Colloquium in Mathematical Engineering

neapōlis

UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II
SCUOLA POLITECNICA E DELLE SCIENZE DI BASE

Alfio Quarteroni

MOX, Politecnico di Milano and EPFL, Lausanne

Mathematical and Numerical Models for Multi-physics Applications

TUESDAY, DECEMBER 4, 2018, 14:00 - 16:30

Complesso di Monte S. Angelo, Aula delle lauree ex-Presidenza di Scienze

Lecture 1: Mathematical models for the heart and the circulation

Abstract - Mathematical models based on first principles can describe the interaction between electrical, mechanical and fluid-dynamical processes occurring in the heart, as well as the coupling with the external circulation. This is a classical multi-physics problem featuring multi-scale solutions in space and time. Appropriate numerical strategies need to be devised to allow for an accurate and computationally effective simulation of these processes in both physiological and pathological regimes. This presentation will address some of these issues and a few representative applications of clinical interest.

Acknowledgment: The work presented in this talk is part of the project iHEART that has received funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (grant agreement No 740132)

THURSDAY, DECEMBER 6, 2018, 14:00 - 16:30

Complesso di Monte S. Angelo, Aula delle lauree ex-Presidenza di Scienze

Lecture 2: The ICDD (Interface Control Domain Decomposition) method for the solution of Multi-physics problems

Abstract - Interface Control Domain Decomposition (ICDD) is a method designed to address partial differential equations (PDEs) in computational regions split into overlapping subdomains. The "interface controls" are unknown functions used as Dirichlet boundary data on the subdomain interfaces that are obtained by solving an optimal control problem with boundary observation.
When the ICDD method is applied to classical (homogeneous) elliptic equations, it can be regarded as (yet) another domain decomposition method to solve elliptic problems.
However, what makes it interesting is its convergence rate that is grid independent, its robustness with respect to the possible variation of operator coefficients, and the possibility to use non-matching grids and non-conforming discretizations inside different subdomains.
ICDD methods become especially attractive when applied to solve heterogeneous PDEs (like those occurring in multi-physics problems). A noticeable example is provided by the coupling between (Navier) Stokes and Darcy equations, with application to surface-subsurface flows, or to the coupling of blood flow in large arteries and the fluid flow in the arterial wall. In this case, the minimization problem set on the interface control variables, that is enforced by ICDD method, can in principle assure the correct matching between the two "different physics" without requiring the a-priori determination of the transmission conditions at their interface.

FRIDAY, DECEMBER 7, 2018, 9:30 - 12:00

Dipartimento di Matematica e Applicazioni "R. Caccioppoli", Sala Professori I Livello

Lecture 3: Reduced Order Models for Analysis and Synthesis of Complex Systems

Abstract - Projection-based reduced-order models (ROMs) provide efficient strategies to tackle parametrized partial differential equations, multi-query problems (control and inverse problems, for instance), and yield real-time simulations of complex problems. Essential ingredients are the regularity and low dimensionality of solution manifolds, the use of Offline/Online computational stratagems, the availability of a posteriori error estimates, and the use of low-dimensional approximation spaces.
In this talk I will recall the mathematical concepts behind Reduced Basis (RB) methods (a special family of ROM), provide both algebraic and geometrical interpretation, illustrate their properties of stability, convergence, exponential accuracy (under suitable regularity assumptions on the solution manifold), and I will address some examples of linear and nonlinear PDEs.

Alfio Quarteroni

MOX, Politecnico di Milano and EPFL, Lausanne (professor emeritus)
Member of Accademia dei Lincei
Member of Academia Europea
Member of the European Academy of Sciences

Alfio Quarteroni is Professor of Numerical Analysis and Director of MOX at Politecnico of Milan (Italy). Formerly, he was the Director of the Chair of Modeling and Scientific Computing at EPFL (Swiss Federal Institute of Technology), Lausanne (Switzerland), from 1998 until the end of 2017. He is the founder (and first director) of MOX at Politecnico of Milan (2002) and of MATHICSE at EPFL, Lausanne (2010). He is the co-founder (and President) of MOXOFF, a spin off company at Politecnico in Milan (2010).

Prof. Quarteroni is the author of 25 books, the editor of 9 books, and the author of more than 300 articles published in international scientific journals and conference proceedings. He is a member of the Editorial Board of 25 International scientific journals and he is the Editor in Chief of two book series published by Springer.

Prof. Quarteroni has been an invited or plenary speaker in more than 300 International conferences and academic seminars. In particular, he had been invited speaker at the International Congress of Mathematicians (ICM) in 2002 in Beijing, and plenary speaker at the ICM in 2006 in Madrid.

Among his many awards and honors are: the NASA Group Achievement Award for the pioneering work in Computational Fluid Dynamics in 1992, the Fanfullino della Riconoscenza 2006, Città di Lodi, the Premio Capo D'Orlando 2006, the Ghislieri prize 2013, the International Galileo Galilei prize for Sciences 2015, the Euler Lecture in Berlin in 2017, Th Pedro Nunes Lectures in Lisbon in 2018. Prof. Quarteroni is the recipient of two European Research Council (ERC) Advanced Grants: "MATHCARD" 2008, "I-HEART" 2017 and of two ERC PoC (Proof of Concept) grants in 2012 and 2015, he held the Galilean Chair from the Scuola Normale Superiore, Pisa, Italy, in 2001, and received a honorary degree in Naval Engineering from the University of Trieste, Italy, in 2003. Prof. Quarteroni is SIAM Fellow (first round), and IACM (International Association of Computational Mechanics) Fellow. He is a member of the Italian Academy of Science, the European Academy of Science, the Academia Europaea, and the IMU Circle.

Prof. Quarteroni's research interests concern Mathematical Modelling, Numerical Analysis, Scientific Computing, and their applications to Fluid Mechanics, Geophysics, Medicine and the improvement of sports performance. His research group at EPFL has contributed to the preliminary design of Solar Impulse, the Swiss long-range, experimental, solar-powered aircraft project, and carried out the mathematical simulation for the performance optimization of the Alinghi yacht, the winner of two editions (2003 and 2007) of the America's Cup.