The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Comparison of stabilization techniques for CutDG methods

Maximilian Bergbauer[1,*], Peter Munch[1,2], André Massing[3], Martin Kronbichler[4] and Wolfgang A. Wall[1]

[1] Technical University of Munich, Garching, Germany
E-mail: {maximilian.bergbauer,peter.muench,wolfgang.a.wall}@tum.de
[2] Helmholtz-Zentrum Hereon, Geesthacht, Germany
[3] Norwegian University of Science and Technology, Trondheim, Norway
E-mail: andre.massing@ntnu.no
[4] Uppsala University, Uppsala, Sweden
E-mail: martin.kronbichler@it.uu.se

Keywords: *CutDG, high order, stabilization, ghost penalty, unfitted, agglomeration*

We present a comparison between different stabilization techniques for high order CutDG methods regarding accuracy and numerical performance. In this work, we analyze the behavior of derivative-face-based ghost penalty [1], volume-based ghost penalty [4] and agglomeration of small cut cells [2]. All methods are applied to elliptic problems on various geometries with focus on critical cut cell scenarios. We perform numerous numerical experiments to compare these methods with respect to error quantities as well as computational efficiency in terms of throughput of matrix-vector products and residual assembly in one, two and three space dimensions. The performance analysis relies on the current state-of-the-art for higher-order basis functions in fitted-mesh scenarios, the matrix-free evaluation of discretized differential operators with SIMD vectorization over cell batches [3], for which the present contribution develops novel realizations for the three stabilization approaches in cut elements. The main goal of this work is to critically assess the three different stabilization methods in well-defined benchmark scenarios with varying geometry and polynomial degree of the shape functions.

REFERENCES

[1] C. Gürkan and A. Massing. A stabilized cut discontinuous Galerkin framework for elliptic boundary value and interface problems. *Comput. Methods Appl. Mech. Eng.*, Vol. **348**, pp. 466–499, 2019.

[2] A. Johansson and M. G. Larson. A high order discontinuous Galerkin Nitsche method for elliptic problems with fictitious boundary. *Numer. Math.*, Vol. **123**, pp. 607–628, 2012.

[3] M. Kronbichler and K. Kormann. Fast matrix-free evaluation of discontinuous Galerkin finite element operators. *ACM Trans. Math. Softw.*, Vol. **45**, pp. 29:1–40, 2019.

[4] J. Preuß. Higher order unfitted isoparametric space-time FEM on moving domains. Master's thesis, University of Göttingen, 2018.

*Corresponding and presenting author