Tangential–Normal Decomposition for Constructing Finite Elements

Long Chen
University of California, Irvine

We present a unified framework based on the tangential–normal (t–n) decomposition for constructing finite elements. Using the H(div)-conforming element as a motivating example, we show how vector and tensor fields can be systematically decomposed on each subsimplex into tangential (bubble) and normal (trace) components. The framework applies to a broad class of tensor fields, including vectors, symmetric tensors, traceless tensors, and other constrained tensor structures. This decomposition enables a redistribution of degrees of freedom onto faces, yielding finite element spaces that satisfy discrete inf–sup conditions.

The t–n decomposition naturally extends to finite element differential forms, providing a new basis construction in finite element exterior calculus. A key feature is the development of a dual pair of degrees of freedom and shape functions. The framework also incorporates classical Lagrange elements, facilitating practical implementation in existing FEM infrastructures.

This is joint work with Xuehai Huang (Shanghai University of Finance and Economics).

Hybridizable Symmetric Stress Elements on the Barycentric Refinement in Arbitrary Dimensions

Xuehai Huang
Shanghai University of Finance and Economics

Hybridizable $H(\mathrm{div})$-conforming finite elements for symmetric tensors on simplices with barycentric refinement are developed in this work for arbitrary dimensions and any polynomial order. By employing barycentric refinement and an intrinsic tangential-normal (t-n) decomposition, novel basis functions with explicit formulas are constructed to redistribute degrees of freedom while preserving $H(\mathrm{div})$-conformity and symmetry, and ensuring inf-sup stability. These hybridizable elements enhance computational flexibility and efficiency, with applications to mixed finite element methods for linear elasticity. Numerical experiments are provided to validate the theoretical results.

Distributional Finite Elements with Applications for Elasticity, Fluids, and Curvature - Part 2

Joachim Schöberl
Institute of Analysis and Scientific Computing, TU Wien

Vector-valued function spaces, their finite element sub-spaces, and relations between these spaces are well understood within the de Rham complex. The framework of differential forms and Hilbert complexes provides a unified framework for any space dimension. Various matrix-valued finite element spaces have been introduced and analyzed more or less independently. In this presentation we put these spaces into a so called 2-complex. We present applications in fluid dynamics, solid mechanics and relativity.

Finite element spaces for tensor fields

Yakov Berchenko-Kogan
Florida Institute of Technology

A useful feature of finite element exterior calculus spaces is that they work equally well on triangulations of surfaces as they do on triangulations of regions of the plane. Fundamentally, this feature is due to the metric-independence (affine-invariance) of these spaces and their interelement continuity conditions. However, some spaces, even as simple as tangent vector fields with full continuity, do not have metric-independent proxies. Consequently, while we can discretize them on planar domains using just Lagrange elements, we encounter fundamental difficulties when working on triangulations of surfaces due to the angle defect.

I will discuss recent results on constructing finite element spaces of tensor fields in each of these contexts. In the metric-dependent context, we develop a versatile class of finite element spaces called blow-up finite elements, which, in particular, provides enough flexibility to resolve the angle defect problem for vector fields with full continuity. Such elements can be used for the vector Laplacian in the surface Stokes equations and to construct the distributional Riemann curvature. Meanwhile, in the metric-independent context, we construct new affine-invariant finite element spaces of double forms (form-valued forms). Such elements have applications to elasticity and to constructing test functions for the distributional Riemann curvature tensor.

Double forms: Decomposition and discretization

Evan Gawlik
Santa Clara University

A $(p+q)$-tensor that alternates in its first p arguments and last q arguments is called a double form or a (p,q)-form. This talk will discuss the space $\Lambda^{p,q}$ of (p,q)-forms, its algebraic structure, and its discretization with finite elements. I will highlight two important algebraic tools: a canonical decomposition of $\Lambda^{p,q}$, and a natural map s from $\Lambda^{p,q}$ to $\Lambda^{p+1,q-1}$ that antisymmetrizes the first $p+1$ arguments. I will discuss a few ways of deriving the decomposition, its interplay with the map s, and its role in the construction of finite element spaces for $\Lambda^{p,q}$. I will also discuss some algebraic aspects of the map s, including its behavior under composition and inversion. This talk is based partly on joint work with Yakov Berchenko-Kogan and partly on joint work with Anil Hirani.

Finite Element Systems at your service

Snorre H. Christiansen
Department of Mathematics, University of Oslo, Norway

The framework of Finite Element Systems (FES) has been developed to give a uniform description of finite element spaces. It provides an additional layer of abstraction between general Sobolev complexes, and the known examples of subcomplexes constructed in finite element theory. It can be phrased in the language of category theory, as presheaves, and identifies key underlying algebraic assumptions. In this talk I will focus on how general algebraic tools, such as the long exact cohomology sequence associated with a short exact sequence of complexes, apply in the FES setting, to prove that the global cohomology of a FES is correct when it has unisolvent degrees of freedom, as required by Ciarlet's definition, and sequence exactness on elements.

Cohomology on discrete complexes: finite elements, splines and distributions

Ting Lin
Peking University

In this talk, I will discuss some results on the cohomology of discrete complexes. For conforming discretizations, we present a framework that yields cohomological results. As a byproduct, a locally bounded cochain interpolation operator can be constructed. For the finite element–distribution complex, we analyze the cohomology of the BGG complexes in two and three dimensions. Finally, we investigate the Scott–Vogelius finite element pair and its matrix-valued generalization, interpreting them through the lens of spline complexes.

Path homologies and cohomologies on digraphs

Yong Lin
Tsinghua University

We will introduce the path homologies, cohomologies and homotopy theory on digraphs. We also study the spectrum of Hodge Laplacian of path homologies. This talk is based on the joint works with Grigoryan, Muranov, Yau and Zhang.

Writing DEC using Christiansen’s generalized Whitney forms

Johnny Guzmán
Brown University

In this talk we use Whitney forms on the primal mesh and generalized Whitney forms developed by Christiansen on the dual mesh to write DEC only using forms. This allows one to view DEC in a more FEEC-like setting. We then are able to use FEEC like analysis to give an error analysis for the Hodge Laplacian. It is important to note that for the zero Laplacian the analysis was already performed by Schulz and Tsogtgerel and we use some of their techniques to analyze all the Hodge Laplacians. Our results only hold for uniformly well centered meshes which is quite limiting in practice. We are also able to prove superconvergence results when there is symmetry in the meshes. This is joint work with Pratyush Potu.

BGG for DEC in two dimensions with applications to biharmonic equation and planar elasticity

Anil N. Hirani
University of Illinois at Urbana-Champaign

We descirbe a new Bernstein-Gelfand-Gelfand (BGG) inspired construction in the framework of discrete exterior calculus (DEC) for planar domains. This includes the definition of new cochains, first Bianchi sum (diagonal s operators), and exterior covariant derivatives. This allows us to define symmetric tensors, second order operators like Hessian, and symmetric gradient in a cochains framework. We use these constructions to derive new numerical methods for the biharmonic equation and displacement formulation of planar elasticity. Joint work with Snorre Christiansen, Kaibo Hu, and Chengbin Zhu.

Approximation by the Wachspress coordinates on polytopes

Yanqiu Wang
Nanjing Normal University

Generalized barycentric coordinates (GBCs) can be used to construct conforming and nonconforming finite element discretizations on polytopal meshes. In this talk, we briefly introduce the Wachspress GBC, its usage in approximating the H^1, $H(\mathrm{div})$, $H(\mathrm{curl})$ spaces, and applications to biharmonic equations as well as Stokes equations.

Since the Wachspress GBCs are rational functions, the approximation error analysis is not as clear as for polynomials. There has been a persistent misunderstanding that the approximation rate of Wachspress coordinates deteriorates on meshes containing short edges. Through a careful examination of shape-regularity conditions for convex polygons and the structure of rational functions, we are recently able to correct this misunderstanding in 2D. We prove the almost optimal approximation rate of Wachspress GBCs in H^1 norm on convex polygonal meshes satisfying only the maximal angle condition and the bounded aspect ratio condition. One can now feel free to use CVT meshes, which are high-quality polygonal meshes but may contain short edges, in the discretization.

A new approach to the analysis of parametric finite element approximations to mean curvature flow

Buyang Li
Hong Kong Polytechnic University

Parametric finite element methods have been highly successful in approximating the evolution of surfaces governed by various geometric flows, including mean curvature flow, Willmore flow, and surface diffusion. However, the convergence of Dziuk's parametric finite element method, along with many other commonly used parametric finite element schemes for geometric flows, remained an open problem.

In this talk, I will present a new approach and analytical framework for studying parametric finite element approximations of surface evolution under geometric flows. The key idea is to estimate the projected distance between the computed surface and the exact surface, rather than comparing their particle trajectories, as is done in pre-existing analyses. This new framework reveals hidden geometric structures within geometric flows — for example, the full H^1-parabolicity in mean curvature flow — which enables us to establish the convergence of Dziuk's parametric FEM using finite elements of degree $k \geq 3$ for surfaces in three-dimensional space.

Moreover, this framework provides a foundational tool for analyzing other geometric flows and for designing parametric finite element methods with artificial tangential motions aimed at maintaining high mesh quality of evolving surfaces.

Modeling physical systems by double complexes

Jan Martin Nordbotten
Department of Mathematics, University of Bergen

Arguably, the important role of mathematics in modern society is not simply a reflection of the beauty of logical structures, but is justified by the surprisingly close correlation between mathematics and many physical phenomena. Similarly, the importance of the de Rham complex lies not just in its mathematical importance, but is equally due to the fact that Hodge-Laplace operators on the de Rham complex correspond to the differential operators in some of the most important field equations that arise in continuum mechanics.

The de Rham complex can naturally be combined with several other complexes arising in mathematical analysis. This results in double complexes, which can be reduced to single-graded total complexes. It is now of interest to ask if these constructions are of purely mathematical interest, or if the resulting double complexes also have an intrinsic physical interpretation. Concretely: When does the Hodge-Laplace operator of total complexes provide the differential model of real systems?

In this talk, we will survey two particular double complexes: The Čech-de Rham complex and the mixed-dimensionalde Rham complex (a generalization of the simplicial de Rham complex). We will show that the Hodge-Laplacian on each resulting total complex models real physical system.

Furthermore, when the open cover generating the Čech-de Rham complex is suitably chosen relative to a simplicial triangulation, the resulting Hodge-Laplace equations lead to different physical models of the same physical system. In view of this, we also discuss approximation properties between the Čech-de Rham complex and the simplicial de Rham complex.

This presentation builds on joint work with Jon Eivind Vatne, Wietse M. Boon, and Daniel F. Holmen.

Extending Morley-Wang-Xu elements beyond the $m \leq n$ barrier

Shuonan Wu
Peking University

The well-known Morley-Wang-Xu (MWX) elements provide a family of nonconforming finite element spaces for solving $2m$-th order elliptic problems on n-dimensional simplicial meshes, under the constraint $m \leq n$. In a previous work, we extended this framework to the critical case $m = n + 1$ by constructing nonconforming elements that maintain unisolvence and convergence through a careful matching between degrees of freedom and shape function spaces. This talk presents a further development of this line of research: a unified framework for constructing canonical nonconforming finite element spaces for any $m \geq 1$ and any $n \geq 1$. These spaces are defined through a recursive design principle and a multi-level structure that preserves the essential properties required for convergence.

"Abusing" FEEC - And Getting Away with it

Ralf Hiptmair
ETH Zurich, Switzerland

joint work with W. M. Boon, W. Tonnon, and E. Zampa

The Stokes problem on $\Omega \subset \mathbb{R}^d, d = 2, 3$, has variational formulations set in (subspaces of) $V := \{\mathbf{v} \in \mathbf{H}^1(\Omega) : \operatorname{div} \mathbf{v} = 0\}$, which are connected to the Stokes complex and naturally accommodate Dirichlet no-slip boundary conditions for the velocity.

An alternative are formally equivalent vorticity-velocity-pressure formulations, which lead to variational problems in $\mathbf{H}(\mathrm{curl}, \Omega)$ and $\mathbf{H}(\mathrm{div}, \Omega)$ and appear to be readily amenable to Galerkin discretization based on FEEC. Yet, these variational formulations are not compatible with common boundary conditions; enforcing those directly leads to instabilities.

I am going to discuss to different "physical" boundary conditions, their incorporation into the FEEC discretization of $\mathbf{H}(\mathrm{curl}, \Omega)$-based variational formulations:

(i) Navier slip condition, see [W. M. Boon, R. Hiptmair, W. Tonnon, and E. Zampa, H(curl)-based approximation of the stokes problem with slip boundary conditions, arXiv:2407.13353 (math.NA) 2024], and

(ii) no-slipp boundary conditions imposed weakly by means of Nitsche's method, see [W. M. Boon, W. Tonnon, and E. Zampa, H(curl)-based approximation of the Stokes problem with weakly enforced no-slip boundary conditions, Comput. Methods Appl. Mech. Engrg., 448 (2026)].

Structure-preserving Discontinuous Galerkin Finite Element Methods for Port-Hamiltonian Dynamical Systems

Yan Xu
University of Science and Technology of China

In this talk, we present discontinuous Galerkin (DG) finite element discretizations for a class of hyperbolic port-Hamiltonian dynamical systems.

The key point in constructing a port-Hamiltonian system is a Stokes-Dirac structure. Instead of following the traditional approach of defining the strong form of the Dirac structure, we define a Dirac structure in weak form, specifically in the input-state-output form. This is implemented within broken Sobolev spaces on a tessellation with polyhedral elements. After that, we state the weak port-Hamiltonian formulation and prove that it relates to a Poisson bracket. In our work, a crucial aspect of constructing the above-mentioned Dirac structure is that we provide a conservative relation between the boundary ports. Next, we state DG discretizations of the port-Hamiltonian system by using the weak form of the Dirac structure and broken polynomial spaces of differential forms, and we provide a priori error estimates for the structure-preserving port-Hamiltonian discontinuous Galerkin (PHDG) discretizations.

The accuracy and capability of the methods developed in this paper are demonstrated by presenting several numerical experiments.

Finite Element Exterior Calculus with Splines

Deepesh Toshniwal
Delft University of Technology, The Netherlands

Finite Element Exterior Calculus (FEEC) is a powerful framework for developing stable and compatible discretizations of partial differential equations and provides a systematic approach to discretizing problems in computational electromagnetism and fluid mechanics. This talk explores recent developments in isogeometric versions of FEEC, with a special focus on adaptive structure-preserving discretizations. We will discuss spline spaces that support different notions of adaptivity (e.g., through local refinement or via tunable section-space parameters), discuss the challenges that appear in their use within FEEC, and show some example applications.

A finite element surface Stokes complex

Michael Neilan
University of Pittsburgh

We present a non-conforming finite element Stokes complex on triangulated surfaces. The construction is based on a new structure-preserving surface Scott–Vogelius finite element pair for the Stokes problem. The discrete (Stokes) spaces are defined using novel Piola-based degrees of freedom that enforce weak continuity conditions across surface mesh edges while preserving the exactly divergence-free property. This approach naturally gives rise to non-conforming H^2-surface elements, analogous to the Euclidean C^1 Hsieh-Clough-Tocher space.

Finite Element Hessian and Divdiv Complexes

Jun Hu
Peking University

The linearized Einstein-Bianchi system is derived from the vacuum Einstein equations where the Ricci tensor vanishes and consequently leads to the reduction of the Riemann tensor to the Weyl tensor. Following the Bel decomposition with respect to timelike unit vectors, the Weyl tensor can be separated into electric and magnetic components. Due to the second Bianchi identity, these linearized electric and magnetic tensors obey Maxwell-type equations, analogous to those governing the electric and magnetic field vectors:

$$\frac{\partial \boldsymbol{E}}{\partial t} + \operatorname{curl} \boldsymbol{B} = 0, \quad \operatorname{div} \boldsymbol{E} = 0,$$
$$\frac{\partial \boldsymbol{B}}{\partial t} - \operatorname{curl} \boldsymbol{E} = 0, \quad \operatorname{div} \boldsymbol{B} = 0,$$

with electric and magnetic tensor fields $\boldsymbol{E}$ and $\boldsymbol{B}$, respectively. This system is similar to the Maxwell equations. But an essential difference is that the unknowns $\boldsymbol{E}$ and $\boldsymbol{B}$ are a symmetric and traceless matrix, rather than vectors. This distinction presents a significant challenge in constructing stable finite elements. By introducing a new variable $\sigma(t) = \int_0^t \operatorname{div}\operatorname{div} \boldsymbol{E} ds$, the LEB system can be reformulated as:

$$\frac{\partial \sigma}{\partial t} = \operatorname{div}\operatorname{div} \boldsymbol{E},$$
$$\frac{\partial \boldsymbol{E}}{\partial t} = -\operatorname{Gradgrad} \sigma - \operatorname{sym}\operatorname{curl} \boldsymbol{B},$$
$$\frac{\partial \boldsymbol{B}}{\partial t} = \operatorname{curl} \boldsymbol{E}.$$

Here the operator sym curl denotes the symmetrized curl operator.

For this equivalent system, there are two associated complexes. One is the following Gradgrad complex:

$$P_1(\Omega) \xrightarrow{\subset} H^2(\Omega;\mathbb{R}) \xrightarrow{\text{Gradgrad}} H(\operatorname{curl},\Omega;\mathbb{S}) \xrightarrow{\text{curl}} H(\operatorname{div},\Omega;\mathbb{T}) \xrightarrow{\text{div}} L^2\left(\Omega;\mathbb{R}^3\right) \longrightarrow 0,$$

where the space $P_1(\Omega)$ consists of polynomials of degree not greater than 1 , the space $H^2(\Omega;\mathbb{R})$ consists of square-integrable scalar functions with square-integrable gradients and Hessians, the space $H(\operatorname{curl},\Omega;\mathbb{S})$ consists of square-integrable matrices with square-integrable curl, taking value in the space $\mathbb{S}$ of symmetric matrices, the space $H(\operatorname{div},\Omega;\mathbb{T})$ consists of square-integrable matrices with square-integrable divergence, taking value in the space $\mathbb{T}$ of traceless matrices, and the space $L^2\left(\Omega;\mathbb{R}^3\right)$ consists of square-integrable functions, valued in $\mathbb{R}^3$. The second complex is the Divdiv complex, which is dual to the Gradgrad complex above,

$$RT \xrightarrow{\subset} H^1\left(\Omega;\mathbb{R}^3\right) \xrightarrow{\text{dev grad}} H(\text{ sym curl}, \Omega;\mathbb{T}) \xrightarrow{\text{sym curl}} H(\text{ Div div},\Omega;\mathbb{S}) \xrightarrow{\text{Divdiv}} L^2(\Omega;\mathbb{R}) \to 0,$$

where RT denotes the lowest order Raviart-Thomas space, and for matrices $A \in \mathbb{R}^{3\times 3}$ $\operatorname{dev} A = A - \frac{1}{3}\operatorname{tr}(A) I$ with $\operatorname{tr}(A)$ of A being the trace and I the identity matrix. The spaces in this complex are defined analogously to those in the Gradgrad complex. Both complexes are exact when the domain Ω is contractible and Lipschitz. These complexes are instrumental in designing stable FEMs for the LEB system, involving variables such as σ, $\boldsymbol{B}$, and $\boldsymbol{B}$, by constructing the corresponding finite element complexes.

This talk constructs the finite element Gradgrad and Divdiv complexes on tetrahedral grids, which is exact if the domain is contractible and Lipschitz.

The latent variable proximal point algorithm for variational problems with inequality constraints

Patrick E. Farrell
University of Oxford and Charles University

The latent variable proximal point (LVPP) algorithm is a new framework for solving infinite-dimensional variational problems with inequality constraints. The algorithm is a saddle point reformulation of the Bregman proximal point algorithm. At the continuous level, the two formulations are equivalent, but the saddle point formulation is more amenable to discretisation.

LVPP yields numerical methods with observed mesh-independence for obstacle problems, contact, fracture, plasticity, and others besides. In many cases this mesh independence is achieved for the first time. The framework also extends to more complex constraints, providing means to enforce convexity in the Monge-Ampère equation and gracefully handling quasi-variational inequalities, where the underlying constraint depends implicitly on the unknown solution.

In this talk we describe the LVPP algorithm in a general form and apply it to a number of problems from across mathematics.

Structure-preserving discretisation of $\mathrm{SO}(3)$ rotations for Cosserat continua

Adam Sky
Institute of Computational Engineering and Sciences, Department of Engineering, Faculty of Science, Technology and Medicine, University of Luxembourg

We examine structural compatibility issues that arise in finite element discretisations of geometrically exact Cosserat continua. In such models, independent rotational degrees of freedom are described by a micro-rotation field $\overline{\boldsymbol{R}} \in \mathrm{SO}(3)$, whose interaction with the deformation gradient $\boldsymbol{F}$ through the Cosserat strain $\overline{\boldsymbol{R}}^T \boldsymbol{F} - \boldsymbol{1}$ is often linked to shear- and membrane-locking phenomena in reduced-dimensional formulations. While classical discretisations of $\boldsymbol{F}_h = \mathrm{D}\boldsymbol{\varphi}_h$ based on Lagrange elements readily represent constant stretches, the corresponding discrete rotations $\overline{\boldsymbol{R}}_h$ living on a nonlinear manifold without a canonical polynomial interpolation do not generally agree with polar $\boldsymbol{F}_h$. This mismatch can impede the reconstruction of identity strains and is associated with locking behaviour.

To mitigate these issues, we introduce a novel geometric structure-preserving interpolation framework, aimed at improving compatibility between discrete kinematic fields. This construction places the relevant quantities in spaces of comparable structure, facilitating closer alignment between the micro-rotation and the polar part of the deformation gradient. The resulting formulation extends naturally to Cosserat solids, shells, and beams and retains consistency with curvature measures derived from geodesic discretisations.

We outline the formulation, explore suitable discrete pairings, and provide numerical illustrations indicating the potential of this approach to reduce locking and enhance geometric fidelity in Cosserat finite element models.

Energy- and helicity-conserving enriched Galerkin method for Navier-Stokes equations

Qian Zhang
Jilin University

In this talk, I will present an efficient enriched Galerkin (EG) method for the incompressible Navier–Stokes equations. In contrast to existing EG formulations, our approach enriches the first-order continuous Galerkin space with piecewise constants defined on edges in two dimensions and on faces in three dimensions. This enrichment acts as a correction to the normal component of the

CG velocity space, enabling an inf-sup stable discretization. Building on this enriched space, we employ a velocity reconstruction operator and discretize the convective term in its rotational form. This leads to two time-stepping schemes that preserve both discrete kinetic energy and helicity in the inviscid limit: a fully nonlinear Crank–Nicolson scheme, and a linear, computationally cheaper variant obtained by temporally linearizing the convective term.

De Rham complexes for nonlinear Hodge-Laplacians

Martin Licht
Technical University of Dresden

Nonlinear Hodge-Laplace equations generalize the classical p-Laplace equation to vector calculus and exterior calculus. Sobolev de Rham complexes beyond Hilbert spaces are central in this endeavor. We address several fundamental questions: smooth approximation theory, cohomology theory, and Poincare-Bogovskii operators. We combine techniques in functional analysis, Lipschitz topology, and sheaf theory.

Conforming lifting and adjoint consistency for the Discrete de Rham complex of differential forms

Silvano Pitassi
University of Montpellier

Discrete de Rham (DDR) methods provide non-conforming but compatible approximations of the continuous de Rham complex on general polytopal meshes. Owing to the non-conformity, several challenges arise in the analysis of these methods. In this work, we design conforming liftings on the DDR spaces, that are right-inverse of the interpolators and can be used to solve some of these challenges. We illustrate this by tackling the question of the global integration-by-part formula. By non-conformity of the discrete complex, this formula involves a residual -- which can be interpreted as a consistency error on the adjoint of the discrete exterior derivative -- on which we obtain, using the conforming lifting, an optimal bound in terms of the mesh size. Our analysis is carried out in the polytopal exterior calculus framework, which allows for unified proofs for all the spaces and operators in the DDR complex. Moreover, the liftings are explicitly constructed in finite element spaces on a simplicial submesh of the underlying polytopal mesh, which gives more control on the resulting functions (e.g., discrete trace and inverse inequalities).

Uniform Poincaré inequalities for the discrete de Rham complex of differential forms

Marien-Lorenzo Hanot
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We are interested in Poincaré inequalities for the "Polytopal Exterior Calculus" method. This method allows for polytopal meshes in any dimension n. The spaces are collections of local polynomial spaces associated with entities of different dimensions (with k-cells for $k \in \{0, ..., n\}$), and the discrete differential operators are defined by mimicking the Stokes formula.

In this non-conforming setting, retrieving the Poincaré inequalities from those in continuous spaces is challenging. Instead, we construct a potential for the exterior derivative directly in the discrete setting. A key step is finding an appropriate distribution of values on the k-skeleton of the mesh. This intermediate result is of independent interest because its setting is similar to those found in schemes based on Mimetic Finite Differences, Compatible Discrete Operators or Discrete Geometric Approach.

In this talk, I will show how tools from homological algebra can be used to construct a potential for the exterior derivative on a cochain complex supported on the polytopal mesh and explain how we can complete such potential with higher-order contributions to solve the original problem.

Some p-robust a posteriori error estimates based on auxiliary spaces

Yuwen Li
Zhejiang University

This talk presents polynomial-degree-robust (p-robust) equilibrated a posteriori error estimates for H(curl), H(div) and H(divdiv) problems, based on H^1 auxiliary space decomposition. The proposed framework employs auxiliary space preconditioning and regular decompositions to decompose the finite element residual into H^1 residuals that are further controlled by classical p-robust equilibrated a posteriori error analysis. As a result, we obtain novel and simple p-robust a posteriori error estimates of H(curl)/H(div) conforming methods and mixed methods for the biharmonic equation. In addition, we prove guaranteed a posteriori upper error bounds under convex domains or certain boundary conditions.