobby for tariffs as punishment. After a finite punishment period, the non-dumping equilibrium is restored. Conditions are derived on the degree of substitutability and observability that allow non-dumping under an infinite horizon. The model suggests the degree of substitutability between goods and the market interest rate, affect the likelihood of dumping. (JEL F13, D43) Joint work with Fernanda A. Ferreira and Alberto Pinto.

Keywords: dumping, tariffs, lobbying, carrot and stick strategy

Plenary Session 16.

Date: Thursday, 15h00

Speaker: Maria José Pacifico (IM-UFRJ, Brasil)

Title: Lorenz geometric systems: fastly decay for its first return map and a logarithm law for its hitting time

Abstract: We shall verify that the first return map associated to a geometric Lorenz atractor is fastly mixing and using this together some results about local dimension we shall proof that the hitting time associated to the flow depends only on the point pre-fixed, showing that a geometric Lorenz flow behaves as an iid system. This is a joint result with S. Galatolo.

Plenary Session 17.

Date: Thursday, 17h40

Speaker: Livio Flaminio (U. Lille, France)

Title: On the quantitative equidistribution of nilfows and Weyl sums

Abstract: The content of this talk is work in progress with G. Forni. It is well know that the equidistribution of the fractional parts of polynomials sequences with irrational leading coeeficient can be derived from the unique ergodicity of (certain) nilflows. We will present some results on the speed of convergence of ergodic averages of nilflows under Diophantine conditions and discuss the relation with known results and conjectures on bounds of Weyl sums (exponential sums for polynomial sequences). The method of proof is based on the analysis of the action of a suitable rescaling on the space invariant distributions for nilflows.

Plenary Session 18.

Date: Friday, 9h00

Speaker: Yunping Jiang (Department of Mathematics, Queens College of the City University of New York, Flushing, NY 11367-1597 and Department of Mathematics, Graduate School of the City University of New York, 365 Fifth Avenue, New York, NY 10016)

Title: Teichmüller Structures and Dual Geometric Gibbs Type Measure Theory for Continuous Potentials

Abstract: The Gibbs measure theory for smooth potentials is an old and beautiful subject and has many important applications in modern dynamical systems. For continuous potentials, it is impossible to have such a theory in general. In this talk, I will present a dual geometric Gibbs type measure theory for certain continuous potentials following some ideas and techniques from Teichmüller theory for Riemann surfaces. Furthermore, we will show that the space of those continuous potentials has a Teichmüller structure. Moreover, this Teichmüller structure is a complete structure and is the completion of the space of smooth potentials under this Teichmüller structure. Thus our dual geometric Gibbs type theory is a completion of the Gibbs measure theory for smooth potentials from the dual geometric point of view.

Keywords: Circle endomorphism, Symbolic space, Dual symbolic space, Dual derivative (Scaling Function), Dual Gibbs measure, Quasisymmetic homeomorphism, Symmetric homeomorphism

Plenary Session 19.

Date: Friday, 11h40

Speaker: C. A. A. de Carvalho (Instituto de Física, Universidade Federal do Rio de Janeiro, C.P. 68528, Rio de Janeiro, RJ 21941-972, Brasil)

Title: Sigma-Decomposition in Semiclassical Physics

Abstract: We derive a semiclassical approximation to the partition function of a one-dimensional quantum mechanical anharmonic oscillator using a path-integral representation. Given an inverse temperature β, the path-integral sums over closed paths parameterized by their coincident endpoints x_0, and by their time of travel βh. Each path is weighed by the exponential of minus its classical Euclidean action. The semiclassical approximation is obtained by considering the minima of the action, and quantum statistical fluctuations around them.We show that the extrema of the action provide a sigma-decomposition [1] of the $x_0 - \beta$ plane. We give a prescription [2] for taking the minima appropriately into account whenever we cross caustics separating regions of different number of extrema.

Keywords: Sigma-Decomposition ; Semiclassical Statistical Physics.

References: [1] M. Peixoto and R. Thom, C. R. Acad. Sc. Paris I, 303, 629 and 693 (1986); 307, 197 (1988)
[2] C. A. A. de Carvalho, R. M. Cavalcanti, E. S. Fraga, and S. E. Jorás, Physical Review E, 65, 056112 (2002)

Plenary Session 20.
Date: Friday, 15h00

Speaker: Sebastian van Strien

Plenary Session 21.

Date: Friday, 17h40

Speaker: Mauricio Peixoto (IMPA, Brasil)

Title: A survey of focal decomposition

Abstract: The concept of focal decomposition was introduced in [1] in the context of the 2-point boundary value problem

$$\bar{x} = f(t, x, \dot{x}), \qquad x(t_1) = x_1, \qquad x(t_2) = x_2 \tag{1}$$

the simplest and oldest of all boundary value problems.
Consider now the space $\mathbb{R}^4(t_1, x_1; t_2, x_2)$ of all pair of points in $\mathbb{R}^2$. If i is the number of solutions of the problem (1), a non negative integer or ∞ , we say that i is the index of the point $(t_1, x_1; t_2, x_2)$. Call Σ_i the totality of points of $\mathbb{R}^4(t_1, x_1; t_2, x_2)$ with index i. These sets then determine a partition

$$\mathbb{R}^4 = \Sigma_1 \cup \Sigma_2 \cup \cdots \cup \Sigma_\infty$$

the focal decomposition associated to the 2-point boundary value problem (1).
This focal decomposition is then the object of study.
From the work of Peixoto and Thom [2] the possibility of a general, analytic theory became clear. We have then an existence theorem which says that under a certain properness condition expressed in terms of the solutions of (1), the sets Σ_i are the unions of strata of an analytical Whitney stratification of $(t_1, x_1; t_2, x_2)$ - space $\mathbb{R}^4$ minus the diagonal $t_1 = t_2$. See [3].
Afterwards Kupka and Peixoto [4] extended the concept of focal decomposition in the context of an analytical Riemannian manifold.
In this context natural relationships of focal decompositions with such objects as Brillouin zones, semi-classical quantization and Diophantine equations were discovered.

References: [1] M. M. Peixoto, On Endpoint Boundary Value Problems, J. Diff. Equ. 44 (1982), 273-280.
[2] M. M. Peixoto and R. Thom, Le point de vue énumeratif dans les problems aux limites pour les équations différentielles ordinaires I, II, C.R. Acad. Sci. 303 (1986), 629-632, 693-698 ; Erratum 307 (1988), 197-198.
[3] M. M. Peixoto and A. R. da Silva, Focal decomposition and some results of S. Bernstein on the 2-point boundary value problem, J. London Math. Soc. (2) 60 (1999), 517-547.
[4] I. Kupka and M. M. Peixoto, On the Enumerative Geometry of Geodesics, From Topology to Computation, Proceedings of the Smalefest, Springer-Verlag (1993), 243-253.

Thematic Sessions

Dynamic Field Theory and Applications 1.
Date: Monday, 10h00

Organizers: Wolfram Erlhagen (Wolfram.erlhagen@mct.uminho.pt), Anwar Hussein (anwarh@mct.uminho.pt)

DFTA 1.1.
Authors: Stephen Coombes (School of Mathematical Sciences, University of Nottingham, Nottingham, NG7 2RD, UK)

Title: Bumps, breathers, and waves in a neural network with threshold accommodation

Abstract: Many of the equations describing the dynamics of neural systems are written in terms of firing rate functions, which themselves are often taken to be threshold functions of synaptic activity. Dating back to work by Hill in 1936 it has been recognized that more realistic models of neural tissue can be obtained with the introduction of state-dependent dynamic thresholds. In this talk I will discuss a specific phenomenological model of threshold accommodation that mimics many of the properties originally described by Hill. Importantly I will show how to explore the consequences of this dynamic threshold at the tissue level, by modifying a standard neural field model of Wilson-Cowan type. As in the case without threshold accommodation classical Mexican-Hat connectivity is shown to allow for the existence of spatially localized states (bumps) in both one and two dimensions. Importantly an analysis of bump stability in one dimension, using recent Evans function techniques, shows that bumps may undergo instabilities leading to the emergence of both breathers and traveling waves. Moreover, a similar analysis for traveling pulses leads to the conditions necessary to observe a stable traveling breather. In the regime where a bump solution does not exist direct numerical simulations show the possibility of self-replicating bumps via a form of bump splitting. Simulations in two space dimensions show analogous localized and traveling solutions to those seen in one dimension. Indeed dynamical behavior in this neural model appears reminiscent of that seen in other dissipative systems that support localized structures, and in particular those of coupled cubic complex Ginzburg-Landau equations. Further numerical explorations illustrate that the traveling pulses in this model exhibit particle like properties, similar to those of dispersive solitons observed in some three component reaction-diffusion systems.

Keywords: neural field models; pattern formation;

References: [1] S. Coombes and M.R. Owen, Exotic dynamics in a firing rate model of neural tissue with threshold accommodation, AMS Contemporary Mathematics 440 "Fluids and Waves: Recent Trends in Applied Analysis", (Ed. Fernanda Botelho, Thomas Hagen, and James Jamison), 123-144 (2007) http://eprints.nottingham.ac.uk/457/
[2] S. Coombes and M.R. Owen, Bumps, breathers, and waves in a neural network with spike frequency adaptation, Physical Review Letters 94 (2005) 148102. http://eprints.nottingham.ac.uk/149/

DFTA 1.2.

Authors: John Wyller (Department of Mathematical Sciences and Technology, Norwegian University of Life Sciences, P.O.Box 5003, N-1432 NORWAY)

Title: Bumps in a two - population neuronal field model

Abstract: We review the properties of a two population neuronal field model of the Wilson - Cowan type investigated in Blomquist et al [1] and Wyller et al [2]. The model is characterized by different firing threshold values for the excitatory and the inhibitory population. The first part of the talk will be devoted to the study of the existence and stability of bumps in the Heaviside limit of the firing rate functions [1]. It turns out that the generic picture consists of two pulse pairs for each set of threshold values, a 'narrow' one and a 'broad one'. The narrow one turns out to be unstable for all relative inhibition times, while the broad one is stable for small and moderate values of the relative inhibition times and is converted to a breather due to a Hopf - type of bifurcation as the relative inhibition time exceeds a certain threshold. The second part of the talk will deal with pattern formation due to a Turing type of instability mechanism [2]. It is demonstrated that for steep firing rate functions we get patterns consisting of spatial oscillations which looks similar to the bumps obtained in the Heaviside limit, while the shallow firing rate regime produces spatio - temporal oscillations. The final part of the talk is devoted to some preliminary results regarding the stability of bumps when the temporal kernels of the network are modeled by means of a - functions.

Keywords: Neural field models; existence and stability of bumps; pattern formation

References: [1] P. Blomquist, J. Wyller and G.T. Einevoll, Localized activity patterns in two-population neuronal network, Physica D, 206, 180–212, (2005). (http://arken.umb.no/ gautei/forskning/blomquist-2005.pdf)
[2] J. Wyller, P. Blomquist and G.T. Einevoll, Turing instability and pattern formation in a two-population neuronal network, Physica D, 225,75–93 (2007). (http://arken.umb.no/ gautei/forskning/wyller-2007.pdf)

Dynamical Systems 1.

Date: Monday, 10h00

Organizers: Alberto Adrego Pinto (aapinto@math.uminho.pt), Maria Joana Torres (jtorres@math.uminho.pt), Salvatore Cosentino (scosentino@math.uminho.pt)

DS 1.1.

Authors: Mike Todd (FCUP, Portugal)

Title: Multifractal analysis for multimodal maps

Abstract: Let $f : I \to I$ be a C map of the interval I with critical points. Given an equilibrium state μ_φ for a Hölder potential $\varphi : I \to R$, the local dimension $d_{\mu_\varphi}(x)$ measures how concentrated μ_φ is at this point. The dimension spectrum encodes the Hausdorff dimension of level sets of d_{μ_φ}. This spectrum can be understood via induced maps (X, F), where $F = f^t$ for some inducing time t. A major challenge for maps with critical points is to find inducing schemes which 'see' a sufficiently large subset of the space. In this talk I will explain how this problem can be overcome, and hence that the dimension spectrum is encoded by a function related to the pressure of some potentials involving φ. These results apply to Collet-Eckmann maps, as well as to maps with weaker growth conditions.

DS 1.2.

Authors: Alejandro Kocsard (IMPA Rio de Janeiro, Brasil)

Title: First cohomology group and invariant distributions

Abstract: Let $\Gamma : G \times M \to M$ be a smooth action of the Lie group Γ on a closed differentiable manifold M. A map $A : G \times M \to R$ is said to be a cocycle over Γ when it satisfies

$$A(hg, x) = A(h, \Gamma(g, x)) + A(g, x), \qquad \forall g, h \in G, \forall x \in M.$$

On the other hand, a cocycle A is called a coboundary if there exists $u : M \to R$ verifying

$$A(g, x) = u(\Gamma(g, x)) - u(x), \qquad \forall g \in G, \forall x \in M.$$

This kind of objects appears very naturally in different contexts in dynamics. Indeed, a lot of questions about the dynamical properties of Γ, especially those on rigidity, can be reduced to determine whether a given cocycle is a coboundary. In this lecture we shall discuss several aspects of this problem and talk about the necessity of studying the space of Γ-invariant distributions (in Schwartz' sense) when we are trying to determine the structure of the first *cohomology group* of Γ, i.e. the quotient space of cocycles modulo coboundaries. Finally, we will talk about cohomological rigidity, presenting some examples and discussing some recent results about classification of cohomologically rigid $R-$ and $Z-$actions on low dimensional manifolds.

DS 1.3.

Authors: Ana Cristina Moreira Freitas (CMUP and FEP) and Jorge Milhazes Freitas, Mike Todd (CMUP)

Title: Statistical properties of the maximum for non-uniformly hyperbolic dynamics

Abstract: We consider discrete time non-uniformly hyperbolic dynamical systems and study extreme value laws, that is, the asymptotic distribution of the partial maximum of observable random variables evaluated along the orbits of the systems. We show that there is a close link between extreme value laws and the laws for the hitting time statistics. This enables us to use techniques from one context to obtain results in the other. In particular, we prove that any multimodal interval map with an absolutely continuous invariant measure must satisfy the classical extreme value laws, which generalizes the work of Collet (2001) on Gumbel's law for unimodal maps with exponentially decay of correlations.

Keywords: Return Time Statistics, Extreme Value Theory, Non-uniform hy- perbolicity, Interval maps.

References: [1] P. Collet, Statistics of closest return for some non-uniformly hyperbolic systems, Ergodic Theory & Dynamical Systems, 21, 401-420 (2001)

DS 1.4.

Authors: Ana Margarida Rodrigues (IUPUI Indianapolis, USA)

Kinetic Theory and Applications.

Date: Monday, 10h00

Organizer: Ana Jacinta Soares (ajsoares@math.uminho.pt)

KTA 1.

Authors: Simone Calogero (U. Granada, Spain)

Title: The relativistic Fokker-Planck equation

Abstract: There is a huge physical and mathematical literature on the classicalÊ Fokker-Planck equation, but very little has been done on its relativistic counterpart. This situation is quite surprising, as for certain applications of the Fokker-Planck dynamics (e.g., in plasma physics), relativistic effects can hardly be neglected. To remedy this gap in the literature, we initiate here the mathematical study of a relativistic Fokker-Planck equation. Unfortunately it seems that no agreement has been reached yet on the precise form of this equation.Ê Therefore we start by proposing a plausible (in our opinion) argument to justify the relativistic Fokker-Planck equation considered in this talk. We then proceed by proving that homogeneous solutions converge exponentially fast in time to the Jüttner equilibrium distribution.
This talk is based on a joint work (in progress) with Juanjo Nieto, Ê Óscar Sánchez and Juan Soler (University of Granada).

KTA 2.

Authors: Manuel Portilheiro (U. Autónoma de Madrid, Spain)

Title: A Fourier transform method for relaxation of kinetic equations

Abstract: I will describe a new method based on the Fourier transform to obtain a relaxation limit of the Boltzmann-Poisson system for electron density. The relaxion will be obtained for two different scalings: the *low field scaling* and the *drift-colision balance scaling*, corresponding to two different regimes of the equation. To introduce the method and the weak sense of solution (disipative solutions), I will start with the example of a two velocity toy model.

Keywords: R

elaxation of kinetic systems; weak solutions; dissipative solutions;
AMS codes:3

5L65; 78A40, 82C40;

References: [1] Manuel Portilheiro, Weak Solutions for equations defined by accretive operators. I, Proceedings of the Royal Society of Edinburgh, 133, 1193–1207 (2003).
[2] Manuel Portilheiro, Weak Solutions for equations defined by accretive operators. II, Relaxation limits, Journal of Differential Equations, 195, 66–81 (2003).
[3] Manuel Portilheiro and Athanasios Tzavaras, Hydrodynamic limits for kinetic equations and the diffusive approximation of radiative transport for acoustic waves, Transactions of the American Mathematical Society, 395, 529–565 (2007).

KTA 3.

Authors: Fabio Chalub (U. Nova de Lisboa, Portugal)

Title: Continuous models for genetic evolution in large populations

Abstract: We start from discrete evolutionary models in finite populations. Namely, we use the Wright-Fisher process for n different phenotypes. In the limit of large population, we obtain a partial differential equation for the evolution of the distribution of probability among the n phenotypes. This equation has degeneracies in the boundaries. It also divides in two parts, representing two natural processes: one for the natural selection and the other for the genetic drift. We analyze it and show its compatibility with other models in the literature.
This is a joint work with M. O. Souza.

KTA 4.

Authors: Filipe Oliveira (U. Nova de Lisboa, Portugal)

Title: An H-Theorem for Chemically Reacting Gases

Abstract: The trend to equilibrium of a quaternary mixture undergoing a reversible reaction of bimolecular type is studied in a quite rigorous mathematical picture within the framework of Boltzmann equation extended to chemically reacting gases. A characterization of the reactive summational collision invariants, equilibrium Maxwellian distributions and entropy inequality allow to prove two main results under the assumption of uniformly boundedness and equicontinuity of the distribution functions. One of the results establishes the tendency of the reacting mixture to evolve to an equilibrium state as time becomes large. The other states that the solution of the Boltzmann equation for chemically reacting mixture of gases converges in strong L^1-sense to its equilibrium solution.
This is a joint work with Gilberto M. Kremer and Ana Jacinta Soares.

Keywords: Boltzmann equation; Reacting gases; Trend to equilibrium.

AMS codes:76P05; 80A32; 82C40; 35B35

KTA 5.

Authors: Ana Jacinta Soares (U. Minho, Portugal)

Title: Kinetic theory for chemical reactions without a barrier

Abstract: In the literature of the Boltzmann equation (BE) extended to chemically reacting gases [1], only few works consider reactive processes without a barrier but the corresponding collision terms are restricted to some particular chemical regimes for which no significant changes are needed at the model level [2]. On the other hand, chemical reactions without a barrier are of great interest in many engineering applications of reactive flows and other processes arising in organic chemistry, chemical physics and biophysics [3, 4]. Accordingly, a new model of the BE for binary reactive mixtures is here proposed with the aim of describing symmetric reversible reactions without a barrier, assuming appropriate reactive cross sections without activation energy and introducing suitable improvements in the elastic and reactive collision terms. The resulting model assures the correct balance equations and law of mass action, as well as good consistency properties for what concerns equilibrium and entropy inequality. Moreover different chemical regimes of slow and fast reactions can be described by means of the proposed model.
This is a joint work with Giselle M. Alves and Gilberto M. Kremer.

Keywords: Kinetic theory; Mathematical modeling of fluids; Chemically reacting mixtures; Reaction effects

AMS codes:76P05; 76V05; 80A32; 82B40 82C40

References: [1] V. Giovangigli, Multicomponent Flow Modeling. Birkhauser, Boston (1999).
[2] B.D. Shizgal and A. Chikhaoui, On the use temperature parameterized rate coefficients in the estimation of non-equilibrium reaction rates, Physica A, vol. 365, pp. 317-332 (2006).
[3] J.P. Hessler, New empirical rate expressions for reactions without a barrier: Analysis of the reaction of CN with O2, J. Chem Phys., vol. 111, pp. 4068- 4076 (1999).

Dynamics and Biology 1.

Date: Monday, 16h00

Organizers: Gabriela Gomes (ggomes@igc.gulbenkian.pt), Bruno Oliveira (bmpmo@fcna.up.pt), Nico Stollenwerk (nico@igc.gulbenkian.pt)

DB 1.1.

Authors: Bruno Oliveira (U. Porto, Portugal), N. J. Burroughs (U. Warwick, UK), A. A. Pinto (U. Minho, Portugal), M. Ferreira (U. Minho, Portugal)

Title: Stability analysis of a model of local immune responses with regulatory T cells

Abstract: The primary function of the immune system is the protection of the host from pathogen invasion. During such an invasion, T cells under exposure to their specific antigen are activated leading to secretion of growth cytokines (predominantly interleukine 2, denoted IL2), and expression of the IL2 receptor which triggers cytokine driven proliferation. Under most circumstances, the immune system is able to successfully remove the pathogen. However, the immune system may also target self antigens (autoimmunity) and cause tissue damage and death. Regulatory T cells (Tregs) limit such autoimmune responses by growth inhibition of T cells. Therefore, the immune system has to achieve a delicate balance between appropriate immune activation and immune response suppression. How such a balance is established and controlled is studied in this presentation. Our motivation is the observation that T cell proliferation through cytokines already has such a control structure; cytokine driven growth exhibits a quorum population size threshold. We propose that Tregs locally adjust these thresholds by inhibiting IL2 secretion. The immune response-suppression axis is then a balance between the local numbers of activated T cells and activated Tregs. We study the effects in the quorum T cell population thresholds by the parameters of the model and we describe the equilibria manifold in a neighbourhood of the default values for the parameters and variables.

Keywords: Immunology, Tregs, cytokines, secretion inhibition, growth model, quorum threshold, ODE model.

References: [1] R. J. de Boer and P. Hogeweg, Immunological discrimination between self and non-self by precursor depletion and memory accumulation. Journal of Theoretical Biology 124 343 (1987).
[2] N.J. Burroughs, B. M. P. M. Oliveira and A. A. Pinto, Regulatory T cell adjustment of quorum growth thresholds and the control of local immune responses. Journal of Theoretical Biology 41 134–141 (2006).

[3] S. Sakaguchi. Naturally arising CD4+ regulatory T cells for immunological selftolerance and negative control of immune responses. Annual Review of Immunology 22, 531 (2004).
[4] A. M. Thornton and E. M. Shevach, CD4+CD25+ immunoregulatory T cells suppress polyclonal T cell activation in vitro by inhibiting interleukine 2 production. Journal of Experimental Medicine 188, 287 (1998).

DB 1.2.

Authors: José Martins (Leiria, Portugal), Alberto A. Pinto (U. Minho, Portugal) and Nico Stollenwerk (U. Lisboa, Portugal)

Title: Stable equilibria in moment closure and stochastically quasi-stable equilibria in SIS model

Abstract: In this work we study for the SIS model, also known as the birth-death process, the dynamics of the higher moments of infected. From the master equation of the process, we deduce the dynamic equations for the moments and to close these equations we use a recursive process that consists in applying the moment closure technique to approximate the higher moments by lower ones. The first approximation, and the simplest, is the mean field approximation. Under this approximation, the model exhibits a poor behavior and it is not satisfactory. Considering two moments, we use the Gaussian approximation and we observe some unbiological regions that can be understood as limitations of the model. Considering more moments, we observe the critical value of the infection rate ß increasing and computing the stationary states, in the moment closure approximation, we approach the quasi-stationary states of the SIS model.

Keywords: Stochastic processes; SIS model; Moment closure; Quasi-stationary states.

DB 1.3.

Authors: Ricardo Águas, Lisa White, Robert Snow, Gabriela Gomes (Instituto Gulbenkian de Ciência, Portugal)

Title: Prospects for malaria eradication in sub-Saharan Africa

Abstract: A characteristic of Plasmodium falciparum infections is the gradual acquisition of clinical immunity resulting from repeated exposures to the parasite. While the molecular basis of protection against clinical malaria remains unresolved, its effects on epidemiological patterns are well recognized. Accumulating epidemiological data constitute a valuable resource that must be intensively explored and interpreted as to effectively inform control planning. We apply a mathematical model to clinical data from eight endemic regions in sub-Saharan Africa. The model provides a quantitative framework within which differences in age distribution of clinical disease are assessed in terms of the parameters underlying transmission. The shorter infectious periods estimated for clinical infections induce a regime of bistability of endemic and malaria-free states in regions of mesoendemic transmission. The two epidemiological states are separated by a threshold that provides a convenient measure for intervention design. Scenarios of eradication and resurgence are simulated. In regions that support mesoendemic transmission, intervention success depends critically on reducing prevalence below a threshold which separates endemic and malaria-free regimes.

DB 1.4.

Authors: Sander van Noort, Marta Nunes, Gareth Weedal, Gabriela Gomes (Instituto Gulbenkian de Ciência, Portugal)

Title: Variant surface antigen repertoire of Plasmodium falciparium shaped by two-level

Abstract: The evolutionary mechanisms by which pathogens evade immune responses to establish chronic and repeated infections pose major challenges to theoretical research. In Plasmodium falciparum, the erythrocyte membrane protein 1 (PfEMP1) family are important virulence factors and targets of host antibody response. Transcriptional switching between the 60 var genes encoding PfEMP1 permits antigenic variation and immune evasion. Molecular and serological studies implicate a relatively conserved subset of these proteins expressed in patients with severe forms of malaria, while more polymorphic groups relate to uncomplicated malaria. These observations motivate the development of syndrome specific vaccines against severe forms of malaria. Here we formulate an evolutionary mechanism that shapes the repertoire of parasite genes and host antibodies in agreement with the observations. We construct a mathematical model that combines within-host competition and between-host transmission, and introduce the notion of dominance to characterise the within-host competitive potential of specific variant surface antigens (VSAs). The model predicts a bimodal frequency distribution of variants permitting the identification of a small group of genes encoding VSAs with superior within-host competitive ability, and a more diverse group encoding low-dominance VSAs that are able to evade the immunity evoked in the host population. A monotonic VSA dominance profile generates two opposing selective forces and, consequently, two distinct groups of genes emerge in adaptation to naïve and partially immune hosts, respectively.

Dynamic Field Theory and Applications 2.

Date: Monday, 16h00

Organizers: Wolfram Erlhagen (Wolfram.erlhagen@mct.uminho.pt), Anwar Hussein (anwarh@mct.uminho.pt)

DFTA 2.1.

Authors: Nicolas Rougier and Axel Hutt (INRIA Lorraine, France)

Title: Synchronous and Asynchronous Integration of Dynamic Neural Fields

Abstract: In [1], we've introduced a dynamic model of visual attention based on the Continuum Neural Field Theory [2] that explained attention as being an emergent property of a dynamic neural field. The fundamental property of the model is its facility to select a single stimulus out of several perfectly identical input stimuli. In the absence of external noise and with a zero initial state, the theoretical mathematical solution of the field equation predicts the final equilibrium state to equally represent all of the input stimuli. This finding is valid for synchronous numerical computation of the system dynamics where elements of the spatial field are computed all together at each time point. However, asynchronous computation, where elements of the spatial field are iterated in time one after the other yields different results leading the field to move towards a single stable input pattern. This behavior is in fact quite similar to the effect of noise on dynamic fields.

The present work aims at studying this phenomenon in some details and characterizes the relation between noise, synchronous evaluation (the regular' mathematical integration) and asynchronous evaluation in the case of a simple dual-particle system. More generally, we aim at explaining the behavior of a differential equation system when it is considered as a set of particles that may or may not iterated by synchronous computations.
PACS: 02.30.Hq, 07.05.Mh, 84.35.+i

Keywords: Synchronous computation, Asynchronous computation, Dynamic Neural Fields

References: [1] Rougier, N. and Vitay, J. Emergence of attention within a neural population. Neural Networks, 19(5):573-581 (2006).
[2] Taylor, J. G. Neural bubble dynamics in two dimensions: foundations. Biological Cybernetics, 80, 393-409 (1999).

DFTA 2.2.

Authors: Anwar Hussein (U. Minho, Portugal)

Title: Traveling pulse solutions in a neural field model with asymmetric connectivity functions

Abstract: In this talk I will analyse the activity of a one-dimensional neural field model developed by Amari [1]. His approach was to analyse a homogeneous neural field with a symmetric connection function of lateral inhibition type resulting in stationary pulse solutions. Here I will show that if the connection function is asymmetric, then the neural fieled may exhibit travelling pulse solutions. I will construct travelling pulse solutions for the case of a Heaviside step function for which I will derive the shape and velocity of the pulses. I will further determine the necessary conditions for the stability of the travelling pulses using Evans function techniques.

References: [1] S. Amari. Dynamics of pattern formation in lateral inhibition type neural fields. Biological Cybernetics, 27:77–87, 1977.
[2] S. Coombes and M. R. Owen. Evans functions for integral neural field equations with Heaviside firing rate function. SIAM Journal on Applied Dynamical Systems, 34:574–600, 2004.

Dynamical Systems in Gravitation 1.

Date: Monday, 16h00

Organizer: Filipe Mena (fmena@math.uminho.pt)

DSG 1.1.

Authors: Ana Nunes (CFTC Univ. Lisboa, Portugal)

Title: The set of planar orbits of second species

Abstract: We present a numerical study of the set of orbits of the planar circular restricted three body problem which undergo consecutive close encounters with the small primary, or orbits of second species. The value of the Jacobi constant is fixed, and we restrict the study to consecutive close encounters which occur within a fixed time interval. With these restrictions, the full set of orbits of second species is found numerically from the intersections of the stable and unstable manifolds of the collision singularity on the surface of section that corresponds to passage through the pericenter. A 'skeleton' of this set of curves can be computed from the solutions of the two-body problem. The set of intersection points found in this limit corresponds to the S-arcs and T-arcs of Hénon's classification which verify the energy and time constraints, and can be used to construct an alphabet to describe the orbits of second species. We give numerical evidence for the shift on this alphabet that describes all the orbits with infinitely many close encounters with the small primary, and sketch a proof of the symbolic dynamics. In particular, we find periodic orbits that combine S-type and T-type quasi-homoclinic arcs.

DSG 1.2.

Authors: Simone Calogero (U. Granada, Spain)

Title: Dynamical Systems in Cosmology

Abstract: We employ dynamical systems tecnhiques to study the asymptotic behaviour of Bianchi I solutions of the Einstein equations with anisotropic matter. The matter model is not specified explicitely, but only through a set of mild and physically motivated assumptions. There are different possible scenarios for the past and future asymptotics of solutions, which we are able to classify in terms of a single parameter β that describes the property of the matter model in the limit towards the initial singularity. Examples of matter models which are covered by our analysis are collisionless matter, described by the Vlasov equation, and elastic matter for a wide variety of constitutive equations of state.

DSG 1.3.

Authors: José Pedro Mimoso (FC- U. Lisboa, Portugal)

Title: The Dynamics of Scalar Fields in Cosmology

Abstract: Scalar field models have been a focal point in cosmology during the last two decades or so. They play a central role in inflationary models, they arise in modified gravity theories that extend Einstein's General Relativity (GR) which are, often, quantum motivated, and, recently, they have been put forward as a dark component of the universe. Here we analyse their dynamics in the framework of isotropic cosmologies presenting an unified approach that encompasses models both in Eintein's GR and more general metric gravity theories. We also envisage the possible existence of an internal space in the case of multi-fields models. We perform a qualitative analysis of the major dynamical features of these models, discussing the existence of asymptotic regimes and their connection to a classification of the scalar fields potentials. A special interest is devoted to the interplay between scalar fields and matter which gives rise to scaling behaviour.

DSG 1.4.

Authors: Dulce Pinto (Univ. Minho, Portugal)

Title: Numerical stability of Polydeuces

Abstract: The stability of the recently discovered Saturn satellite Polydeuces has not been fully studied yet. We use data from the Cassini probe group (NASA and Queen Mary, London) in order to numerically study the stability of the orbit of Polydeuces. We treat the system Saturn-Dione-Polydeuces as a planar, circular, restricted three body problem where Polydeuces is librating around the L_5 Lagrangian point in a tadpole motion. We analyze the eccentricity evolution of Polydeuces trajectory, the Poincaré section and the indicator of its maximum Lyapounov characteristic exponent. Our results suggest that the Polydeuces orbit is stable for at least 10^5 Dione-years.

Dynamic Field Theory and Applications 3.

Date: Tuesday, 10h00

Organizers: Wolfram Erlhagen (Wolfram.erlhagen@mct.uminho.pt), Anwar Hussein (anwarh@mct.uminho.pt)

DFTA 3.1.

Authors: Gregor Schöner (Bochum, Germany)

Title: Dynamic Field Theory as a conceptual framework for understanding embodied cognition

Abstract: Understanding embodied and situated cognition means understanding how cognitive processes are closely linked to sensory and motor processes and depend on the behavioral and environmental context in which they unfold. Such understanding must be based on principles of neural function. Although neurons are discrete units, that discreteness is unrelated to discreteness in behavior, such as when people respond categorically to stimulus or task continua. Similarly, the discrete time structure of neural spiking events is unrelated to discrete behavioral events, such as the initiation of a motor act. The neuronal level of description appropriate for understanding behavior is thus spatio-temporally continuous. Dynamical field theory is a neurally inspired theoretical framework which accounts for how decision events emerge from continuous time processes, how cognitive functions emerge from neuronal interaction, and how experience structures behavior [1]. The talk will illustrate these ideas through examples from movement planning [2], working memory and discrimination [3] and simple forms of robotic perception and cognition [4].

Keywords: neuronal dynamics; autonomous robotics

References: [1] Schöner, G.: Dynamical Systems Approaches to Cognition. In: The Cambridge Handbook of Computational Psychology, Ron Sun, (ed.), Cambridge University Press (2008), pages 101-126
[2] Erlhagen, W., Schöner, G.: Dynamic field theory of movement preparation Psychological Review 109: 545-572 (2002)
[3] Johnson, J.S., Spencer, J.P., Schöner, G.: Moving to higher ground: The dynamic field theory and the dynamics of visual cognition. New Ideas in Psychology (in press, 2008)
[4] Faubel, C., Schöner, G.: Learning to recognize objects on the fly: a neurally based Dynamic Field approach. Neural Networks (in press, 2008)

DFTA 3.2.

Authors: Raymond Cuijpers (Radboud University, The Netherlands), Wolfram Erlhagen (U. Minho, Portugal), Ruud G.J. Meulenbroek (Radboud University, The Netherlands)

Title: Bayesian decision making using neural fields

Abstract: Bayesian statistics has become a popular framework in various fields of experimental psychology such as signal detection theory, speech recognition, cue integration and decision making. However, it is still an open question how the human brain actually incorporates this functionality. One assumption is that the activities of populations of neurons encode probability distributions. Indeed, it has been shown that probabilistic decoding of neuronal activities can be used to predict overt behavior in rat [5] and monkey [1]. However, in order to make statistically optimal decisions it is not only necessary to represent probability distributions, but also to transform likelihoods into beliefs (via Bayes' rule) and propagate beliefs between different levels of representation (via the marginalisation rule). Unlike biological neurons, Bayesian statistics does not involve any temporal dynamics. For example, Bayes' rule will fail for temporally misaligned signals. There are several theoretical extensions like hidden Markov models and dynamic Bayesian networks that remedy this situation, but again it is unclear how such mechanisms could be incorporated in the human brain. Another approach is to implement decision making using neural fields, which have been applied successfully for explaining behavioural data [2,6] and, in robotics, for dealing with complex uncertain environments [4]. Neural fields posses spatial structure and temporal dynamics similar to biological neural populations and, thus, provide temporal dynamics in a natural way.However, they do not necessarily incorporate Bayesian statistics. Here we show how two fundamental statistical laws (Bayes' rule and the marginalisation rule) can be implemented using neural fields.

The result is a truly dynamic framework capable of Bayesian decision making, which is biologically plausible and which can easily be extended with non-Bayesian mechanisms such as learning and memory. We also show how this can be used in a model of goal inference and joint reasoning [3] in which Bayesian statistics is used to model decision making.

Keywords: Bayesian statistics; neural fields; decision making; goal inference

References: [1] Cisek P.: Integrated neural processes for defining potential actions and deciding between them: a computational model. J. Neurosci. 26, 9761-9770 (2006)
[2] Cuijpers R.H., Schie H.T. van, Koppen M., Erlhagen W., Bekkering H.: Goals and means in action observation: a computational approach. Neural Networks 19, 311-322 (2006)
[3] Erlhagen W., Mukovskiy A., Bicho E.: A dynamic model for action understanding and goal-directed imitation. Brain Res. 1083, 174-188 (2006)
[4] O'Keefe J., Dostrovsky J.: The hippocampus as a spatial map: Preliminary evidence from unit activity in the freely-moving rat. Brain Res. 34, 171-175 (1971)
[5] Wilimzig C., Schneider S., Schöner G.: The time course of saccadic decision making: Dynamic field theory. Neural Networks 19, 1059-1074 (2006)

DFTA 3.3.

Authors: Jorge Ibañez (UAM, Spain)

Title: Towards a dynamic field model of inhibition of return

Abstract: INTRODUCTION Reaction times tend to be longer than usual for stimuli that appear a certain time interval after a cue at the same peripheral location as the cue (Posner & Cohen, 1984). This effect is called inhibition of return (IOR). Explanations of IOR often invoke attentional processes, and sometimes also the linking of representations of stimuli and responses. Our goal is to develop a more ecological/dynamical approach in which IOR is seen as an emergent property of sensori-motor processing.

As a first step in this direction, we performed two experiments that differ from most of IOR experiments in that cues and targets could appear at slightly different positions, allowing us to test whether IOR is spatially continuous. This is important because such a spatial continuity is one of the hallmarks of the dynamic model that we aim to apply. Furthermore, the to-be-collected data will allow us to develop the model.
MATERIAL AND METHODS We measured reaction times for cued and uncued targets. In Exp 1, cued targets appeared at one of two locations: at the same location as the cue or just next to that location. In Exp 2, the spatial cue-target relation was sampled randomly. As in most of IOR experiments, we used several cue-target onset asynchronies (CTOAs).
RESULTS IOR was observed in both experiments. Exp 1 showed that the effect is slightly weaker for targets appearing just next to the cued location. Exp 2 revealed a spatial continuity of the effect and provided a quantification of the dependence of the effect on the spatial cue-target relation. In agreement with previous results, both experiments showed that the effect depends continuously on the temporal cue-target relation (i.e., on the CTOAs).
DISCUSSION The continuous dependence of IOR on the spatiotemporal structure of the cue- target relation provides support for the use of dynamic models, because these models are often defined over continuous spaces. We,therefore ,choose to adapt the dynamic field model for movement initiation proposed by Erlhagen and Schoner (2002). In our version of the model, an activation function is defined over a continuous space that represents the different spatial cue-target relations. The main activation function interacts with additional activation functions that represent sensory inputs and observers' predispositions. A response is triggered when the main activation function reaches a threshold value. We are currently trying to achieve a formulation of the model in which IOR and its spatiotemporal characteristics emerge from the interactions among the different elements in the model. It is our belief that such a model would be a useful addition to the typically more cognitive literature on IOR.

References: Erlhagen & Schöner. (2002). Dynamic field theory of movement preparation. Psych Rev, 109, 545-572.
Posner & Cohen. (1984). Components of visual orienting. In Attention and performance Vol. X. (Bouma & Bouwhuis, eds). Erlbaum.

DFTA 3.4.

Author: Alexandre Gepperth (Honda Research Institute, Germany)

Title: Neuro-dynamic systems for real-world computation

Abstract: I present a design concept for intelligent and robust real-world systems focusing on the universal exchangeability of information between different system parts or modules. This leads to consequences including the need for a common representational format (for which I propose a population coding approach), a common system-wide learning algorithm (e.g., simple variant of Hebbian learning) and a flexible fusion and decision making method (for which I suggest dynamic neural fields). Such neuro-dynamic systems can be used to perform a wide range of cognitive functions. I will present two system instances which support this view by demonstrating robust real-world functionality ([1],[2]). One system performs cue fusion, improving the robustness of an object classifier by combining different feature cues in an adaptive and flexible way. The second presented system implements a short-term memory for high-level features, realizing dynamic binding and disambiguation functionalities. Both systems heavily rely on the competitive properties of neural fields for performing binding, fusion and disambiguation, whereas synaptic plasticity is employed for storing large amounts of acquired knowledge in a systematic and persistent way. The talk is concluded by an outlook on future investigations, namely using neuro-dynamic systems in autonomous agents, especially in the domain of intelligent vehicles.

References: [1] Cross-module learning as a first step towards a cognitive system concept. First International Conference on Cognitive Systems, 2008.
[2] A neuro-dynamic memory architecture for short-term feature binding capable of real-world operation. Neural Information Processing Systems (NIPS) 2008, submitted.

Dynamical Systems 2.

Date: Tuesday, 10h00

Organizers: Alberto Adrego Pinto (aapinto@math.uminho.pt), Maria Joana Torres (jtorres@math.uminho.pt), Salvatore Cosentino (scosentino@math.uminho.pt)

DS 2.1.

Authors: Vitor Araujo (UFRJ, Brasil)

Title: Multidimensional Rovella-like singular attractors

Abstract: In a joint work with A. Castro, M. Pacifico and V. Pinheiro we present a multidimensional flow exhibiting a Rovella-like attractor: a partially hyperbolic transitive invariant set with a non Lorenz-like singularity accumulated by regular orbits. Moreover, this attractor has a physical measure with full support which is a u-Gibbs state. As in the 3-dimensional Rovella-like attractor, this example is not robust. The construction introduces a natural class of multidimensional dynamics to which the Benedicks-Carleson arguments can be applied to get persistent non-uniform expansion along the multidimensional central direction.

DS 2.2.

Authors: A. Pinto (Univ. do Minho), J.P. Almeida (U. Minho, Portugal), A. Portela (Univ. de Montevideo)

Title: Golden Tilings

Abstract: A. Pinto and D. Sullivan [3] proved a one-to-one correspondence between: (i) C^{1+} conjugacy classes of expanding circle maps; (ii) solenoid functions and (iii) Pinto-Sullivan's dyadic tilings on the real line. Here, we prove a one-to-one correspondence between: (i) golden tilings; (ii) smooth conjugacy classes of golden diffeomorphism of the circle that are fixed points of renormalization; (iii) smooth conjugacy classes of Anosov difeomorphisms, with an invariant measure absolutely continuous with respect to the Lebesgue measure, that are topologically conjugated to the Anosov automorphism $G(x, y) = (x+y, x)$ and (iv) solenoid functions. The solenoid functions give a parametrization of the infinite dimensional space consisting of the mathematical objects described in the above equivalences. In this case, the expanding dynamics are hidden in the renormalization operator that acts on the minimal set. The link between Anosov diffeomorphisms and diffeomorphisms of the circle, that are smooth fixed points of renormalization, is due to D. Sullivan and E. Ghys. The renormalization operator appears inspired in the works of Feigenbaum and Lanford.

Pinto-Rand [2] proved the equivalence between (i) and (ii). Here, we present the renormalization in a new way, using the construction of a train-track, as an intermediate step (see also Pinto-Rand [2]). The train-track appears as in the works of Thurston, Penner, Williams and Veech, but with a new and relevant feature that corresponds to have a C^{1+} structure associated to it. Here we explicit the definition of golden tilings. The properties of the golden tilings are described using a Fibonacci decomposition for the natural numbers.

References: and Literature for Further Reading

[1] A. A. Pinto, J. P. Almeida, A. Portela, Golden tilings, submitted.
[2] A. A. Pinto, D. Rand, Renormalisation gives all surface Anosov diffeomorphisms with a smooth invariant measure, submitted.
[3] A. A. Pinto, D. Sullivan, The circle and the solenoid, Dedicated to A. Katok on the occasion of his 60th birthday, DCDS-A, 16 (2), 463-504, (2006).

DS 2.3.

Authors: Jorge Milhazes Freitas, Mike Todd (CMUP)

Title: Statistical stability for equilibrium states

Abstract: We consider multimodal interval maps with at least polynomial growth of the derivative along the critical orbit. For these maps Bruin and Todd showed the existence and uniqueness of equilibrium states for the potential $\varphi_t : x \to -t \log |Df(x)|$, for t close to 1. We show that for certain families of this type of maps the equilibrium states vary continuously in the weak* topology, when we perturb the map within the respective family. Moreover, in the case $t = 1$, when the equilibrium states are absolutely continuous with respect to Lebesgue, we show that the densities also vary continuously in the L_1-norm.

Keywords: Statistical stability; equilibrium states.

References:

[BT] H. Bruin, M. Todd, Equilibrium states for interval maps: the potential - $t \log |Df|$, Preprint, arXiv:0704.2199.
[FT] J.M. Freitas, M. Todd, Statistical stability of equilibrium states for interval maps, Preprint, arXiv:math/0709.1395.

DS 2.4.

Authors: Miguel Mendes (FEUP, Portugal)

Title: Codings of trajectories in certain discontinuous map

Abstract: We study certain discontinuous maps by means of a coding map which is based on a special partition of the phase space. This partition is such that the discontinuous points of the map all belong to the union of the boundaries of the elements in the partition. Given a compact phase space our results follow two different directions. For piecewise homeomorphisms we prove that, if the set of points whose trajectory 1comes arbitrarily close to the set of discontinuous points is not the full space then all points not in that set are rationally coded, i.e., their codings eventually settle on a repeated block. In the specific context of piecewise isometries, which are discontinuous maps acting locally as isometries, we give a topological description of the equivalence classes of the coding map in terms of the connected components generated by the preimages of the discontinuity set.

Dynamical Systems in Gravitation 2.

Date: Tuesday, 10h00

Organizer: Filipe Mena (fmena@math.uminho.pt)

DSG 2.1.

Authors: Tiago Charters (CFCT and ISEL Lisboa, Portugal)

Title: Post-inflationary scalar field phase dynamics

Abstract: We study a simple model of a massive inflaton field ϕ coupled to another scalar filed χ with interaction term $g^2\phi^2\chi^2$ for the first stage of preheating to give a full description of the dynamics of the χ field modes, including the behaviour of the phase, in terms of the iteration of a simple family of circle maps.

DSG 2.2.

Authors: Irene Brito (U. Minho, Portugal)

Title: General Relativistic Elasticity - Statics and Dynamics of Spherically Symmetric Metrics

Abstract: General relativistic elasticity has been formulated in the mid-twentieth century due to the necessity to study astrophysical problems such as deformations of neutron star crusts.An introduction is provided to the theory of elasticity in general relativity.Important tensors appearing in this context are presented. In particular, attention is focussed on the elasticity difference tensor, for which an algebraic analysis is performed. Applications are given to static and non-static spherically symmetric configurations. For the latter, dynamical equations are obtained characterizing the behaviour of the space-time in the context of general relativistic elasticity.

DSG 2.3.

Authors: Estelita Vaz (U. Minho, Portugal)

Title: Relating material and space-time metrics within relativistic elasticity: a dynamical example

Abstract: Given a space-time and a continuous medium with elastic properties described by a 3-dimensional material space, one can ask whether they are compatible in the context of relativistic elasticity. The solution to this problem, in general, is quite difficult. Here the problem is described in detail and an example is presented, the space-time metric being non-static and spherically symmetric and the 3-dimensional material metric being conformally flat.

Dynamic Field Theory and Applications 4.

Date: Tuesday, 16h00

Organizers: Wolfram Erlhagen (Wolfram.erlhagen@mct.uminho.pt), Anwar Hussein (anwarh@mct.uminho.pt)

DFTA 4.1.

Authors: P. Gaussier (Member of the Institut Universitaire de France), P. Andry and S. Boucenna (Neuro-cybernetic team, ETIS, CNRS, ENSEA, Univ Cergy-Pontoise, France)

Title: Dynamic fields and interactive systems

Abstract: The dynamical system approach is an interesting framework to analyse and design complex control architectures [7, 6]. Focusing on the dynamics allows to overstep some limitations of functional approaches and to enlight possible emergent properties. For instance, in previous works, using the perception ambiguity, we have shown that a simple visuo-motor homeostat can be used to trigger low level imitation capabilities [5, 4]. Moreover, dynamical neural fields allow to combine easily in a single system different control strategies (different motor commands obtained from different neural networks working at different frequencies can be easily merged in a single neural field allowing the control of several degrees of freedom).

Yet, in these systems performances directly depend on the human capabilities to maintain the interaction. To allow turn taking or simply long term interactions the robot must not be only a reactive system but must be endowed with some 'will' to interact. In recent works, we have shown a simple internal oscillator can be used to maintain low level interactions. To go one step further, we try to address the question of predicting what could be the stable states of a system interacting with its environment [2, 3]. As a toy problem, we have analysed how an expressive robot head could learn to associate the facial expression of a human or another robot with its own internal emotional state. We have shown in the case of a simple reactive architecture that a solution to obtain a stable state of interaction is that the human teacher mimics the robot facial expressions. This idea has been successfully tested with a real robot head. Moreover, we have shown that the robot head can learn through the interaction game to perform in an unsupervised manner a face / non face discrimination by using the capability to predict the rhythm of the interaction [1] as a learning modulation to decide whether some visual features can belong to a face or not. At last, we propose a definition of the shared perception as a dynamical system and question the possibility to develop mathematical tools allowing to predict and study how interacting systems can develop more and more complex skills through the interactions.

References: [1] P. Andry, P. Gaussier, S. Moga, J.P. Banquet, and J. Nadel. Learning and communication in imitation: An autonomous robot perspective. IEEE transactions on Systems, Man and Cybernetics, Part A, 31(5):431-444, 2001.

[2] P. Gaussier, J.C. Baccon, K. Prepin, J. Nadel, and L. Hafemeister. Formalization of recognition, affordances and learning in isolated or interacting animats. In SAB04 (From Animal to Animat), 2004.

[3] P. Gaussier, K. Prepin, and J. Nadel. Toward a cognitive systems algebra: Application to facial expression learning and imitation. In Embodied Artificial Intel ligence, F. Iida, R. Pfeifer, L. Steels and Y. Kuniyoshi (Eds.) published by LNCS/LNAI series of Springer, pages 243-258, 2004.

[4] J. Nadel, A. Revel, P. Andry, and P. Gaussier. Toward communication: first imitations in infants, low-functioning children with autism and robots. Interaction Studies, 5:45-75, 2004.

[5] J.P. Banquet P. Gaussier, S. Moga and M. Quoy. From perception-action loops to imitation processes: A bottom-up approach of learning by imitation. Applied Artificial Intelligence:An international Journal, 12(7-8):701-727, 1998.

[6] M. Quoy, S. Moga, and Ph. Gaussier. Dynamical neural networks for top-down robot control. IEEE Transactions on Man, Systems and Cybernetics, Part A: Systems and humans, 33(4):523-532, 2003.

[7] G. Schöner, M. Dose, and C. Engels. Dynamics of behavior: theory and applications for autonomous robot architectures. Robotics and Autonomous System, 16(2-4):213-245, December 1995.

DFTA 4.2.

Authors: Estela Bicho, Luis Louro, Nzoji Hipolito (U. Minho, Portugal), Wolfram Erlhagen (U. Minho, Portugal)

Title: A dynamic neural field architecture for flexible and fluent human-robot interaction

Abstract: A major challenge in the field of human-robot interaction (HRI) is the design of autonomous robots that are able to interact with people in a human-like way. This requires to endow the robots with some high-level cognitive capacities like decision making, memory, goal inference and anticipation. The talk presents a control architecture for HRI that is inspired by recent experimental findings about the neuro-cognitive mechanisms supporting joint action in humans and other primates. It implements the coordination of actions and goals among the partners as a dynamic pro- cess that integrates contextual cues, shared task knowledge and predicted outcome of others' motor behavior.

The control architecture is formalized by a coupled system of dynamic neural fields representing a distributed network of local but connected neural populations. Different pools of neurons encode task relevant information about action means, action goals and context in form of self-sustained activation patterns. These patterns are triggered by input from connected populations and evolve continuously in time under the influence of recurrent interactions. The dynamic control architecture is validated in a task in which a robot and a human jointly construct a toy robot. We show that the context dependent mapping from action observation onto appropriate complementary actions allows the robot to cope with dynamically changing joint action situations.

Keywords: neural field architecture; human-robot interaction;

References: [1] E Bicho and L Louro and N Hipolito and W. Erlhagen, A dynamic neural field architecture for flexible and fluent human-robot interaction, Proceed- ings of the 2008 International Conference on Cognitive Systems, pp. 179-185, University of Karlsruhe, Germany,
[2] W Erlhagen and A Mukovsky and E. Bicho, A dynamic model for action un- derstanding and goal-directed imitation, Brain Research 1083:174-188, 2006
[3] W Erlhagen and E Bicho, The dynamic neural field approach to cognitive robotics, Journal of Neural Engineering 3:R36-R54, 2006
[4] E Bicho and P. Mallet and G Schöner, Target representation on an autonomous vehicle with low-level sensors, The International Journal of Robotics Research 19, 424-447, 2000

Interacting Particle Systems 1.

Date: Tuesday, 16h00

Organizer: Patrícia Gonçalves (patg@math.uminho.pt)

IPS 1.1.

Authors: Patrícia Gonçalves (U. Minho, Portugal)

Title: Hydrodynamic Limit for a Particle System with degenerate rates

Abstract: We study a conservative particle system with degenerate rates, namely with nearest neighbor exchange rates which vanish for some configurations. Due to this degeneracy the hyperplanes with fixed number of particles can be decomposed into an irreducible set of configurations plus isolated configurations that do not evolve under dynamics. We show that, for initial profiles smooth enough and bounded away from zero and one, under the diffusive scaling, the macroscopic density evolves according to the porous medium equation. Then we prove the same result for more general profiles for a slightly perturbed microscopic dynamics: we add jumps of the Symmetric Simple Exclusion which remove the degeneracy of rates and are properly slowed down in order not to change the macroscopic behavior. (joint work with Cristina Toninelli and Claudio Landim)

IPS 1.2.

Author: Augusto Teixeira (ETH Zürich, Switzerland)

Title: Random walk trajectories and Random Interlacements

Abstract: If one considers a random walk on a large torus $(Z/NZ)^d (d > 2)$, a natural question appears: What does the local picture of the set of visited sites look like for large N? By 'local picture' we mean: the set of visited sites inside a box of fixed diameter. The correct time scale one should run the random walk (to avoid degenerate limits as N goes to infinity) is $uNd, u > 0$, and the limiting law inside the microscopic box is the so called random interlacement at level u. This process can be extended to a translation invariant law on Z^d and that is the main interest of this talk. More specifically, we want to study the percolative properties of the set of vacant sites, i.e. the complement of the interlacement, for the various values of u.

IPS 1.3.

Authors: Eric Gautier (ENSAE, France)

Title: Exit time and persistence of solitons for stochastic Korteweg-de Vries equations

Abstract: (joint work with Anne de Bouard) The Korteweg-de Vries equation is a model of nonlinear shallow water long waves of small amplitude that admit soliton solutions. Soliton are a family of solutions which are progressive localized waves that propagate with constant speed and shape. They can appear in nonlinear and dispersive media, where the two effects compensate. These waves are stable in many ways against perturbations or interactions. We consider random perturbations by an additive noise of small amplitude. It is common in Physics to approximate the solution in the presence of noise, corresponding to an initial datum generating a soliton in the deterministic system, by a randomly modulated soliton (the parameters of the soliton fluctuate randomly). The validity of such an approximation has been proved by A. de Bouard and A. Debussche. We study in more details the exit time from a neighborhood of the soliton and randomly modulated soliton and obtain the scaling in terms of the amplitude of the noise for each approximation. This allows to quantify the gain of an approximation of the form of a randomly modulated soliton in describing the persistence of solitons.

Stochastics, Dynamics and Applications in Economics.

Date: Tuesday, 16h00

Organizers: Athanasios Yannakopoulos (ayannaco@aegean.gr), D. Kravvaritis, N.E. Frangos

SDAE 1.

Authors: A. N. Yannacopoulos (Athens University of Economics and Business, Department of Statistics, Greece)

Title: Convergence to Walrasian prices in random matching Edgeworthian economies

Abstract: A key problem of economic theory is the convergence of the prices in a market to their equilibrium values. Several models have been proposed to answer this problem. Two of the most important are Walras' model of general equilibrium and the model of Edgeworth. We show that under some fairly general and easy to check symmetry conditions, depending on the initial distribution of endowments and the agents pereferences, the sequence of Edgeworthian prices in a random matching economy converges to the Walrasian prices for this economy. The result makes use of the equivariance of the random dynamical system that determines the evolution of prices after each random matching.

SDAE 2.

Authors: D. Kravvaritis (National Technical University of Athens, Greece), V. Papanicolaou and A. N. Yannacopoulos

Title: Similarity solutions for a replicator dynamic equation

Abstract: Replicator dynamics is a well known and generally acceptable scheme for updating strategies in game theory. In this paper we present a generalization of the replicator dynamics updating scheme in the case where the strategy space is infinite dimensional. The replicator dynamcis equation takes the form of a nonlocal nonlinear PDE the solution of which gives the evolution in time of the probability distribution of the players in the strategy space. We study the existence of similarity solutions for this equation and discuss their importance in the understanding of the game dynamics.

SDAE 3.

Authors: Filipe Mena (U. Minho, Portugal)

Title: Forecasting interest rate curves by local states reconstruction

Abstract: Interest rate forecasting is important for arbitrage and risk management in economics. Although a number of works have addressed the problem of modelling interest rate curves, little attention has been paid to the actual forecasting of yield curves as a function of both time and maturity. We use embedding and local phase space reconstruction techniques in order to forecast yield curve dynamics. We compare our results with previous approaches.

SDAE 4.

Authors: Joaquim Baião (U. Minho, Portugal), Rosa Branca Esteves (U. Minho, Portugal) and Alberto Adrego Pinto (U. Minho, Portugal)

Title: Location Choices and Partial Price Discrimination

Abstract: This paper investigates the effects of price discrimination in the location decision of firms in a two-dimensional product differentiation model. Two settings are analysed. In the no-discrimination benchmark, firms choose location and then compete in uniform prices. Here we show that as in Thisse and Irmen (1998) firms choose maximal differentiation in the dominant characteristic and no differentiation in the other one. In contrast, when firms have information to engage in partial price discrimination in the second stage of the game, we show that maximal differentiation with respect to the non-discriminating dimension is a Nash equilibrium candidate, under some restrictions in the transportation costs, regardless of being the dominant characteristic.

Keywords: Location Choices; Price Discrimination; Multi-characteristics space, Duopoply

References: Esteves, R.B. (2008), Price Discrimination with Partial Information: Does it pay-of? NIPE-WP 12/2008.
Irmen, A., and Thisse, J.(1998), Competition in Multi-characteristics Spaces: Hotelling Was Almost Right, Journal of Economic Theory, 78 , 76–102.
Thisse, J. and Vives, X. (1988), On the Strategic Choice of Spatial Price Policy. American Economic Review, 78, 122–137.
Tirole, J. (1988), The Theory of Industrial Organization. The MIT Press. London.

Dynamics and BHP Universality.

Date: Thursady, 10h00

Organizers: Rui Gonçalves (rjasg@fe.up.pt), Silvio Gama (smgama@fc.up.pt)

DBHPU 1.

Author: Luís Vieira (FEUP, Portugal)

Title: Difference equations and the spectra of a family of strongly regular graphs

Abstract: Let n be a natural number and $m = [n/2] + 1$. From a particular element in a basis $B = \{A_1, \cdots, A_m\}$ (where $A_1 = I_n$ is the identity matrix of order n) of an Euclidean Jordan algebra V_n, with as many different eigenvalues as the dimension of the algebra, see [1], another basis B' of idempotents is obtained by exploiting the algebraic and combinatorial properties of V_n. From B', we get easily the character table of V_n . Then fusing all the matrices of B but A_1 and A_m, a strongly regular graph T_1 is obtained when n is even. Additionally, for particular even values of n, other strongly regular graphs included in the Euclidean Jordan algebra V_n are obtained. Finally using m homogeneous linear difference equations of order two the spectra of the strongly regular graph T_1 is determined.

Keywords: graph theory; difference equations;

References: [1] D.M.Cardoso and L. A. Vieira, Euclidean Jordan algebras with strongly regular graphs, Journal of Mathematical Sciences, 120, 881-894 (2004).
[2] S.N. Elaydi, An Introduction to Difference Equations, Springer-Verlag, New York (1960).
[3] P. Henrici, Error Propagation for Difference Methods, John Wiley & Sons, Inc., New York (1063).
[4] J. Faraut and A. Korányi, Analysis on Symmetric Cones, Clarendon Press, Oxford (1994).

DBHPU 2.

Authors: Mário Basto (IPCA, Portugal), Viriato Semiao (IST, POrtugal) Francisco Calheiros (FEUP, Portugal)

Title: Dynamics on spectral solutions of forced Burgers equation

Abstract: Burgers equation $\frac{\partial u}{\partial t} + u\frac{\partial u}{\partial x} = \delta\frac{\partial^2 u}{\partial x^2} + f(x)$ is one of the simplest partial nonlinear differential equation which can develop discontinuities, being the driven equation used to explore unidimensional 'turbulence'. The higher points of the nonlinear waves travel at a higher speed and shocks and discontinuities for low values of δ will tend to appear in the intervals where u is decreasing. Phenomena as wave processes, traffic flow, shocks, acoustic transmission and gas dynamics can be studied starting from this equation. For low values of the viscosity coefficient δ, by discretization through spectral collocation methods, oscillations in Burgers equation can occur. For the Dirichlet problem and under a dynamic point of view, several bifurcations and stable attractors can be observed. Periodic orbits, quasiperiodic and strange ones may arise. Bistability can also be observed. Numerical simulations indicate that the loss of stability of the asymptotic solution of Burgers equation must occur by means of a supercritical Hopf bifurcation.
Many nonlinear phenomena are modeled by spatiotemporal systems of infinite or very high dimension. Coupling and synchronization of spatially extended dynamical systems, periodic or chaotic, have many applications, including communications systems, chaos control, estimation of model parameters and model identifications. For the unidirectionally coupling, numerical studies show the presence of identical and generalized synchronization for different values of spacial points and different values of the viscosity coefficient δ. For u representing the drive variable, v the driven one and α the coupling parameter, nonlinear coupling at the waves velocity v, obtained by replacing the discretized response variable v by $u + \alpha(u - v)$, with $0 < \alpha < 1$, identical or generalized synchronization is achieved, allowing only values of α around 1 in very few cases. This points out the fact that although the partial replacement may not reach synchronization, nonlinear coupling with $0 < \alpha < 1$ may do it.

Keywords: Dynamical systems, Burgers equation, Spectral methods, Synchronization

References: [1] J. M. Burgers. A Mathematical Model Illustrating the Theory of Turbulence, Advanced in Applied Mechanics 1, 171.199 (1948).
[2] H. Dang-Vu, C. Delcarte. Hopf Bifurcation and Strange Attractors in Chebyshev Spectral Solutions of the Burgers Equation, Applied Mathematics and Computation 73, 99–113 (1995).
[3] M. Basto, V. Semiao, F. Calheiros. Dynamics in Spectral Solutions of Burgers Equation, Journal of Computational and Applied Mathematics 205, 296–304 (2006).
[4] L. M. Pecora, T. L. Carroll, G. A. Johnson, D. J. Mar, and J. F. Heagy. Fundamentals of Synchronization in Chaotic Systems, Concepts, and Applications, Chaos, an Interdisciplinary Journal of Nonlinear Science 7, 520–43, 1997.

DBHPU 3.

Authors: Murilo S. Baptista (U. Porto, Portugal), Dariel M. Maranhão José C. Sartorelli (U. São Paulo, Brazil)

Title: Dynamical estimates of chaotic systems from Poincaré recurrences

Abstract: We show that the probability distribution function that best fits the distribution of return times between two consecutive visits of a chaotic trajectory to finite size regions [1, 2] in phase space deviates from the exponential statistics by a small power-law term, a term that represents the deterministic manifestation of the dynamics, which can be easily experimentally detected and theoretically estimated. We also provide simpler and faster ways to calculate the positive Lyapunov exponents and the short-term correlation function by either realizing observations of higher probable returns or by calculating the eigenvalues of only one very especial unstable periodic orbit of low-period.

Finally, we show how to calculate the Kolmogorov-Sinai entropy of arbitrary complex signals and the mutual information between two sets of arbitrary complex signals us- ing recurrences, an approach that ffers an ideal way to deal with data coming from complex systems.

Keywords: Poincaré recurrences, entropy, mutual information, Lyapunov exponent, correlation, complex systems.

References: [1] M. S. Baptista, S. Kraut, C. Grebogi, Phys. Rev. Lett., 95, 094–101 (2005).
[2] M. S. Baptista, D. M. Machado, J. C. Sartorelli, 'Dynamical estimates of chaotic systems from Poincaré recurrences', subm. for publication.

DBHPU 4.

Authors: Rui Gonçalves (U. Porto, Portugal), A. A. Pinto (U. Minho)

Title: Dynamics and Universal fluctuations of the Wolf's sunspot numbers

Abstract: Bramwell, Holdsworth and Pinton discovered the probability density function (pdf) (named BHP after them) for the fluctuations of the total magnetization, in the strong coupling (low temperature) regime for a two-dimensional spin model (2dXY), using the spin wave approximation. The BHP pdf does not have any parameter and it is universal, in the sense that it appears in several physical phenomena. Under the hypothesis of a mean cycle length of 133 months we describe statistically the Wolf's sunspot numbers one-dimensional dynamics. Surprisingly, we observed that the Wolf's sunspot numbers fluctuates according to the universal BHP pdf. We discovered that in a Ruelle-Takens embedding setting of the Wolf's sunspot numbers, the empirical distribution of the predicted normalized first difference revealed a good fit to the BHP pdf. Like this, we link the randomness of the Wolf's sunspot numbers dynamics, a natural and complex dynamical system, with the universal BHP pdf.

Keywords: Dynamical Systems; BHP universality, Sunspots.
PACS codes: 96.60.j, 96.60 qd, 96.60.Ly, 05.65.+b.

References: [1] Bramwell, S.T., Holdsworth, P.C.W., & Pinton, J.F. Universality of rare fluctuations in turbulence and critical phenomena, Nature 396, 552–554, (1998).
[2] Bramwell, S.T., Christensen, K., Fortin, J.Y., Holdsworth, P.C.W., Jensen, H.J., Lise, S., López, J.M., Nicodemi, M. & Sellitto, M. Universal Fluctuations in Correlated Systems, Phys. Rev. Lett. 84, 3744–3747, (2000).
[3] Gonçalves, R., Pinto, A. and Stollenwerk, N., River Durius and Danube daily water level fluctuations, submitted
[4] Kantz, H. and Schreiber, T., Nonlinear Time Series Analysis. Cambridge Univ. Press, (1997).

DBHPU 5.

Authors: R. Chertovskih, S. Gama (FCUP, Portugal), O. Podvigina, V. Zheligovsky(International Institute of Earthquake Prediction Theory and Mathematical Geophysics, Moscow, Russian Federation)

Title: Generation of magnetic field from a dynamical system point of view

Abstract: Magnetic field generation is a fundamental problem of astrophysics. Magnetic fields of planets, stars and other astrophysical objects are usually sustained by conducting fluid flows driven by convection in their interior. One can simulate convective hydromagnetic (CHM) processes in a rotating fluid in a plane layer, regarding this as a model for a segment of a spherical shell in the melted planetary core.

In this work we investigate numerically the influence of rotation on the dynamo properties of the convective fluid flows in a plane layer by examining the structure of the convective hydromagnetic attractors for different values of Taylor number (T a). The existence regions (in T a) of the attractors of different geometry have been explored applying the technique of continuation in the parameter. The problem was studied numerically applying standard pseudospectral methods.The system of equations under consideration is highly symmetric. Attractors have been classified in particular by their symmetries, and bifurcations occurring in the system have been identified in terms of symmetry breaking. More than twenty bifurcations occur in the system on increasing the rotation rate (from T a = 0 up to T a = 2000), including saddle-node, pitchfork and Hopf bifurcations, and Hopf bifurcations of periodic orbits; the attractors are steady states, periodic orbits and tori. RC is supported by the Fundação para a Ciência e a Tecnologia (grant SFRH/BD/23161/2005).

Keywords: convective dynamo; bifurcations in dynamical systems with symmetries

Game Theory and Economics.

Date: Thursday, 10h00

Organizers: Marta Faias (mcm@fct.unl.pt)

GTE 1.

Authors: Fernanda A. Ferreira (IPP Vila do Conde, Portugal), Flávio Ferreira (IPP Vila do Conde, Portugal), Alberto A. Pinto (U. Minho, Portugal)

Title: Leadership and demand uncertainty

Abstract: We give some new contributions to answer the following question: Do first movers really have strategic advantage in practice? The belief of first-mover advantage was widely held among entrepreneurs and venture capitalists, but is now questioned by numerous practitioners. The probability of success of pioneering in a market clearly depends on many factors, including technology, marketing strategy, market demand and product differentiation. We extend Liu's [3] results by focus not only on the effects of the market demand uncertainty, but also on product differentiation and on the 'own' price effect, to explain the advantages and disadvantages of being the leading firm. Usually, the followers in markets get more market information than first movers before sinking their investments. In some industries that we consider to have fairly stable and predictable market demand, the pioneering firm tends to be the biggest player. However, if a market has a high degree of uncertainty, the followers can wait and see the customers' response to the new product introduced by the first movers, as well as move along the differentiation curve'' of innovation. As in Liu's [3] model, we consider that only the first mover (leading firm) faces demand uncertainty. The demand uncertainty is given by a random variable uniformly distributed, with mean μ and standard deviation σ characterizing the demand uncertainty parameter $\theta = (\mu + \sqrt{3}\sigma)/(\mu - \sqrt{3}\sigma)$.

By the time the second mover chooses its output level, that uncertainty is resolved. Therefore, the leading firm possesses first-mover advantage, but the second mover enjoys an informational advantage because it can adjust the production level after observing the realized demand (flexibility). We study the advantages of flexibility over leadership as the degree $0 < Y \leq 1$ of the differentiation of the goods changes, where Y attains the value 1, if the goods are homogeneous, and tends to 0, if the goods are close to independent goods. We find explicit functions I_Y and J_Y, in terms of the degree of differentiation, characterizing the demand uncertainty parameter θ for which the leading firm looses its advantage for some realizations of the demand random variable. We show that the leading firm looses its advantage for high values of the demand intercept, if the demand uncertainty parameter θ is greater than $I_{\&gamma a:}$, and for low values of the demand intercept, if the demand uncertainty parameter θ is greater than J_Y.

Hence, for high values of the demand uncertainty parameter θ only in an intermediate zone of the realized demand does the first mover preserve its advantage. We make an ex-ante analysis by computing the expected value, with respect to the demand realization α, of the profits of both firms in terms of the demand uncertainty parameter θ and of the degree Y of product differentiation. In particular, we prove that, even in the presence of low uncertainty, the expected value of the profit of the second firm increases to higher values than the ones of the leading firm with the increase of the product differentiation. Moreover, we show that there is a value θ_0 such that if the uncertainty parameter θ is greater than θ_0, then the expected profit of the follower firm is always greater than the expected profit of the leading firm. We also make an ex-post analysis by computing and comparing the firms' profits after the demand uncertainty has been resolved. We also compute the probability $P(\pi_2^* > \pi_1^*)$ of the second firm to have higher profit than the leading firm in terms of the demand uncertainty parameter and of the product differentiation.

Keywords: Stackelberg model; Demand uncertainty; Product differentiation. Mathematics Subject Classification: 91A10; 91A80.

References: [1] Ferreira, F.A., Ferreira, F. and Pinto, A.A., Flexibility in Stackelberg leadership. In J. A. Tenreiro Machado, Bela Patkai and Imre J. Rudas (Eds.): Intelligent Engineering Systems and Computational Cybernetics, Springer-Verlag book, 1-8 (2007). (In press)
[2] Ferreira, F.A., Ferreira, F. and Pinto, A.A., Own price influences in a Stackelberg leadership with demand uncertainty, Revista Brasileira de Economia de Empresas, 8, 1-18 (2008). (In press)
[3] Liu, Z., Stackelberg leadership with demand uncertainty, Manage. Decis. Econ., 26, 345-350 (2005).

GTE 2.

Authors: Gabriel Brida(Free University of Bolzano, Italy), Marta Faias (U. Nova Lisboa), A. A. Pinto (U. Minho)

Title: Tourism Choice with Crowding Types

Abstract: We introduce a model of tourism choice where we consider that the choice of a tourism resort by a tourist, depends not only on the characteristics of the product offered by the resort but depends also on the characteristics - crowding types - of the other tourists that have chosen the same resort. By consider the crowding type variable in the preferences of the tourists, the behavior of each tourist is influenced by the behavior of the other tourists then we use a club formation approach and model the framework by means of a Nash game. We establish existence of strategic equilibrium and discuss special cases.

Keywords: Crowding types, Nash equilibrium, Strategic choice of tourism resort.

GTE 3.

Authors: A.A. Pinto (U. Minho, Portugal), B. Oliveira (U. Porto, Portugal), Miguel Ferreira (U. Minho, Portugal)

Title: Patents in new technologies

Abstract: Our analysis adds some new insights to the importance of the use of patents in new technologies. We present a new R&D investment in a Cournot competition model. We thoroughly analyze its short and long term economical effects. For old technologies, the long term economical effects are not very sensitive to small changes in the efficiency of the R&D programs neither to small changes in the market structure. However, for new technologies, the long term economical effects are very sensitive to small changes in the efficiency of the R&D programs and also to small changes in the market structure.

We find a favorable economical region for firm F_1, a favorable economical region for firm F_2 and a recovery region for both firms characterized by the initial production costs of both firms. For new technologies, if Firm F_i decides not to invest or to stay out of the market (in period 1) and if Firm F_j has this private information about Firm F_j's decision, then Firm F_j plays in such a way that will keep Firm F_i out of the market during the entire duration of the game.

Keywords: Strategic R&D, endogenous spillovers, patents.

GTE 4.

Authors: Luís Aguiar-Conraria (U. Minho, Portugal), Nuno Azevedo (U. Porto, Portugal) and Maria Joana Soares (U. Minho, Portugal)

Title: Using wavelets to decompose the time-frequency effects of monetary policy

Abstract: Central banks have different objectives in the short and long run. Governments operate simultaneously at different timescales. Many economic processes are the result of the actions of several agents, who have different term objectives. Therefore, a macroeconomic time series is a combination of components operating on different frequencies. Several questions about economic time series are connected to the understanding of the behavior of key variables at different frequencies over time, but this type of information is difficult to uncover using pure time-domain or pure frequency-domain methods. To our knowledge, for the first time in an economic setup, we use cross-wavelet tools to show that the relation between monetary policy variables and macroeconomic variables has changed and evolved with time. These changes are not homogeneous across the different frequencies.

Keywords: Monetary policy; Time-frequency analysis; Non-stationary time series; Wavelets; Cross-wavelets; Wavelet coherency.

Interacting Particle Systems 2.

Date: Thursday, 10h00

Organizer: Patrícia Gonçalves (patg@math.uminho.pt)

IPS 2.1.

Authors: Milton Jara (Université Catholique de Louvain, Belgique)

Title: Hydrodynamic limit for a zero-range process in the Sierpinski gasket

Abstract: We prove that the hydrodynamic limit of a zero-range process evolving in graphs approximating the Sierpinski gasket is given by a nonlinear heat equation. We also prove existence and uniqueness of the hydrodynamic equation by considering a finite-difference scheme.

IPS 2.2.

Authors: Iesus C. Diniz (U. São Paulo, Brasil)

Title: Poissonian Tree Constructed from Independent Poisson Point Processes

Abstract: We present the construction of a connected graph without cycles (a tree) which has a unique infinite self-avoiding path (an end). The vertices of the graph are the points of a sequence of independent Poisson Point Processes in R^d. When the processes are defined in R, a sufficient condition for the existence of the Poissonian Tree is $\liminf \lambda_k = 0$. If the processes are defined in R^d, a more restricted condition on the sequence of rates is required, namely, $\lambda_k = (\alpha)^k$ where $\alpha \in (0, 1)$.

Complexity of Human Excellence and Expertise.

Date: Thursday, 16h00

Organizers: Leandro Silva Almeida (leandro@iep.uminho.pt), José Fernando Silva Azevedo Cruz (jcruz@iep.uminho.pt)

CHEE 1.

Author: Alberto A. Pinto (U. Minho, Portugal)

Title: Bayesian-Nash Equilibria in the Theory of Planned Action

Abstract: We introduce, in the literature, a Game Theoretical Model of Planned Behavior or Reasoned Action by establishing an analogy between two specific theories. In this analogy, we associate social no to the crowding type and attitude, self efficacy and values and beliefs to the taste type. Using Game Theory concepts, we describe how intentions can be transformed in behavior. According to the Bayesian-Nash Equilibrium, this process will correspond to the best individual decision/response taking in account the collective response. We study the role of the experts and of the leaders in the Game Theoretical Model of Planned Behavior. This analysis can be extended to several examples based in the Game Theoretical Model of Planned Behavior or Reasoned Action.

Keywords: Game Theory; Theory of Planned Action; Bayesian-Nash Equilibria

References: [1] I. Ajzen, Perceived behavioral control, self-efficacy, locus of control, and the theory of planned behavior. Journal of Applied Social Psychology,32, 665 - 683 (2002).
[2] S. Baker, B. Beadnell, M.Gillmore, D. Morrison, B. Huang, S. Stielstra, The Theory of Reasoned Action and the Role of External Factors on Heterosexual Mens Monogamy and Condom Use. Journal of Applied Social Psychology, 38, 1, pp. 97-134 (2008).
[3] D. Daya, P. Gronnb, E. Salas, Leadership capacity in teams,The Leadership Quarterly, 15, 857-880(2004).

CHEE 2.

Authors: Helena Ferreira (U. Minho, Portugal)

Title: Hysteresis in Theoretical Comportamental Games

Abstract: We consider a Theoretical Behavioral Game that consists in a model where people (members) strategically choose a behavior/group that will maximize their (payoff-utility) welfare. The welfare that a single member acquires by choosing a certain behavior depends, not only, on the individual welfare by having that behavior, but also on the other members that have the same behavior/group. These individual decisions/responses do not, necessarily, maximize the common welfare. We present an example where students choose a behavior/group that will correspond to the failure or approval of the students, with some probability. We study individual decisions through Nash Equilibria and show the presence of an hysteresis in the decision/response of this student's model.

Keywords: Game Theory; Behavior; Nash Equilibria; Hysteresis

References: [1] I. Ajzen, Nature and Operation of Attitudes, Annu. Rev. Psychol.52:27 - 58 (2001).
[2] I. Ajzen, L. Davis,J. Williams, The Decision of African American Students to Complete High School: An Application of the Theory of Planned Behavior. Journal of Educational Psychology, Vol. 94, No. 4, 810 - 819 (2002)
[3] I. Ajzen, M. Fishbein, Understanding Attitudes and Predicting Social Behavior,Englewood-Cliffs, NJ: Prentice-Hall (1980).
[4] D. Fudenberg, J. Tirole, Game Theory, 616 pages. MIT Press (1991)
[5] R. Gibbons, Primer In Game Theory, 278 pages. Prentice Hall / Harvester Wheatsheaf (1992).
[6] M. Wooders, E. Cartwright, R. Selten, Social Conformity in Games with Many Players. FEEM Working Paper.(2003) 1

CHEE 3.

Authors: José Fernando A. Cruz and Leandro Almeida (U. Minho, Portugal)

Title: Psychological processes, stability and uncertainty

Abstract: Drawing from several recent theoretical approaches and contributions from psychological science to the study of human excellence and expertise, and grounded in findings from research in several achievement domains (e.g., sport, academic, performing arts, science) we emphasize the complexity and the interactions, as well as the dynamic and changing psychosocial factors and processes associated in the understanding and explanation of exceptional and outstanding performances. In addition to personal and expertise-specific factors (cognitive, affective, motivational or motor), the study of developmental and life trajectories of high and top level performers show the importance of cultural, social and environmental (contextual) facilitative and optimal conditions. The distinction between a person-centered approach (concerned with personal talent, expertise, excellence and wisdom development), and a performance-focused approach (emphasizing the outstanding, expert and high levels of performance on specific tasks) is the departure point for the present contribution and discussion. By changing the experimental and normative emphasis, perhaps a new paradigm in psychological science would be necessary toward a better understanding of the uniqueness and idiosyncrasy of person-context interactions in human development. Some potentially important implications for future research, assessment and study of excellence and expertise are also offered.

Keywords: Excellence; Expertise; Wisdom; Talent Development; Psychological Factors.

References: Araújo, L., Almeida, L., & Cruz, J. (2007). Excellence in achievement contexts: Psychological science applications and future directions. In A. Williamon & D. Coimbra (Eds). Proceedings of the International Symposium on Performance Science - ISPS 2007 (pp. 17-22). Utrecht, The Netherlands: Association Européenne des Conservatoires, Academies de Musique et Musikhcochschulen (AEC).
Araújo, L. S., Cruz, J. F. A., & Almeida, L. S. (2007). Excelência humana: Teorias explicativas e papel determinante do professor. Psicologia, Educação e Cultura, XI (2), 197-221.
Baker, J. & Horton, S. (2004). A review of primary and secondary influences on sport expertise. High Ability Studies, 15, 211-228.
Conroy, D. E., Poczwardowski, A. (2002). Coping responses to failure and success among elite athletes and performing artists. Journal of Applied Sport Psychology, 14, 313 - 329.

Ericsson, K.A. (Ed.) (1996). The road to excellence: The acquisition of expert performance in the arts and sciences, sports and games. Lawrence Erlbaum Associates, Inc..
Gagné, F. (2004). Transforming gifts into talents: The DMGT as a developmental theory. High Ability Studies,15 (2), 119-147.
Gould, D., Dienffenbach, K., & Moffett, A. (2002). Psychological characteristic and their development in olympic champions. Journal of Applied Sport Psychology, 14, 172-204.
Hodges, N.J., Huys, R., Starkes, J.L. (2007). Methodological review and evaluation of research in expert performance in sport. In Tenenbaum, G. & Eklund, R.C. (Eds), Hanbook of Sport Psychlology (pp. 161-183). New Jersey: John Wiley & Sons, Inc. Kunzman, U., & Baltes, P.B. (2003). Wisdom-related knowledge: Affective, motivational, and interpersonal correlates. Personality and Social Psychology Bulletin, 29, 1104-1119. Lazarus, R. S. (2000). How emotions influence performance in competitive sports. The Sport Psychologist, 14, 229-252.
Moon, S. M. (2003). Personal talent. High Abilities Studies, 14, 1, 5-21.
Lubinski, D. & Benbow, C. P. (2006). Study of Mathematically Precocious Youth After 35 years. Perspectives on Psychological Science, 1 (4), 316-345.
Shanteau, J., Weiss, D., Thomas, R., & Pounds, J. C. (2002). Performance-based assessment of expertise: How to decide if someone is an expert or not. European Journal of operational Research, 136, 253-263.
Simonton, D.K. (2001). Talent development as a multidimensional, multiplicative and dynamic process. Current Directions in Psychological Science, 39-43.
Williams, A. M. & Ericsson K. A. (2005). Perceptual-cognitive expertise in sport: Some considerations when applying the expert performance approach. Human Movement Science, 24, 283-307.

Dynamics and Biology 2.

Date: Thursday, 16h00

Organizers: Gabriela Gomes (ggomes@igc.gulbenkian.pt), Bruno Oliveira (bmpmo@fcna.up.pt), Nico Stollenwerk (nico@igc.gulbenkian.pt)

DB 2.1.

Authors: Sandra M. Aleixo (ISEL, Portugal), J. Leonel Rocha (ISEL, Portugal) and Dinis D. Pestana (U. Lisboa, FCUL, DEIO and CEAUL, Portugal)

Title: Dynamics of Populational Growth Models with Allee Effect

Abstract: In this work, we consider populational growth models with Allee effect. These models are proportional to beta densities with shape parameters p and 2, where the dynamical complexity is related with the malthusean parameter r. For $p > 2$, these models exhibit a population dynamics with natural Allee effect. However, in the case of 1, the proposed models do not include this effect. In order to invoke the Allee effect, we present some alternative mechanisms and investigate their dynamics. Using dynamical symbolic techniques, we analise the complex behaviour of these models, in terms of topological entropy, in the parameter plane (r, p), defining different dynamical regimes.

Keywords: Beta Densities, Population Dynamics, Topological Entropy and Allee Effect.
MSC2000 Classification: 60E05, 92D25, 37B10, 37B40

References: [1] S. M. Aleixo, J. L. Rocha and D. D. Pestana, Populational Growth Models in the Light of Symbolic Dynamics (in press), ITI2008 Conference Procedings, (accepted in May of 2008).
[2] D. S. Boukal and L. Berec, Single-species Models of the Allee Effect: Extinction Boundaries, Sex Ratios and Mate Encounters, J. Theor. Biol., 218, (2002), 375-394.
[3] S. Brianzoni, C. Mammana and E. Michetti, Nonlinear Dynamics in a business-cycle model with logistic population growth , Chaos, Solitons and Fractals, (2007), doi:10.1016/j.chaos.2007.08.041
[4] R. S. Cantrell and C. Cosner, Density dependent behavior at habitat boundaries and the Allee effect, Bull. Math. Biol., 69, (2007), 2339-2360.
[5] F. M. Hilker, M. Langlais, S. Petrovskii and H. Malchow, A diffusive SI model with Allee effect and application to FIV, Math. Biosci., 206, (2007), 61-80.
[6] R. Lopez-Ruiz and D. Fournier-Prunaret, Indirect Allee effect, bistability and chaotic oscillations in a predator-prey discrete model of logistic type, Chaos, Solitons and Fractals, 24, (2005), 85-101.
[7] S. P. Rogovchenko and Y. V. Rogovchenko, Effect of periodic environmental fluctuations on the Pearl-Verhulst model , Chaos, Solitons and Fractals, (2007), doi:10.1016/j.chaos.2007.11.002
[8] D. Ruelle, Thermodynamic Formalism, Addison-Wesley, Reading, MA., 1978.
[9] S. J. Schreiber, Allee effects, extinctions and chaotic transients in simple population models, Theor. Pop. Biol., 64, (2003), 201-209.
[10] P. Walters, An Introduction to Ergodic Theory, Graduate Texts in Math., 79, Springer-Verlag, 1981.

DB 2.2.

Authors: Jorge Carneiro (Instituto Gulbenkian, Portugal)

DB 2.3.

Authors: Nico Stollenwerk (U. Lisboa, Portugal)

Title: Rich dynamics in multi-strain epidemiological models:
evolution towards criticality in accidental pathogens, reinfection threshold, and new dengue chaotic attractors

Abstract: As compared to classical epidemiological models multi-strain models show a rich dynamic behaviour, reaching from new thresholds, namely the reinfection threshold in models of partial immunity, for example in influenza, to new deterministically chaotic dynamics, in dengue fever models, and can show evolution to critical thresholds including its large fluctuations for accidental pathogens, e.g. in Neisseria menigitidis epidemiology.

References: [1] Stollenwerk, N., & Jansen, V.A.A. (2003) Meningitis, pathogenicity near criticality: the epidemiology of meningococcal disease as a model for accidental pathogens. Journal of Theoretical Biology 222, 347-359.
[2] Stollenwerk, N., Maiden, M.C.J., & Jansen, V.A.A. (2004) Diversity in pathogenicity can cause outbreaks of menigococcal disease, Proc. Natl. Acad. Sci. USA 101, 10229–10234.
[3] Stollenwerk, N., & Jansen, V.A.A. (2007) Criticality in epidemiology, in Complex Population Dynamics: Nonlinear Modeling in Ecology, Epidemiology and Genetics, eds. Bernd Blasius, Lewi Stone, Jürgen Kurths, (World Scientific Lecture Notes in Complex Systems)
[4] Stollenwerk, N., Martins, J., & Pinto, A. (2007) The phase transition lines in pair approximation for the basic reinfection model SIRI, Physics Letters A 371, 379-388.
[5] Aguiar, M., & Stollenwerk, N. (2007) A new chaotic attractor in a basic multi-strain epidemiological model with temporary cross-immunity, available as: arXiv:nlin/0704.3174.

[6] Massad, E., Chen, M., Ma, S., Struchiner, C.J., Stollenwerk, N., & Aguiar, M. (2008) Scale-free Network for a Dengue Epidemic, Applied Mathematics and Computation 159, 376-381.
[7] Aguiar, M., Stollenwerk, N., & Kooi, B.(2008) Torus bifurcations, isolas and chaotic attractors in a simple dengue model with ADE and temporary cross immunity, Proceedings of 8th Conference on Computational and Mathematical Methods in Science and Engineering, CMMSE 2008, ISBN 978-84-612-1982-7, also available as: arXiv:0806.4576.

Differential Equations.

Date: Thursday, 16h00

Organizers: Carlos Rocha (crocha@math.ist.utl.pt), Henrique Oliveira (holiv@math.ist.utl.pt)

DE 1.

Authors: Carlos Rocha (IST Lisboa, Portugal)

Title: Morse-Smale Attractors for Semilinear Parabolic Equations on the Circle

Abstract: We consider the global attractors for dynamical systems generated by semilinear parabolic equations of the form $u_t = u_{xx} + f(u, u_x)$, defined on the circle $S^1 = R/2\pi Z$. We discuss the characterization of the Morse-Smale attractors for these systems using Sturm permutations.

Keywords: classification of attractors; nonlinear boundary value problems; Morse-Smale systems.

DE 2.

Authors: Henrique Oliveira (IST Lisboa, Portugal)

Title: Bifurcations for non autonomous interval maps

Abstract: In this work we investigate attracting periodic orbits for non autonomous discrete dynamical systems with two maps using a new approach. We study some types of bifurcation in these systems. We show that the pitchfork bifurcation plays an important role in the creation of attracting orbits in families of alternating systems with negative Schwarzian derivative. We study bifurcations with high degeneracy that arise in non autonomous maps of the interval. Finally we study the bifurcations of an alternating system with two quadratic polynomials.

Keywords: Non autonomous system; Bifurcation;
1991 Mathematics subject classification: Primary: 37E05; Secondary: 37E99

References: [1] D'Aniello, Emma & Oliveira, Henrique, Pitchfork bifurcation for non autonomous interval maps, Journal of Difference Equations and Applications, to appear, (2008)
[2] Golubitsky, Martin & Schaeffer, David, Singularities and Groups in Bifurcation Theory, vol I. Springer Verlag, New York Berlin Heidelberg Tokyo (1985)

DE 3.

Authors: Rafael Luís (IST Lisboa, Portugal)

Title: Non-autonomous periodic systems with Allee effect

Abstract: In this work we introduce a new class of maps, called unimodal Allee maps (UAM). These maps arise in the study of population dynamics in which the system has three fixed points, a stable zero fixed point, an unstable positive fixed point (Allee point) and a stable positive fixed point (carrying capacity). We analyse the properties of the Allee points and the carrying capacity and establish their stability, for non-autonomous periodic systems formed by unimodal Allee maps.

Keywords: Allee effect, Unimodal Allee maps, Allee point, Carrying capacity, Composition map, Stability, Domain of attraction.

References: and Literature for Further Reading

[1] Saber Elaydi, Discrete Chaos, Chapman and Hall/CRC, Second Edition (2008).
[2] Saber Elaydi, An Introduction to Difference Equations, Springer third Edition (2005).
[3] J. Li, B. Song, X. Wang, An extended discrete Ricker population model with Allee effects, Journal of Difference Equations and Applications, 13, 4 (2007), 309- 321.
[4] Rafael Luís, Saber Elaydi and Henrique Oliveira, An economic model with Allee effect, Journal of Difference Equations and Applications, Submitted, (2008).

DE 4.

Authors: Rui Ralha (U. Minho, Portugal)

Title: Numerical issues in the stability analysis of linear dynamical systems

Abstract: Linear dynamical systems can be solved exactly, at least in exact arithmetic. However, in practice, inaccuracies in the computation of the eigenvalues of the dynamics matrix may lead to errors in the classification of the system. Such inaccuracies may be due to numerical uncertainty in the initial data and/or rounding errors in the code used for the eigenvalues extraction. We give examples that show that even the best codes available (for instance in Matlab and LAPACK) may fail to compute accurately all the eigenvalues. In particular, we show that there is still scope for improvement in the accuracy of the codes when the matrix defines well all its eigenvalues to high relative accuracy.

Dynamics and Industrial Organization.

Date: Friday, 10h00

Organizers: Flávio Ferreira (flavioferreira@eu.ipp.pt)

DIO 1.

Authors: Fernanda A. Ferreira (IPP Vila do Conde, Portugal), Flávio Ferreira (ESEIG, Portugal), Humberto A. Moreira (Fundaçãoo Getúlio Vargas - RJ, Instituto Brasileiro de Economia, Rio de Janeiro, Brasil), Alberto A. Pinto (U. Minho, Portugal)

Title: Signalling to the home policymaker

Abstract: We consider two Cournot firms, one located in the home country and the other in the foreign country, producing substitute goods for consumption in a third country. The inverse demands in the third country are assumed to be linear and given by

$$p_A = a - bq_A - q_B, p_B = a - q_A - bq_B,$$

where p_A and p_B are the per-unit prices of the goods produced, respectively, by the home and the foreign firms, when q_A units of home output and q_B units of foreign output are sold, and $a > 0$ and $b \geq 1$. We note that the two products are substitutes, and, since $b \geq$ 'cross effects" are dominated by "own effects". Moreover, if b=1, then the goods are homogeneous.

At the beginning of period 1, the home government announces and commits to a period 1 per-unit output/export subsidy for the home firm. At this stage neither the home policymaker nor the foreign firm knows the costs of the firm. However, it is common knowledge that the home firm's marginal costs are constant and either low, c_A^L, or high, c_A^H with Prob$(C_A = c_A^L) = \phi$. No uncertainty attaches to the marginal costs of the foreign firm and it is assumed that it is common knowledge, constant, and given by c_B. Given ϕ and the output subsidy, the two firms choose period 1 outputs to maximize profit. At the end of the first period, the foreign firm and the home policymaker observe the home firm's first-period output and use this information to update their probability assessments regarding the costs of the home firm. Let $\phi(q_{A,1})$ be the common updated probability assessment, where $q_{A,1}$ is the first-period output of the home firm. At the beginning of the second period, given its updated probability assessment, $\phi(q_{A,1})$, the policymaker announces and commits to a period 2 output subsidy for the home firm. Given this subsidy and the foreign firm's updated probability assessment,$\phi(q_{A,1})$, the two firms choose period 2 outputs to maximize profit. We study the influences of the own prices effect on the demand and of the uncertainty on the production costs of the home firm in the signalling strategies by the home firm. We study the influence of a fine balance between the own prices effect and the uncertainty on the costs in the per-unit output subsidy to the home firm when we compare a signalling strategy with a misrepresent low-cost strategy.

Keywords: Signalling strategy; Substitute goods.
Mathematics Subject Classification: 91A10; 91A28; 91A80.

References: [1] Wright, D., Strategic trade policy and signalling with unobservable costs, Review of International Economics, 6, 105-119 (1998)

DIO 2.

Authors: D. Pinheiro (U. Porto, Portugal)

Title: Behavioural scenarios for contingent claims valuation in incomplete markets

Abstract: We describe three different but related scenarios for determination of asset prices in an incomplete market: one scenario uses a market game approach whereas the other two are based on risk sharing or regret minimizing considerations. Furthermore, we point out some new dynamical schemes modelling the convergence of the buyer's and of the seller's prices of a given asset to a unique price.

DIO 3.

Authors: Telmo Parreira (U. Porto, Portugal), Alberto Pinto (U. Minho, Portugal), Rosa Branca Esteves (U. Minho, Portugal)

Title: A Hotelling Network

Abstract: This paper extends the classical Hotelling model to a network, where each firm is located at a node of this network and it shares with its neighboring firms the market located along the branches of the network. We assume that every firm uses the same price for every market where it competes and that it is uncertain about the structure of the network. The Bayesian Nash prices that firms should practice according to the degree of its node are determined.

Keywords: Hotelling Competition, Networks, Incomplete Information

References: [1] Galeotti, A and Vega-Redondo, F. (2005), Strategic analysis in complex networks with local externalities, EUI Working Paper.
[2] A Galeotti, A., Goyal, s. Jackson, M., Vega-Redondo, F and Yariv, L. (2007) Network Games, EUI Working Paper.
[3] Hotelling, H., Stability in Competition, *The Economic Journal*, 39, 41-57 (1929).

DIO 4.

Authors: Vivaldo Mendes, Diana Mendes (ISCTE, Lisbon, Portugal), Orlando Gomes (ESCS, Lisbon, Portugal)

Title: Learning to play Nash in deterministic uncoupled dynamics

Abstract: In a boundedly rational game, where players cannot be as super-rational as in Kalai and Leher (1993), are there simple adaptive heuristics or rules that can be used in order to secure convergence to Nash equilibria? Young (2008) argues that if an adaptive learning rule obeys three conditions - (i) it is uncoupled, (ii) each player's choice of action depends solely on the frequency distribution of past play, and (iii) each player's choice of action, conditional on the state, is deterministic - no such rule leads the players' behavior to converge to Nash equilibra. In this paper we present a counterexample, showing that there are in fact simple adaptive rules that secure convergence in a fully deterministic and uncoupled game. We used the Cournot model with nonlinear costs and incomplete information for this purpose and also illustrate that the convergence to Nash equilibria can be achieved with or without any coordination of the players actions.

Dynamical Systems 3.

Date: Friday, 10h00

Organizers: Alberto Adrego Pinto (aapinto@math.uminho.pt), Maria Joana Torres (jtorres@math.uminho.pt), Salvatore Cosentino (scosentino@math.uminho.pt)

DS 3.1.

Authors: Luís Silva, Nuno Franco (CIMA-U. Évora, Portugal)

Title: Invariants of templates, knots and links generated by renormalizable Lorenz maps

Abstract: We describe the sub-Lorenz templates generated by renormalizable Lorenz maps, in terms of the templates generated by the renormalized map and by the map that determines the renormalization type. Consequently we obtain explicit formulas for the Williams ζ function of renormalizable sub-Lorenz templates and also for the genus and the braid index of renormalizable Lorenz knots and links.

DS 3.2.

Authors: Nuno Franco, Luís Silva (CIMA- U. Évora, Portugal)

Title: Effective computation of the multivariable Alexander polynomial, genus and trip number of Lorenz links

Abstract: Given two different representations of a Lorenz link, we compare how they affect the computation of the multivariable Alexander polynomial. We also compare the Alexander polynomial with the trip number and genus. Our experimental results lead us to conjecture that, for Lorenz knots, the Alexander polynomial is an equivalent invariant to the pair (trip number, genus). Finally we give a counterexample in the case of Lorenz links.

Keywords: Alexander Polynomial; genus; trip number; Lorenz knots

DS 3.3.

Authors: Acilina Caneco (ISEl and CIMA-U. Évora, Portugal), Clara Grácio (CIMA-U. Évora, Portugal), J. Leonel Rocha (ISEl, Portugal) and Sara Fernandes (CIMA-U. Évora, Portugal)

Title: On the relationship between the synchronizability of a network and some graph invariants

Abstract: In this paper we establish the relation between some graph parameters, particularly, clustering coefficients and conductance, with the synchronization of the network.
There is a recent interest in the study of how the parameters relating the topology of the graph affect the synchronizability of the network associated with the graph. As results between the conductance and the synchronizability are known, we address our work to the relations between clustering and conductance of a graph in order to analyze the effect of clustering in the amplitude of the synchronization interval.

References: [1] S.L. Bezrukov, Edge Isoperimetric Problems on Graphs, Graph Theory and Combinatorial Biology, Bolyai Soc. Math. Stud., 7, 157-197, (1999).

[2] F. Comellas and S. Gago, Synchronizability of complex networks, J. Phys. A: Math. Theor, 40, 4483-4492, (2007).
[3] Z. Duan, W. Wang, C. Liu, G. Chen, Are networks with more edges easier to synchronize?, arXiv:0711.2442v1, (2007).
[4] S. Elaydi, Discrete Chaos, Second Edition: With Applications in Science and Engineering, Chapman & Hall/CRC, 2 edition, (2007).
[5] P. E. Kloeden, Synchronization of Discrete Time Dynamical Systems, Journal of Difference Equations and Applications, 10, (13-15), 1133 - 1138, (2004).
[6] P. N. McGraw and M. Menzinger, Clustering and the synchronization of oscillator networks, Phys. Rev. E, 72, 015101(R), (2005).

DS 3.4.

Authors: Pawel Pilarczyk (U. Minho, Portugal)

Title: Computational-topological approach to the classification of global dynamics of multiparameter systems

Abstract: We introduce an algorithmic method for obtaining a database of global dynamical behaviours encountered in a multi-parameter family of discrete dynamical systems on a bounded set in Rn In this approach, the region of parameters and the phase space are both divided into a finite number of boxes, and for each parameter box the corresponding family of dynamical systems is represented by means of a combinatorial multivalued map. This map is an outer approximation valid for the entire family and is computed with interval arithmetic. The analysis of dynamics is conducted at the combinatorial level with fast graph algorithms. The recurrent dynamics is captured in a combinatorial version of the Conley-Morse decomposition, leaving gradient-like dynamics in the remainder of the phase space, which together provide a schematic picture of global dynamics. Automatic homology computation algorithms are used to compute the Conley index which allows to reconstruct certain properties of invariant sets found in the combinatorial way.

Abstract: Morse decompositions for adjacent parameter boxes are matched and provide rigorous continuation results, and also allow to detect possible bifurcations. A nonlinear overcompensatory Leslie population model is used as a sample dynamical system which illustrates the effectiveness of this approach. This is joint work with Zin Arai (Kyoto University), William Kalies (Florida Atlantic University), Hiroshi Kokubu (Kyoto University), Konstantin Mischaikow (Rutgers University), and Hiroe Oka (Ryukoku University). AMS Subject Classification. Primary: 37B35. Secondary: 37B30, 37M99, 37N25, 92-08.

Keywords: Dynamical system; Global dynamics; Conley index; Morse decomposition; Leslie population models; Combinatorial dynamics; Rigorous numerics; Computational dynamics; Multiparameter system

DS 3.5.

Authors: Sara Fernandes (CIMA-U. Évora, Portugal) and Mouhaydine Tlemçani (Centro de Geofísica de Évora (CGE), Portugal)

Title: Analysis of long time behaviour using symbolic dynamics

Abstract: Time series issued from two different physical systems described by similar dynamic's equations are modelized and analyzed here from a phase space point of view. Long term events are pointed out using symbolic dynamicís tools. It is shown that these new approach can be an alternative to classical time series analysis methods.

Keywords: Dynamical systems; time series; symbolic dynamics

References: [1] Fernandes S, Sousa Ramos J, Conductance, laplacian and mixing rate in discrete dynamical systems, Nonlinear Dynamics 44, N 1-4, 117-126 (2006)
[2] F. Takens, Detecting strange attractors in turbulence, Lecture Notes in Mathematics, vol. 898: 366-381, Springer Berlin / Heidelberg.(1981)
[3] M Tlemcani, P. M. Ramos, F. M. Janeiro and A. Cruz Serra, Impedance Measurements using Analog to Digital Converters and Ellipse Fitting Signal Processing Algorithms 6th Conference on Telecomunications conftele 2007. Peniche May 2007.
[4] D.Lind, M.Marcus, An Introduction to Symbolic Dynamics and Coding, Cambridge University Press, UK, (1995)

Fractional Calculus 1.

Date: Friday, 10h00

Organizer: J.A. Tenreiro Machado (jtm@isep.ipp.pt)

FC 1.1.

Authors: J. Tenreiro Machado (IPP, Portugal)

Title: Fractional Calculus

Abstract: In 1695 L'Hôpital wrote a letter to Leibniz asking for the meaning of $D^n y$ for $n = 1/2$. Leibniz replied 'It seems that useful consequences shall be drawn from these paradoxes one day, as there are no paradoxes that do not prove useful'. The term 'Fractional Calculus' (FC) was adopted at that time and is used even nowadays, although many researchers find more adequate the terminology 'integration and differentiation of arbitrary order'. Starting with the ideas of Leibniz many important mathematicians developed the theoretical concepts, but practical aspects were not evident. During the thirties A. Gemant and O. Heaviside applied FC in the areas of mechanical and electrical engineering, respectively. Nevertheless, these important contributions were somehow forgotten and only during the eighties, we find relevant work, by A. Oustaloup, that developed a pioneering work in the FC application in automatic control systems. In the same period, FC emerged as an important tool associated with phenomena such as fractal and chaos and, consequently, in the modelling of dynamical systems.

The ongoing research of FC application addresses many different aspects such as viscoelasticity and damping, biology, electronics, signal processing, system identification, diffusion and wave propagation, percolation, modeling, identification, and control. Bearing these ideas in mind, this lecture introduces the FC fundamental mathematical aspects and discuses some of their consequences. Based on the FC concepts, the lecture reviews the main approaches for implementing fractional operators and discusses the adoption of FC in control systems. Finally are presented some applications in the areas of modelling and control, namely fractional PID, heat diffusion systems, electromagnetism, fractional electrical impedances, evolutionary algorithms, robotics, and nonlinear system control.

Keywords: Fractional calculus; modelling; simulation.

References: [1] K. B. Oldham, J. Spanier, The Fractional Calculus, Academic Press (1974).
[2] A. Oustaloup, La Commande CRONE: Commande Robuste d'Ordre Non Entier, Editions Hermés (1991).

[3] K. S. Miller, B. Ross, An Introduction to the Fractional Calculus and Fractional Differential Equations, Wiley & Sons (1993).
[4] S. G. Samko, A. A. Kilbas, O. I. Marichev, Fractional Integrals and Derivatives. Gordon and Breach (1993).
[5] I. Podlubny, Fractional Differential Equations, Academic Press (1999).
[6] Jocelyn Sabatier, Om Agrawal, J. Tenreiro Machado (ed), Advances in Fractional Calculus: Theoretical Developments and Applications in Physics and Engineering, Springer (2007).
[7] J. A. Tenreiro Machado, Analysis and Design of Fractional-Order Digital Control Systems, Systems Analysis-Modelling-Simulation, Gordon & Breach Science Publishers, 27(2-3), 107-122, ISSN: 0232-9298 (1997).
[8] J. A. Tenreiro Machado, A Probabilistic Interpretation of the Fractional- Order Differentiation, FCAA - Journal of Fractional Calculus & Applied Analysis, 6(1), 73-80 (2003).
[9] J. A. Tenreiro Machado, Isabel S. Jesus, Alexandra Galhano, Fractional Order Electromagnetics, Signal Processing, Elsevier, 86(10), 2637-2644 (2006).
[10] J. A. Tenreiro Machado, Alexandra M. S. Galhano, Statistical Fractional Dynamics, ASME Journal of Computational and Nonlinear Dynamics, 3(2) (2008).

FC 1.2.

Authors: Ramiro Barbosa (IPP, Portugal), J.A. Tenreiro Machado (IPP, Portugal)

Title: Fractional Control and Dynamic Systems

Abstract: The concepts involved with fractional calculus (FC) theory - the area of mathematics that handles the derivatives and integrals to an arbitrary order (real or complex order) - are, nowadays, applied in almost all areas of science and engineering. Its ability to yield superior modeling and control in many dynamical systems is well recognized. In this presentation, we will introduce the fundamental aspects associated with the application of FC to the control of dynamic systems. The following topics will be briefly covered: introduction to fractional-order calculus, frequency and time domain analysis of fractional-order systems, approximations to fractional-order operators, controller design for fractional-order systems and analog and digital circuits for fractional-order control systems. Finally, we will show some applications of fractional order controllers in the real time control of an experimental system.

Keywords: Fractional calculus; Fractional-order control; Fractional dynamics;

References: [1] K. B. Oldham, J. Spanier, The Fractional Calculus. Academic Press, New York (1974).
[2] I. Podlubny, Fractional Differential Equations. Academic Press, San Diego (1999).

Fractional Calculus 2.

Date: Friday, 16h00

Organizer: J.A. Tenreiro Machado (jtm@isep.ipp.pt)

FC 2.1.

Authors: Manuel F. Silva, J.A. Tenreiro Machado(IPP, Portugal)

Title: Fractional Control of Legged Robots

Abstract: Fractional calculus (FC) is being used in several distinct areas of science and engineering, being recognized its ability to yield a superior modelling and control in many dynamical systems. In this perspective, this article illustrates one application of FC in the area of control systems. A fractional-order PD controller is proposed for the control of an hexapod robot with 3 dof legs. It is demonstrated the system's superior performance by using the FC concepts.

Keywords: Fractional Calculus; PID; Fractional Control; Tuning; Hexapod Robot

References: [1] M.F. Silva and J.A.T. Machado, A Historical Perspective of Legged Robots, Journal of Vibration and Control, Vol. 13(9-10), pp. 1447-1486, (2007).
[2] M.F. Silva, J.A.T. Machado and I.S. Jesus, Modelling and Simulation of Walking Robots With 3 dof Legs, in: MIC 2006 - The 25th IASTED Int. Conf. on Modelling, Identification and Control. Lanzarote, Spain, (2006).
[3] M.F. Silva, J.A.T. Machado and A. M. Lopes, Fractional Order Control of a Hexapod Robot, Nonlinear Dynamics - Special Issue on 'Fractional Derivatives and Their Applications', Vol. 38(1-4), pp. 417-433, (2004).
[4] M.F. Silva, J.A.T. Machado and R. S. Barbosa, Complex-Order Dynamics in Hexapod Locomotion, Signal Processing, Vol. 86(10), pp. 2785-2793, (2006).
[5] M.F. Silva and J.A.T. Machado, Fractional Order PDa Joint Control of Legged Robots, Journal of Vibration and Control − Special Issue on Modeling and Control of Artificial Locomotion Systems, Vol. 12(12), pp. 1483-1501, (2006).

FC 2.2.

Authors: Lino Figueiredo and J.A. Tenreiro Machado (IPP, Portugal)

Title: Fractional Analysis of Traffic Dynamics

Abstract: This article presents a dynamical analysis of several traffic phenomena, applying a new modelling formalism based on the embedding of statistics and Laplace transform. The new dynamic description integrated the concepts of fractional calculus lead to a more natural treatment of the continuum of the TF parameters intrinsic in this system. The results of using classical system theory tools point out that it is possible to study traffic systems, taking advantage of the knowledge gathered with automatic control algorithms.

Keywords: Fractional Calculus; Modelling; Dynamical Traffic Analysis; Traffic Control

References: [1] L. Figueiredo, J. Machado, J. Ferreira, Dynamical Analysis of Freeway Traffic, IEEE Transactions on Intelligent Transportation Systems, Vol 5, No 2, (2004)
[2] L. Figueiredo, J. Machado, J. Ferreira, On the Dynamics Analysis of Freeway Traffic, in Proc.6th IEEE Intelligent Transportation Systems Conference, Shanghai, China, pp. 358-363, 2003
[3] K. B. Oldham and J. Spanier, The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order, Academic Press, New York (1974)
[4] I. Podlubny, Fractional Differential Equations, Academic Press, San Diego (1999)

References: [5] J. A. Tenreiro Machado, A probabilistic Interpretation of the Fractional-Order differentiation, FCAA - Journal of Fractional Calculus & Applied Analysis, vol. 6, n. 1, pp. 73-80 (2003)
[6] L. Figueiredo, J. Machado, J. Ferreira, Dynamics of Freeway Traffic, in Proc.8th IEEE Intelligent Transportation Systems Conference, Vienna, Austria (2005)

FC 2.3.

Authors: Cecília Reis(ISEP, IPP, Portugal) and J.A. Tenreiro Machado (IPP, Portugal)

Title: Fitness Function Evaluation using Fractional Calculus

Abstract: This paper proposes a Genetic Algorithm (GA) for the synthesis of combinational logic circuits. The fitness function evaluation is calculated using Fractional Calculus. This new concept extends the classical fitness function by introducing a fractional-order dynamical evaluation. The dynamic fitness function results from an analogy with control systems where it is possible to benefit the proportional algorithm by including a differential component. The experiments reveal superior results when comparing with the classical fitness method.

Keywords: Fractional Calculus; Genetic Algorithms; Digital Circuits;

References: [1] D. E. Goldberg, Genetic Algorithms in Search Optimization and Machine Learning, Addison-Wesley (1989)
[2] S. Louis and G. Rawlins, Designer Genetic Algorithms: Genetic Algorithms in Structure Design, Proceedings of the Fourth International Conference on Genetic Algorithms (1991)
[3] C. Coello and A. Christiansen and A. Aguirre, Using Genetic Algorithms to Design Combinational Logic Circuits,Intelligent Engineering through Artificial Neural Networks, pp. 391-396 (1996)
[4] K. B. Oldham and J. Spanier, The Fractional Calculus: Theory and Applications of Differentiation and Integration to Arbitrary Order, Academic Press, New York (1974)
[5] J. Machado, Analysis and Design of Fractional-Order Digital Control Systems, SAMS Journal Systems Analysis, Modelling, Simulation, pp. 107-122 (1997)
[6] C. Reis, J. Machado and J. Cunha, Evolutionary Design of Combinational Logic Circuits, Journal of Advanced Computational Intelligence and Intelligent Informatics, pp. 507-513 (2004)
[7] C. Reis, J. Machado and J. Cunha, Evolutionary Design of Combinational Circuits using Fractional-Order Fitness, Proceedings of the Fith EU- ROMECH Nonlinear Dynamics Conference, pp. 1312-1321 (2005)

FC 2.4.

Authors: Isabel S. Jesus(ISEP, IPP, Portugal), J.A. Tenreiro Machado (IPP, Portugal)

Title: Implementation of Fractional Electromagnetic Potential Through a Genetic Algorithm

Abstract: The Maxwell equations play a fundamental role in the well established formulation of the electromagnetic theory. In fact, these equations ex- pressing the basic laws of electricity and magnetism, but only involve the integer-order calculus and, therefore, it is natural that the resulting classical models adopted in electrical engineering reflect this perspective. Recently, a closer look for the electrical phenomena motivated a new perspective towards the replacement of classical models by fractional-order mathematical descriptions. Bearing these ideas in mind, in this study we apply the classical expressions for the static electric potential under the viewpoint of the fractional calculus. The fractional-order electrical potential approximation is implemented through a genetic algorithm, that is a search technique used to find approximate solutions in optimization problems.

Keywords: Fractional calculus; Electric potential; Genetic Algorithms;

References: [1] Richard P. Feynman, Robert B. Leighton, Matthew Sands, The Feynman Lectures on Physics: Mainly Electromagnetism and matter, Addison-Wesley Pub. Company (1964).
[2] N. Engheta, On Fractional Calculus and Fractional Multipoles in Electro- magnetism, IEEE Transactions on Antennas and Propagation, 44(4), 554-566 (1996).

[3] J. A. Tenreiro Machado, Isabel S. Jesus, A Suggestion from the Past?, Journal of Fractional Calculus & Applied Analysis - FCAA, 7(4) (2004).
[4] D. E. Goldberg, Genetic Algorithms in Search Optimization and Machine Learning, Addison-Wesley (1989).
[5] I. S. Jesus, J. A. T. Machado and J. B. Cunha, Application of genetic algorithms to the implementation of fractional electromagnetic potentials, in Proc. of The Fifth International Conference on Engineering Computational Technology - ECT'06, Spain (2006).
[6] I. S. Jesus and J. T. Machado, An Evolutionary Approach for the Synthesis of Fractional Potentials, Fractional Calculus and Applied Analysis - FCAA, 11 (2008).

Hamiltonian Dynamics and Applications.

Date: Friday, 16h00

Organizers: Diogo Pinheiro (dpinheiro@fc.up.pt), João Lopes Dias (jldias@iseg.utl.pt)

HDA 1.

Authors: C.A.A. de Carvalho (UFRJ), M. Peixoto (IMPA), D. Pinheiro (U. Porto, Portugal), A.A. Pinto (U. Minho)

Title: Asymptotic universality of non-isochronous potentials

Abstract: Galileo, on the XV century, observed that the small oscillations of a pendulum seem to have constant period. In fact, the Taylor expansion of the period map of the pendulum is constant up to second order in the initial angular velocity around the stable equilibrium. It is well known that, for small oscillations of the pendulum and small intervals of time, the dynamics of the pendulum can be approximated by the dynamics of the harmonic oscillator. We study the dynamics of a family of mechanical systems that includes the pendulum at small neighbourhoods of the equilibrium but after long intervals of time so that the second order term of the period map can no longer be neglected. We characterize such dynamical behaviour through a renormalization scheme acting on the dynamics of this family of mechanical systems. The main theorem states that the asymptotic limit of this renormalization scheme is universal: it is the same for all the elements in the considered class of mechanical systems. As a consequence we obtain an universal asymptotic Peixoto focal decomposition for this family of mechanical systems.

Keywords: Mechanical Systems, Renormalization, Focal Decomposition.

HDA 2.

Authors: João Lopes Dias (Universidade Técnica de Lisboa, ISEG)

Title: Renormalization of quasiperiodic dynamics

Abstract: We will present renormalization methods for quasiperiodic motion in Hamiltonian systems and vector fields on the multidimensional torus. In particular, we will discuss reducibility of quasiperiodically forced circle flows.

HDA 3.

Authors: Mário Bessa (FCUP, Portugal)

Title: Hamiltonian elliptic dynamics on symplectic 4-manifolds

Abstract: We consider C^2 Hamiltonian functions on compact 4-dimensional symplectic manifolds to study elliptic dynamics of the Hamiltonian flow, namely the so-called Newhouse dichotomy. We show that for any open set U intersecting a far from Anosov regular energy surface, there is a nearby Hamiltonian having an elliptic closed orbit through U . Moreover, this implies that for far from Anosov regular energy surfaces of a C^2-generic Hamiltonian the elliptic closed orbits are generic. This is a joint work with João Lopes Dias [1] and is the Hamiltonian version of a result of Newhouse [2].

Keywords: Hamiltonian vector field, Partial hyperbolicity, elliptic point.

References: [1] M. Bessa and J. L. Dias, Hamiltonian elliptic dynamics on symplectic 4-manifolds, Proc. Amer. Math. Soc. (To appear).
[2] S. Newhouse, Quasi-elliptic periodic points in conservative dynamical systems, Am. J. Math. 99 (1977), 1061-1087.

HDA 4.

Authors: Pedro Duarte (CMAF/DM-FCUL)

Title: Hamiltonian systems on polyhedra

Abstract: We describe a class of Hamiltonian systems on simple polyhedra, which includes several models from game dynamics (e.g., conservative Lotka-Volterra systems). A technique to detect complex dynamical behaviour along the polyhedron edges is explained.

Keywords: Hamiltonian system; Lotka-Volterra system;

References: [1] P. Duarte, Dynamics along the edges of simple polyhedrons Preprint (2006).
[2] P. Duarte, R.L. Fernandes, W. Oliva, Dynamics on the attractor of Lotka-Volterra equations, pp 143-189, Journal of Differential Equations 149 (1998).

Industrial Organization and Economics.

Date: Friday, 16h00

Organizers: Rosa Branca Esteves (rbranca@eeg.uminho.pt)

IOE 1.

Authors: Cristina Januário (ISEL, Portugal)

Title: Topological entropy and the controlled motion of profits in a chaotic economic model

IOE 2.

Authors: Fernando Alexandre (U. Minho, Portugal)

Title: Optimal monetary policy

IOE 3.

Authors: Luís Aguiar-Conraria (U. Minho, Portugal)

Title: Energy Cartel Pricing and Macroeconomic Dynamics

Abstract: It is known that a few oil producing countries control a huge share of the international oil markets. These countries behave like a cartel. OPEC, for example, is an explicit cartel whose pricing strategies have changed accross time. In the OPEC website, one finds the following quote: "One of the most common misconceptions about OPEC is that the Organization is responsible for setting crude oil prices. Although OPEC did in fact set crude oil prices from the early 1970s to the mid-1980s, this is no longer the case." On the other hand, it is common knowledge that OPEC fixes production quotas. So it is reasonable to infer that, from mid 1980s, OPEC has been setting the quantity.
It is known from the empirical literature that there was a structural change on the macroeconomic impact of oil, which occurred at some point in the mid 1980s. Using a standard neoclassical growth model, we show that dependence of production on foreign energy can have a dramatic impact on the likelihood of indeterminacy. If the cartel sets a price and adjust the production to the demand, then self-fulfilling expectations driven busyness cycles are easier to arise. On the other hand, if the cartel chooses the quantity, and lets the price adjust, the reverse happens. A calibration exercise based on estimated share of foreign inputs in production for OECD countries shows that, if the supply curve is horizontal, the required increasing returns to scale can be reduced by as much as 64%. With a vertical supply the required increasing returns to scale may increase by 200%.

IOE 4.

Authors: Orlando Gomes (Escola Superior de Comunicação Social, IPL, Lisbon, Portugal)

Title: The Dynamics of Learning in Optimal Monetary Policy

IOE 5.

Authors: Rosa Branca Esteves (NIPE and Departamento de Economia, U. Minho)

Title: Price Discrimination with Private and Imperfect Information

Abstract: This paper investigates the competitive and welfare effects of information quality improvements in markets where firms can price discriminate after observing a private and noisy signal about a consumer's brand preference. I show that firms charge more to customers they believe have a brand preference for them, and that this price has an inverted-U shaped relationship with the signal's accuracy. In contrast, the price charged after a disloyal signal has been observed falls as the signal's accuracy rises. While industry profit and welfare fall as price discrimination is based on increasingly more accurate information, the reverse happens to consumer surplus. The model is also extended to a public information setting. For any level of the signal's accuracy, moving from public to private information, will boost industry profit and welfare and reduce consumer surplus.

Keywords: Competitive Price Discrimination; Imperfect Information, Welfare, Bayesian Games.

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Author Index