Geophysical Research Abstracts
Vol. 15, EGU2013-14106, 2013
EGU General Assembly 2013

Unfitted Two-Phase Flow Simulations in Pore-Geometries with Accurate

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The development of better macro scale models for multi-phase flow in porous media is still impeded by the lack of suitable methods for the simulation of such flow regimes on the pore scale. The highly complicated geometry of natural porous media imposes requirements with regard to stability and computational efficiency which current numerical methods fail to meet. Therefore, current simulation environments are still unable to provide a thorough understanding of porous media in multi-phase regimes and still fail to reproduce well known effects like hysteresis or the more peculiar dynamics of the capillary fringe with satisfying accuracy.
Although flow simulations in pore geometries were initially the domain of Lattice-Boltzmann and other particle methods, the development of Galerkin methods for such applications is important as they complement the range of feasible flow and parameter regimes. In the recent past, it has been shown that unfitted Galerkin methods can be applied efficiently to topologically demanding geometries. However, in the context of two-phase flows, the interface of the two immiscible fluids effectively separates the domain in two sub-domains. The exact representation of such setups with multiple independent and time depending geometries exceeds the functionality of common unfitted methods.
We present a new approach to pore scale simulations with an unfitted discontinuous Galerkin (UDG) method. Utilizing a recursive sub-triangulation algorithm, we extent the UDG method to setups with multiple independent geometries. This approach allows an accurate representation of the moving contact line and the interface conditions, i.e. the pressure jump across the interface. Example simulations in two and three dimensions illustrate and verify the stability and accuracy of this approach.