Biographical sketch of Habib Ammari

Professor of Applied Mathematics
Department of Mathematics, ETH Zürich

Personal data

Born June 28, 1969, in Eljem, Tunisia; married; one son; French-Tunisian citizen; Swiss permanent resident.

Contact information

Department of Mathematics, ETH Zürich
ETH-Zentrum, HG G 57.3, CH-8092 Zürich
Email: habib.ammari@math.ethz.ch
http://www.sam.math.ethz.ch/~hammari

Educational record

Habilitation Degree, Mathematics, January 1999, University of Paris VI, France.

Doctor of Philosophy, Applied Mathematics, May 1995, Ecole Polytechnique, France.

Master of Science, Applied Mathematics, June 1993, Ecole Polytechnique, France.

Bachelor of Science, July 1992, Ecole Polytechnique, France.

Baccalaureate, June 1988, Tunisia, Presidential Prize.

Research interests

Wave propagation in complex media, inverse problems and imaging.

Awards and honors

Fellow of the American Mathematical Society, Class 2022

Member of the Academia Europaea, 2021–.

Member of the European Academy of Sciences, 2018–.

Highly Cited Researcher in Mathematics by Clarivate Analytics, 2016.

Member of the Tunisian Academy of Sciences, Letters, and Arts, 2015–.

Khwarizmi International Award 2015 in Basic Sciences.

Kuwait Prize 2013 in Basic Sciences.

European Research Council Advanced Investigator Grant 2010–2016.

Professional experience

Full-Professor of Applied Mathematics, ETH Zürich, 2015–

Director of Research (first class) at the French National Center for Scientific Research, Department of Mathematics and Applications, Ecole Normale Supérieure, 2010-2015.

Director of Research (second class) at the French National Center for Scientific Research, Center of Applied Mathematics, Ecole Polytechnique, 2006-2010.

Adjunct Professor in Applied Mathematics at Ecole Polytechnique, 2005-2015.

Researcher at the French National Center for Scientific Research, 1997-2006.

Researcher at Ecole Polytechnique, 1995-1997.

Books

8 authored books (2 published by the American Mathematical Society, 1 published by Princeton Academic Press, 1 by World Scientific, and 4 by Springer).

10 edited books (5 published by the American Mathematical Society, 3 by Springer, 1 by the French Society of Industrial and Applied Mathematics, and 1 by the French Mathematical Society).

Publications

More than 250 papers in leading international peer-reviewed journals (SIAM journals (80 papers), Trans. AMS, JEMS, Arch. Rat. Mech. Anal., Comm. Math. Phys., Math. of Comp., Num. Math., CPDE, Ann. Sci. Ecole Norm. Sup., J. Math. Pures Appl., Proc. AMS, Math. Ann., Proc. Natl. Acad. Sci. USA, ...).

Publication citations

MathSciNet: 5370 Sum of Times Cited by 1524 Authors;

ISI Knowledge: 6799 Sum of Times Cited; h-index: 43;

GoogleScholar: 13424 sum of Times Cited; h-index: 57; i10 index: 222.

List of PhD students and postdocs advised

37 PhD students: N. Béreux (PhD 1998), C. Latiri-Grouz (PhD 1999), A. Khelifi (PhD 2002), F. Triki (PhD 2002), K. Touibi (PhD 2004), S. Soussi (PhD 2004), E. Iakovleva (PhD 2004), H. Zribi (PhD 2005), K. Laouti (PhD 2006), A. Dossevi (PhD 2007), A. Kozhemyak (PhD 2008), W.K. Park (PhD 2009), P. Garapon (PhD 2009, Best Thesis Prize at Ecole Polytechnique), S. Khan (PhD 2010), L. Guadarrama Bustos (PhD 2010), V. Jugnon (PhD 2010, Best Thesis Prize at Ecole Polytechnique), J.B. Bellet ((PhD 2010), A. Wahab (PhD 2011), T. Boulier (PhD 2013), L. Giovangigli (PhD 2014), L. Seppecher (PhD 2014); P. Millien (PhD 2015), M. Ruiz (PhD 2017), T. Wintz (PhD 2017), W. Zhang (PhD 2017), W. Wu (PhD 2018), F. Romero (PhD 2018), B. Fitzpatrick (PhD 2018), A. Dabrowski (PhD 2018), L. Baldassari (PhD 2021), E. Orvehed Hiltunen (PhD 2021), B. Davies (PhD 2021), K. Imeri (PhD 2021), A. Scapin (PhD 2021), J. Cao (2021-.), T. Kosche (2021-.), and K. Alexopoulos (2021-.).

24 postdocs: M. Lim (2003-2006), E. Kim (2005-2006), J.P. Groby (2006-2007), S. Gdoura (2009-2010), A. Rozanova (2006-2007), C. Poignard (2006-2008), H. Lee (2007-2008), G. Ciraolo (2008-2009), K. Kalimeris (2009-2010), E. Bretin (2009-2011), Y. Deng (2012-2013), W. Jing (2011-2013), M.P. Tran (2012-2013), L. Nguyen (2011-2013), H. Wang (2011-2014), A. Waters (2013-2015), G. Alberti (2014-2016), H. Zhang (2013-2015), T. Widlack (2015-2016), G. Zheng (2015-2016), D. Gontier (2015-2016), S. Yu (2015-2019), A. Vanel (2018-2021), and F. Feppon (2020-).

Selected recent synergetic activities

Member of the European Research Council Starting Grant Panel (PE1), 2013–.

Member of the Cancer Plan Panel of the French National Institute of Health and Medical Research, 2011–2014 and 2016–.

Member of the Scientific Committee of the Mediterranean Institute for Mathematical Sciences.

Member of the Scientific Committees of the Applied and Inverse Problems Conferences 2013, 2017, and 2019, and member of the Calderon Prize Committee 2013.

Member of the evaluation committee of the Institut de Mathématiques de Marseille, 2016.

Member of the evaluation panel of INRIA, 2018.

Member of the Peter Henrici Prize Committee 2019.

Editorial board member of Journal de l'Ecole Polytechnique, Journal of Computational Physics, Mathematical Methods in the Applied Sciences, SIAM Journal on Imaging Sciences, Inverse Problems and Imaging, Journal of Inverse and Ill-posed Problems, and Zürich Lectures in Advanced Mathematics.

Organizer of Minicourse on Mathematics of Emerging Biomedical Imaging IV (March 24-26, 2010); III (February 4-6, 2009); II (February 11-13, 2008); I (March 21-23, 2007), Institut Henri Poincaré, Paris.

Visiting professorships

Mathematical Sciences Research Institute, Berkeley (2001), Institute of Pure and Applied Mathematics, UCLA (2003), Seoul National University (2006), Korean Institute of Advanced Science and Technology (2012), Yonsei University (2013, 2014, 2015).

Major scientific achievements

The aim of H.A.'s research is to develop new mathematical and numerical tools, frameworks and inversion methods to address emerging modalities in nanophotonics and nanophononics, medical imaging, nondestructive testing, and environmental inverse problems. His research synergizes asymptotic imaging, stochastic modelling, and analysis of both deterministic and stochastic wave propagation phenomena in order to go further in the fields of mathematical imaging and wave propagation in complex media in order to solve challenging problems posed by new imaging modalities and new optical and acoustic materials.

H.A.'s work has been exceptionally well recognized. H.A. is not only a world class leading expert in the mathematical aspects of imaging and wave propagation in complex media but also a very influential scientific figure. Whenever he got involved in a challenging applied problem in imaging, he resolutely succeeded in proposing a very apposite, innovative, and unified approach for solving it. His work has opened new avenues of research in algorithms for target classification using wave measurements, modeling of multi-wave hybrid imaging and time-reversal techniques in elasticity. All of these problems, which have pertinent applications in diverse domains of science were considered to be very elusive and intriguing.

In his recent book *Mathematical and Statistical Methods for Multistatic Imaging* published by Springer-Verlag in 2013, H.A. has designed very novel frameworks for the detection, localization, dictionary recognition and tracking of a target from wave measurements. He introduced the concept of generalized polarization tensors, analyzed the spectral properties of the first-order polarization tensors, and pioneered the rigorous use of random matrix theory in wave imaging. He also developed an efficient numerical framework for eddy current imaging problems. By extracting conductivity tensors from eddy current data and comparing them with precomputed ones at multiple frequencies, he initiated the use of classification approaches in imaging from induction data. These contributions are gradually changing the comprehension and handling of inverse problems. They rely on a very profound understanding of wave propagation phenomena and lead to efficient algorithms for various imaging paradigms with precise estimations of convergence, resolution, and stability properties.

In his book *Mathematical Methods in Elasticity Imaging* published by Princeton University Press in 2015, H.A. proposed incredibly efficient algorithms for time reversal in viscoelastic media. He also developed highly effective optimal control algorithms for imaging the shear modulus distribution in a tissue from internal measurements of the displacement field. These are fundamental contributions to the field of elasticity imaging.

Another of his books *Introduction of Emerging Biomedical Imaging* was published by Springer-Verlag in 2008, wherein he introduced the concept of using interior perturbations and modulations of the probed medium in order to achieve better image resolution and stability. His work on multi-wave imaging prototypes has opened the door to a lot of mathematical and numerical studies by many groups working around the globe. This book is now considered a classic and serves as a useful reference tool for a generation of scientists interested in hybrid imaging.

Since that reference book, H.A. has had many more outstanding achievements in the field of medical imaging. He introduced a mathematical framework for cell membrane imaging and understood the fundamental mechanisms underlying the fact that effective biological tissue electrical properties and their frequency dependence reflect tissue composition and physiology. H.A. has fathomed how the dependence of the effective electrical admittivity on the frequency measures the complexity of the cellular organization of the tissue. He has also introduced a mathematical and computational framework for nanoparticle imaging. A comprehensive treatment of H.A.'s research on super-resolution biomedical imaging is provided in his recent book *Mathematics of Super-resolution Biomedical Imaging* published by World Scientific.

Super-resolution imaging refers to modern techniques aimed at achieving resolution beyond conventional limits. H.A. developed various mathematical and computational techniques to accomplish this, providing a solid foundation on which to further develop the knowledge and skills needed for practical application of the techniques. These techniques include scale separation techniques, dynamical separation techniques, spectral separation approaches, dictionary matching techniques, and resonant media.

H.A. unified the mathematical theory of metamaterials, super-resolution in resonant media, sub-wavelength bandgap opening, and double-negative metamaterials. In his book *Mathematical and Computational Methods in Photonics and Phononics* recently published by the American Mathematical Society, H.A. introduced the notion of sub-wavelength resonance and addressed challenging problems in wave propagation problems at sub-wavelength scales. The results obtained in this book can be used for the accurate modelling of nanodevices.

H.A.'s contributions to imaging and wave propagation in complex media bridge the gap between mathematics, physics, and real-world applications, particularly in the fields of nanophotonics and phononics, medicine and nondestructive testing. They have been recognized as extremely outstanding from the point of view of mathematics as well as physics.

Major contributions to the early career of excellent researchers

H.A. also has an exemplary record in mentoring students and postdoctoral researchers. He has attracted brilliant Ph.D. students and postdoctoral researchers from the elite institutes of the world (Ecole Normale Supérieure, Ecole Polytechnique, Cambridge, Oxford, Columbia, UCLA, Seoul National University, Chinese Academy of Sciences, ...). He advised thirty four PhD students and twenty four postdoctoral researchers. Many of them went to the top ranked universities in the United States of America (Pierre Garapon to Stanford, Vincent Jugnon and Laurent Seppecher to MIT, Sheraz Khan to Harvard, etc.) after completing their PhD's with him. Two of his students won the prize for best thesis at Ecole Polytechnique.

Examples of leadership in industrial innovation or design

H.A. has been establishing many fruitful industrial partnerships with Thalès, the Nuclear Energy Agency (CEA), L'OREAL, Schlumberger, and Supersonic Imagine. Some of his students went to work in high-tech companies and are playing a key role in the rapid transfer of the mathematical tools he developed on imaging from academia to industry. The interdisciplinary approaches he has been developing in medical imaging and nondestructive testing are expected to have an important societal impact.

Selected Recent Publications

1. H. Ammari, B. Fitzpatrick, H. Kang, M. Ruiz, S. Yu, and H. Zhang, Mathematical and Computational Methods in Photonics and Phononics. Mathematical Surveys and Monographs, Volume 235, American Mathematical Society, Providence, 2018, 509 pages.
2. H. Ammari, J. Garnier, H. Kang, L. Nguyen, and L. Seppecher, Mathematics of Super-resolution Biomedical Imaging. Modelling and Simulation in Medical Imaging, Volume 2, Imperial College Press, London, 2016, 534 pages.
3. H. Ammari, E. Bretin, J. Garnier, H. Kang, H. Lee, and A. Wahab, Mathematical Methods in Elasticity Imaging. Princeton Series in Applied Mathematics, Princeton University Press, 2015, 240 pages.
4. H. Ammari, E.O. Hiltunen, and S. Yu, Subwavelength guided modes for acoustic waves in bubbly crystals with a line defect. Journal of the European Mathematical Society, DOI 10.4171/JEMS/1126.
5. H. Ammari, E. Orvehed Hiltunen and S. Yu, A high-frequency homogenization approach near the Dirac points in bubbly honeycomb crystals. Archive on Rational Mechanics and Analysis, 238 (2020) 1559-1583.
6. S. Yu and H. Ammari, Hybridization of singular plasmons via transformation optics. Proceedings of the National Academy of Sciences of the United States of America, 116 (2019), 13785-13790.
7. S. Yu and H. Ammari, Plasmonic interaction between nanospheres. SIAM Review, 60 (2018), no. 2, 356-385.
8. H. Ammari, P. Millien, M. Ruiz, and H. Zhang, Mathematical analysis of plasmonic nanoparticles: the scalar case. Archive on Rational Mechanics and Analysis, 224 (2017), 597-658.
9. H. Ammari and H. Zhang, A mathematical theory of super-resolution by using a system of sub-wavelength Helmholtz resonators. Communications in Mathematical Physics, 337 (2015), 379-428.
10. H. Ammari, T. Boulier, J. Garnier, and H. Wang, Shape identification and classification in electrolocation. Proceedings of the National Academy of Sciences of the United States of America, 111 (2014), 11652-11657.