

# Curriculum Vitae and Research Résumé

OMAR LAKKIS

## CURRICULUM VITÆ

**Generalities.** My name is *Omar Lakkis*. I was born on 4 May 1970 in Jbeil (Lebanon). I am an *Italian (EU)* and *Lebanese* citizenship. I currently live, with my partner Vera De Alti, in Brighton, England, where I work at the *University of Sussex* as a *Lecturer in Mathematics*.

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### Education, degrees and qualifications.

- 1997–2002 Ph. D. in Applied Mathematics and Scientific Computing, University of Maryland, USA.
- 2000 Teaching qualification for secondary (high) school education in mathematics, Italy.
- 1991–1996 Laurea cum Laude (equiv. 3 + 2 B.Sc–M.Sc.) in Mathematics, Università degli Studi di Trieste, Italy.
- 1988: English language certificate (Advanced Level), American Language Centre, Jbeil (Lebanon).
- 1987: Baccalaureate (equivalent of UK A-Levels) Sciences and Maths branch, Collège Maristes Champville, Dik el-Mehdi (Lebanon).

### Language skills.

- Fluent in Arabic, English, French, Italian, Slovene.
- Working knowledge (speaking & reading) of Esperanto, (modern) Greek and Spanish.
- Some basic knowledge (listening & reading) of Croatian, German, Portuguese, Russian and Serbian.

### Information technology skills.

- Operating systems: (admin level) Linux, BSD Unix, Solaris Unix, Apple's Mac OS X. Some basic (user level) knowledge of Microsoft Windows.
- Programming and scripting languages: C, C++, Fortran, Matlab r/Octave, Perl, Python, Bourne, C shell, CGI, php, html, LATEX.
- Solid experience with the scientific computing libraries: ALBERTA and GSL. Graphics: OpenGL, GLTools, Geomview, Paraview, GRAPE. Scientific: Octave, Matlab r, Scilab, Mathematica, Maple.

### Employment.

- 2004–now: *Lecturer in Mathematics* (tenure since 2007) at the Department of Mathematics, University of Sussex, England UK.
- 2003–2004: *Post-doctoral researcher* at the Institute of Applied and Computational Mathematics of the Foundation for Research and Technology Hellas, Heraklion, Greece. (Sponsors: European Union HYKE-RTN and Marie Curie Fellowship.)

- 2002: *Postdoctoral researcher* at the Università di Milano, Italy. (Sponsor: Italian MURST “Assegno di Ricerca”.)
- 1997–2001: *Graduate research and teaching assistant* in Mathematics, University of Maryland, USA.
- 1996–1997: *Teacher of Mathematics* at the Italian language school Scuola Pier Paolo Vergerio in Koper, Slovenia.
- 1994–1996: *Manager, IT specialist and instructor, and library assistant within co-operative Tempi Moderni s.c.a r.l.* Trieste, Italy.
- 1991–1994: Various “student jobs” (decoration, newspaper distribution, catering) held for temporary periods.
- 1990–1991: Gap year assistant at the Psychiatric service centre “Franco Basaglia”, Trieste, Italy.

### **Awards and prizes.**

- 2001: PhD Dissertation Fellowship at the University of Maryland, College Park, Maryland.
- 1997–1999: Avron Douglass Fellowship for Graduate Studies at University of Maryland, College Park, Maryland.
- 1997: Predoctoral training studentship from Università di Trieste, Italy, spent one semester at ETH, Zürich, Switzerland.
- 1995: Award for fee-free, travel and accommodation included, Summer Course attendance at the Scuola Interuniversitaria di Perugia, Italy.
- 1992: Tempus EU studentship exchange awarded to spend one semester at Karlovà Univerza, Prague, Czech.

### **Administration.**

- I have often represented the Department of Mathematics and the University of Sussex as an invited/contributed speaker at International Scientific Meetings (e.g., CPDE 2009 Warwick UK, EFEF 2008 Göteborg SE, NMEE 2008 Crete GR, ENUMATH 2007 Graz AT) and seminars in various universities (e.g., Manchester UK 2008, Oxford UK 2007, Clermont-Ferrand FR 2006).
- M.Sc. in Mathematics Programme Convenor, at the University of Sussex (2008–now).
- RAE2008 Contributor for Applied Mathematics, at the University of Sussex (23rd position overall, 9th position for Research only within the UK).
- Academic Misconduct Panel member, at the University of Sussex (2007–now).
- Preprint and technical report online publishing responsibility (2007–now).
- Preparation of ingenious event (2007).
- Seminar organiser at the Department of Mathematics, University of Sussex (2006–now).
- Webmeister for the Department of Mathematics, University of Sussex (2004–now).
- Provision and planning of computing equipment. Bid and purchase under SRIF-3 of “Archimedes” a 64 processor cluster owned jointly with Physics (2005–now).
- Computing infrastructure and staff supervision, purchase planning and maintenance direction, Department of Mathematics (2004–now).
- Undergraduate Curriculum Development and Assessment Workgroup member (2004–2006).
- Active participation in various open day and recruitment events (2004–now).
- Advertisement of Mathematics studies Sussex at various colleges (e.g., Eastleigh 2006, Winchester 2007, Guernsey 2008).
- Design and production of fully documented LATEX-ed Lecture Notes, Exercise Databases and Sample Computer Code for the courses: Introduction to Pure Maths (G5087), Analysis (G5085),

Advanced Differential Equations (G1156), Numerical Differential Equations (841G1) and Monetary Theory Analysis (G5078).

### **Student supervision and teaching.**

#### *Postgraduate, D.Phil and Ph.D.*

- 2009–10 Expected: Mr Tristan Pryer. Project: *Recovery techniques in finite element methods for evolution and nonlinear problems*, (D.Phil. in Mathematics, EPSRC funding)
- 2010–11 Expected: Mr Chandrashekar Vinkataraman. Project: *Finite element methods on growing domains for biological reaction-diffusion processes* (DPhil candidate, joint supervision)
- 2009–10 Expected: Ms Daniela Schraeder (DPhil candidate second supervisor).

#### *External duties.*

- Opponent to Fardin Saedpanah's Ph.D. Thesis defence, Chalmers University, Göteborg Sweden.

#### *Undergraduate and Master's.*

- 2008: Mr Giles Smith (Sussex JRA Bursary).
- 2007: Ms Sarah Bernardez-Agrafojo (M.Sc. in Mathematics, Sussex).
- 2006: Mr Keitaro Asaba (M.Sc. in Mathematics, Sussex).
- 2005: Mr Tristan Pryer (M.Math., Sussex 2005).

#### *Courses taught.*

- 2007–2009: *Monetary Theory Analysis* (previously *Financial Mathematics*), University of Sussex, advanced undergraduate and Financial Mathematics master's level.
- 2004–2009: *Numerical Differential Equations*, University of Sussex, master's level.
- 2005–2009: *Introduction to Pure Mathematics*, University of Sussex, undergraduate level.
- 2005–2007: *Analysis*, University of Sussex, undergraduate level.
- 2004–2006: *Advanced Differential Equations*, University of Sussex, year 3 & 4 level.
- 1997–2001: various courses (e.g., Calculus, Theoretical Computer Science, Differential Equations, Numerical Analysis) taught or assisted for, University of Maryland.

#### *Teaching support activities.*

- Academic Advising at University of Sussex: 10 students/year on average.
- Curriculum design.
- Open and admission days support.
- Advertising and branding in high schools accross the country and abroad.

### **Learned societies and networks.**

- European Mathematical Society (2007–now)
- London Mathematical Society (2007–now)
- Maric Curie Foundation (2004–now)
- Society for Industrial and Applied Mathematics (2002–2004)
- EPSRC network “Multiscale and Multiphysics” (2004–2006)
- HYKE EU research and training network, Crete Branch (2003–2004)

### **Research support.**

### *Organised events.*

- 2008.03: Computational Stochastic Differential Equations workshop at Hausdorff Institute, Bonn, Germany.
- 2007.07: S4C07 Sussex Summer School on Scientific Computation 2007: ALBERTA Finite Elements, University of Sussex, Brighton, UK. Sponsored by the University of Sussex.
- 2007.02: macsdiem07 Multiscale Analysis and Computations for Stochastic Differential Equations and Modelling, Conference at University of Sussex, Brighton, UK. Sponsored by EPSRC UK.
- 2004–2006: Two “Multiscale and Multiphysics” EPSRC Network meetings. Sponsored by EPSRC UK.

### *Review and refereeing.*

- AMS Mathematical Reviews (MathSciNet)
- Applied Numerical Mathematics
- IMA Journal on Numerical Analysis
- Interfaces and Free Boundaries
- Mathematical Models and Methods in Applied Sciences
- Mathematics of Computation
- SIAM Journal on Numerical Analysis
- Springer-Verlag, Mathematics SUMS

### **Research income and grants.**

- 2009.07: Royal Society International Travel Grant *Error Control in Discontinuous Galerkin Methods for Evolution Problems* **2,540 £**
- 2009.06: London Mathematical Society, small collaboration grants *Pointwise a posteriori error estimates for Phase-Field models*, **400 £**.
- 2008.02–04: Hausdorff Institute for Mathematics, project *Computational Stochastic Phase-Field Models* special program on “Computational Mathematics”. **17,600 €**
- 2005–2007: Nuffield foundation grant for young researchers on *Finite Element Methods for Stochastic Partial Differential Equations*, **4,000 £**.
- 2004: Marie Curie Fellowship at FORTH, Iraklio, GR (2004), **24,000 €** .
- 2003: TMR HYKE spent at FORTH in Iraklio, GR (2003). **24,000 €** .
- Assegno di ricerca, Dipartimento di Matematica, Università di Milano, IT (2002). **14,000 €**
- 2001.02–05: Core Participant Fellowship, GBM program, IPAM, Los Angeles, California USA 2001. **15,000 \$**
- 2000.06–12: NSF Research Assistanship, University of Maryland, College Park, Maryland USA. **8,000 \$**

### **Research lectures and talks (selection).**

#### *Invited talks and minisymposia.*

- 2009.07: ENUMATH 2009, Uppsala SE.
- 2009.06: MAFELAP 2009, Brunel Uxbridge UK.
- 2009.05: Numerical Stochastic Partial Differential Equations, ICMS Edinburgh, Scotland UK.
- 2009.03: Adaptivity, robustness and complexity of multiscale algorithms, ICMS Edinburgh, Scotland UK.
- 2009.01: New Directions in Computational PDE’s, Warwick, England UK.

- 2008.12: MATHEON-Workshop "Efficiency and Modeling with Computational Stochastic Partial Differential Equations" Humboldt Universität Berlin, DE.
- 2008.09: 4th Workshop on Numerical Methods in Evolution Equations, FORTH Crete, GR.
- 2008.07: John Crank's Legacy, Brunel University, Uxbridge, England UK.
- 2007.09: ENUMATH 2007, Graz, AT.
- 2006.06: Discontinuous changes in behaviour issues in partial differential equations. Euroconference in Anogia, Crete, GR.
- 2006.04: MULTISCALE network workshop, University of Warwick, Coventry, UK.
- 2005.09: Computational Stochastic Differential Equations, Buedlewo Mathematics Conference Center, PL.
- 2005.06: Free Boundary Problems : Theory and Applications, Universidade de Coimbra, PT.
- 2004.09: 2nd Workshop on Numerical Methods for Evolution Equations, Foundation for Research and Technology Hellas, Heraklion of Crete, GR.
- 2004.04: Around Hyperbolic and Kinetic Equations 2 : Midterm Review, ENS Paris, FR.
- 2003.12: Geometrically Based Motions (Reunion 2), Lake Arrowhead, IPAM-UCLA California.
- 2003.04: Interphase 2003, Isaac Newton Institute, Cambridge, UK.
- 2002.09: Geometrically Based Motions (Reunion), Lake Arrowhead, IPAM-UCLA CA, USA.
- 2001.11: South Eastern Conference on Applied Mathematics, North Carolina State University, Raleigh, NC, USA.
- 2001.10: Numerical Methods for Free Boundary Problems, DMV-Seminar Oberwolfach, DE.
- 2001.06: Geometrically Based Motions, IPAM-UCLA Lake Arrowhead, California.

*Contributed talks.*

- 2007.09: ENUMATH 2007, Graz, AT.
- 2007.06: EFEF5, the 5th European Finite Element Fair, CIRM, Luminy, Marseille, FR.
- 2007.09: Multiscale and Adaptivity, Bath, England UK.
- 2006.06: MAFELAP 2006, Brunel University, London, UK.
- 2006.01: MULTISCALE network annual meeting, University of Sussex, Brighton, UK.
- 2004.05: EFEF2, the 2nd European Finite Element Fair, Berlin, DE.
- 2002.06: Free Boundary Problems, Trento, IT.
- 2002.01: Interphase 2001, UMD, College Park, Maryland USA.
- 2000.10: Finite Element Circus, Rutgers University, New Brunswick, New Jersey.
- 2000.08: Mathematical Aspects of Evolving Interfaces, CIM/CIME Euro-Summer School, Funchal (Madeira), Portugal.
- 1999.01: Partial Differential Equations Escuela de Verano Internacion«al, Temuco, Chile.

*Seminars.*

- 2009.03: Technische Universitet Eindhoven, NL. CASA Seminar.
- 2008.01: University of Manchester, England UK. Numerical Analysis Seminar.
- 2007.10: Oxford University Computational Laboratory Seminar, Oxford, England UK.
- 2005.12: Séminaire d'Analyse Numérique, Université Blaise Pascal, Clermont-Ferrand, FR.
- 2005.11: Mathematics Seminar, Department of Mathematics, University of Leicester, England UK.
- 2004.03: Seminar, Department of Mathematics, Imperial College London, England UK. Error Control for Parabolic Problems via Elliptic Reconstruction.

- 2004.03: Applied and Numerical Analysis Seminar, Department of Applied Mathematics Irakleio, GR . Elliptic Reconstruction and Fully Discrete Heat Equation.
- 2003.12: PDEs and Applied Math Seminar, Department of Mathematics University of Maryland, College Park, MD USA. Computing Epitaxial Growth with Attachment-Detachment Kinetics.
- 2003.11: Seminario di Matematica Applicata, Dipartimento di Matematica Università degli Studi di Milano, IT. Computing Epitaxial Growth with Attachment-Detachment Kinetics.
- 2003.04: Applied and Numerical Analysis Seminar, Department of Applied Mathematics Iraklio, GR. Finite Element Method for Epitaxial Growth with Attachment-Detachment Kinetics.
- 2003.02: Applied and Numerical Analysis Seminar, Department of Applied Mathematics Iraklio, GR. A Posteriori Error Estimates and their Reliability for the Mean Curvature Flow.
- 2002.12: Crystal Growth Group Seminar, Stiftung caesar Bonn, DE. Error Control for the Mean Curvature Flow of Graphs.
- 2002.06: Seminario di Matematica Applicata, Università di Milano, Italia, IT. A Posteriori Error Estimates and their Reliability for the Mean Curvature Flow.
- 2002.04: Numerical Analysis Seminar, UMBC, MD, Maryland USA. A Posteriori Error Analysis and Adaptivity for the Mean Curvature Flow.
- 2001.05: Institute for Pure and Applied Mathematics, Los Angeles, California USA. A posteriori error analysis and adaptivity for the mean curvature flow
- 2001.02: Numerical Analysis Seminar, University of Maryland, College Park, Maryland USA. An a posteriori error estimate and adaptivity for the mean curvature flow of graphs
- 2001.07: Dipartimento di Scienze Matematiche, Università degli Studi di Trieste. Una stima a posteriori dell'errore per il moto di grafi secondo curvatura media.
- 2001.12: Istituto di Analisi Numerica del CNR Pavia. Stime a posteriori e adattività nel calcolo via elementi finiti del moto per curvatura media.
- 1998.08: PDE and Applied Math Seminar, University of Maryland USA. Existence of solutions for a class of semilinear polyharmonic equations with critical exponential growth.

## RESEARCH SUMMARY AND PUBLICATIONS

This is a brief description of my research broadly divided by subjects I have dealt or I am dealing with. I give a summary of the results that I have obtained and some ideas about how I plan to carry on the work.

**Stochastic models in phase transition and their approximation.** I started looking at stochastic partial differential equations in 2004, after a discussion with Georgios Kossioris and Markos Katsoulakis in Crete, about the reach of stochastic version of phase-field models such as the Allen–Cahn model. This is an intriguing area of phase-transition theory which takes into account naturally occurring random fluctuations. We have obtained a new computational method for the Allen–Cahn equation, which we have fully justified in one dimension for white noise [5].

Encouraged by this first success in such a challenging area, I have started looking at the possibility of describing the dynamics of multiple interfaces via simulations and, mostly, deriving mathematical justifications of such calculations, which are to be found already in sectors of applied physics. In collaboration with Marco Romito (Florence) and Georgios Kossioris (Crete), in part at the Hausdorff Institute for Mathematics in Bonn (2008) we have laid the foundations for our next project. A first paper is now in preparation about the dynamics of interfaces in one dimension [6]. A second, more computationally oriented paper could be produced, possibly with the help of a research assistant.

We are planning to move to the higher dimensional situation, where the noise needs to be correlated for such stochastic PDE's to be tractable numerically. Two challenges must be met in this project: (a) the fast calculation of the covariance effect (currently we are doing this with an iterative matrix square root finder and, concurrently, via an incomplete Cholesky factorisation, but fast Fourier methods and H-matrix techniques will be explored), (b) adaptive mesh refinement to have a computationally feasible method. The adaptive mesh refinement cannot be based on heuristic considerations, such as the gradient modulus, that work well in the deterministic case. The reason for this is that the solution is quite rough, uniformly bounded in  $L_2$  but not in  $H^1$ . This requires a careful a posteriori error analysis which we are developing at the moment with Demlow, Georgoulis and Makridakis.

### **Adaptive finite element methods.**

*Nonlinear problems.* In my PhD dissertation [10], I have investigated the error control of a finite element scheme for the graph formulation of the *mean curvature flow* (MCF). I established *a posteriori error estimates* for the semi-discrete scheme. Such error estimates were innovative in many respects, such as the use of exotic “geometric pseudonorms” to measure the error by respecting the geometric nature of the equations. Ad hoc energy techniques were used leading to “conditional” error estimator which are much sharper than “unconditional” estimators that could be derived with standard methods. Sharpness of estimators is a fundamental property: without it adaptive schemes will be far from efficient. These results were illustrated with extensive numerical experimentation and published jointly with my Ph.D. supervisor Ricardo Nochetto (Maryland) [13].

Concepts, mainly adaptive finite elements for geometric motions, from my Ph.D. were useful in a joint project with Eberhard Bänsch and the Crystal Group at *cæsar* Bonn on the simulation of epitaxial growth for semiconductor manufacture [1].

Numerical schemes for stationary fully nonlinear equations, which my student Tristan Pryer (Sussex) is studying for his D.Phil. with me and Holger Wendland (Sussex). While Holger is interested

in applying RBF methods, we are also interested in developing FE schemes. Tristan's aim is to develop a sound method for Monge–Ampère and Pucci like equations and, possibly, apply adaptive principles to efficiently compute singular solutions.

*Evolution equations.* It was natural for me to get involved into the challenges posed by deriving adaptive methods for evolution problems, as my Ph.D. dissertation was about such a problem. Fundamental questions such as *a posteriori error control* in evolution problems constitute in fact the core of my research work, since my Marie Curie Fellowship stay in Crete, Greece (2003–2004). Jointly with Charalambos Makridakis we have thoroughly explored the potential of applying the *elliptic reconstruction technique* (ERT) in analysing linear parabolic problems and obtaining a posteriori error estimates in nonstandard norms, such as the least-square ( $L_2$ ) norm [12, 11] via duality and energy methods [resp.].

Alan Demlow (Kentucky) joined in our team to develop a framework for maximum norm ( $L_\infty$ ) and pointwise error estimates, using heat kernel estimates and the ERT [2].

ERT was also useful in analysing the error in fully discretized parabolic problems measured in the (standard) energy norm. For instance, spatially nonconforming methods such as the *discontinuous Galerkin* methods which have become quite popular; this was the topic of my joint paper [3] with Emmanuil Georgoulis (Leicester), with whom we are currently developing a framework for second order hyperbolic equations such as the Wave, and possibly Schrödinger equations. These equations are quite important in mathematical physics.

The ERT has been tested also in a nonresidual estimator context, such as *gradient recovery* methods which we dealt with in collaboration with my student Tristan Pryer [14].

I am currently exploring two ramifications of this area of research:

**Wave equation:** This is an exciting area, where a posteriori error control is almost inexistent due to the inherent challenges posed by the conservative nature of the equations. We are currently improving on the existent literature by analysing more schemes which are better suited for the hyperbolic nature of the equation. What is encouraging is that the computational methods for type of equation will benefit immensely from error control and their applications are widespread, to cite an example explained to me by Mark Hindmarsh (Sussex) the wave version of the Allen–Cahn model can be used to describe the formation of strings in the early Universe. Most of my current work in this area is in collaboration with Georgoulis and Makridakis, and other possible collaborators are Hindmarsh and Stig Larsson (Chalmers, SE) and his team. I am writing a *EPSRC grant proposal*, to be submitted later this year, with Georgoulis on the subject.

**Nonlinear problems:** This is, for me at least, the natural extension and the ultimate aim of developing the elliptic reconstruction technique. I am currently working on such research and its applications in biological and social modelling with Georgoulis, Anotida Madzvamuse (Sussex), Chandrashekar Venkataraman (Sussex). Other collaborators could be Vanessa Styles (Sussex) and Erik Burman (Sussex). I am planning a solo *EPSRC grant proposal* to be submitted this spring on this subject.

**Nonlinear elliptic problems, variational and topological methods.** I got my Laurea (Masters) degree in 1996, from the Università di Trieste, Italy in general mathematics. In my Masters thesis [7], I undertook the study of theoretical aspects of elliptic PDE's. Specifically, I established existence [8] and regularity [9] results for higher order elliptic problems using tools from the calculus of variations, topological methods and nonlinear analysis. Although my research activity is not

directly related to this sector of mathematics, I still have the chance to exploit the accumulated know-how in my current work.

#### REFERENCES

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- [4] Emmanuil Georgoulis, Omar Lakkis, and Charalambos Makridakis. A posteriori error control for the wave equation. Technical report, University of Sussex, In preparation.
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- [14] Omar Lakkis and Tristan Pryer. Gradient recovery in adaptive methods for parabolic equations. preprint@arXiv: submitted, University of Sussex SMRR-2009-8, Brighton, UK, May 2009.