DEMETRIO LABATE

CURRICULUM VITAE

(May 2008)

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PERSONAL DATA

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EDUCATIONAL BACKGROUND

2000 Ph.D. in Mathematics, Georgia Institute of Technology, Atlanta, GA
Thesis: *Time–frequency characterization of pseudodifferential operators.*
Advisor: Christopher Heil

1995 M.S. in Applied Mathematics, Georgia Institute of Technology, Atlanta, GA

1994 Ph.D. in Electrical Engineering, Politecnico di Torino, Torino, Italy
Thesis: *High-frequency electromagnetic field due to lightning. A fractal model.*
Advisor: Flavio Canavero.

1991 B.S. in Electrical Engineering, Politecnico di Torino, Torino, Italy

EMPLOYMENT HISTORY

2003–present	North Carolina State University, Dept. of Mathematics, Assistant Professor
2000–2003	Washington University in St.Louis, Dept. of Mathematics, Chauvenet Lecturer of Mathematics
1994–2000	Georgia Institute of Technology, School of Mathematics, Graduate assistant
1991–1994	Politecnico di Torino Dept. of Electrical Engineering, Graduate assistant

VISITS to OTHER RESEARCH INSTITUTIONS

- Universidad Autonoma Madrid, Spain (invited by Hernandez), December 2003
- Universita' di Torino, Italy, (invited by E. Cordero and L. Rodino), June 2006
- Washington University in St.Louis, St. Louis, (invited by G. Weiss), January-February 2007
- Nuhag Center at the University of Vienna, Austria, (invited by H. Feichtinger and K. Gröchenig), April 2007
- University of Genoa, Italy, (invited by F. DeMari and G. Mauceri), June 2007

TEACHING EXPERIENCE

		NCSU:	
Spring 2008	Math 515	Real Analysis I	16 students
Fall 2007	Math 425	Mathematical Analysis	20 students
Fall 2007	Math 242	Calculus III	50 students
Fall 2006	Math 797	Introduction to Wavelets	7 students
Fall 2006	Math 242	Calculus III	47 students
Fall 2006	Math 425	Mathematical Analysis	20 students
Spring 2006	Math 515	Real Analysis I	17 students
Fall 2005	Math 242	Calculus III (2 sections)	99 students
Spring 2005	Math 715	Real Analysis II	7 students
Fall 2004	Math 515	Real Analysis I	20 students
Fall 2004	Math 242	Calculus III	30 students
Spring 2004	Math 242	Calculus III	38 students
Fall 2003	Math 242	Calculus III	50 students
		Washington University:	
Spring 2003	Math 233	Calculus III	73 students
Fall 2002	Math 217	Differential Equations	58 students
Fall 2002	Math 519	Harmonic Analysis	7 students
Spring 2002	Math 404	Numerical Methods	7 students
Fall 2001	Math 141	Accelerated Calculus I	35 students
Fall 2001	Math 217	Differential Equations	61 students
Spring 2001	Math 142	Accelerated Calculus II	18 students
Fall 2000	Math 320	Introduction to Probability and Statistics	63 students
Fall 2000	Math 141	Accelerated Calculus I	28 students
		Georgia Tech:	
Summer 1999	Math 2508	Calculus V	49 students
Winter 1999	Math 2502	Finite differences and differential equations	13 students
Fall 1998	Math 2502	Finite differences and differential equations	37 students
Summer 1998	Math 2502	Finite differences and differential equations	18 students
Spring 1998	Math 2502	Finite differences and differential equations	31 students
Winter 1998	Math 1508	Calculus II	39 students
Fall 1997	Math 1508	Calculus II	45 students
Summer 1997	Math 2508	Calculus V	27 students

Spring 1997	Math 1711	Mathematics for management I	54 students
Winter 1997	Math 1713	Mathematics for management III	43 students
Fall 1996	Math 1713	Mathematics for management III	37 students
Summer 1996	Math 2502	Finite differences and differential equations	31 students
Spring 1996	Math 1713	Mathematics for management II	46 students
Winter 1996	Math 1713	Mathematics for management III	46 students
Fall 1995	Math 1509	Calculus III	35 students
Spring 1995	Math 2508	Calculus V	35 students

OTHER EDUCATIONAL ACTIVITIES

Summer 2007: Research Experience for Undergraduates (REU), *Edge detection using multidimensional wavelets*

STUDENTS

1. Vishal Patel (Master), *Wavelets and approximation theory*, 2006
2. Chris Brasfield (Master), *Numerical homogenization using Complex Wavelets*, 2008

3. Sheng Ying (Ph.D, joint advisor, ECE Dept), *Edge analysis and detection using shearlets*, 2009 (expected)

PUBLICATIONS

1. G. Vecchi, D. Labate, F. G. Canavero, *Fractal Determination of Parameters in Lightning and ESD model*, in: Proceedings of the 1992 International Aerospace and Ground Conference on Lightning and Static Electricity, Atlantic City, N.J., USA, October 6-8, (1992).
2. G. Vecchi, D. Labate, F. G. Canavero, *Fractal Approach to Lightning Radiation on a Tortuous Channel*, Radio Science, **29**(4), pp. 691-704 (1994).
3. D. Labate, F. G. Canavero, A. DeMarchi, *A Comparison of Fractal Dimension and Spectrum Coefficient*, Metrologia, **31**, pp. 51-53 (1994).
4. G. Vecchi, F. G. Canavero, D. Labate, *Fractal modeling of high-frequency noise due to lightning*, in: Proceedings X RiNEm, Cesena, Italy, September 21-23, (1994).
5. B. Dilecce, L. Isnardi, D. Labate, F. G. Canavero, *Exact Spice model of field coupling to multiconductor transmission lines*, in: Proceedings Int. Symp. EMC 1994, Sendai, Japan, May 16-20, pp. 12-15 (1994).
6. D. Labate, *Time–frequency analysis of pseudodifferential operators*, Monatsh. Math., **133**, pp. 143-156 (2001).
7. D. Labate, *Pseudodifferential operators on modulation spaces*, J. Math. Anal. Appl., **262**, pp. 242-255 (2001).
8. D. Labate, *A unified characterization of reproducing systems generated by a finite family*, J. Geom. Anal., **12(3)**, pp. 469-491 (2002).
9. E. Hernandez, D. Labate, G. Weiss, *A unified characterization of reproducing systems generated by a finite family, II*, J. Geom. Anal., **12(4)**, pp. 615-662 (2002).

10. P. Gressman, D. Labate, G. Weiss, E. Wilson, *Affine, quasi-affine and co-affine wavelets*, in Beyond Wavelets, G. Welland (Ed.), Studies in Computational Mathematics, Elsevier, 2003.
11. E. Hernandez, D. Labate, G. Weiss, E. Wilson, *Oversampling, quasi affine frames and wave packets*, Appl. Comput. Harmon. Anal., **16**, pp. 111–147 (2004).
12. D. Labate, G. Weiss, E. Wilson *An Approach to the Study of Wave Packet Systems*, Contemp. Math., **345**, Wavelets, Frames and Operator Theory, pp. 215-236 (2004).
13. K. Guo, D. Labate, W. Lim, G. Weiss, E. Wilson, *Wavelets with composite dilations*, Electr. Res. Ann. AMS, **10**, pp.78-87 (2004).
14. D. Labate, E. Wilson, *Connectivity in the set of Gabor frames*, Appl. Comput. Harmon. Anal., **18**, pp. 113-132 (2005).
15. D. Labate, and G. Weiss, *Wavelets associated with Composite Dilations*, in: Matemáticas: investigación y educación. Un homenaje a Miguel de Guzmán. Universidad Complutense de Madrid, Ed.Anaya, Madrid, 2005.
16. D. Labate, W. Lim, G. Kutyniok and G. Weiss, *Sparse Multidimensional Representation using Shearlets*, Wavelets XI (San Diego, CA, 2005), 254-262, SPIE Proc. **5914**, SPIE, Bellingham, WA, 2005.
17. K. Guo, G. Kutyniok, and D. Labate *Sparse Multidimensional Representations using Anisotropic Dilation and Shear Operators* in: Wavelets and Splines: Athens 2005 (Proceedings of the International Conference on the Interactions between Wavelets and Splines. Athens, GA, May 16-19, 2005), G. Chen and M. Lai (eds.).
18. K. Guo, D. Labate, W. Lim, G. Weiss, and E. Wilson, *Wavelets with Composite Dilations and their MRA Properties*, Appl. Comput. Harmon. Anal., **20**, 231-249 (2006).
19. K. Guo, D. Labate, W. Lim, G. Weiss and E. Wilson, *The theory of wavelets with composite dilations*, in Harmonic Analysis and applications, in: Harmonic Analysis and Applications, C. Heil (ed.), pp. 231-249, Birkauser, 2006.
20. G. Kutyniok, and D. Labate, *The Theory of Reproducing Systems on Locally Compact Abelian Groups*, Colloquium Math., **106**, 197-220 (2006).
21. K. Guo and D. Labate, *Some Remarks on the Unified Characterization of Reproducing Systems*, Collectanea Math., **57**, 279-293 (2006).
22. K. Guo and D. Labate *Optimally Sparse Multidimensional Representation using Shearlets*, SIAM J. Math. Anal., **39** 298–318, (2007).
23. G. Kutyniok and D. Labate, *The Construction of Regular and Irregular Shearlet Frames*, J. Wavelet Theory Appl., **1**, 1-10 (2007).
24. G. Easley, W. Lim, and D. Labate, *Optimally Sparse Image Representations using Shearlets*, Proc. 40th Asilomar Conf. on Signals, Systems and Computers, Monterey (2006), pp. 5.
25. K. Guo and D. Labate, *Sparse Shearlet Representation of Fourier Integral Operators*, ERA-MS, **14**, 7-19 (2007).
26. K. Guo and D. Labate, *Representation of Fourier Integral Operators using Shearlets*, J. Fourier Anal. Appl., **14**, 327–371, (2008).

27. G. Easley, W. Lim, and D. Labate, *Sparse Directional Image Representations using the Discrete Shearlet Transform*, Appl. Comput. Harmon. Anal., **25**, 25–46, (2008).
28. G. Kutyniok, and D. Labate, *Resolution of the Wavefront Set using the Continuous Shearlet Transform*, to appear in Trans. AMS, pp. 31, (2008).
29. S. Yi, D. Labate, G. R. Easley, and H. Krim, *Edge Detection and Processing using Shearlets*, accepted to 2008 IEEE Int. Conf. on Image Processing (ICIP), pp. 4 (2008).
30. K. Guo, D. Labate and W. Lim, *Edge Analysis and Identification using the Continuous Shearlet Transform*, submitted to Appl. Comput. Harmon. Anal., pp. 31, (2008).
31. G. R. Easley, D. Labate, and F. Colonna, *Shearlet Based Total Variation for Denoising*, pp. 11, submitted to IEEE Trans. Image Process (2008).
32. S. Yi, D. Labate, G. R. Easley, and H. Krim, *A Shearlet approach to Edge Analysis and Detection*, pp. 16, submitted to IEEE Trans. Image Process (2008).

COLLOQUIUM and SEMINAR TALKS

1. *High-frequency electromagnetic field due to lightning. A fractal model*, Electromagnetic Seminar, Politecnico di Torino, December 1994.
2. *Fractal modeling of high–frequency electric field due to lightning*, Electromagnetic Seminar, Universita' La Sapienza, Roma, November 1995.
3. *Pseudodifferential operators*, Graduate Seminar, Georgia Institute of Technology, Atlanta, GA, May 1997.
4. *Hilbert transform*, Analysis Seminar, Georgia Institute of Technology, Atlanta, GA, February 1998.
5. *Time–frequency analysis of pseudodifferential operators*, YAMS 99, Fuhrman University, Greenville, SC, July 8, 1999.
6. *Composition of pseudodifferential operators*, Analysis Seminar, GaTech, Atlanta, GA, September 28, 1999.
7. *Composition of pseudodifferential operators*, Analysis Seminar, York University, Toronto, October 29, 1999 (invited by M. W. Wong).
8. *Time–frequency analysis of pseudodifferential operators*, Analysis Seminar, Politecnico di Torino, December 1999 (invited by F. Ricci).
9. *Composition of pseudodifferential operators*, 106th Annual Meeting of AMS, Washington DC, January, 2000 (invited by S. Casey and D. Walnut).
10. *Time–frequency analysis of pseudodifferential operators*, SIAM–SEAS 2000, UGA Athens, March 2000.
11. *Time–frequency analysis of pseudodifferential operators*, Analysis Seminar, Washington University, September 2000 (invited by G. Weiss).
12. *Pseudodifferential operators on modulation spaces*, 957th AMS Meeting, University of Toronto, Ontario, Canada, September 2000 (invited by M. W. Wong).
13. *A Unified Characterization of Reproducing Systems Generated by a Finite Family*, Wavelet Seminar, Washington University, September 2001 (invited by G. Weiss).

14. *A Unified Characterization of Reproducing Systems Generated by a Finite Family*, 2001 Gabor Workshop, University of Vienna, December 2001 (invited by H. Feichtinger).
15. *A Unified Characterization of Reproducing Systems Generated by a Finite Family*, Colloquium, Politecnico di Torino, Torino, December 2001 (invited by A. Tabacco).
16. *A Unified Characterization of Reproducing Systems Generated by a Finite Family*, AMS Sectional Meeting, Atlanta, March 2002 (invited by C. Heil and Y. Wang).
17. *Oversampling of Reproducing Systems*, Wavelet Seminar, Washington University, September 2002 (invited by G. Weiss).
18. *A Unified Theory of Reproducing Function Systems*, Colloquium, GaTech, Atlanta, September 2002 (invited by C. Heil).
19. *A Unified Theory of Reproducing Function Systems*, Colloquium, Kansas State University, December 2002 (invited by L. Pigno).
20. *A Unified Theory of Reproducing Function Systems*, AMS Annual Meeting, Baltimore, January 2003 (invited by C. Heil and P. Jorgesen).
21. *A Unified Theory of Reproducing Function Systems*, Colloquium, University of Houston, February 2003 (invited by M. Papadakis).
22. *A Unified Theory of Reproducing Function Systems*, Colloquium, DePaul University, February 2003 (invited by A. Zayed).
23. *A Unified Theory of Reproducing Function Systems*, Colloquium, Saint Louis University, February 2003 (invited by J. Hebda).
24. *A Unified Theory of Reproducing Function Systems*, Colloquium, University of Central Florida, March 2003 (invited by Z. Nashed).
25. *A Unified Theory of Reproducing Function Systems*, Colloquium, North Carolina State University, March 2003 (invited by J.P. Fouque).
25. *Efficient Representations of Multivariable Functions*, Probability Seminar, North Carolina State University, October 2003 (invited by M. Kang).
26. *Efficient Representations of Multivariable Functions*, Wavelet Seminar, Washington University, December 2003 (invited by G. Weiss).
27. *The theory of composite wavelets*, Wavelet Seminar, Washington University, February 2004 (invited by G. Weiss).
28. *An approach to the theory of reproducing systems on lca groups.* Washington University in St.Louis. International Workshop on wavelets. March 2004 (invited by G. Weiss and E. Wilson)
29. *Composite Wavelets. A new tool for efficient multi-dimensional representations.* International Conference in Computational Harmonic Analysis Vanderbilt University, Nashville, May 2004 (invited by A. Aldroubi).
30. *Directional representations in mathematics and signal processing.*, Wavelet Seminar, Washington University, February 2005 (invited by G. Weiss).
31. *Wavelets with Composite Dilations and their MRA Properties.* Vissta Seminar, North Carolina State University, February 2005 (invited by H. Krim).

32. *Wavelets with Composite Dilations and their MRA Properties.* Workshop on Sparse Representation in Redundant Systems, CSCAMM, University of Maryland, College Park, May 2005 (invited by J. Benedetto and E. Tadmor).
33. *Localization of the Wavefront Set using the Continuous Shearlet Transform*, Wavelet Seminar, Washington University in St.Louis, May 2005, (invited by G. Weiss).
34. *Sparse representations using shearlets* SPIE Conference, Wavelet XI, San Diego, August 2005, (invited by M. Papadakis).
35. *Optimally Sparse Representation using Shearlets*, Wavelet Seminar Washington University in St.Louis, January 2006, (invited by G. Weiss).
36. *Optimally Sparse Image Representation using Shearlets*, Vissta Seminar, ECE NCSU, February 2006 (invited by H. Krim).
37. *Optimally Sparse Representation using Shearlets*, International Workshop on Wavelets, Washington University in St.Louis, April 2006, (invited by G. Weiss and E. Wilson).
38. *Optimally Sparse Representation using Shearlets*, Current Trends in Harmonic Analysis and Its Applications: Wavelets and Frames, University of Colorado Boulder, May 2006 (invited by K. Merrill or J. Packer).
39. *Sparse Representation using Shearlets*, Pseudo-Differential Operators, Quantization and Signals, Centro Internazionale Matematico Estivo (CIME), Cetraro, June 2006 (invited by G. Rodino).
40. *Sparse Representation using Shearlets*, Colloquium Talk, University of Genova, July 2006 (invited by F. DeMari).
41. *Shearlet Representation of Fourier Integral Operators*, Wavelet Seminar, Washington University in St.Louis, April 2006, (invited by G. Weiss).
42. *Shearlet Representation of Fourier Integral Operators, II*, Wavelet Seminar, Washington University in St.Louis, October 2006, (invited by G. Weiss).
43. *Wavelets and Iterated Function Systems*, Wavelet Seminar, Washington University in St.Louis, January 2007, (invited by G. Weiss).
44. *Sparse Multidimensional Representation using Shearlets. Theory and Applications*, Colloquium, NuHAG, Faculty of Mathematics, University of Vienna, April 2007, (invited by C. Gröchenig).
45. *Sparse Shearlet Representation of Fourier Integral Operators*, Colloquium, NuHAG, Faculty of Mathematics, University of Vienna, April 2007, (invited by C. Gröchenig).
46. *Sparse Multidimensional Representation using Shearlets. Theory and Applications*, Illinois-Missouri Applied Harmonic Analysis Meeting, Washington University in St.Louis, April 2007, (invited by G. Weiss and E. Wilson).
47. *Sparse Multidimensional Representation using Shearlets. Theory and Applications.*, 31-st SIAM–SEAS Meeting University of Memphis, May 2007, (invited by P. Casazza and A. Powell).
48. *Sparse Multidimensional Representations using Shearlets. Theory and Applications.*, Colloquium Talk, University of Genova, July 2007 (invited by F. DeMari).

49. *Edge modeling using the continuous shearlet transform*, Wavelet Seminar, Washington University in St.Louis, December 2007, (invited by G. Weiss).
50. *Sparse Multidimensional Representations using Shearlets. Theory and Applications.*, Colloquium Talk, University of Houston, April 2008 (invited by M. Papadakis).

ORGANIZATION of MEETINGS

• Special session on *Efficient Multidimensional Representations* at the International Conference in Computational Harmonic Analysis Vanderbilt University, Nashville, May 2004 (joint with M.Do)

• Special session on *Advanced Wavelet Representations*, at the SPIE Conference, Wavelet XI, San Diego, August 2005 (joint with H.Krim)

PROFESSIONAL SOCIETIES

1. American Mathematical Society (AMS).
2. Sigma Xi.
3. SPIE Society for Optical Engineering.

HONORS and AWARDS

1. Fellowship of the Italian National Science Foundation, 1991–1994.
2. Fellowship of the Sanpaolo Bank Foundation for study abroad, 1994-1995.
3. Sigma Xi Best Ph. D. Thesis Award, *Time–Frequency Analysis of Pseudodifferential Operators*, Georgia Institute of Technology, 2001.
4. Faculty Research and Professional Development (FR&PD) Award, *Wavelet-Galerkin Solutions of Multidimensional Hyperbolic Problems*, NCSU, 2005.
5. NSF Grant (PI), Applied Mathematics, *Sparse Shearlet Representation: Analysis, Implementation and Applications*, $ 179,708, 07/01/2006-06/30/2009.
6. NSF Career Award, Applied Mathematics, *Sparse directional multiscale representations: theory, implementation and applications*, $ 422,025, 07/01/2008-06/30/2013.

REFEREE EXPERIENCE

• Referee for the mathematical journals: Advances in Computational Mathematics; Applied and Computational Harmonic Analysis; Applied Numerical Mathematics; Contemporary Mathematics; Electronic Research Announcements AMS; Journal of Fourier Analysis and Applications; Journal of Geometric Analysis; Journal of Mathematical Analysis and Applications; Journal of Sampling Theory in Signal and Image Processing; International Journal of Wavelets, Multiresolution and Information Processing; Positivity; Proceedings AMS; SIAM Journal of Mathematical Analysis.

• Referee for the engineering journals: IEEE Transactions on Image Processing; IEEE

Transactions on Signal Processing; IEEE Transactions on Information Theory.

• Panelist for the National Science Foundations, 2008

EDITORIAL EXPERIENCE

Editorial Board of JP Journal of Wavelets.

CURRENT FIELDS of INTEREST

Primary: Harmonic analysis, especially wavelets and time-frequency analysis and their application to multidimensional signal and image processing.
Secondary: Real and functional analysis, pseudodifferential operators.

PAST and CURRENT RESEARCH PROJECTS
(Number in brackets refer to my publication list above)

• **Unified characterization of reproducing systems** (2002-2005) [8-12,14,20]
Most of the function systems used in mathematics and applications to analyze (and "reproduce") functions and signals are obtained by applying a countable family of operators to one or finitely many generators. Wavelets and Gabor systems are the two best known examples. Jointly with E. Hernandez (U.Autonoma of Madrid), E. Wilson and G. Weiss (Washington U. in St.Louis) we introduced a general approach to describe in a unified manner a large class of such reproducing systems, and provide simple equations which characterize the generators of such systems. This approach extended several previous results, such as those by A.Ron and Z.Shen. One novelty of our approach is that we were not restricted to wavelet systems with expansive dilations or containing a single dilation set. Other applications of this approach involved the construction and analysis of wave packets and oversampled affine systems.
• **Wavelets with composite dilations** (2003-present) [13,15,16,18,19]
The idea of building wavelet-like systems using more than one dilation set started as an intellectual curiosity (stimulated by the unified approach described above) but eventually evolved into a very relevant project. In collaboration with G. Weiss, E.Wilson and W.Lim (Washington U. in St.Louis), we showed that there is a variety of such wavelet-like systems where one dilation set is expansive, while the second one is area-preserving. The resulting composite wavelets exhibit those geometric properties of directionality and anisotropy which are needed for efficient multidimensional representations and are advocated in the applied literature for image processing applications. As an additional benefit of our approach, there is multiresolution analysis associated with composite wavelets.
• **Optimally sparse representations using shearlets** (2004-present) [17,21-23,25,26,28]
The tight frame of shearlets was introduced as a special case of wavelets with composite dilations. Jointly with K.Guo (U.Missouri), we showed that shearlets provide optimally sparse representations for a large class of two-dimensional functions with discontinuities along smooth edges. The only other system with similar sparsity properties is given by the curvelet system of Candès and Donoho. However, the shearlet framework has a simpler mathematical structure: in particular, unlike curvelets, shearlets are obtained by applying dilations and translations to a single generator. Thanks to their properties, shearlets are very effective in the analysis of Fourier Integral Operators, as well as in the characterization of singularities of multidimensional functions and distributions (collaborations with K. Guo and G.Kutyniok, U.Giessen).
• **Image processing and analysis using shearlets** (2005-present) [24,27,28-32]
Jointly with W.Lim (LeHigh U.) and G.Easley (U.Maryland), we obtained a fast numerical implementation of the shearlet transform. Numerical tests to image denoising demonstrated

that this approach is extremely competitive against other state-of-the-art methods, including curvelets and contourlets. Other numerical applications involve the detection and analysis of edges and are currently being investigated in collaboration with G.Easley and H.Krim (NC State University). These tests also indicate the potential of the shearlet transform in image identification and shape recognition.

• **Time frequency analysis of pseudodifferential operators** (1999-2001) [6,7]
Following some previous results by K.Gröchenig and C.Heil, I applied Gabor tight frames to decompose pseudodifferential operators and study their boundedness and trace class properties. The modulations spaces were shown to provide appropriate symbol classes for such operators.

• **Fractal modeling of Electrostatic Discharge** (1992-1994) [1-4]
I debuted as an electrical engineering student by using fractal geometry to model the path of the electrostatic discharge occurring during a lightning strike (jointly with F.Canavero and G.Vecchi, Politecnico di Torino). The fractal dimension was used to provide an effective quantitative measure for the irregularities of the discharge path. Through this project I was exposed to several mathematical problems, and this eventually led me to pursue a career in mathematics.