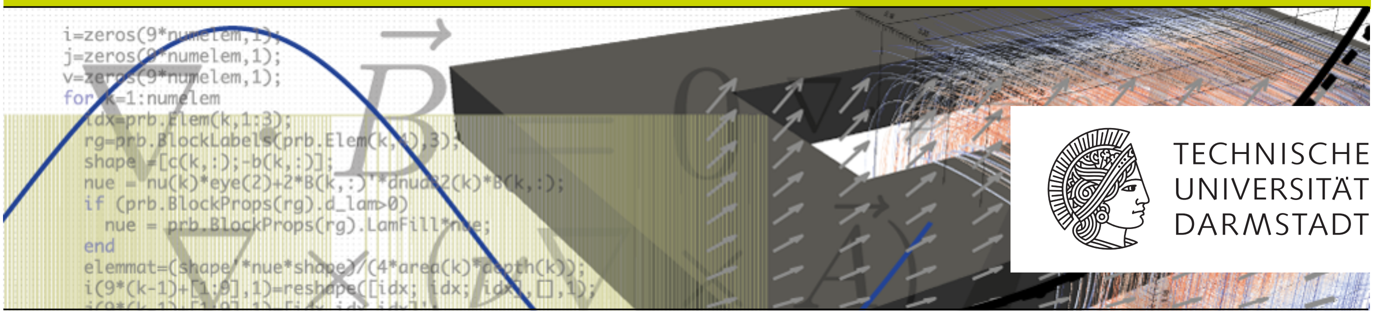
The dual universe: generalizing the Buffa-Christiansen complex

PhD Position

Numerical Analysis / Scientific Computing / Electrical Engineering

Start: Immediately



Graduate School of Computational Engineering

Institut für Theorie Elektromagnetischer Felder

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Motivation

Second-order boundary value problems are often posed in the spaces H^1, $\mathbf{H}(\mathbf{curl})$, $\mathbf{H}(\mathrm{div})$, and L^2, respectively. Together with the differential operators **grad**, **curl**, and div these spaces form a Hilbert complex. The complex can be expressed in terms of differential forms, and generalized to $d > 0$ dimensions. For a numerical treatment, the domain of the problem might be discretized by a simplicial complex, the mesh, for example by tetrahedral finite elements for $d = 3$. A conforming discretization of the Hilbert complex is given by the Whitney complex, which encompasses nodal, edge, facet and cell elements of lowest polynomial order, for $d = 3$.

Recently Annalisa Buffa and Snorre Christiansen introduced a dual finite element complex on the barycentric refinement. It inherits all the beneficial properties from the Whitney complex, such as mesh association, local support, interpolation and approximation properties, discrete exterior derivatives represented by incidence matrices. This so-called *B-C complex* is in stable duality to the Whitney complex. The B-C complex was successfully applied in the construction of highly efficient Calderón preconditioners for electromagnetic wave propagation problems, and for superior mesh coupling techniques at interfaces. However, the B-C complex is so far only known for $d = 1, 2$.

Tasks

The open PhD position is devoted to extending and generalizing this work in several respects, like dimensions $d > 2$, higher polynomial order, and manifolds with curvature. Such results would allow novel mesh coupling techniques as well as Galerkin discretizations of boundary value problems on certain classes of polygonal meshes dual to a simplicial complex.

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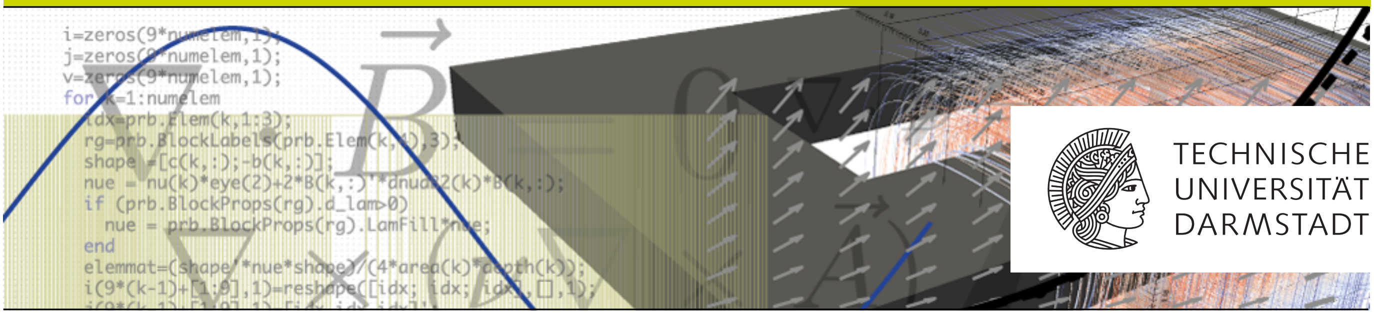
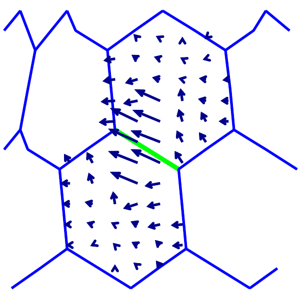
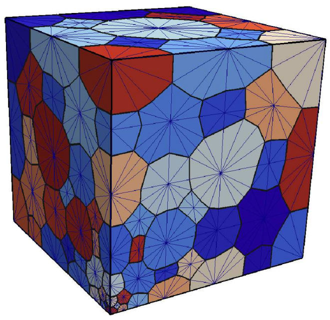


Prerequisites

A strong background in (numerical) mathematics as well as basic knowledge in functional analysis is required. An independent and persistent way of working is expected. The open position is well-suited for math graduates, as well as theoretically inclined graduates in electrical or computational engineering.

(a) 

(b) 

(a) Euclidean vector proxy of the B-C basis 1-form associated with the center edge; (b) Dual complex created from the barycentric refinement of a simplicial complex on a cube. Source: Julian Rimoli, Barycentric Subdivision Meshes in Computational Solid Mechanics, Georgia Institute of Technology, with kind permission.

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