Discontinuous Galerkin Methods for fluid dynamical problems with dynamic boundaries: multiphase flows

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ABSTRACT

Discontinuous Galerkin (DG) methods can be constructed for arbitrary convergence orders if the solution to the continuous problem is sufficiently smooth. This assumption does not hold for multiphase flows, which are mixtures of two or more immiscible fluids with different density and viscosity and also depend on surface tension effects. In such flows, the pressure and the velocity gradient are discontinuous at the fluid interface. Any high-order method applied to this problem requires a special treatment of this singularity in order to obtain its designed performance.

We are going to present a DG discretization for multiphase flow problems, which employs an adaption of the approximation space ("cut cells") in each time-step to the position of the fluid interface and is therefore able to achieve high convergence order. Since the shape and position of the interface can be almost arbitrary, one has to deal with difficulties like arbitrarily small cut cells. Furthermore, since the approximation space depends on time, one also has to adopt the temporal integration in order to deal with cut cell which change their shape over time.

Within the past years, several building blocks of such a method were presented: this includes numerical integration on cut cells, precise evaluation of curvature and level-set algorithms to compute the evolution of the interface. In the integration of those blocks into a full multiphase-solver, one has to consider complex non-linear interactions, e.g. between the interface dynamics and the approximation space: the flow velocity determines the evolution of the fluid interface which then changes the approximation space. Therefore, the presentation will not only cover a short review of the individual building blocks but will also discuss several pitfalls which may occur in the combination of these blocks.

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