

FCT Relatório Científico 2008 Print: 05-09-2013 10:47:52 [Centro de Matemática e Aplicações - CMA]

### General Information

<b>Name of Research Unit:</b>	(MAT-LVT-297) Centro de Matemática e Aplicações - CMA
<b>Coordinator:</b>	Maria Luísa Martins Macedo de Faria Mascarenhas
<b>Main Scientific Domain:</b>	Matemática
<b>Other Subdomains:</b>	n/a

### Host Institutions

<b>Leading Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa
<b>Other Institutions Involved:</b>	

### Objectives & Achievements

#### Unit Description

CMA/UNL is a research centre located at the Faculty of Sciences and Technology of the New University of Lisbon. This faculty, the biggest of the 8 Faculties and Institutes of the New University, with more than 6000 students and 400 teaching staff, is located at Monte de Caparica in the south bank of Tagus river.

FCT granted to CMA/UNL, two large rooms in the first floor of the Mathematics Department building. Young researchers not belonging to Mathematics Department use this facilities for everyday work as well as other members for small meetings and discussions.

Presently, the CMA has approximately 50 active researchers and around 80 persons associated (PhD and MSc students, national and foreign collaborators, members not classified as active members, etc).

It is organized in six distinct research groups better described below. Most researchers are affiliated to the Mathematics Department of FCT/UNL and share the second floor offices at the Mathematics Department building and a common budget. The interaction among the different research subjects and activities is increasing steadily.

The leadership is ensured by the Director, in accordance with the decisions of the Scientific Council composed by all the active doctors of the CMA and the everyday management is taken care by an executive committee of three, presided by the director. The administrative matters, mainly those related with accounting, are dealt by the administrative collaborators of the Mathematics Department. The by-laws of the CMA are available in a written regulation, that has been changed in 2008 final trimester, to contemplate the classification of the researchers in two additional classes according to recent productivity indicators.

#### General Objectives

CMA was created as framework for the research carried out by members of the Mathematics Department of FCT/UNL and other researchers that cooperate with them.

Some of the more mature members of the Mathematics Department of FCT/UNL belong to other research centers, namely some centres of the University of Lisbon. Since Mathematics Department is part of a Science and Engineering school, it seems natural that our research has initially developed in Applied Mathematics: first Statistics, Operations Research, Actuarial Sciences And Algebra and, more recently, Differential Equations and Numerical Analysis. We stress the fact that a great part of our recent PhD and PhD students supervised by members of CMA, come from others schools.

Presently CMA is organized into 6 research groups that carry out these own sub-projects:

- Algebra;
- Differential Equations and Numerical Analysis;
- Statistical Inference;
- Actuarial and Financial Mathematics;
- Distribution Theory;
- Operational Research.

The research goal of CMA being those of these groups we now consider them briefly.

Combinatorics, Additive Number Theory, Ockham Algebras, Semigroups and Graphs – We intended to continue the investigation done so far with the same main objectives.

Differential Equations – The recent creation of DENA allowed the formation of a homogeneous, young and active group committed in the exchange of scientific experience and to the development of modern and state-of-the-art research in the following areas: Differential Equations, Calculus of Variations, Dynamical Systems and Numerical Analysis.

Statistical Inference – we aim at a systematic development of inference for mixed models, both orthogonal and non orthogonal. Moreover we intend to apply Linear Statistical Inference in various domains: Ecology, Hydrology, etc.

Actuarial and Financial Mathematics – dynamic relations price liquidity for risk management; simulation and stochastic algorithms; equilibrium problems in mathematical economics; ruin problems and credibility theory.

Distribution Theory – development and comparative study of near-exact distributions for several likelihood-ratio test statistics; development of multivariate distributions with Generalized Integer Gamma marginals and wrapped Gamma and related distributions; distributions of estimators for the extremal index.

Operational research– Developpments in non linear (global optimization for non convex problems, free derivative methods, complementarity) and combinatorial optimization (location, hub location and semi definite optimization), management science (reverse logistic, star classification) and simulation (seismic simulation).

## Objectives & Achievements

### Main Achievements during the year of 2008

The specific scientific accomplishments reached during the year 2008 are to be found in the reports of the different research groups.

The overall scientific production of the teams was the following.

TEAM.....	Papers	Other Pub.	PhD awarded	MsSc awarded
Algebra.....	6	-	1	-
Statistical Inference.....	17	-	5	-
Distribution Theory .....	7	-	4	1
Diff. Equat. & Num. Anal.....	11	-	3	-
Operat. Research.....	4	-	7	1
Act. & Fin. Math. ....	4	-	5	2

This shows an average of approximately 1 publication per researcher per year.

## Activities

### Integrative/multidisciplinary activities during the year of 2008

The research group Differential Equations and Numerical Analysis carried a weekly seminar all along the year allowing interaction with other disciplines at FCT/UNL.

Through the different research projects there were significant interactions with researchers from Mathematical Economy, Medical Schools, Agronomy, Informatics and Computation. Some of the research members, some of the collaborators and some of the PhD and Master students, develop their professional activities in the industry (energy, banking and insurance) thus allowing very beneficial interactions.

### Outreach activities during the year of 2008

Members of the research groups Differential Equations and Numerical Analysis, Operations Research, Algebra and Distribution Theory were involved in several sessions of Clube Mat. which proposes Saturday afternoon mathematical activities for children and their parents.

## Funding

	2008	2009	2010
LA FCT	0,00	0,00	0,00
Units FCT	68.922,49	187.687,50	131.381,25
Projects FCT	34.200,00	46.337,60	50.773,60
Other (National)	0,00	200,00	0,00
Other (International)	0,00	0,00	0,00
National Industry	0,00	0,00	0,00
International Industry	0,00	0,00	0,00
	<b>103.122,49</b>	<b>234.225,10</b>	<b>182.154,85</b>

## General Indicators

	2006	2007	2008	2009	2010	Total
No. of Researchers Proposed	0,00	0,00	0,00	0,00	0,00	0,00
No. of Researchers Hired (LA)	0,00	0,00	0,00	0,00	0,00	0,00
<b>Balance</b>	0,00	0,00	0,00	0,00	0,00	0,00
No. of Researchers Hired (Ciência Programme)	0,00	0,00	4,00	2,00	0,00	6,00
No. of Researchers integrated with PhD	32,00	42,00	49,00	48,00	50,00	
Training Masters (Master thesis completed)	5,00	6,00	6,00	5,00	0,00	22,00
Training PhDs (PhD thesis completed)	12,00	12,00	9,00	7,00	1,00	41,00

## Researchers Hired

Name	Start Date	End Date	Other Institution
No researchers found...			

## Technical Personnel Hired

Name	Start Date	End Date	Other Institution
------	------------	----------	-------------------

**Technical Personnel Hired**

Name	Start Date	End Date	Other Institution
No technical personnel found...			

**Additional Comments****Additional Comments**

Although the selection process of the four researchers, of Ciência 2008, ended in 2008 and these researchers entered the CMA in 2008, their official contracts will star only in 2009.

The precise general funding data for the CMA is not yet available. The figure reported in UNITS is the executed budget according to FCT/MCTES data. The figure reported in Projects FCT is estimated with data delivered by the members of the research groups.

**Research Groups**

Reference	Title / Principal Investigator
RG-LVT-297-1846	<u>Algebra</u> (Maria Helena Coutinho Gomes de Almeida Santos)
RG-LVT-297-1849	<u>Differential Equations and Numerical Analysis</u> (Fabio Augusto da Costa Carvalho Chalub)
RG-LVT-297-1850	<u>Operational Research</u> (Maria Isabel Azevedo Rodrigues Gomes)
RG-LVT-297-3843	<u>Statistics and Risk Management</u> (Manuel Leote Tavares Ingles Esquivel)
RG-T-LVT-297-1847	<u>Statistical Inference</u> (João Tiago Praça Nunes Mexia)
RG-T-LVT-297-1848	<u>Distribution Theory</u> (Carlos Manuel Agra Coelho)
RG-T-LVT-297-1852	<u>Actuarial and Financial Mathematics</u> (Manuel Leote Tavares Ingles Esquivel)

FCT Relatório Científico 2008 Print: 05-09-2013 10:50:21 [Centro de Matemática e Aplicações - CMA]

## Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1846) Algebra
<b>Principal Investigator:</b>	Maria Helena Coutinho Gomes de Almeida Santos
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

CMA budget.

## Objectives & Achievements

### Objectives

Prosecute ongoing research on the following topics.

The structure of sumsets in additive number theory.

Repetitions in combinatorics on words.

Let  $G$  and  $H$  be two graphs and  $c$  a positive number. Each edge of  $G$  has weight 1 and each  $H$ -subgraph of  $G$  has weight  $c$ . An  $H, c$ -decomposition of  $G$  is a partition of the edge set of  $G$  such that each part is either a single edge or forms a graph isomorphic to  $H$  and the weight of the decomposition is the sum of the weights of each element in the decomposition. Let  $f(G, H, c)$  be the smallest possible weight in an  $H, c$ -decomposition of  $G$ . We intend to study the problem of finding the smallest value  $f(n, H, c)$  such that any graph of order  $n$  admits an  $H, c$ -decomposition with weight at most  $f(n, H, c)$ . Since this value depends on the structure of the graph  $H$ , our main goal is to find its asymptotic value for any graph  $H$ .

Minimal rank of matrices associated with a graph and the equivalence class graph. Properties of the equivalence class graph and particularly cases for that we have the minimum rank of the matrix equal to the order of the equivalence class graph.

Relation between perturbing the  $i$ th-diagonal entry of an Hermitian matrix  $A$  and extracting the principal submatrix  $A(i)$  from  $A$  with respect to the possible changes in multiplicity of a given eigenvalue.

Development of a theory of non-commutative motives.

Strong endomorphism kernel property in Ockham Algebras and MS-algebras.

Regular Semigroups.

### Main Achievements

A complete description is given and used to both generalize and improve prior work about Hermitian matrices whose graph is a given tree.

Construction of a homotopy theory of Spectral categories.

An endomorphism on an algebra  $A$  is said to be strong if it is compatible with every congruence on  $A$  and  $A$  is said to have the strong endomorphism kernel property if every congruence different from the universal congruence is the kernel of a strong endomorphism on  $A$ . We consider this property in the context of Ockham algebras. In particular, for those MS-algebras that have this property we describe the structure of their dual space in terms of 1-point compactifications of discrete spaces.

It was determined the structure of naturally ordered regular semigroups that have an inverse transversal in the case where the inverse transversal is a monoid.

In a semigroup where every element has a biggest inverse, necessary and sufficient conditions for the set of biggest inverses to be an inverse transversal were obtained.

In principally ordered regular semigroups, it was determined precisely when the set of biggest pre-inverses is a subsemigroup and proved that in this case it is an inverse transversal of the semigroup.

Necessary and sufficient conditions for an ordered  $E$ -inversive semigroup to be a Dubreil-Jacotin semigroup were determined and it was proved that when the set of regular elements is a subsemigroup it contains a multiplicative inverse transversal.

## Group Productivity

### Publications in peer review Journals

Blyth, TS; Santos, MHA, "Naturally Ordered Regular Semigroups with an Inverse Monoid Transversal", Semigroup Forum 76, (2008), 71-86.

Blyth, T. S.; Silva, H. J. "The strong endomorphism kernel property in Ockham algebras". Comm. Algebra 36 (2008), no. 5, 1682—1694.

Johnson, Charles R.; Saiago, Carlos M., "Branch duplication for the construction of multiple eigenvalues in an Hermitian matrix whose graph is a tree". Linear Multilinear Algebra 56 (2008), no. 4, 357--380.

Johnson, Charles R.; Leal Duarte, António; Saiago, Carlos M., "The structure of matrices with a maximum multiplicity eigenvalue". Linear Algebra Appl. 429 (2008), no. 4, 875--886.

**Group Productivity**

Kao, Jui-Yi; Rampersad, Narad; Shallit, Jeffrey; Silva, Manuel Words avoiding repetitions in arithmetic progressions, Theoret. Comput. Sci. 391 (2008), no. 1-2, 126--137.

Sousa, T, "Friendship Decompositions of Graphs" Discrete Mathematics Volume 308, Issue 15, 2008, Pages 3352-3360.

**Master and Ph.D. thesis completed**

Silva, Manuel PhD January 2008: "Binary Linear Forms and Finite Partitions Over The Natural Numbers"

**Internationalization****PRIZES**

CMA and the researcher Gonalo Tabuada received the prize "Programa de Estímulo à Investigação 2008" from Fundação Calouste Gulbenkian.

FCT Relatório Científico 2008 Print: 05-09-2013 10:51:21 [Centro de Matemática e Aplicações - CMA]

### Group Description

**Title of Research Group:** (RG-LVT-297-1849)  
Differential Equations and Numerical Analysis

**Principal Investigator:** Fabio Augusto da Costa Carvalho Chalub

**Main Scientific Domain:** Matemática

**Group Host Institution:** Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

### Funding, source, dates

#### Funding, source, dates

Fabio Chalub (P. coordinator):

PTDC/MAT/66426/2006

"Mathematical models of evolutionary processes", funded by FCT/Portugal

Funding: 49.000 euros. (2008--2010)

Filipe Oliveira (P. coordinator):

PTDC/MAT/68615/2006

"Kinetic Models and Applications",

Starting Date: 01/04/2007

Duration: 36 months.

Total funding: 20.000 euros.

Executed in 2008: 6200 euros

M. Luísa Mascarenhas (P. coordinator)

POCI/PPCDT/MAT/60587/2004, Asymptotic Analysis applied to Continuum Mechanics (2005-2009)

Total funding: 31 500 Euros

Existing funds: 7 200 Euros

Rogério Martins:

POCI/Mat/57258/2004, 2004/2008.

Differential Equations and Applications to Epidemiology. Together with Carlota Gonçalves (FCUL), Gabriela Gomes (IGC), Luís Sanchez (FCUL), Alessandro Margueri (FCUL), Ricardo Roque (ISEL), José Maria Gomes (FCUL), Paula Rodrigues (FCTUNL).

Filipa Caetano: Project ANR-SHPCO2 (post doc fellowship, since September the 1st.)

Ana M. Ribeiro: Post-doc scholarship from National Science Foundation FCT.

Rita Ferreira: PhD fellowship from CMU-Portugal Program in Applied Mathematics.

### Objectives & Achievements

#### Objectives

We intended to work in the following subareas:

- 1) Calculus of Variations and Optimization (A. M. Ribeiro, J.M. Gomes, M. L. Mascarenhas, N. Arada, R. Ferreira, T. Guerra)
- 2) Conservation Laws (F. Caetano , F. Oliveira)
- 3) Dynamical Systems (A. P. Pimenta, R. Martins)
- 4) Factorization of Boundary Value Problems (B. Louro, M. C. Soares, M. Orey)
- 5) Kinetic Models (F.A.C.C. Chalub, F. Oliveira)
- 6) Mathematical Modelling (Biology / Mechanics) (N. Arada, F.A.C.C. Chalub)
- 7) Functional Analysis (J. Marques, M.F. Veiga)

More specifically our objectives are:

A.M. Ribeiro initiated the study of relaxation problems closely related with image segmentation models; Eventually, she will study some homogenization problems.

M.L. Mascarenhas and R. Ferreira will proceed previous works in dimension reduction and homogenization. They will also initiate the study of some 3D-2D divergence free models. M.L. Mascarenhas will collaborate with L.Trabucho, from CMAF and G. Bouchitté from the Univ. of Toulon et du Var, in spectral problems in thin domains.

## Objectives & Achievements

J.M. Gomes will study the existence of multibump nodal solutions for indefinite nonlinear elliptic problems and the geometrical properties of level states of ground-state solutions, i.e. of the minimizers of the Dirichlet integral under a volume constraint.

F. Caetano research is about the coupling of hyperbolic systems of conservation laws through a thin fixed interface located in the spatial domain.

F. Oliveira aims to prove/disprove the existence of global strong solutions for a large class of Benney-like systems with polynomial nonlinearities in all functions. Also, the study of the linear stability of travelling waves for such systems will be carried out. Concerning kinetic models, F.Oliveira will study some degenerate Fokker-Planck Equation arising in population dynamics.

A.P. Pimenta will study the algebraic structure of the periodic orbits set of the unimodal families, in particular, the quadratic and the tent maps, viewed in terms of the Galois theory applied to the iteration of quadratic maps.

R. Martins expects to find original ways to study synchronization in linearly coupled oscillators. He plans to use some theories developed by R. Smith to show the existence of invariant manifolds for systems of no identical oscillators, proving the existence of the so-called generalized synchronization. On the other hand he plans to continue the study of some models coming from liquid crystals in the presence of an alternating shear and magnetic fields. Numerical analysis suggests the existence of a cascade of subharmonics with increasing period

B. Louro, M.C. Soares and M.Orey are pursuing the development of the theory of factorization of boundary value problems, in particular they intend to complete the study of the Riccati equation for the cases obtained by the referred decomposition.

F.A.C.C. Chalub will focus on mathematical models in evolutionary biology. These models lead to drift-diffusion differential equations of degenerated type. Furthermore, these models show links with Fokker-Planck equation, Boltzman equation, Langevin equation, and replicator dynamics .

N. Arada and T. Guerra will carry out the analytic and numerical study of control problems for a class of incompressible non-Newtonian fluids. (Ph.D. Thesis of T.Guerra).

J. Marques will carry out his research on extension and representation of linear operators. Attention will also be given to orthonormal sets in inner product spaces and algebras of operators.

M.F. Veiga, will study some compactness problems and some questions related with separability and the Axioms of countability.

Strong collaboration will continue with CMAF and CFTC, from the University of Lisbon, with CAMGSD, from IST, and with CMAT from University of Minho. The interaction with Physics and Engineering departments inside FCT-UNL is one of our main goals.

Other goals:

1. Collaboration in the international Programs in Mathematics with CMU and Austin-Texas.
2. The organization of the meeting, from 8 to 12 September 2008, under the title Calculus of Variations and its Applications: from Engineering to Economy.
3. The organization of the first workshop of the CMU-Portugal ICTI program, New Developments in PDE & Calculus of Variations, 11 September, 2008.
4. To attract and motivate young people to Mathematics. We address students of all ages, regularly visiting schools, organizing mathematical exhibitions and dedicated conferences. We also wish to attract engineering students, inside and outside of our school, organizing and divulgating more advanced seminars.

## Main Achievements

General achievements

Our team produced 14 publications: 11 papers in high level peer-reviewed journals, 2 science diffusion papers and a teaching book.

We organized a weekly scientific seminar: Seminário de Análise, where we receive national and international specialists in the area of Differential Equations and Numerical Analysis. Also due to this seminar, we are creating and we are improving scientific collaboration with our colleagues from other departments in the Faculdade de Ciências e Tecnologia.

We also participated in several national and international conferences, where our main scientific results were communicated.

Other important achievement was, besides our participation in the international Mathematic Programs CMU-Portugal and Austin Texas Portugal, the collaboration in the 3rd cycle in Mathematic, in association with the Faculdade de Ciências, Universidade de Lisboa.

The team also collaborated in important outreach activities as:

Directive board of the Sociedade Portuguesa de Matemática (SPM) (F. Oliveira)

Programa Novos Talentos em Matemática, Fundação Calouste Gulbenkian (Filipe Oliveira)

Committee of Applied Mathematics of the European Mathematical Society (EMS) (M.L. Mascarenhas)

Organization of Club de Matemática (<http://ferrari.dmat.fct.unl.pt/clubemath/>),

dedicated to young students from Ensino Básico e Secundário (M.C. Soares)

Scientific divulgation events, sponsored by SPM – Tarde de Matemática no Porto (F. Chalub)

Specific achievements

Ana M. Ribeiro - It was obtained the relaxed functional for decoupled models, that is when the dependence on the gradient of  $u$  is decoupled from the  $u$  and  $v$  dependence. This case was treated both when  $v$  is in  $L_p$  with  $p$  infinity and  $p > 1$ . The general case (not necessarily decoupled) with  $v$  in the space of bounded integrable functions was also treated if the initial functional has an integrand which is cross-quasiconvex. A paper is being prepared.

## Objectives & Achievements

Bento Louro, M. do Céu Soares, Maria d'Orey - An article accepted for publication: "Factorization by invariant embedding of a boundary value problem for the Laplace operator", *System Modeling and Optimization, IFIP International Federation for Information Processing*, to appear.

Filipa Caetano - We introduced a domain decomposition algorithm for a class of nonlinear reaction-diffusion equations. We performed the numerical implementation of

this algorithm, in dimension 2, and proved its convergence in some situations. A paper is being prepared.

Filipe Oliveira Concerning the Zolotarov-Rubenchik equation, we established the pointwise convergence of the magnetic field  $B$  to a solution of the cubic nonlinear Schrödinger equation, in the adiabatic limit. Our next goal is to prove the uniform convergence.

In what concerns Boltzmann-like equations, we derived a shock-wave profile for a discrete velocity model of the Boltzmann equation with multiple collisions. We now plan to carry out stability analysis of shock profiles. Finally, we established an H-theorem and the trend to equilibrium for a model describing a chemically active mixture of gases.

M. Luísa Mascarenhas and Rita Ferreira – as a consequence of their research, an article accepted for publication and some papers in preparation.

Rogério Martins – An article accepted for publication: M. Guerra, R. Pinto, R. Martins, J.P. Casquilho, On the effect of a rotating magnetic field or sample on the bend Freedericksz critical field in nematic slabs, accepted for publication on the *Molecular Crystals and Liquid Molecular Crystals and Liquid Crystals (MCLC) journal*. ISI IF: 0.554

## Group Productivity

### Publications in peer review Journals

1) F. Caetano, "The linearization of a boundary value problem for a scalar conservation law", *Communications in Mathematical Sciences*, pp. 651-667, 2008.

ISI IF: 1.378

2) F.A.C.C.Chalub and M.O.Souza, "A non-standard evolution problem arising in population genetics", *Comm. Math. Sciences* 7(2) 489–502 (2009).

ISI IF: 1.378

3) F.A.C.C.Chalub and M.O.Souza, "Discrete versus continuous models in

evolutionary dynamics: from simple to simpler – and even simpler – models", *Math. and Computer Modelling*, 47 (7-8) 743-754 (2008).

ISI IF: 0.527

Citations in 2008 (total): 45 (web of science).

4) Ferreira, Rita; Mascarenhas, M. Luísa "Waves in a thin and periodically oscillating medium", *C. R. Math. Acad. Sci. Paris* 346 (2008), no. 9-10, 579--584.

ISI IF: 0.350

5) N. Bouarroudj, J. Henry, B. Louro and M. Orey, "On a direct study of an operator Riccati equation appearing in boundary value problems factorization", *Appl. Math. Sci. (Ruse)* 2 (2008), no. 46, 2247--2257.

6) J. Deus Marques, "On vectorial inner product spaces", *Int. J. Pure Appl. Math.* 42 (2008), no. 2, 227--234.

7) M. Guerra, R. Pinto, R. Martins, J.P. Casquilho, "On the effect of a rotating magnetic field or sample on the bend Freedericksz critical field in nematic slabs", accepted for publication on the *Molecular Crystals and Liquid Molecular Crystals and Liquid Crystals (MCLC) journal*.

ISI IF: 0.554

8) Bouchitté, Guy; Fonseca, Irene ; Mascarenhas, M. Luísa "The Cosserat Vector In Membrane Theory : A Variational Approach", accepted for publication in *Journal of Convex Analysis* (<http://www.heldermann.de/JCA/JCA16/JCA162/jca16018.htm>).

ISI IF: 0.771

9) F. Oliveira, "Adiabatic limit of the Zakharov-Rubenchik Equation", *Reports on Mathematical Physics*, Vol. 28-12, pp. 13-27 (2008).

ISI IF: 0.624

10) F. Oliveira and A. J. Soares, "A note on a Discrete Boltzmann Equation with multiple collisions", *Journal of Mathematical Analysis and Applications*, Vol. 341-2, pp. 1476-1481 (2008).

ISI IF: 0.872

11) G. Kremer, F. Oliveira and A. J. Soares, "H-Theorem and trend to equilibrium of chemically reacting mixture of gases", accepted for publication in *Kinetic and Related Models*.

### Other publications National

Science Diffusion:

1) Fabio A. C. C. Chalub, "The Saros cycle: obtaining eclipse periodicity from Newton's laws". Accepted for *Revista Brasileira de Ensino de Física*.

2) Fabio A. C. C. Chalub "A regular commentary in the magazine 'Gazeta de Matemática', published by the Portuguese Mathematical Society, called 'Na linha de Frente', since 2008 (in Portuguese).



**Group Productivity**

Text book:

3) A. Alves de Sá, B. Louro, Sucessões e Séries, Teoria e Prática, Livraria Escolar Editora, Lisboa 2008.

**Organization of conferences**

1. Together with the Operations Research Group we organized the international meeting CVA 2008, from 8 to 12 September 2008, under the title Calculus of Variations and its Applications: from Engineering to Economy

(<http://ferrari.dmat.fct.unl.pt/cva2008/>)

2. Together with CMU, FC-UL and IST-UTL, we organized of the first workshop of the CMU-Portugal ICTI program in Mathematics (<http://www.math.cmu.edu/CNA/CNAevents/icti08/index.html>)

under the title New Developments in PDE & Calculus of Variations, 11 September, 2008.

**Internationalization**

Our team participates in the ICTI and CoLab programs in Mathematics, with the Carnegie Mellon University (CMU) (<http://icti.math.cmu.edu/>) and with the University of Austin at Texas (UTA) (<http://www.utAustinportugal.org/mathematics/>), respectively.

Ana M. Ribeiro - Pos-doc at CNA (Center for Nonlinear Analysis) from Carnegie Mellon University between September 2007 and August 2008, under the supervision of I. Fonseca.

During the pos-doc it was developed research work in the area of the Calculus of Variations as well as an active participation in the seminars, working groups and conferences organized by CAN.

Filipa Caetano - worked in Laboratoire Jacques Louis Lions, in Paris, in 2008.

Fabio Chalub - Two international invited talks: 1 in Brazil and 1 in Italy, and also the participation in a MSc jury in Brazil.

M. Luísa Mascarenhas - visited Carnegie Mellon University from 4th to 18th April 2008.

Conference at Center of Nonlinear Analysis: Some geometrical effects in dimension reduction

Rita Ferreira integrates the PhD student in the program in Mathematics CMU-Portugal.

Our team also collaborates with scientists from the following universities:

Carnegie Mellon Univ. INRIA, Univ. Complutense, Univ. Federal Fluminense, Univ. Federal Paraná, Univ. Granada, Univ. Libre Bruxelles, Univ. Toulon.

FCT Relatório Científico 2008 Print: 05-09-2013 10:52:13 [Centro de Matemática e Aplicações - CMA]

### Group Description

<b>Title of Research Group:</b>	(RG-LVT-297-1850) Operational Research
<b>Principal Investigator:</b>	Maria Isabel Azevedo Rodrigues Gomes
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

### Funding, source, dates

#### Funding, source, dates

The group receives its share of the common budget of the CMA.

- Isabel Salema Member: POCTI/AMB/57566/2004 – LogInv: Gestão e modelação de cadeias logísticas globais com fluxos de retorno. PI : Ana Póvoa.-

- Ana Luísa Custódio Member: PTDC/MAT/64838/2006 - Computational Mathematical Finance PI: Luís Nunes Vicente.

### Objectives & Achievements

#### Objectives

The activities of the group are organized in three main areas of research: Combinatorial Optimization, Nonlinear Optimization and Management Science. Some of the members develop research work in more than one of these areas.

The year of 2008 was the first year in which all members had a Ph.D, which justifies the increase of autonomous work, the appearing of new research areas and the establishment of new collaborations.

Some effort was made in order to increase internal partnerships and to exploit synergies. A group of researchers integrated in the unit applied to a common research project and set the basis for a future collaboration in network optimization.

The majority of the fruitful collaborations with researchers outside the group was maintained, in some cases even increased, allowing the consolidation of the past research work.

#### Main Achievements

Recent work in this group includes:

##### A1- (PAA)

- Global optimization methods for nonconvex programs, in particular for the Fractional Quadratic Problem (FQP). Copositive formulations for the FQP. Relaxations based on Copositive formulations.

- Automization of Tabu Search via the tuning of parameters using a Fuzzy Inference Ruled based system. Applications to the Exam Timetabling Problem (ETP). Generalizations for the multicriteria case using weighting functions aggregation.

- Reduction of the number of membership functions in linguistic variables.

- A decisional method for handling inconsistent linear programming problems.

##### A2- (ISC)

- Study of a location problem which involves modular distribution costs. For this problem new discretized models were proposed. The new models performed better than the traditional models that are usually applied to this type of problems.

- A mixed integer linear programming formulation for Project Scheduling with flexible resources. Development of some valid inequalities.

##### A3 - (MCB)

- Combination of a spectral projected gradient method with preconditioning strategies to solve bound constrained nonlinear optimization problems.

##### A4- (ALC)

- Incorporation of Minimum Frobenius Norm (MFN) quadratic models in direct-search methods. The approach taken was to maintain the structure of directional direct-search methods, organized around a search and a poll step, and to use the set of previously evaluated points generated during a direct-search run to build the models. The minimization of the models within a trust region provided an enhanced search step.

- New release of the computational code SID-PSM, motivated by the good numerical performance obtained with the incorporation of MFN models in direct-search.

##### A5 - (SBB)

##### A6- (MIS)

- Definition of measures for environmental impacts of complex systems such as global supply chains. The environmental impact of the human activity is a "hot topic" in the modern society. Companies are being forced to evaluate and redesign their supply chains to face new environmental legislation. The research has been centered in the design and management of supply chains with reverse flows. In particular, it has been analyzed ways to measure environmental impacts of complex systems such as global supply chains. Mathematical programming models that integrate environmental impacts in the design of global supply chains are being developed.

##### A7- (NCM)

- Modifications of Adaptive Heuristic Algorithms to be applied to Continuous Time Scheduling Environment. Continuous Time Scheduling problems usually have a high level of intractability. Adaptive Heuristic Algorithms were adapted to the Continuous Time Scheduling Environment and were tested with several instances found in literature.

### Objectives & Achievements

- A Multilinear Regression Simulation Annealing algorithm for stellar classification. Stellar Classification could be approached as a combinatorial problem, where the objective function is the difference between the characteristics of an unknown stellar body and the characteristics of an already classified star. The problem is to find the star that minimizes the mentioned difference, among billions of stellar bodies existing in an Astrophysics Catalog. An algorithm for filtering information, based on Simulated Annealing and using Multilinear Regression, was developed and tested.

A8 – (MCV)

- Use of Semidefinite Optimization techniques to analyze propositional formulae. Given a propositional formula, two questions arise. Is this formula satisfiable? Is this formula a contradiction? In some cases convex optimization (Semidefinite Optimization) can give an answer to these questions. Research was developed on ways of "translating" the answer given by Semidefinite Optimization to propositional formula "language".

### Group Productivity

#### Publications in peer review Journals

P. Amaral, J. Júdice and H. D. Sherali, A reformulation linearization convexification algorithm for optimal correction of an inconsistent system of linear constraints, *Computers & Operations Research*, 35, 1494 – 1509, 2008.

I. Correia, L. Gouveia and F. Saldanha da Gama, Solving the Variable Size Bin Packing Problem with Discretized Formulations, *Computers & Operations Research*, 35, 2103 – 2113, 2008.

A. L. Custódio, J. E. Dennis Jr. and L. N. Vicente, Using simplex gradients of nonsmooth functions in direct search methods, *IMA Journal of Numerical Analysis*, 28, 770 – 784, 2008.

C. Audet, A. L. Custódio and J. E. Dennis Jr., Erratum: Mesh adaptive direct search algorithms for constrained optimization, *SIAM Journal on Optimization*, 18, 1501 – 1503, 2008.

#### Other publications International

P. Amaral and T. Pais, Managing the Tabu List Length Using a Fuzzy Inference System: An Application to Exams Timetabling, 7th International Conference on the Practice and Theory of Automated Timetabling – PATAT 2008, Montreal, Canada, 2008.

Tiago Cardal Pais and Paula Amaral, Using weight aggregation in tabu search for multiobjective exams timetabling problem, MTISD 2008. *Methods, Models and Information Technologies for Decision Support Systems - Università del Salento, Lecce, Italy, 2008.*

I. Salema, A.P.F.D. Barbosa-Póvoa and A.Q. Novais, Design of a recovery network in Portugal: the electric and electronic equipment case, IEMC - International Engineering Management Conference, Lisbon, Portugal, 2008.

I. Salema, A.P.F.D. Barbosa-Póvoa and A.Q. Novais, Analysis and Retrofit of the EEE, Production and Operations Management Society Conference, POMS, La Jolla, USA, 2008.

A. Cunha, I. Salema, A.P.F.D. Barbosa-Póvoa and A.Q. Novais, An Optimization Model for the Design of Closed Loop Supply Chains with Minimum Environmental Impacts, Computer Aided Chemical Engineering - European Symposium on Computer Applications in Process Engineering, 2008.

#### Other publications National

I. Correia, L. L. Lourenço and F. Saldanha da Gama, Multi-Skill Resource-Constrained Project Scheduling: Formulations and Inequalities, working paper n.º17/2008, Operations Research Center, Faculty of Science, University of Lisbon, 2008.

A. L. Custódio, H. Rocha and L. N. Vicente, Incorporating Minimum Frobenius Norm Models in Direct Search, preprint 08-51, Dept. of Mathematics, Univ. Coimbra, 2008.

#### Master and Ph.D. thesis completed

MSc (Matemática, FCT-UNL) Supervisor: Paula Amaral; Student: Tiago Cardal Pais; Dissertation Title: "Uma abordagem baseada na Pesquisa Tabu para o problema da geração de horários de exames.";

#### Patents/proptypes

Computational codes:

-A. L. Custódio and L. N. Vicente, SID-PSM: A pattern search method guided by simplex derivatives for use in derivative-free optimization (MATLAB), Version 1.0 Web Page: <http://www.mat.uc.pt/sid-psm>

#### Organization of conferences

Ana Luísa Custódio: Member of the Organizing Committee of the conference Calculus of Variations: From Engineering to Economy, 8 to 10 September 2008, Centro Internacional de Matemática, New University of Lisbon, Portugal.

OR-CMA Seminars Organizer : Isabel Salema

-Construção de calendários de exames utilizando Pesquisa Tabu Tiago Pais (Uninova, FCT-UNL)

-Redução do Número de Funções de Pertença num Sistema de Inferência Fuzzy Margarida Gomes (Uninova, FCT-UNL)

-Projecto de Cadeias de Abastecimento com Fluxo de Retorno: Custos versus Impactes Ambientais Ana Cunha (DMS - INETI)

-Optimização de uma Rede de Recolha de Produtos Eléctricos e Electrónicos em Portugal Isabel Gomes Salema (FCT-UNL)

-Modelação do Desempenho Académico de Alunos de Licenciatura da FCT-UNL Ruy Costa (FCT-UNL)

**Group Productivity****Internationalization**

Collaborative research and publication with:

- Hanif Sherali, Virgínia Tech, USA;
- C. Audet, École polytechnique de Montréal, Canada;
- John Dennis Jr, Rice University, USA.

I. Correia:

- GOM 2008 (Graph and Optimization Meeting), Saint-Maximin, La Sainte Baume, France, 24-27 August, 2008. (invited) -
- ISOLDE XI – Eleventh International Symposium on Locational Decisions, Santa Barbara, California, USA, 26 June – 1 July, 2008.
- IWOR – International Workshop on Operational Research, Madrid, Spain, 5-7 June, 2008. (invited)
- IO 2008, 13th Conference of the Portuguese Operations Research Association (APDIO), Vila Real, Portugal, 17-19 March, 2008.

P. Amaral:

- 7th International Conference on the Practice and Theory of Automated Timetabling – PATAT 2008, Montreal, Canada, 2008.
- MTISD 2008. Methods, Models and Information Technologies for Decision Support Systems - Università del Salento, Lecce, Italy, 18-20 September 2008. (invited)
- Calculus of Variations: From Engineering to Economy, Centro Internacional de Matemática, New University of Lisbon, Portugal, 8-10 September 2008. (invited)
- two conferences at: IO 2008, 13th Conference of the Portuguese Operations Research Association (APDIO), Vila Real, Portugal, 17-19 March, 2008.

I. Salema:

- the WEEE recovery system, EWGLA, Elche, Spain, 2008.
- Production and Operations Management Society Conference, POMS, San Diego, USA, 2008.
- IEMC, Estoril, Portugal, 2008.
- IO 2008, 13th Conference of the Portuguese Operations Research Association (APDIO), Vila Real, Portugal, 17-19 March, 2008.

N.C. Martins:

- three communicationst at the: 13th Conference of the Portuguese Operational Research Association (APDIO), Vila Real, Portugal, 17-19 March, 2008.

M. C. Brás:

- 13th Conference of the Portuguese Operations Research Association (APDIO), Vila Real, Portugal, 17-19 March, 2008.

FCT Relatório Científico 2008 Print: 05-09-2013 10:54:07 [Centro de Matemática e Aplicações - CMA]

**Group Description**

**Title of Research Group:** (RG-LVT-297-3843)  
Statistics and Risk Management

**Principal Investigator:** Manuel Leote Tavares Ingles Esquivel

**Main Scientific Domain:** Matemática

**Group Host Institution:** Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

**Funding, source, dates****Objectives & Achievements****Group Productivity**

FCT Relatório Científico 2008 Print: 05-09-2013 11:32:59 [Centro de Matemática e Aplicações - CMA]

## Group Description

<b>Title of Research Group:</b>	(RG-T-LVT-297-1847) Statistical Inference
<b>Principal Investigator:</b>	João Tiago Praça Nunes Mexia
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

## Funding, source, dates

### Funding, source, dates

CMA budget and:

PTDC/MAT/69850/2006 (2007 a 2010) – “Modelos Lineares Mistos”

PTDC/AGR-AAM/71649/2006 (2007 a 2010) - “Draught Risk”.

PTDC/AGR-CFL/64146/2006 (2007 a 2010) – “Decision Support Tool for Interacting Forest and Fire Management”.

## Objectives & Achievements

### Objectives

We intend to carry out research on Mixed Models and to continue to apply Linear Statistical Inference. Since we now had a project on Mixed Models our research will be closely linked with that project. The project considered four research areas:

- Algebraic structures of mixed models - namely we intend to apply the results of Zmyslony (1980) on estimable functions and linear combinations of variance components for which we have BLUE and BQUE estimators;
- Stochastic search algorithms without regularity requirements we intend to develop such algorithms to enable us to carry out maximum likelihood estimation for non orthogonal normal models. We point out that usually the stochastic search algorithms require the solution to lay in a known compact set.
- Inference - the results of Zmyslony (1980) may be considered as an extremely general version of the Gauss-Markov theory. We intend to obtain BLUE using the study of the algebraic structure of the model. Next, introducing the normality assumption we intend to obtain maximum likelihood estimators for whose computation we may rely on the stochastic search algorithms developed in the preview task.
- Lastly we intend to extend our methods to models obtained crossing and nesting simple models. When two models are crossed we obtained a model where treatments are the combinations of the treatments of both initial models. When nesting models we nest inside each treatment of a model all the treatments of other model. Moreover we intend to consider structured families of models. We now have a model of the family for each treatment of a base model. The goal being the simultaneous study of the models in the family.

On the applied side we intend to play an active part on the project on drought management. As before we intend the work to be carry out with an active participation of PhD students. Presently there are 15 PhD students working with us. As mentioned above some of these students are supervised by foreign scientists. This trend forwards internationalization is to continue thus the research project on Mixed Models was formulated as a Polish-Portuguese endeavors. We intend to try to launch other project involving, at this case, international cooperation. As we already

mentioned we intend to study models in which the same parameters are relevant both for the mean vector and variance-covariance matrix. The study of such models could be the object of one such project.

### Main Achievements

On the theoretical side:

We pursued the study of the algebraic structure of mixed models having published three papers (4,6,7) on this subject. These papers also included results useful for inference. We continued the study of stochastic vortexes, having published a paper (8). We point out that such a vortex exists even and only if there is a limit distribution (for open populations).

With relation to STATIS methodology we published a paper (1) that generalizes former formulations. Also in connection with this subject we published a paper (5) on approximate normality.

On the applications side:

We continued our studies on Joint Regression Analysis (JRA) having published five papers (10,11,12,13,14). On the complex constituted by AIDS and it's co-infections we published two papers (16,17). On draught management we published a paper (9). On other applied fields we published three papers (2,3,15). Besides this, five PhD supervised by members of the research line were completed.

## Group Productivity

### Publications in peer review Journals

1. Areia, A., Oliveira, M.M. and Mexia, J.T. (2008). Models for series of studies based on geometrical representation. *Statistical Methodology*. doi:10.1016/j.stamet.2007.09.001.
2. Bras, A; Cotrim, CZ; Vasconcelos, I, et al. (2008). Asynchronous DNA replication detected by fluorescence in situ hybridisation as a possible indicator of genetic damage in human lymphocytes. *Oncology Reports*. 19(2):369-375.
3. Covas, R., Pascual, L., “Pricing Daily Electricity Transfer Capacities in the Spain-France Interconnection”, *IEEE-Xplore*, 2008.

### Group Productivity

4. Carvalho, F., Mexia, J. T. , Oliveira, M. M. (2008) Canonical Inference and Commutative Orthogonal Block Structure. *Discussiones Mathematicae – Probability and Statistics* 28 (2), 171-181.
5. Ferreira, D; Ferreira, S; Ramos, L and Mexia, J.T. (2008) Normal approximation to the product of a Non Central Chi-Square by an Independent Normal Variable - *Journal of Applied Mathematics* Vol. 1, No 2, 185--192.
6. Ferreira, S.S., Ferreira, D. and Mexia, J.T. (2008). Double tier cross nesting design models. *Journal of Interdisciplinary Mathematics*. 11(2):275-289.
7. Fonseca, M., Mexia, J.T., Zmyslony, R. (2008). Inference in normal models with commutative orthogonal block structure. *Acta et Commentationes Universitatis Tartuensis de Mathematica*, Vol.12:3-16
8. Guerreiro, G.R., Mexia, J.T. (2008). Stochastic vortices in periodically reclassified populations. *Discussiones Mathematicae - Probability and Statistics*, 28(2) pp. 209-227.
9. Moreira, E.E.; Coelho, C.A.; Paulo, A.A.; Pereira, L.S.; Mexia, J.T. (2008). SPI-based drought category prediction using loglinear models. *Journal of Hydrology*. 354:116-130.
10. Pereira, D. and Mexia, J.T. (2008). Selection proposal of cultivars of spring barley in the years from 2001 to 2004, using Joint Regression Analysis. *Plant Breeding*, 127(5): 452-458.
11. Pereira, D. and Mexia, J.T. (2008). Application of Selective F tests in Joint Regression Analysis. *Journal of Statistical Theory and Practice*. 1(3-4):71-81.
12. Pinto, I., Nunes, C. and Mexia, J.T. (2008). Analysis of a with-covariates model for the Environmental Indexes. *Biometrical Letters*, 45(2): 9-21.
13. Oliveira, A., Oliveira, T. and Mexia, J.T. (2008). Analysis of residuals and adjustment in JRA. *Biometrical Letters*, 45(1): 45-54.
14. Oliveira, A., Oliveira, T. , Mejza, S. and Mexia, J.T. (2008). Joint Regression Analysis applied to genotype stability evaluation over years. *Biuletyn Instytutu Hodowli i Aklimatyzacji Roslin*. 250:225-235.
15. Rodrigues, P.C., Mejza, S., Mexia, J.T. (2008). Structuring genotype X environment interaction: an overview. *Biuletyn Instytutu Hodowli i Aklimatyzacji Roslin*. 250:110-119.
16. Sequeira, I., Mexia, J.T. and Nunes, S. (2008). Double minimization for logit models with an additive two factors structure. *Biometrical Letters*, 45(1): 69-80.
17. Sequeira, I.J., Nunes, S. and Mexia, J.T. (2009). Relating the incidences of AIDS and opportunistic diseases in the European Union, *Biometrical Letters*, (status: accepted).

### Master and Ph.D. thesis completed

- João T. Mexia, co-director; PhD Student: Dora Prata Gomes; Title: Estimação Pontual e Intervalos de Índice Extremal; FCT/UNL.
- João T. Mexia, director; PhD Student: Elsa Moreira; Title: Famílias Estruturadas de Modelos com Modelo Base Ortogonal; FCT/UNL.
- João T. Mexia, director; PhD Student: João Lita da Silva; Title: Consistência Forte de Estimadores o Estimador dos Mínimos Quadrados; FCT/UNL.
- João T. Mexia, director; PhD Student: Amílcar Oliveira; Title: Estabilidade em ACR e condução dinâmica de planos de melhoria; Universidade Aberta.
- João T. Mexia, director; PhD Student: Vera Montes de Jesus; Title: Jordan algebras and crossing of factorial and fractional replicates; FCT/UNL.

### Organization of conferences

Researchers of the line have been involved in the organization of: The 15th International Workshop on Matrices in Statistics, in honour of Professor T.W. Anderson 90th birthday, Tomar – Portugal, 2008

João Tiago Mexia has been in the organizing boards of 3 conferences:

IWMS/08 – for chair of the Organizing Committee;

IMST/08 – member of the International Advisory Board;

LINSTAT/08 – member of the Scientific Committee.

### Internationalization

Fernandes, C., Ramos, P., Ferreira, S. and Mexia, J., "Commutative Jordan algebras piling - application to step nested designs". 17th International Workshop on Matrices and Statistics, 23 a 26 de Julho de 2008, Universidade Nova de Lisboa e Instituto Politécnico de Tomar, Tomar, Portugal.

Ferreira, S., Ferreira, D., Fernandes, C. and Mexia, J. "Fiducial inference with and without pivot variables". 3rd Workshop on Statistics, Mathematics and Computation and 1st Portuguese-Polish Workshop on Biometry, 21 a 22 de Julho de 2008, Universidade da Aberta, Lisboa, Portugal.

Ferreira, D., Ferreira, S., Ramos, P. and Mexia, J. "Three-way crossed classification with interaction". 3rd Workshop on Statistics, Mathematics and Computation and 1st Portuguese-Polish Workshop on Biometry, 21 a 22 de Julho de 2008, Universidade da Aberta, Lisboa, Portugal.

G.R. Guerreiro e J.T. Mexia, "Stochastic Vortices in periodically reclassified populations - an application to Pension Funds" Samos 2008, 5th Congress on Actuarial Science and Finance, University of Aegeon, Greece 23 a 26 de Julho de 2008.

Covas, R. "Genealogical Tree of Mixed Linear Models", International Conference on Interdisciplinary Mathematical & Statistical Techniques, Memphis – USA, 2008.

Covas, R. and Mexia, J.T. "Fiducial Densities and Pivot Variables", LINSTAT-2008, Bendlewo, Poland, 2008.

FCT Relatório Científico 2008 Print: 05-09-2013 11:34:37 [Centro de Matemática e Aplicações - CMA]

### Group Description

<b>Title of Research Group:</b>	(RG-T-LVT-297-1848) Distribution Theory
<b>Principal Investigator:</b>	Carlos Manuel Agra Coelho
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

### Funding, source, dates

#### Funding, source, dates

The main funding source for 2008 was our share of the overall funding for CMA (FCT/UNL) provided by FCT/MCTES.

Other funding sources:

- Research project PTDC/AGR-AAM/71649/2006 – 'Gestão do risco em secas: identificação, monitorização, caracterização, predição e mitigação' (2007-2010), whose PI is Professor Luís Santos Pereira from Instituto Superior de Agronomia/Lisbon University of Technology. (funding: 2000 Euros)

- Research Project POCI/CLI/60006/2004 e PPCDT/CLI/60006/2004– 'Interação entre os ciclos de água e carbono em eucaliptais' (2005-2009), whose PI is Doctor Abel Martins Rodrigues from Instituto Nacional de Recursos Biológicos, I.P. (INRB/MADRP) (funding: 1000 Euros)

### Objectives & Achievements

#### Objectives

I - In the area of the near-exact distributions the objectives were:

a) continuation of the development of near-exact distributions for statistics used in tests of complex structures in variance-covariance matrices, as the ones for the block-matrix sphericity and the block-scalar sphericity tests for one or several populations and the multiple sphericity test for several populations, obtained from the decomposition of the corresponding null hypotheses into sequences of nested, more elementary and conditionally independent hypotheses, allowing this way for the building of near-exact characteristic functions from adequate decompositions of the characteristic functions of the statistics corresponding to those elementary hypotheses;

b) conclusion of the construction of a general approach leading to the development and formulation of general near-exact distributions for l.r.t. statistics used in Multivariate Statistics;

c) continuation of the development of a general approach for the development of l.r.t. statistics and their near-exact distributions for tests used in Multivariate Statistics whose null hypotheses being too complex may be split into more elementary and conditionally independent hypotheses, which may lead to a more general test which may include both extended sphericity test families referenced above.

II - In the area of exact distributions, the objectives were:

a) conclusion of the development of simple expressions for the distribution of the product of independent Gamma r.v.'s and of the Generalized Variance, preferably under a form that may be adequate to obtain near-exact distributions for l.r.t. statistics based on the Generalized Variance;

b) start of studies on the relation of the distribution of products of powers of independent Uniform random variables with the distribution of some statistics.

III - In the area of extreme-value distributions, the objectives were:

- estimation of parameters in heavy tailed models as the the tail index and high quantiles (in collaboration with Prof. Ivette Gomes from the Department of Statistics of the University of Lisbon).

#### Main Achievements

All objectives were achieved.

I - near-exact distributions:

a) near-exact distributions for likelihood ratio statistics to test elaborate structures of covariance matrices were developed, and the results are being prepared for submission for publication;

b) a general approach for the development and formulation of near-exact distributions for likelihood ratio statistics used in Multivariate Statistics was given a new look and submitted for publication;

c) we carried on the work on the development of a general approach for the development of l.r.t. statistics and their near-exact distributions for tests used in Multivariate Statistics whose null hypotheses may be split into more elementary and conditionally independent hypotheses, and it was possible to develop a l.r.t. and corresponding test statistic which includes as particular cases both extended sphericity test families referenced above and some first results were prepared for publication;

II - exact distributions:

a) the development of simple expressions for the distribution of the product of independent generalized Gamma r.v.'s under a form adequate to obtain near-exact distributions for l.r.t. statistics based on the Generalized Variance was continued in a joint work with Prof. Barry Arnold from the University of California at Riverside;

b) studies on the relation of the distribution of products of powers of independent Uniform random variables with the distribution of some statistics were started, also in a joint work with Prof. Barry Arnold from the University of California at Riverside.



## Objectives & Achievements

III - extreme-value distributions:

– work on the estimation of parameters in heavy tailed models as the the tail index and high quantiles was carried on in collaboration with Prof. Ivette Gomes from the Department of Statistics of the University of Lisbon.

## Group Productivity

### Publications in peer review Journals

Published:

Marques, F. J., Coelho, C. A. (2008) Near-exact distributions for the sphericity likelihood ratio test statistic. *Journal of Statistical Planning and Inference*, 138, 726-741. [WOS:000253099800014] [MR 2382885(2008k:62115)] [Zbl 1138.62033]

Moreira, E. E., Coelho, C. A., Paulo, A. A., Pereira, L. S., Mexia, J. T. (2008). SPI-based drought category prediction using loglinear models. *Journal of Hydrology*, 354, 116-130. [WOS:000257005800010]

Caeiro, F. and Gomes, M.I. (2008). Minimum-Variance Reduced-Bias Tail Index and High Quantile Estimation. *Revstat*, 6, 1-20.

Accepted:

Coelho, C. A., Marques, F. J. The advantage of decomposing elaborate hypotheses on covariance matrices into conditionally independent hypotheses in building near-exact distributions for the test statistics. *Linear Algebra and its Applications*.

Caeiro, F., Gomes, M.I. and Henriques Rodrigues, L. Reduced-bias tail index estimators under a third order framework. *Communications in Statistics - Theory and Methods*.

Gomes, M.I., Pestana, D. and Caeiro F. A note on the asymptotic variance at optimal levels of a bias-corrected Hill estimator. *Statistics and Probability Letters*.

Caeiro, F. and Gomes, M.I. (2009?). Semi-parametric secondorder reduced-bias high quantile estimation. *Test*.

### Other publications National

Prata Gomes, Dora. e Neves, M. M. (2008). A escolha do número de estatísticas ordinais de topo na estimação do índice extremal. In I. Oliveira et al. (eds.), *Edições SPE, XVI Congresso Anual SPE, Vila Real*.

Caeiro, F. e Gomes, M. I. (2008). Caudas pesadas: t de Student e variante assimétrica versus metodologia semi-paramétrica. *Actas do XV Congresso Anual da SPE - Da Teoria à Prática*, 127-136.

Marques, F. J., Coelho, C. A. (2008). O teste de esfericidade para várias amostras – como usar a decomposição da hipótese nula na construção de aproximações quase-exactas para a estatística de teste. *Pré-publicação 7/2008, Dep. Mat., FCT/UNL*.

Marques, F. J., Coelho, C. A., Arnold, B. C. (2008). A general near-exact distribution theory for the most common likelihood ratio test statistics used in Multivariate Statistics. *Pré-publicação 5/2008, Dep. Mat., FCT/UNL*.

### Master and Ph.D. thesis completed

Gomes, D. P. (2008). Métodos Computacionais na estimação pontual e intervalar do índice extremal (Computational methods in point and interval estimation of extremal index). Ph.D. Thesis, Fac. Ciências e Tecnologia, Univ. Nova de Lisboa.

FCT Relatório Científico 2008 Print: 05-09-2013 11:36:10 [Centro de Matemática e Aplicações - CMA]

### Group Description

<b>Title of Research Group:</b>	(RG-T-LVT-297-1852) Actuarial and Financial Mathematics
<b>Principal Investigator:</b>	Manuel Leote Tavares Ingles Esquivel
<b>Main Scientific Domain:</b>	Matemática
<b>Group Host Institution:</b>	Faculdade de Ciências e Tecnologia - Universidade Nova de Lisboa

### Funding, source, dates

#### Funding, source, dates

[MF]- Fundação para a Ciência e a Tecnologia (FCT). "Beliefs, speculation and temporary equilibrium." Ref: PTDC/ECO/64968/2006.

[MF]- 2008: CRUP - Acções Integradas Luso-Espanholas, Acção N° E-113/08.

[MF]- SA0870A08: Junta de Castilla y León. "Mercados, Coaliciones e Información." Duração: Janeiro de 2008 a Dezembro de 2010.

[GdR]- PhD Scholarship from the Portuguese Foundation for science and technology (FCT) until October 2008. Scientific researcher at the Humboldt University of Berlin, from November 2009 to April 2009. Scientific researcher at Ecole Polytechnique in France, from May 2009 onwards.

[CAV]- Sponsorship from the bank Millennium BCP, S.A. – part of Ph.D. tuition fees.

### Objectives & Achievements

#### Objectives

[GdR]- Is currently finishing the process of submitting his PhD thesis for evaluation. He also took a position at Ecole Polytechnique in Paris and he is working on the topics of Backward stochastic differential equations (continuous or with jumps), Systemic risk, Default risk.

[CAV]- Currently undertaking a PhD program at Frankfurt School of Finance & Management, Centre for Practical Quantitative Finance, with Prof. Dr. Uwe Wystup.

[MLA]- During 2008 the main objective was to submit a paper of the methodology applied on the PhD Thesis.

[PM]- Build estimating procedures and prove asymptotic properties in the Brownian motion with drift threshold model.

[JBS]- Apply machine learning kernel methods to the calibration of mathematical finance models.

[RC]- To continue the work under development to obtain approximations and bounds for the expected present value of dividend payouts, in finite horizon, considering the classical risk model modified by the inclusion of a dividend barrier.

[MF]- To explore the strategic foundations of the competitive equilibrium in two different contexts, namely, exchange economies with private and differential information structures as in Radner (1968) and Yannelis (1991) and economies with a nonatomic continuum of traders and a continuum of differentiated commodities as in Mas-Colell (1975), Jones (1984) and Ostroy and Zame (1994). A strategic foundation for competitive equilibrium must show how strategic interaction by rational agents leads to competitive, price taking behavior.

[MLE]- Further study of the general method introduced for the management of price/liquidity risk. We intended to explore a threshold regime switching structure for the price and liquidity diffusions model, with the intent of explaining the market behavior. We will develop applications of the probability generation functions of real valued random variables to statistical estimation procedures useful for financial applications. Continuation of the PhD co-direction work of M. Carvalho in the area of random algorithms for global optimization. Continuation of the collaboration with Banco de Investimento Global in the interest rate derivative products pricing project.

[MBC] During 2008 one main resarch objective entailed the conclusion and submission of part of the work developed under the PhD thesis. This work is currently collecting helpful suggestions from some of our research partners abroad.

#### Main Achievements

[GdR]- In Imkeller & Dos Reis (2009) we managed to give an answer to the topic of numerics for quadratic growth BSDE and at present time I am (with my co-authors) making the final corrections to the review we received concerning the Horst, Pirvu & Dos Reis (2009) work.

[CAV]- Research work in the field of Quantitative Finance focused on subjects relevant for pricing and hedging of contingents claims. In particular, on pricing of equity exotic options, and on option hedging on models that include discrete dividends. Future subjects of research will include the analysis and comparison of structured products.

[JBS]- Machine learning calibration of the Vasicek interest rate model with Gaussian processes.

[RC]- It was obtained several numerical values and bounds for the expected present value of dividend payouts, in finite horizon, considering the classical risk model modified by the inclusion of a dividend barrier and also an extension of this risk model by requiring the shareholders to provide the initial surplus and to pay the deficit at ruin each time it occurs. A paper presenting the numerical algorithms and numerical values was produced and submitted for publication in ASTIN Bulletin, one of the main references in Actuarial Mathematics. The preprint is available at

<http://www.dmat.fct.unl.pt/fct/listarPrePubs.do?ano=2008&sub=investiga>.

This work was presented, by invitation, in the CEMPARE Seminar.

[PM]- Finishing and defense of the PhD thesis in 2008.

## Objectives & Achievements

[MLE]- The PhD direction of M. Carvalho was concluded. A new technique for converting an asymptotic (almost sure or in probability) relation between random variables into an approximation relation in the Kolmogorov distance sense was introduced and applied to linear and non linear examples.

[MBC] A general stochastic optimization method for extremum estimators (Newey & Mcfadden, 1994; Andrews, 1999; Mexia & Corte Real, 2003) was proposed. The introduced master method includes several instances of stochastic optimization methods such as the classical Solis and Wets algorithm and the stochastic zig-zag method (Mexia et al, 1999). The convergence of this master method was established making use of assumptions typical in the literature (Esquivel, 2006). The allocation of some research time on the optimal calibration of singular spectrum methods was also proven to be very fruitful being awarded with the ERS IASC young researcher award - Compstat 2008 (joint work with Paulo C. Rodrigues)

## Group Productivity

### Publications in peer review Journals

[MF]- Approximate Equilibrium in Pure Strategies for a Two-Stage Game of Asset Creation, *Decisions in Economics and Finance*, 31, 117-136 MR2443086.

[MLE]- Esquivel, M. L., Probability generating functions for discrete real-valued random variables. *Theory Probab. Appl.* 52 (2008), no. 1, 40—57, MR2354573.

[CAV]- Veiga, C., Wystup, U. Closed Formula for Options with Discrete Dividends and its Derivatives. *Applied Mathematical Finance*, (status: accepted).

[MLA]- Afonso, M. L., Calculating continuous time ruin probabilities for a large portfolio with varying premium: *Astin Bulletin*, (status: accepted).

### Other publications International

[MBC]- Rodrigues, P., de Carvalho, M. (2008) "Monitoring Calibration of the Singular Spectrum Analysis Method," *Proceedings of the International Conference on Computational Statistics*, Paula Brito Ed., Physica-Verlag

[MBC]- de Carvalho, M., Rodrigues, P. (2008) "A Singular Spectrum Analysis of the New York Stock Exchange Composite Index," *Proceedings of the 31st Annual Meeting of the European Accounting Association*

[GdR]- Imkeller and Dos Reis, Path regularity and explicit convergence rate for BSDE with truncated quadratic growth, Preprint, 2009, (status: submitted and waiting referee result)

[GdR]- Horst, Pirvu, and Dos Reis, On securitization, Market completion and equilibrium risk transfer, Preprint, 2009, (status: making corrections as indicated by the referee).

[RC]- Cardoso, R., "Dividends and ruin problems in finite time", *ASTIN Bulletin*, (status: submitted).

### Master and Ph.D. thesis completed

[PM]& [MLE]- PhD Thesis: "Brownian Motion with Drift Threshold Model", Student: Pedro Mota; Direction: Manuel L. Esquivel, FCT/UNL.

[MLA]- PhD Thesis: "Evaluation of ruin probabilities for surplus processes with credibility and surplus dependent premiums", ISEG/UTL.

[MLE]- Master Thesis Direction: "Modelos de Apreçamento e Cobertura para Derivados sobre Matérias-primas", Student: Isabel Cabrera, FCT/UNL.

[MLE]- Master Thesis Direction: "Seguro de Dependência: Proposta de um modelo de avaliação financeiro-actuarial", Student: Rute Baião Carrujo, FCT/UNL.

[RC]- Master Thesis Direction: "Construção de uma tarifa de responsabilidade civil automóvel" Student: Susete Tomás Santos, FCT/UNL.

[RC]- Master Thesis Direction: "Cálculo de provisões técnicas não vida no âmbito do projecto Solvência II", Student: Tânia Sofia Marques Novo, FCT/UNL.

[RC] & [PCR]- Master Thesis Direction: "Impacto das alterações à Lei de Bases da Segurança Social na solvência dos fundos de pensões", Student: Ana Isabel Martins, FCT/UNL.

### Organization of conferences

[MF]- CVA2008- Calculus of Variations and its Applications: from Engineering to Economy, 8 a 11 de Setembro de 2008 na Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa

[MLE]- 1º Congresso Ibérico de Actuários, member of the Scientific Committee.

[RC]- 1º Congresso Ibérico de Actuários, member of the Organizing Committee.

### Internationalization

Professors Bernt Oksendal (Oslo University, Norway), Michael Sorensen (University of Copenhagen, Denmark) and Mathieu Kessler (Cartagena University, Spain) visited the research line.

### PRIZES

[MLA]- Prize Instituto de Seguros de Portugal for the best PhD dissertation in Mathematics Applied to Economy and Management of ISEG/UTL.

[MBC]- International Association for Statistical Computing ERS IASC Young Researcher Award, 2008 (co-recipient: Paulo C. Rodrigues).

**Group Productivity**

[CAV]- 2008 – Deutscher Akademischer Austausch Dienst Prize for the outstanding achievement of a foreign student.

## INVITED ADDRESSES

[MF]- Seminars in Economics Department, Vanderbilt University, EUA, Abril 2008.

[MF]- II Workshop on Economic Theory – Frontiers Economic Theory and Applications.

[MBC]- "Stochastic Optimization Inference Methods," International Conference on Optimization SIGOPT 2008.

[MBC]- "A Regression Method for Censored Length-Biased Survival Times," Universidade da Beira Interior.

[RC]- CEMAPRE/ISEG/UTL Seminar.

[MLE]- Invited organizer of a special session in: "Statistical and Stochastic Methods for Financial Mathematics", International Conference on Interdisciplinary Mathematical & Statistical Techniques .

## CONFERENCE CONTRIBUTED TALKS

[MF]- IASK International Conference Advances in Tourism Research; 1º Congresso Ibérico de Actuários; 2nd Annual Meeting of the Portuguese Economic Journal; 3rd World Congress of the Game Society; Dynamics and Applications.

[MBC]- International Conference on Applied Mathematical Programming and Modelling – APMOD 2008; International Biometric Conference; International Workshop on Matrices and Statistics , Tomar – Portugal.; International Conference on Computational Statistics (3 talks).

[GdR]- 8th German Open Conference on Probability and Statistics; Bachelier Finance Society; Fifth World Congress; Third Conference on Numerical Methods in Finance, France; Fourth General Conference on Advances Mathematical Methods in Finance, Norway.

[CAV]- Bachelier Finance Society's 5th World Congress.

International Conference on Interdisciplinary Mathematical and Statistical Techniques - IMST 2008 / FIM XVI, Memphis University, Memphis, EUA, May 15-18 2008:

- [MBC]

- [JBS] & [MLE]

- [JBS] & [PCR]& [MLE] - with L. Ventura, S. Magalhães,

- [MLE]

- [MLE] with Isabel Cabrera.