Dr. Mohamed Aziz BOUKRAA – Curriculum Vitae

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Research Interests

Mathematical Modeling, Inverse Problems, Wave Propagation, Seismic Imaging, Full Waveform Inversion, Numerical Analysis, Partial Differential Equations, Finite Element Method, Scientific Computing, High Performance Computing, Applications to realistic environments.

Education

2018-2021 **Doctorate in Applied Mathematics**, Laboratory of Mathematics Nicolas Oresme (LMNO), University of Caen Normandy, France

Title : «*Méthodes inverses à régularisation évanescente pour l'identification de conditions aux limites en théorie des plaques minces*»
English Title : «*Fading regularization inverse methods for the identification of boundary conditions in thin plate theory*»
Thesis supervisor : Pr. *Franck Delvare*
Defended: December 14, 2021
Comity members :
-M. Mejdi AZAIEZ, Professeur des universités, Institut Polytechnique de Bordeaux
-M. Leonardo BAFFICO, Maître de conférences, Université de Caen
-Mme. Amel BEN ABDA, Professeur des universités, ENIT de Tunis
-Mme. Laëtitia CAILLÉ, Maître de conférences, Université de Poitiers
-M. Fabien CAUBET, Maître de conférences (HDR), Université de Pau et des Pays de l'Adour
-Mme. Juliette LEBLOND, Directeur de recherche, INRIA Centre de Recherche Sophia Antipolis
-M. Liviu MARIN, Professeur des universités, Université de Bucarest

2016-2018 **Master's degree in Mathematics, Spec. Optimization and Mathematical Physics**
University of Toulon, France

2013-2016 **Bachelor's degree in Mathematics**
University Jean Monnet, Saint-Étienne, France

Experience

Research Experience

Sep 2022 - **Postdoctoral position**
Août 2024 *INRIA (IDEFIX Team), Ensta Paris, Institut Polytechnique de Paris and EDF R&D*

«***Development of inverse problem methodologies for interface imaging, application to the rock-concrete interface for a hydroelectric dam***»

The research project is carried out within the IDEFIX team of *INRIA Paris Saclay* center. It consists of a collaboration between *EDF R&D* (Electricity of France), *INRIA* and the *Institut Polytechnique de Paris*. The objective is to work on interface imaging problems arising in electricity production sites. The main case study is the imaging of the interface between the concrete of a dam and the rock on which it is built. To deal with this application, we developed a quantitative reconstruction method based on full-waveform inversion (FWI) techniques

using non-destructive seismic waves generated from the dam's walls. The aim is then to couple this approach with sampling methods for this complex geometric configuration. The goal is to achieve this for two types of non-destructive testing, mechanical waves which correspond to ultrasonic measurements and electromagnetic waves which correspond to RADAR measurements. The analysis takes into account both real and simulated measurements, with the aim of optimizing future measurement campaigns.

Sep 2021 -   **Contractual assistant professor ("ATER" contract)**
Août 2022   *Polytech Clermont INP (département IMDS)) & Laboratoire de mathématiques Blaise Pascal (LMBP)*

      http://polytech.univ-bpclermont.fr/ & https://lmbp.uca.fr/

The position is a one-year full-time job, associated with both the *Mathematical Engineering and Data Science (IMDS)* department of the Polytech Clermont INP engineering school for the teaching part and the *laboratory of mathematics Blaise Pascal* for the research part. This contract started 3 months before my thesis defense. It made it possible to cover this period of the end of the thesis and also to finalize the articles resulting from my thesis. Research activities have also been carried out such as participation in seminars and conferences as well as research missions abroad.

Sep 2018 -   **Doctoral thesis** (PDF : https://tel.archives-ouvertes.fr/tel-03526539)
Dec 2021   *Laboratory of Mathematics Nicolas Oresme (LMNO), University of Caen Normandy, France*

      «***Fading regularization inverse methods for the identification of boundary conditions in thin plate theory***»

My thesis, started in September 2018 under the supervision of Pr. Franck Delvare, at the University of Caen Normandy, was defended on December 14, 2021.
In this thesis, we investigate the solution of the Cauchy problem associated with the biharmonic equation using the fading regularization method proposed by A. Cimetière, F. Delvare, M. Jaoua, and F. Pons (2000-2001). A particular attention is devoted to the numerical implementation of the iterative algorithm used for the resolution and this by using various numerical methods such as the method of fundamental solutions and the finite element method while proposing a new stopping criterion of the iterative algorithm. Once the mathematical problem, with mathematical boundary conditions, has been treated, the study thus carried out is then generalized to the study of the Cauchy problem in thin plate theory, since in mechanics, the bending of thin plates under Kirchhoff-Love's assumptions, is governed by the same differential equation. From a numerical point of view, plate finite elements based on Kirchhoff theory known as discrete Kirchhoff finite elements are combined with the fading regularization technique to solve the problem. This strategy made it possible to obtain accurate reconstructions of the solution and of its normal derivative on the whole boundary, in particular for non-smooth geometries. The results thus obtained were an inspiration for the use of plate-type finite elements to solve Cauchy problems associated with second order partial differential equations. The obtained results are very competitive with those of previous studies. Robustness against high level noisy data is also an advantage of this strategy.

Mar 2018 -   **Research internship** (2nd year Master's degree research project)
Aug 2018   *Alten SA, Alten Innovation Center, Chaville (île-de-France 92)*

      «***Modeling the performance of an image reconstruction device for images degraded by raindrops***»

As part of the second year of my Master's degree research project, I chose to do a research internship within the company Alten in the Parisian region. The subject is part of the theme of driving assistance systems that Alten is constantly developing in its R&D centers. The research carried out concerns the design of a system of stereoscopic cameras, embedded on cars, whose role is to reconstruct the image of the scene in the event that it is degraded by raindrops. The established strategy is to design performance models based on the intrinsic characteristics of the cameras, the geometric characteristics of the device and the characteristics of the drops, which will allow to evaluate the performance of each parameter on the reconstruction capacity of the scene. This internship combines both theoretical and numerical modeling skills as well as the ability to build a performance model with a probabilistic aspect.

Mar 2017 -   **Research internship** (1st year Master's degree research project)
Jun 2017   *Laboratoire LIS, SeaTech, University of Toulon*

      «***Observability of linear control systems and proof of convergence of the deterministic Kalman filter***»

The internship consists of a research project during my first year of my Master's degree. It was carried out at the *LIS* laboratory of the *SeaTech* engineering school of the University of Toulon. The subject enters the field of automatic and control systems, where we studied in particular the observability of linear control systems by taking the Kalman filter as an example of an observer. We finally established its proof of convergence in a deterministic framework as well as the numerical validation of this result.

Teaching Experience

Sep 2021 -
Août 2022
Polytech Clermont INP, Université de Clermont Auvergne
Contractual assistant professor (one-year full-time job: 192h)

- **Tutorials for first year in engineering cycle (common block)**

  - Maths TC (3 groups×18h) : Matrix reduction, Jordan diagonalization, Solving differential systems, Laplace transformation,...

  - Probability et Statistics (2 groups×12h) : Discrete Laws, Continuous Laws, Estimates, Confidence Interval, Hypothesis Testing,...

  - Numerical analysis (3 groups×14h): Methods of solving linear systems, Interpolation and approximation of functions, Numerical solving of differential equations,...

- **Lectures and Tutorials, double degree course Architect-Engineer**

  - Level Bac+3 (1 group: 14h Lecture + 16h Tutorial): Matrix reduction, Jordan diagonalization, Reduction of quadratic forms, Conics, Solving differential systems, Double integrals,...

  - Level Bac+1 (1 group: 14h Lecture + 16h Tutorial): Study of functions, Derivatives and primitives, Differential equations, Integral calculation,...

Oct 2019 -
Sep 2021
University of Caen Normandy
Part-time teacher, amendment to the doctoral contract (25h+50h).

- **Lectures and Tutorials of Calculation Techniques for first year of Bachelor degree** (Teaching of general mathematics: Analysis, Complex Numbers, Plane and Space Geometry,...)

  - 2020-2021: 2 groups × 25h (Bachelor in Mechanics).
  - 2019-2020: 1 group × 25h (Bachelor in common block Maths-Mechanics)

Skills

Linguistic	*French* : Native	**Software**	*Matlab*
	Arabic : Native		*FreeFEM - PETSc - MPI*
	English : Fluent		*Python*
	Spanish : Intermediate		*Maple*
			Latex
			GMsh

International Collaborations

- **Visiting Researcher at the National School of Engineers of Tunis - PHC Utique Project**
  Duration: 07/01-31/2020 & 07/01-31/2022
  Description: The research mission is part of the PHC Utique project. It consists in collaboration with Tunisian researchers from LAMSIN laboratory. This collaboration occurred twice, first during my second year of thesis and later during my ATER contract. Our joint efforts were focused on the development of finite element algorithms with fading regularization method for solving inverse problems. While significant progress was made during these visits, there are ongoing opportunities for further research and development in this area.

International Schools

- **Bath Symposium on Inverse Problems and Artificial Intelligence in Medicine**, University of Bath, UK, June 2025. bathsymposium.ac.uk

- **Geilo Winter School 2025 on Inverse Problems**, SINTEF / NTNU, Geilo, Norway, January 2025. sintef.no/geilowinterschool/2025-inverse-problems

- **French–Romanian Summer School on Applied Mathematics**, University of Bucharest, Sinaia, Romania, July 3–11, 2019. sites.google.com/marinliviu/summer-school-2019

Publications and communications

Journal papers

1. **Boukraa,** M. A., Amdouni, S., Delvare, F. "Fading regularization FEM algorithms for the Cauchy problem associated with the two-dimensional biharmonic equation". *Mathematical Methods in the Applied Sciences*, 2023; 46(2): 2389–2412. DOI: 10.1002/mma.8651

2. **Boukraa,** M. A., Delvare, F., Caillé, L. "Fading regularization method for an inverse boundary value problem associated with the biharmonic equation". *Journal of Computational and Applied Mathematics*, 2025; 440: 115755. DOI: 10.1016/j.cam.2025.115755

Conference proceedings with peer review

1. **Boukraa**, M. A., Audibert, L., Bonazzoli, M., Haddar, H., & Vautrin, D. High-Resolution Seismic Imaging for Dam-Rock Interface using Full-Waveform Inversion. *Waves 2024, Berlin, 2024*. DOI: 10.17617/3.MBE4AA

2. **Boukraa**, M. A., Bonazzoli, M., Haddar, H., Audibert, L., & Vautrin, D. Imaging a dam-rock interface with inversion of a full elastic-acoustic model. *ICIPE 2024, Brazil*. HAL: hal-04661884

3. **Boukraa**, M. A., Audibert, L., Bonazzoli, M., Haddar, H., & Vautrin, D. Imagerie d'interface barrage-fondation par inversion de forme d'onde complète. *E3S Web of Conferences, vol. 504, p. 04002, 2024*. DOI: 10.1051/e3sconf/202450404002

Talks in International Conferences

1. 11th International Conference on Inverse Problems, Control and Shape Optimization (PICOF 2025), Hammamet, Tunisia, October 28–31, 2025. https://picof2025.sciencesconf.org/

2. IEEE International Ultrasonics Symposium (IUS 2025), Utrecht, Netherlands, April 2025. https://2025.ieee-ius.org/

3. Ultrasonic Imaging and Tissue Characterization Conference (UITC 2025), Silver Spring, MD, USA, April 2025.

4. 48th Scandinavian Symposium on Physical Acoustics (SSPA 2025), Geilo, Norway, January 26–29, 2025. Norsk Fysisk Selskap – SSPA 2025

5. WAVES 2024 (16th International Conference on Mathematical and Numerical Aspects of Wave Propagation), Berlin, Germany, June 2024. WAVES 2024

6. 11th International Conference on Inverse Problems in Engineering (ICIPE24), Rio de Janeiro, Brazil, June 2024. https://icipe2024.org/

7. 11th International Conference on Inverse Problems in Mechanics of Structures (IPMS 2024), Valletta, Malta, May 2024. https://www.ipms-conference.org/ipms2024/

8. 11th Applied Inverse Problems Conference (AIP 2023), Göttingen, Germany, September 2023. https://aip2023.de/

9. 10th International Conference on Inverse Problems, Control and Shape Optimization (PICOF'22), Caen, France, October 25–27, 2022. https://picof22.sciencesconf.org/

10. 10th International Conference on Inverse Problems in Engineering (ICIPE20), Francavilla al Mare (Chieti), Italy, May 15–19, 2022. https://iopscience.iop.org/article/10.1088/1742-6596/2444/1/011001

Other Talks

1. Journées Scientifiques AGAP Qualité Géophysique Appliquée, Poitiers, France, March 26–28, 2024. `https://www.agapqualite.org/2023/07/11/journees-scientifiques-agap-26-au-28-mars-2024/`

   Extended paper: DOI: 10.1051/e3sconf/202450404002

2. Congrès des Jeunes Chercheurs en Mécanique (Méca-J 2023), Online, August 28–30, 2023. https://mecaj2023.sciencesconf.org/

3. 11ème Biennale de la Société de Mathématiques Appliquées et Industrielles (SMAI 2023), Le Gosier, Guadeloupe, France, May 22–26, 2023. https://smai2023.math.cnrs.fr/fr/

4. Congrès Français de Mécanique (CFM 2022), Nantes, France, August 29 – September 2, 2022. https://cfm2022.fr/

5. 45ème Congrès National d'Analyse Numérique (CANUM 2022), Évian-les-Bains, France, June 13–17, 2022. https://canum2020.math.cnrs.fr

6. Congrès des Jeunes Chercheurs en Mécanique (Méca-J 2021), Online, August 25–27, 2021. http://meca-j.sciencesconf.org

7. 10ème Biennale de la Société de Mathématiques Appliquées et Industrielles (SMAI 2021), La Grande-Motte, France, June 21–25, 2021. https://smai2021.math.univ-toulouse.fr

8. 9ème Biennale de la Société de Mathématiques Appliquées et Industrielles (SMAI 2019), Guidel-Plages (Morbihan), France, May 13–17, 2019. http://smai.emath.fr/smai2019/index.php

Activities of Collective Interest

- **Participation at "Semaines d'Etudes Mathématiques et Entreprises" (SEME)**

  Pointe-à-Pitre, Guadeloupe, May 15-19, 2023
  https://semeantilles.sciencesconf.org/
  Joint Work: "Optimal distribution for steam production" with D. Borne and G. Gargantini
  Industry Collaboration: Refinery Industry SARA (Pôle 972, Martinique)

- **Organizing committee member of the international conference PICOF'22**

  Caen, October 25-27, 2022 (https://picof22.sciencesconf.org/)

- **Organization of the workshop "Chercheurs-Chercheuses"**

  Dôme de Caen, February 02, 2020

References