



Mathematical Modelling and Scientific Computing: an Effective Way to Understand Reality

Preface to Two Special Issues Dedicated to Alfio Quarteroni on the occasion of his 70th birthday

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This is the first of two special issues of the Vietnam Journal of Mathematics, which are dedicated to Alfio Quarteroni on the occasion of his 70th birthday. Nine papers are presented in this publication, Issue 4 of Volume 50, and another 10 will be presented in Issue 1 of Volume 51. We thank all authors and referees of this volume for their enthusiastic participation in this adventure.

We are delighted and honored to introduce Professor Alfio Quarteroni to the readers.

Alfio Quarteroni started his studies at the University of Pavia, Italy, as a student of the prestigious Collegio Ghislieri, and he graduated in Mathematics in 1975. He began his

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academic career as a researcher at the Institute of Numerical Analysis of the Italian Research Council (CNR), where he stayed from 1976 to 1986 under the inspiration and guidance of Professors Enrico Magenes and Franco Brezzi. During these years, in collaboration with Claudio Canuto and visiting international laboratories in France and the United States, he made his fundamental contribution to the development of spectral methods. “Anything in the numerical analysis of spectral methods for partial differential equations relies on the following basic result”, Christine Bernardi and Yvon Maday wrote several years after, about a theorem that Canuto and Quarteroni published in 1982.

From 1986 to 1989, Alfio Quarteroni was a full professor in Numerical Analysis and Director of the Department of Mathematics at the Catholic University in Brescia. During these years, halfway between Brescia and Pavia, where his collaboration with the CNR continued, he approached the research field of domain decomposition methods. In 1989 he published with Donatella Marini a seminal paper on the “Dirichlet-Neumann method”, which provided a fundamental contribution to the set-up of effective and parallelizable domain decomposition procedures for partial differential problems.

In 1989 he moved to the Department of Mathematics of the Politecnico di Milano, where he still has his headquarters. Yet, in the last three decades, he also worked in many other prestigious places.

He was a professor of Mathematics at the University of Minnesota from 1990 to 1992. From this very stimulating experience shared with Alberto Valli (and their loved families), the best-seller books “Numerical approximation of partial differential equations” and “Domain Decomposition Methods for Partial Differential Equations” were conceived.

In 1992 Alfio Quarteroni was called by the Nobel prize winner Carlo Rubbia to be the Scientific Director of CRS4 (Center for Advanced Research and Development in Sardinia), a position he held until 1998. During this period, he started realizing the enormous potential of using mathematical and numerical tools for better understanding the human cardiovascular system, a field of research he is still pursuing today.

In 1998, he joined the Ecole Polytechnique Fédérale de Lausanne as a Full Professor of Mathematics and Director of the Chair of Modelling and Scientific Computing, a position he maintained until his retirement in 2017, to be immediately appointed Professor Emeritus. This period gave him a lot of satisfaction and notoriety (we will resume his many achievements later).

Meanwhile, in 2002, in collaboration with Sandro Salsa, Director of the Department of Mathematics of Politecnico di Milano at that time, Alfio Quarteroni founded the Laboratory of Mathematical Modelling and Scientific Computing (MOX), which, just this year, celebrates its first 20 years of intense research activity. In the same period, he also contributed to the set-up at Politecnico di Milano of the innovative and extremely successful Bachelor and Master Courses on “Mathematical Engineering”.

From 2009 to 2014, he was the first director of the Center for Advanced Modeling Science (CADMOS) at EPFL, dedicated to developing long-term expertise in computational science, high-performance computing, and modeling large and complex systems. In 2010, he founded MATHICSE, the Mathematical Institute of Computational Science and Engineering at EPFL (of which he was the first Director), and contributed to the set-up of the MathLab Laboratory at SISSA, Trieste, Italy (of which he was Scientific Coordinator until 2015).

His incredible organizational capabilities do not end with academic institutions but also cover more industrial enterprises.

Indeed, in 2010 he founded with two colleagues MOXOFF, a spinoff of the Politecnico di Milano, intending to make mathematical tools developed at MOX suitable for industrial exploitation. The Company now counts more than 30 employees.

The scientific contributions of Alfio Quarteroni cover a broad spectrum of topics in applied mathematics, numerical analysis, and scientific computing: spectral (element) methods, domain decomposition techniques for partial differential equations, reduced basis methods, computational fluid dynamics, fluid-structure interaction, cardiovascular mathematics, and, more recently, the use of deep learning techniques in the context of the solution of partial differential equations. He is undoubtedly one of the top innovators in the field, combining numerical analysis with practical implementations. He stands out because of his extraordinary success in applying his work to a large variety of important and challenging real-life problems, ranging from earthquake simulations to numerical models of the human cardiovascular system and heart function. In the latter field, he established an impressive research network also involving several medical researchers and was granted by the European Commission two ERC Advanced Grants, MathCard (2008–2013) and iHeart (2017–2022), and two ERC PoC Awards, Mart4AAARisk (2015) and From Math to Ward (2015). The iHeart project is one of the first attempts in the world to create a complete mathematical model of the human heart, which includes all the physiological processes: electrochemical, mechanical, and fluid-dynamic from the cellular level to the whole organ. It is a project that involves collaboration with medical institutions and demonstrates how top-class mathematics can help medical doctors to develop better treatments. Interdisciplinarity is indeed another important characteristic of the work of Alfio Quarteroni. For instance, his capability to interact with naval engineers was instrumental in performing the appropriate fluid dynamics calculations for the stunning victories of the Swiss sailing team Alinghi in the 2003 and 2007 editions of America's Cup. For this achievement, Alfio Quarteroni was awarded the Laurea Honoris Causa in Naval Engineering by Università di Trieste, Italy.

The list of the other numerous research projects in which Alfio Quarteroni had a leading role is too long to be shown here. We only want to mention that at the start of the Covid epidemic, which strongly hit Italy at the beginning of 2020, he decided to set up at the MOX Lab a working team for the development of an epidemiological model integrated with the available data to provide possible guidance to the Italian Health authority. For this project, he received a special grant from the Italian government.

His terrific scientific production also testifies to the outstanding research activity of Alfio Quarteroni: about 400 referred papers and more than 20 scientific books, some of which were translated into several languages. He is editor of numerous scientific journals and of two renown series of volumes of Springer.

In 2022 he was ranked n.48 in the Top Scientist-Mathematics from research.com and n.1 in Italy.

He gave more than 500 invited lectures worldwide. We mention that he is one of the few applied mathematicians who has given a plenary talk at the International Congress of Mathematicians (2006 in Madrid) and been a Member of the Fields Medal Committee of the International Mathematical Union (2019-22).

Alfio Quarteroni has been awarded several renowned prizes and honors during his career. We just cite the NASA Group Achievement Award for the pioneering work in Computational Fluid Dynamics in 1992, the Ghislieri prize in 2013, the International Galileo Galilei prize for sciences in 2015, the Euler Lecture in 2017, and the Euler Medal from ECCOMAS in 2022. He is a member of several prestigious Academies of Science, including the Italian Accademia Nazionale dei Lincei, the European Academy of Science, the Academia Europea, and the Lisbon Academy of Sciences.

Besides his research achievements, Alfio Quarteroni stands out for his teaching, communication, and mentoring capabilities. His textbooks have been adopted in numerous Universities worldwide and inspired thousands of students. He has also written books for the popularization of mathematics. Indeed, dissemination of mathematics has always been one of his goals, pursued through public conferences, participation in radio programs, and interviews given to newspapers and magazines.

Whoever had the opportunity to attend his lectures has been fascinated by Alfio's skill in exposing complex concepts with clarity and by the enthusiasm and passion that he transmits.

Scores of Ph.D. students at Politecnico di Milano and EPFL have had the opportunity to experience his guidance, dedication, availability, and good spirit. He has never let them down.

Some of his former students are now pursuing successful academic careers at Universities or Research centers. Some have instead found their place in the industry, covering positions with responsibility. It is further proof of the interdisciplinary nature of several research activities of Alfio Quarteroni, which are well appreciated beyond the academic boundaries.

His dedication to his family, his wife Fulvia, and two daughters, Silvia and Marzia, is remarkable. Despite all the places he has visited, his familiar headquarter has always been a fixed point in his life: Lodi, a small town near Milan. He would return home regularly from wherever he was working at that time. Someone has estimated that all his travels sum up a distance sufficient to go back and forth to the moon twice!

Alfio Quarteroni is an outstanding mathematician. He can grasp the fundamental aspects of a problem with incredible quickness, formalizing them from a mathematical point of view and choosing the most suitable numerical methods to solve them. To deal with real-world issues, an applied mathematician should be capable of interacting with experts from other disciplines, and listening to their needs, be they doctors, engineers, or athletes. Alfio Quarteroni embodies all these qualities. On his 70th birthday, we sincerely wish him good health and serenity and many more years of (not only) mathematical success.

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