Vitae for Nathalie Revol

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Diplomas

- **PhD thesis in Applied Mathematics**, entitled *Complexity of the parallel evaluation of arithmetic circuits*, defended in 1994 at INPG (Institut National Polytechnique de Grenoble), supervised by Jean Della Dora and Jean-Louis Roch, with highest distinction.
- **Master of Applied Mathematics**, of the University Joseph Fourier (Grenoble), 1990, with distinction.
- **Ingénieur diploma** of the ENSIMAG (École Nationale Supérieure d'Informatique et de Mathématiques Appliquées de Grenoble) in 1990, with distinction.

Education

- **PhD thesis** in applied mathematics at INPG, November 1990 - August 1994.
- **Monitorat** in applied mathematics at ENSIMAG (kind of teaching assistant), November 1990 - August 1993.
- **DEA** in applied mathematics at University Joseph Fourier, Grenoble, 1989 - 1990.
- **ENSIMAG** (École Nationale Supérieure d'Informatique et de Mathématiques Appliquées de Grenoble), 1987 - 1990. 4th year in Computer Science and 5th year in Scientific Computing.
- **Classes préparatoires** at lycée du Parc, Lyon, 1985 - 1987.

Research and teaching experience

- **Research scientist** at INRIA (Institut National de Recherche en Informatique et en Automatique), since September 2002, within the Arenaire team (until 2011) and now AriC, LIP (Laboratoire de l'Informatique du Parallélisme), École Normale Supérieure de Lyon.
- **Associate professor** at University of Sciences and Technologies of Lille, Laboratoire ANO (Analyse Numérique et Optimisation), from January 1996 to August 2002.
- **INRIA sabbatical leave** within the project Arenaire, LIP, École Normale Supérieure de Lyon, from September 2000 to August 2002.
- **Attachée temporaire d'enseignement et de recherche (ATER)** (temporary research and teaching assistant, with more teaching than during "Monitorat"), ENSIMAG, September 1993 - August 1995.
- **Moniteur** (teaching assistant) at ENSIMAG, November 1990 - August 1993.

1 Summary of research activities

1.1 Research conducted in Lyon: computer arithmetic and numerical quality

The two main questions regarding the issue of numerical quality of computations are, in this work, to determine how far a computed result lies from the exact result, and to enclose this unknown exact result. More precisely, the influence of the computer arithmetic is considered: usually, floating-point arithmetic is employed in numerical computations [H02]. The goal is to get *verified results*, it is twofold. One issue is to determine a bound on the error betwen the exact (unknown) result and the result computed using floating-point arithmetic. Another issue is to compute with sets, that is, to compute an enclosure of the exact result, without referring to any approximate result computed by any other means. In both cases, my tool of predilection is interval arithmetic [N90, JKDW01, MKC09, T11], along with the tuning of the computing precision required to achieve the prescribed accuracy.

Definition and standardization of interval arithmetic (2000-).
Interval arithmetic is used and implemented for decades. However, only the usual arithmetic operations have reached a consensual definition. Comparisons or the handling of exceptional cases, such as $\sqrt{[-2,3]}$ for instance, have received many different interpretations [68,38].
For instance, we made choices, such as returning `Invalid` for $\sqrt{[-2,3]}$, which led to the MPFI, *Multiple Precision Floating-point Interval arithmetic* library (available from `http://gforge.inria.fr/projects/mpfi/`) developed by F. Rouillier and myself. MPFI is a C library implementing interval arithmetic [6,44], based upon MPFR (cf. `http://www.mpfr.org/`). In MPFI, intervals are represented by their endpoints which are floating-point numbers with arbitrary precision. The last version has been released in January 2012.
In 2008, the interval arithmetic community felt that interval arithmetic was mature enough to be standardized [43]. With R. B. Kearfott, we have created and chaired since then the IEEE 1788 working group for the standardization of interval arithmetic (cf. `http://grouper.ieee.org/groups/1788/`). The development of the standard [37] now reaches its completion (end 2014). The mathematical model detailed by the standard is the set-based model. Future revisions may encompass other models such as modal arithmetic [G12].

Variants of interval arithmetic for improved accuracy (2002-).
Arithmetic on Taylor models is an extension of interval arithmetic which partly cures the so-called *dependency problem* of interval arithmetic. Taylor models are a representation of a function: they consist of a Taylor expansion plus an interval remainder. This remainder encloses the truncation error.
F. J. Cháves Alonso, during his PhD thesis co-supervised with M. Daumas, implemented Taylor models arithmetic and the proof of containment of each operation within PVS, a formal proof checker. Formal proof adds an extra level of guarantee to results computed using interval arithmetic. He then developed strategies to automate the proofs. This tool is used to prove bounds on expressions and inequalities [70].
M. Berz et al. [MB01] implemented Taylor models arithmetic using floating-point arithmetic and used the interval remainder to enclose also the roundoff errors. I proved that the arithmetic operations defined by M. Berz and K. Makino correctly take into account the roundoff errors due to the computations performed with floating-point arithmetic [7,71]. Again, these results have been formally checked using Coq [3]. Further work, with increased computing precision [71] or with more general polynomial models, may be undertaken.
Affine arithmetic [SF97] is another approach which also partly cures the dependency problem. In this arithmetic, each variable is considered as an affine combination of independent noises. With J. Ninin, we propose algorithms to implement this arithmetic using floating-point arithmetic, that are guaranteed to take roundoff errors into account in a very tight manner, and we implement them in the IBEX library [84].

Verification of floating-point computations in linear algebra (2007-).
We focused on the verification of the solution of a linear system, computed using floating-point arithmetic. Compared to the approach proposed by Rump in [Ru05] we managed to reduce the execution time by resorting to optimized floating-point BLAS3 routines as often as possible [64], by relaxing (enlarging) intervals when possible [39,60], and at the same time we managed to improve the accuracy of the results by using

double-double computations only for well-chosen variables [62] (following the approach in [DHKLMR06]), without significant time penalty. This work has been done with H. D. Nguyen [4,58,55] during his PhD thesis supervised by G. Villard and myself.
Future work will consist in designing verified computations with acceptable execution time on high-performance architectures, for other problems such as matrix factorizations.

Set-computations and enclosures (2001-).
With H.D. Nguyen, we proposed new algorithms for the product of matrices, either with floating-point or with interval coefficients, that offer a tradeoff between the accuracy (the width) of the result and the execution time [39], in line with [Ru05, R12, OORO12]. Getting an efficient, or even correct, implementation of these algorithms requires "taylor-made" optimizations of the code, as the behavior of numerical codes on emerging architectures such as multicores is not reproducible [1]. With P. Théveny, we obtained an implementation comparable to the MKL, within a factor less than 2, for interval matrices [2].
Another topic I worked on is the dynamics of a stable linear Infinite Impulse Response (IIR) filter with unstable interval simulation: the choice of a larger sampling period can cure this problem [76].
Eventually, I plan to return to the interval Newton algorithm [HG83], that determines all zeros of a function over a given input interval. It has been adapted for arbitrary precision interval arithmetic, implemented using MPFI and experimented [9]: the computing precision can be automatically and dynamically adapted to fulfill the computing needs and reach the required accuracy, without re-starting the whole execution of the program. For this algorithm to start with, and generally speaking [Ro05], I plan to investigate carefully the impact of the floating-point arithmetic, and to translate results from numerical analysis to interval analysis. Being able to determine when and how the computing precision must be increased [69] is a topic for future research. The long-term goal of this work is the design and implementation of a solver for global optimization problems [HW04, K96].

Automation (2006-2011).
As this has been mentioned several times earlier, the tuning of the best evaluation formula or variant of interval arithmetic, or of the right computing precision, is crucial for performances, be they execution time or accuracy of the results. However, hand-tuning is tedious, error-prone and time-consuming. A first project towards more automation was the ANR project EVA-Flo (`http://www.ens-lyon.fr/LIP/Arenaire/EVA-Flo/`), led by me. The EVA-Flo project focused on the way a mathematical formula is evaluated in floating-point arithmetic. The approach was threefold: study of algorithms for approximating and evaluating mathematical formulae, validation of such algorithms, and automation of the process or rather of several steps of this process. The LEMA language [40] is intended to enable the communication between the different tools in charge of each of these steps.

Floating-point arithmetic and elementary functions (2000-2006).
The IEEE-754 standard [IEEE-754] specifies floating-point formats and arithmetic operations. We have proposed an extension of this standard to elementary functions [8]. An issue related to the standardization of floating-point arithmetic, and more specifically of mathematical functions, is the implementation of special functions with correct rounding; we proposed an algorithm for the error functions erf and erfc in arbitrary precision in [42]. We have also proposed an algorithm for the reduction of the arguments of trigonometric functions [M97]: this algorithm is always accurate and, for most cases, it is also fast [5].
Another aspect of this work includes the joint development, with P. Pelissier and P. Zimmermann, of a software named `mpcheck` that tests the quality of the implementation of elementary functions (accuracy, output range…) and also its use to test various mathematical libraries.

Parallelization of automatic speech recognition [R89] (2000).
Y.O. Mohamed El Hadj, PhD student supervised with E.M. Daoudi, and myself have determined a static estimate of the computational load and thus a static load distribution among the processors, which yields efficiencies ranging from 65% to 80% on a cluster of 12 PCs [83].

1.2 Research conducted in Lille: arithmetic and parallelism

Interval arithmetic and parallelism (1999-2000). My target application with interval arithmetic is the global optimization of a continuous function; this problem can be solved by Hansen's algorithm [HW04, K96], which is a Branch&Bound algorithm and has an exponential worst-case complexity. In order to reduce its execution time, we have studied its parallelization: it is quite difficult because the execution graph is not predictable [92]. We obtained good performances with a homogeneous architecture [45] and the adaptation to heterogeneous distributed architectures, using MC-PM^2 [47,46] developed by B. Planquelle, PhD student at LIFL, based on PM^2 [DNM97] was considered.

Interval arithmetic: constrained global optimization (2000). The problem is to find the global optimum of a continuous function on a domain defined by constraints. A first approach consists in simplifying Hansen's algorithm in order to keep a smaller dimension for the working vector space (cf. DEA of N. Baeyens, 2000), than the classical approach based on the Lagrangian.

Multiple precision arithmetic (1997). With J.-C. Bajard (LIM, Marseille), we wrote a chapter on multiple precision arithmetic [18] for the book on computer arithmetic which was the achievement of a working group managed by J.-M. Muller. With students, we have experimented several multiple precision algorithms.

Floating-point arithmetic (1998). Following a discussion with J.-C. Yakoubsohn (LAO, Toulouse), I have proposed accelerated Shift-and-Add algorithms [M97] for the computation of elementary functions: the last steps are replaced by one step of Euler or Runge-Kutta method. The benefits are between 33% and 75% of the computation time [11].

1.3 Research conducted for the PhD

I have done my PhD entitled *Complexity of the parallel evaluation of arithmetic circuits* within the "Computer Algebra and Parallelism" team of the LMC laboratory in Grenoble, supervised by J.-L. Roch and J. Della Dora. I defended my thesis in August 1994.

Subject. The underlying idea was that the algebraic properties of arithmetic operations can be used in order to extract the intrinsic parallelism of some programs (arithmetic expressions, straight-line programs) [MRK86, MT87] such as programs of scientific computing and linear algebra in particular [48,82].

Result: a new algorithm for the parallel evaluation of arithmetic programs over lattices. The main result of my PhD is a new algorithm for the parallel evaluation of straight-line programs with operations taking place in a lattice [12]. A distributive lattice is an important algebraic structure, since the Boolean algebra, which is fundamental in complexity, belongs to it.

Towards a compiling tool. This algorithm enables one to transform sequential programs into parallel programs with a complexity as good as that of the tailor-made parallel programs for the sort problem, exact arithmetic operations and some algorithms in computer algebra. I have implemented a simulator and then a compiler-parallelizer for arithmetic expressions with T. Gautier (DEA).

1.4 Conclusion

This work shows how numerical analysis, arithmetic and parallelism can interact. It illustrates the different steps done in scientific computing, to design and implement an efficient algorithm on a computer, circumventing numerical problems by choosing the proper arithmetic and the efficiency problems by taking benefit from optimized routines and high-performance architectures. The goal is to offer guarantees on the results of numerical computations and to prove that the overhead to get guarantees remains small.

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2 Publications

Most of these publications can be downloaded as research reports (extended versions of the published articles), along with slides of the presentations, from my Web page : `http://perso.ens-lyon.fr/nathalie.revol/`

Journals

[1] *Numerical reproducibility and parallel computations: Issues for interval algorithms*, N. Revol and P. Théveny, IEEE Transactions on Computers, to appear.

[2] *Parallel Implementation of Interval Matrix Multiplication*, N. Revol and P. Théveny, Reliable Computing, vol. 19, no. 1, pp 91–106, 2013.

[3] *A Validated Real Function Calculus*, P. Collins, M. Niqui and N. Revol, Mathematics in Computer Science, vol. 5, issue 4, pp 437-467, 2011.

[4] *Solving and Certifying the Solution of a Linear System*, H. D. Nguyen and N. Revol, Reliable Computing, vol. 15, no. 2, pp 120-131, 2011.

[5] *A new range-reduction algorithm*, N. Brisebarre, D.Defour, P. Kornerup, J.-M. Muller and N. Revol, IEEE Transactions on Computers, vol. 54, no. 3, pp 331-339, 2005.

[6] *Motivations for an arbitrary precision interval arithmetic and the MPFI library*, N. Revol and F. Rouillier, Reliable Computing, vol. 11, no. 4, pp 275-290, 2005.

[7] *Taylor models and floating-point arithmetic: proof that arithmetic operations are validated in COSY*, N. Revol, K. Makino and M. Berz, Journal of Logic and Algebraic Programming, vol. 64, pp 135–154, 2005.

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[10] *Validating polynomial computations with complementary automatic methods*, P. Langlois and N. Revol, to appear in Mathematics and Computers in Simulation. `http://www.inria.fr/rrrt/rr-4205.html`

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National journals

[13] *First steps towards more numerical reproducibility*, F. Jézéquel, Ph. Langlois and N. Revol, ESAIM: M2AN (Mathematical Modelling and Numerical Analysis), to appear.

[14] *JDEV 2013 : Développer pour calculer*, partie *Des outils pour calculer avec précision* et partie *Comment calculer avec des intervalles* (in french), F. Langrognet, F. Jézéquel and N. Revol, HPC magazine, 2013.

[15] *Arithmétique par intervalles* (in french), N. Revol, Calculateurs Parallèles, vol. 13, pp 387–426, 2001.

Books and chapters of books

[16] *Handbook of Floating-Point Arithmetic*, J.-M. Muller, N. Brisebarre, F. de Dinechin, C.-P. Jeannerod, V. Lefèvre, G. Melquiond, N. Revol, D. Stehlé and S. Torres, Birkhäuser Boston, 2010.

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Editorial work

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[24] *Numerical reproducibility in HPC: issues in floating-point arithmetic and in interval arithmetic*, N. Revol and P. Théveny, McMaster University, Hamilton and University of Toronto, Canada, 2013.
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Invited conferences in France

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[61] *Taylor Function Calculus for Hybrid System Analysis: Validation in Coq*, P. Collins, M. Niqui and N. Revol, NSV3 (Numerical Software Verification), Edinburgh, Scotland UK, July 2010.
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[67] *Introduction to Interval Arithmetic and to some Interval-Based Software Systems*, N. Revol, ECMI'08, Introductory Conference to Minisymposium MS09, United Kingdom, 2008.
[68] *Survey of proposals for the standardization of interval arithmetic*, N. Revol, SWIM'08, Montpellier, France, 2008.
[69] *Automatic adaptation of the computing precision*, N. Revol, V Taylor Models Workshop'08, Toronto, Ontario Canada, May 2008
[70] *Automatic strategies to evaluate formulas on Taylor models and generate proofs in PVS*, F. Cháves, M. Daumas, C. Muñoz and N. Revol, ICIAM'07, Zurich, Switzerland, July 2007.
[71] *Implementing Taylor models arithmetic with floating-point arithmetic*, N. Revol, ICIAM'07, Zurich, Switzerland, July 2007.
[72] *Implementing Taylor models arithmetic using floating-point arithmetic: bounding roundoff errors*, N. Revol, Taylor Models Workshop'06, Boca Raton, Florida, December 2006
[73] *Design choices and their limits for an interval arithmetic library. The example of MPFI.*, N. Revol, SCAN'06, Duisburg, Germany, September 2006.
[74] *Computation of the error functions erf and erfc in arbitrary precision with correct rounding*, S. Chevillard and N. Revol, IMACS'05, Paris, France, 2005. Augmented version presented at the conference ICMS'06, Castro Urdiales, Spain, September 2006.
[75] *Bounding roundoff errors in Taylor models arithmetic*, N. Revol, IMACS'05, Paris, France, 2005.
[76] *Convergent linear recurrences (with scalar coefficients) with divergent interval simulations*, N. Revol, SCAN'04, Japan, 2004.
[77] *Multiple precision interval arithmetic and application to linear systems*, N. Revol, ACA'03, USA, 2003.
[78] *MPFI: a library for arbitrary precision interval arithmetic*, N. Revol and F. Rouillier, SCAN'02, France, 2002.
[79] *Motivations for an arbitrary precision interval arithmetic and the MPFI library*, N. Revol and F. Rouillier, Validated Computing, Canada, 2002.
[80] *Newton iteration using multiple precision interval arithmetic: the univariate case*, N. Revol, ALA'2001 (Algèbre Linéaire et Arithmétique), Rabat, Morocco, 2001.
[81] *Parallelization of continuous global optimization*, N. Revol, Y. Denneulin, J.-F. Méhaut and B. Planquelle, (abstract), 19th IFIP TC7 conf. on System Modelling and Optimization, Grande-Bretagne, 1999.
[82] *Parallel evaluation of circuits over lattices*, N. Revol and J.-L. Roch, (poster) ISSAC'95, Canada, 1995.

Unpublished research reports

[83] *Parallelization of automatic speech recognition*, Y.O. Mohamed El Hadj, N. Revol and A. Meziane. `http://www.inria.fr/rrrt/rr-4110.html`.

In preparation

[84] *Fast Reliable Implementation of Arithmne Arithmetic using Floating-point Arithmetic*, J. Ninin and N. Revol, 2014.

Lectures in schools

[85] *Arithmétique flottante et intervalles*, N. Revol and P. Théveny, École CNRS *Précision et reproductibilité en calcul numérique*, Fréjus, March 2013.
[86] *Précision et arithmétique flottante : outils, bibliothèques*, N. Revol and P. Théveny, JDEV : Journées du Développement Logiciel, École Polytechnique, September 2013.
[87] *Introduction à l'arithmétique par intervalles*, N. Revol and P. Théveny, professional training entitled "Contrôler et améliorer la qualité numérique d'un code de calcul industriel", Collège de l'X, Paris, November 2013.

[88] *Calcul numérique sur des ensembles, vérification de calculs numériques : un outil de choix, larithmétique par intervalles*, N. Revol, SIESTE 2010-2011 (students seminar), ENS Lyon, France, April 2011.

[89] *Arithmétique des ordinateurs : calculer de façon rapide, fiable, précise*, N. Revol, SIESTE 2007-2008 (students seminar), ENS Lyon, France, September 2007.

[90] *Introduction à l'arithmétique d'intervalles*, N. Revol, École Jeunes Chercheurs en Algorithmique et Calcul Formel, Grenoble, March 2004.

[91] *Arithmétique d'intervalles*, N. Revol, Spring school of Theoretical Computer Science on Computer Arithmetic, Prapoutel, March 2001.

[92] *Parallélisation d'applications irrégulières : exemples en optimisation combinatoire et en optimisation globale par intervalles*, N. Revol, Autumn school on Parallel and Distributed Computing ParDi, Oujda, Morocco, October 1999. `ftp://ano.univ-lille1.fr/pub/2000/ano417.ps.Z`

3 Software writing and distribution

They are available from my Web page: `http://perso.ens-lyon.fr/nathalie.revol/software.html`.

MPFR++: C++ interface for the MPFR library (`http://www.mpfr.org/`) developed by the INRIA project Caramel (Nancy), 2 900 lines. Used in the Arithmos project, Antwerpen, Belgium. No more maintained.

MPFI (*Multiple Precision Floating-point Interval arithmetic library*): C/C++ library still under development, joint work with F. Rouillier, 7 500 lines. Used by F. Rouillier to isolate real roots of polynomials. Other users in Europe (France, Germany, Belgium, United Kingdom) and farther (USA, Colombia,. . .).

4 Supervision of research activities

P. Théveny (PhD thesis, MESR grant, 2011-2014) works on the parallel implementation of some algorithms for linear algebra using interval analysis. For the product of matrices with interval coefficients, several algorithms, that exhibit different tradeoffs between accuracy and speed, have been compared. Their accuracy has been extensively analyzed. Their speed is high, through a parallel implementation by blocks, with the optimization of block sizes and use of vectorization. It reaches performance comparable to the Intel MKL's one. This work also led to thoroughly analyze numerical reproducibility issues and to propose recommendations to circumvent these issues.

D. Pfannholzer (unfinished PhD thesis in computer science, MEFI Mediacom-Nano 2012 grant, 2009-2011, co-supervised 50%-50% with Florent de Dinechin) worked on the automated generation of code for elementary functions and more precisely for the exponentials. He automated the range reduction, which was not yet tackled. After two years, he received a very good offer and did not complete his PhD.

H.D. Nguyen (PhD thesis in computer science, INRIA Cordi-S grant, 2007-2011, co-supervised 85% by me and 15% by Gilles Villard) worked on problems in linear algebra and interval arithmetic. He reached a trade-off for the product of interval matrices: his algorithm is more accurate than the fastest algorithm and only a bit slower. He also worked on the verification of the solution of linear systems: starting from an approximate solution, computed using floating-point arithmetic, he improved its accuracy. Simultaneously he computed and refined an enclosure of the error between the computed solution and the exact one. His results exhibit very good time and accuracy. His is now a post-doctoral fellow if the University of California at Berkeley, under supervision of J. Demmel.

P. Théveny (expert engineer, 2009-2010) has been hired for the ANR project EVA-Flo. He worked on the design and the implementation of the LEMA language, that extends MathML for the representation of floating-point data. He also updated the MPFI library. After a master in computer science, P. Théveny obtained a grant for a PhD. thesis at ENS de Lyon.

F.J. Cháves Alonso (PhD thesis in computer science, European contract MathLogAps grant, 2004-2007, co-supervised 75% by me and 25% by Marc Daumas) worked on the implementation and certification of the Taylor models arithmetic on the formal proof assistant PVS. He implemented arithmetic operations and several transcendental functions (exp, atan, sin) on Taylor models and proved the containment property in PVS. He developed strategies to build the Taylor model corresponding to a given expression and to prove the containment property or bounds on this expression, hiding the step-by-step process. He now gives lectures at the University Politecnico Grancolombiano at Bogota, Colombia.

Y.O. Mohamed El Hadj (PhD thesis in computer science, U. Oujda - Morocco, European contract INCO-DAPPI grant, 1998-2001, co-supervised 25% by me and 75% by El Mostafa Daoudi) worked on the parallelization of automatic speech recognition. He is now assistant professor in Riyadh, Saudi Arabia.

B. Planquelle has worked on a PhD in computer science (MESR grant, 1997-2002) entitled *Multithreaded environment for distributed and heterogeneous architectures*, he was supervised by J.-M. Geib, J.-F. Méhaut and myself (33% each). He has extended the multithreaded runtime environment PM^2 for multi-clusters and has parallelized Hansen's algorithm for interval global optimization on a shared-memory architecture. He was not able to bear the heavy working load of finishing his PhD and writing his manuscript (he is strongly disabled) and he gave out his PhD. He is now computer scientist at rectorat of Lille.

N. Dessart (master in computer science, 2004) worked on the development, implementation and comparison of various algorithms solving linear systems with arbitrary precision interval arithmetic. **J.-B. Verchay (master in mathematics and computer science, 2003)** worked on the implementation of Remes' algorithm for polynomial best approximation, in multiple precision arithmetic. **N. Baeyens (master in math. 2000)** has done his final project on the handling of constraints in interval global optimization. **S. Czech (master in computer science 1998)** has worked on the implementation of Hansen's algorithm with M. Petitot, Y. Denneulin (LIFL) and myself. **T. Gautier (master in applied math. 1992)** has done his final project with J.-L. Roch and myself on the design of the compiler-parallelizer and on the specialization of programs.

I have also supervised 2 projects in maîtrise (4th year) of applied math., 3 projects in maîtrise of computer science, 2 training periods in licence (3rd year) of computer science and 5 projects in 3rd year of IUP GMI (4th year, professional diploma in computer science).

5 Responsibilities and collaborations

Co-chair, with R. B. Kearfott, of the IEEE 1788 working group for the standardization of interval arithmetic. The standard defines intervals, their representation, operations including exceptional cases, and the handling of exceptions. Several mathematical models have been considered, the "set-based" model is entirely defined. The document is 100 pages long and should be adopted by the end of 2014. Revisions and extensions are already envisioned.

Responsible of the ANR project "EVA-Flo: Evaluation et Validation Automatique pour le calcul Flottant", (2006-2010, `http://www.ens-lyon.fr/LIP/Arenaire/EVA-Flo/`), involving 4 teams: Arenaire (LIP-U. Lyon, ENS Lyon), Dali (U. Perpignan), Fluctuat (LIST, CEA Saclay), Tropics (INRIA Sophia Antipolis). The goal of the project is to evaluate and to validate small pieces of critical codes and to automate this process.

European contract MathLogAps: Early Stage Research Training Site in MATHematical LOGic and APplicationS (2004-2008, `http://www.maths.manchester.ac.uk/logic/mathlogaps/`) including 3 partners in Leeds, Munich and Lyon: it is devoted to the training of students in mathematical logic. This contract funded the PhD thesis of F. J. Cháves Alonso, co-supervised with M. Daumas. It offered the opportunity to visit other centers for the PhD students, and to gather during one workshop per year (I co-organized the workshop in 2007).

European contract INCO-DC DAPPI. This contract between 3 partners (Mons-Belgium, Lille-France and Oujda-Morocco) focused on recent advances in parallelism. It consisted in organizing a post-graduate school where I gave a lecture, a conference in May 2001 and in co-supervising 2 PhD, one between Oujda and Mons and the other between Oujda and Lille (Y. O. Mohamed El Hadj).

Guest co-editor of a special issue of the *Journal of Computational and Applied Mathematics* on Linear Algebra and Arithmetic, with S. El Hajji and P. Van Dooren, 2004, of a special issue of *Theoretical Computer Science* on Real Numbers and Computers, with M. Daumas, 2006, of a volume of *LNCS* on Reliable Implementation of Real Numbers Algorithms: Theory and Practice, with P. Hertling, Ch.M. Hoffmann and W. Luther, 2008, of a topical issue following SCAN 2010 of *Computing* with G. Alefeld, 2012.

Chair of the program committee of *SCAN 2010: 14th GAMM - IMACS International Symposium on Scientific Computing, Computer Arithmetic and Validated Numerics* (27-30 September 2010, Lyon, France).
Member of the program committees of *Real Numbers and Computers* (27-29 April 1998, Paris), of the *3rd seminar on numerical techniques for industrial problems* (11-12 March 1999, Rennes), of *Linear algebra and arithmetic* (18-31 May 2001, Rabat, Morocco), of the seminar on *Reliable Implementation of Real Number Algorithms: Theory and Practice* (8-13 January 2006, Dagstuhl, Germany), of *SCAN'06* (26-29 September 2006, Duisburg, Germany), of *CCA'08: Computability and Complexity in Analysis* (20-22 August 2008, Hagen, Germany), of *NSV3: Numerical Software Verification* (15 July 2010, Edinburgh, Scotland, United Kingdom), of *PASCO'10: 4th International Workshop in Parallel and Symbolic Computation* (21-23 July 2010, Grenoble, France), of *ICMS 2010: The Third International Congress on Mathematical Software conference* (13-17 September 2010, Kobe, Japan), of *NSV-2011: Fourth International Workshop on Numerical Software Verification* (14 July 2011, Cliff Lodge, Snowbird, Utah), of *SIAM Conference on Applied Algebraic Geometry 2011* (6-9 October 2011, Raleigh, North Carolina, USA), of *MACIS 2011: Fourth International Conference on Mathematical Aspects of Computer and Information Sciences* (19-21 October 2011, Beijing, China), of *SCAN 2012* (23-29 September 2012, Novosibirsk, Federation of Russia), of *SCAN 2014* (21-26 September 2014, Würzburg, Germany).

Organization of conferences: *Computer algebra week* (19-23 June 1994, Marseille) with G. Villard and E. Tournier, *2nd seminar on new techniques for sparse matrices in industrial problems* (28-29 April 1997, Lille) with C. Le Calvez, *Linear algebra and arithmetic* (18-31 May 2001, Rabat, Morocco), *Numerical Algorithms* (1-5 October 2001, Marrakesh, Morocco), *Real Numbers and Computers* (3-5 September 2003, Lyon, France), *Forum des Jeunes Mathématiciennes - Mathématiques, Informatique et Sciences du Vivant* (30-31 January 2004, Paris, France), session on Computer Arithmetic, *School for Young Researchers on Algorithms and Computer Algebra*, (29th March-2nd April 2004, Grenoble, France), session on Computer Arithmetic, *Rencontres Arithmétique de l'Informatique Mathématique* (22-25 January 2007, Montpellier, France), *3rd MATHLOGAPS Workshop* with F. Wagner and E. Jaligot (24-30 June 2007, Aussois, France), *RAIM 2009: 3es Rencontres " Arithmétique de l'Informatique Mathématique "* (26- 28 octobre 2009, Lyon, France), *L(yo)nBox 2012: LinBox high performance kernels meeting* (16-21 July 2012, Lyon, France))
Chair of the organizing committee for *SCAN 2010: 14th GAMM - IMACS International Symposium on Scientific Computing, Computer Arithmetic and Validated Numerics* (27-30 September 2010, Lyon, France): 123 participants from 20 countries, for *13e Forum des Jeunes Mathématicien-ne-s* (13-15 novembre 2013, Lyon, France): 59 participants, in charge of the organization and of the program about gender issues, consisting in an introductory conference, a job-meeting, a theater play, a mentoring session.

Member of board of examiners for PhD theses: for M. Charikhi in January 2005 (U. Paris 6), for L. Lamarque in December 2006 (U. Bourgogne) and for O. Mullier in May 2014 (Polytechnique).
External referee for B. Zheng in December 2013 (U. McMaster, Hamilton, Canada).

International collaboration: non institutional with R. B. Kearfott (U. Louisiana at Lafayette) for the IEEE 1788 working group, and with M. Berz (U. Michigan) and K. Makino (U. Illinois), with an invitation to the mini-workshop on Taylor models, Miami, Florida, USA, 2002. Invitation of Ned Nedialkov (U. McMaster, Ontario, Canada) by INRIA in June-July 2008 and of T. Csendes (Univ. Szeged, Hungary), at U. Lille in January 2000.

National collaborations. Participant of the **PEPS project "Quarenum: Qualité et Reproductibilité Numériques dans le Calcul Scientifique Haute Performance"** (2013) involving 4 partners (Paris 6, Perpignan, Lyon, Onera), of the **ANR project "HPAC: High-Performance Algebraic Computations"** (2011-2014) involving 4 partners (Grenoble, Paris 6, Montpellier and Lyon), of the **INRIA-STMicrolectronics project "Mediacom - Nano 2012"** (2009-2012) in relation with the PhD grant of D. Pfannholzer, of the AHA (Adaptive and Hybrid Algorithms, cf. `http://aha.gforge.inria.fr/`) group (INRIA-IMAG) on the combination of algorithms that can adapt to the context (data or architecture). I was co-responsible with S. Lesecq of the working group on *Set computing in automatics* in 2004-2005 (`http://www-lag.ensieg.inpg.fr/gt-ensembliste`). I took part in the working group on computer arithmetic *AriNews* (`http://listes.ens-lyon.fr/wws/info/arinews.lip`), in the working group on the validation of numerical computations on embedded systems, in the working group *Collaboration of solvers* of the GDR ALP and in the cooperative actions of the INRIA *Certified computer arithmetic* and *ResCapa*.

Member of the recruiting committees for permanent junior research scientists at INRIA Rhône-Alpes (2007, 2009, 2010, 2011, 2013 and 2014), member of *commissions de spécialistes* (committees devoted to the recruitment of new lecturers) in applied mathematics at the University of Sciences and Technology of Lille (2000-2004), in applied mathematics at the University Joseph Fourier of Grenoble (2000-2006), in computer science at the École Normale Supérieure de Lyon (2004-2008), member of *comités de sélection* in computer science at the University Paris 6 in 2010, in computer science at the University Claude Bernard Lyon 1 in 2010 and in computer science at the University Paris Sud in 2014. I am a member of the committee for post-doc at INRIA Grenoble - Rhône Alpes since 2007.

Animation and administration at LIP - ENS Lyon: member of the lab council between 2007 and 2011 and since 2013, **at USTL:** creation of a new master in applied mathematics at USTL (cf. `http://ano.univ-lille1.fr/deaMA/`), member of the department committee, creation and animation of the working group of the ANO laboratory with J.-P. Chehab.

6 Teaching

During my PhD I have taught at ENSIMAG (1990-1995) and between 1996 and 2000 I was associate professor at the University of Sciences and Technologies of Lille. A major part of my lectures was devoted to adult classes. Since 2000 I work in Lyon and give or organize several lectures at École Normale Supérieure.

Teaching at École Normale Supérieure de Lyon and at ISFA
Algorithms and arithmetics, 5th year diploma in computer science and also in applied math., 24h with G. Villard, 2001-2003.
Applications of computer science, series of lectures for the doctoral students in sciences (computer science, mathematics, chemistry, biology. . .) 2001-2007.
Validation in scientific computing, master in computer science, 24h, 2006-2007.
Certified linear algebra, master in computer science, 24h with C.-P. Jeannerod and N. Louvet, 2009-2010.
Algorithms for certified linear algebra, master in computer science, 24h with C.-P. Jeannerod and N. Louvet, 2011-2012.
Numerical Algorithms, master pro in computer science, 15h with C.-P. Jeannerod and N. Louvet, 2012-2014.

Teaching at Université des Sciences et Technologies de Lille
Discrete optimization, 5th year professional diploma in math. engineering, 24h lectures and projects, 2000.
Symbolic and numerical computation, modelling, preparation to the competition for math. teachers, 30h lectures and exercises, 1999-2000.
Initiation to Unix, Matlab and Maple, master math, 20h lectures and labs, 1996-1999.
Numerical algorithms, 4th year in CS, 28h exercises and labs, 1998-2000.
Scientific computing, 4th year in applied math, 36h exercises, 1999-2000.

Operational research, 3rd year professional diploma in CS and in CS applied to management (adult class), 50h lectures, exercises and projects, 1996-1999.
Programming in Ada 1 and 2, 2nd year in math and CS, 44h and 52h lectures, exercises and labs, 1996-1997.
Mathematics, 2nd year in biology (adult class), 80h lectures and exercises, 1996-1999.

Teaching at ENSIMAG
Scientific programming week, 4th year, 30h, 1990-1995.
Scientific computing: projects in ODEs and matrix computations, 4th year, 24h, 1990-1995.
Ordinary differential equations, exercise classes, 4th year, 12h, 1990-1994.
Numerical analysis, lectures and exercise classes, 3rd year, 56h, 1993-1995.
Dynamical systems (labs, 1993) and *Computer algebra* (lecture and labs, 1995), classes for the lecturers in "mathématiques spéciales". Handouts available from my Web page `http://perso.ens-lyon.fr/nathalie.revol/` (in french).

Schools
I have given lectures for professional training entitled "Controlling and improving the numerical quality of an industrial computing code", Paris, France, November 2013, at JDEV : Journées du Développement Logiciel, École Polytechnique, September 2013 at a Spring school on Accuracy and Reproducibility in Numerical Computations, Fréjus, France, March 2013, at a School for Young Researchers, Grenoble, France, March 2004, at a Spring school on Computer Arithmetic, Prapoutel, France, March 2001, and at an Autumn school on Parallel and Distributed Computing, Oujda, Morocco, October 1999.

7 Dissemination of scientific knowledge ($\simeq 5\%$ of my time)

I give scientific conferences for high-school pupils since 2012, mainly but not exclusively for the Science Fair in October and for the Mathematics Week in March. I belong to the steering committee of the MMI (Maison des Mathématiques et de l'Informatique) of Lyon and to the "dissemination committee" of LabEx MILyon since 2011, and to the scientific committee of CapMaths consortium since 2012. I belonged to the national committee for the national phase of the "Faites de la science" competition in 2010. I take part in various manifestations since 2003 intended for A-level students (before university) to discuss the choice of scientific careers (between 3 and 5 presentations per year). I gave presentations for teachers in mathematics to introduce the notions of algorithms and complexity and also computer arithmetic (2002-2003). I gave presentations for a wide audience on the same topics, as follow-ups of a movie on mathematics and neurosciences (2004). 2000 was the year of mathematics: with C. Calgaro we have written a paper on numerical analysis in the magazine of the USTL dedicated to the industrialists of the region. I have accompanied school groups for the 2000 and 2001 editions of the Science Feast.

8 Experience diversity and geographic mobility

I did my PhD in Grenoble on the complexity of the parallel evaluation of arithmetic circuits. In Lille, I have worked on multiple precision arithmetic, on floating-point arithmetic, then on interval arithmetic with M. Petitot and on the parallelization of an algorithm based on this arithmetic with J.-F. Méhaut, Y. Denneulin and B. Planquelle. With Y.O. Mohamed El Hadj, we studied the parallelization of automatic speech recognition. Since October 2000, I work at INRIA within the Arenaire project (LIP, Lyon), first on sabbatical leave and now as research scientist. My research covers many aspects of multiple precision and interval arithmetic (definition, standardization, implementation) and their use for reliable computing, be it for computing on large sets or for assessing the numerical quality of results computed using floating-point arithmetic.