

SCALABLE PRECONDITIONERS AND SOLVERS FOR HIGH-ORDER FINITE ELEMENTS AND ISOGEOMETRIC ANALYSIS

LUCA F. PAVARINO¹, SIMONE SCACCHI²
AND OLOF B. WIDLUND³

¹Department of Mathematics, University of Pavia
Via Ferrata 5, 27100 Pavia, Italy
luca.pavarino@unipv.it and <https://sites.google.com/unipv.it/lucafp/home>

²Department of Mathematics, University of Milan
Via Saldini 50, 20133 Milano, Italy
simone.scacchi@unimi.it and <http://users.mat.unimi.it/users/scacchi/>

³Department of Mathematics, Courant Institute of Mathematical Sciences, New York
University
251 Mercer Street, New York, N.Y. 10012-1185, USA
obw1@nyu.edu

ABSTRACT

High-order discretization methods — including high-order finite elements and Iso-geometric Analysis (IGA) — have established themselves as powerful paradigms for the numerical solution of partial differential equations, offering superior accuracy per degree of freedom and, in the case of IGA, exact geometry representation through NURBS and related spline technologies. A hallmark of these approaches is the use of high polynomial degrees, which poses unique challenges for solver design but also opens new opportunities for high-performance computing. This minisymposium focuses on the design, analysis, and implementation of scalable preconditioners and solvers tailored to high-order finite element and isogeometric discretizations, with emphasis on robustness with respect to the polynomial degree p , scalability with respect to the mesh size h , and parallel efficiency on modern HPC architectures. A broad spectrum of algorithmic approaches is within scope, including Domain Decomposition Methods (DDM) such as FETI, BDDC, and Schwarz methods; multigrid and multilevel preconditioners; low-rank and hierarchical solvers; and tensor-product techniques that exploit the structure of spline discretizations. A key computational advantage of high-order discretizations is that increasing the polynomial degree yields denser local stiffness matrices compared to low-order methods

on equivalent meshes, resulting in a more favorable computation-to-communication ratio. This makes high-order finite elements and IGA particularly well-suited for massively parallel execution, provided that solvers and preconditioners are designed to exploit this structure effectively. Contributions will span p-robust and h-robust preconditioners; spectral analysis of solver operators in the high-order and spline setting; multilevel and coarse space construction strategies; multi-patch and non-conforming coupling strategies; and scalability studies on large-scale parallel architectures. Both theoretical foundations and practical algorithmic developments are welcome. The minisymposium aims to bring together researchers from numerical linear algebra, computational mechanics, and high-performance computing to discuss recent advances and open problems in this rapidly evolving area.

SPEAKERS

1. Mark Ainsworth (Brown University): tentative title.
2. Pablo Brubeck (University of Oxford): tentative title.
3. Durkbin Cho (Dongguk University)
4. Hanyu Chu (University of Pavia): Isogeometric block BDDC/FETI-DP preconditioners for the three-field Biot's consolidation model.
5. Patrick Farrell (University of Oxford): tentative title.
6. Charlie Parker (U.S. Naval Research Laboratory): tentative title.
7. Giancarlo Sangalli (University of Pavia)
8. Thomas Takacs (RICAM)
9. Stefan Takacs (Johannes Kepler University Linz)
10. Mattia Tani (University of Pavia)
11. Elena Zampieri (University of Milan)
12. Stefano Zampini (KAUST)