Conforming hp finite elements for pyramids

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The efficient meshing of complicated geometries often relies on the simultaneous use of tensor-product and unstructured simplicial meshes. A conforming coupling requires also pyramidal elements. The construction of finite elements on pyramids is somewhat non-standard, leading e.g. to rational basis functions.

We present a general framework for the construction of conforming high-order pyramidal elements for $H^1(\Omega)$, $H(\mathrm{curl},\Omega)$, $H(\mathrm{div},\Omega)$, and $L_2(\Omega)$. Our approach relies on the explicit treatment of higher-order kernel and range spaces of the canonical differential operator. The constructed sequence of finite element spaces automatically inherits the global exactness of a continuous de Rham sequence, which provides stable discretizations for mixed problems as well as spectral correctness of $H(\mathrm{curl})$- and $H(\mathrm{div})$-conforming finite elements. Moreover, the construction of parameter-robust Schwarz-type preconditioners easily carries over to pyramidal elements.

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