Isogeometric analysis two-fluid flow: towards correct energy evolution

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The unconditionally stable violent two-fluid flow on arbitrary grids is sought after. For this purpose we would like to devise a formulation that is guaranteed to decay energy, in the absence of external forcing. This decay should be as close the the physcal decay as possible, that is the numerical decay should be minimal. The formulation with favorable energy characteristics can be useful when investigating surface instabilities in LNG sloshing. In LNG slohsing subtile instabilities at the interface make a big difference in the final solution, therefore these instabilities need to be simulated as accurately as possible.

In [1, 2], it is shown that strongly coupling the level-set [3] convection with the flow solver gives robustness and potentially efficiency and accuracy advantages. The next essential step towards energy conservation would be to include redistancing within the strong coupling. For this a new level-set formulation is developed that circumvents explicit redistancing. Additionally, this approach corrects some issues when the level-set is used on non-uniform grids.

An important ingredient in the formulation is the use of exactly compatible Isogeometric spaces for the velocity and pressure approximation. These allow exactly divergence free solutions. Heaving this helps on two fronts. First it helps the Navier-Stokes formulation to have the correct energy behaviour. Additionally, when the velocity field would not be exactly divergence free mass would be created and destroyed at these location in space, this does not play nice with global mass correction in the level-set formulation.

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