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Combination of different mesh types for an ADER-DG method

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In this study we combine different mesh types to increase the performance of our simulation algorithm but keeping its flexibility. On the one hand meshes for highly complex geometries can be constructed a lot easier using unstructured meshes. On the other hand, as recent studies showed, computations on regular meshes require much less CPU time.

Our simulations are accomplished by an approach using Arbitrary high-order DERivatives (ADER) for the time integration of a Discontinuous Galerkin (DG) method which is a finite-element method allowing for discontinuities at element interfaces similar to finite-volume schemes. In 2D, the flux computation over edges linking elements of different mesh types could remain unchanged. Here, both element types (triangulars and quadrilaterals) can share the interface with exactly the same edge. In 3D such a simple mesh combination is no more possible since a tetrahedron can never tie in with the base area of a hexahedron. Either one includes pyramids as an intermediate layer, which we want to avoid, or one has to introduce so-called non-conforming boundaries, i.e. an interface between the different meshes, where the element sides of both mesh types need not use the same edges and element vertices. Thus, the fluxes for the according neighbor over the element sides are computed pointwise on Gaussian integration points. Therewith, the neighbor information has to be provided for each single Gauss point of an element side belonging to the non-conforming boundary which complicates the MPI parallelization.

Besides, using non-conforming boundaries also affords to refine or coarsen purely quadrilateral or hexahedral meshes. Element interfaces at non-conforming boundaries do not have to coincide between neighbors.

In order to examine the performance we show applications for mixed meshes as well as for non-conforming boundaries connecting different mesh spacings of the same mesh type.