AMC TRR277

B03

Modelling and Simulation of Concrete 3D Printing Based on a Massively Parallel Multi-Phase, Multi-Component LBM Approach

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Project summary

Concrete printing processes are influenced by the presence of air or other ambient fluids. Ambient fluids do not only contribute to momentum and energy transport but they also diminish the printing quality when trapped between layers. We develop models of the printing process based on high-fidelity multi-phase Lattice Boltzmann simulations capturing the dynamics of cement paste, ambient fluid and aggregates.

Key collaborations in 1st funding period

A04
- Joint velocity measurement of shotcrete jet using Granular Particle Image Velocimetry
- Viscosity and yield stress fitting using fishbone tool

AMC-MERCATOR-FELLOW Prof. Dr. Laura De Lorenzis
- Conservative phase field model for Selective Laser Melting
- A new lattice Boltzmann scheme for linear elastic solids

Main outcome of 1st funding period

Non-Newtonian Lattice Boltzmann Method
- Yield stress realized in Lattice Boltzmann by vanishing collision time
  - ✓ no regularization required
- Analytical solution for relaxation rate for Bingham fluids
  - ✓ no internal iterations required

High density ratio multi-phase model
- Evaluation of velocity-formulation
  - ✓ not sufficiently stable at high density ratios due to small denominator
- New split distribution formulation
  - ✓ better stability, yet still insufficient for high density ratio
- New sharp interface formulation
  - ✓ appropriate for high-density ratio and velocities

Evolution of multi-phase model

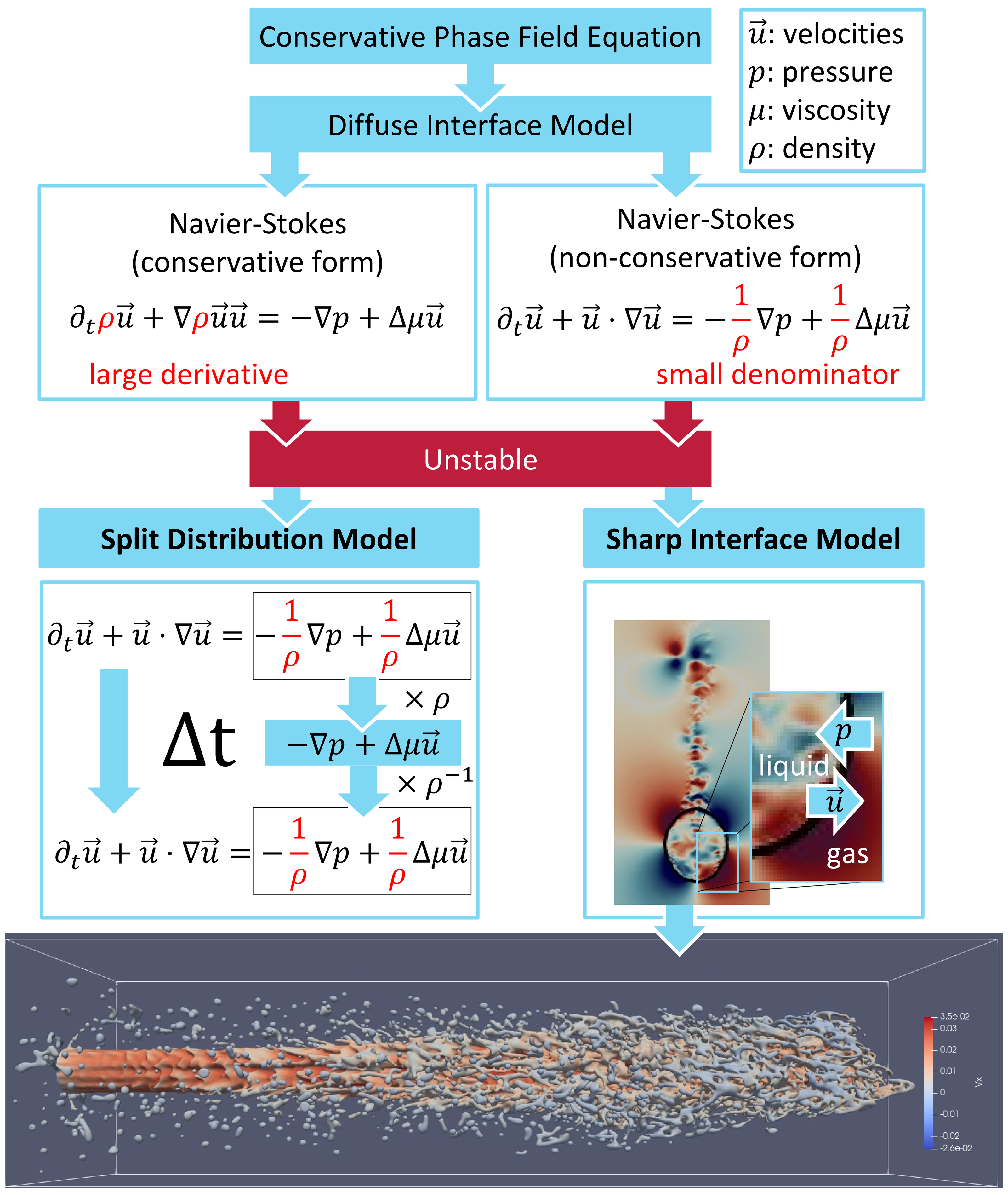
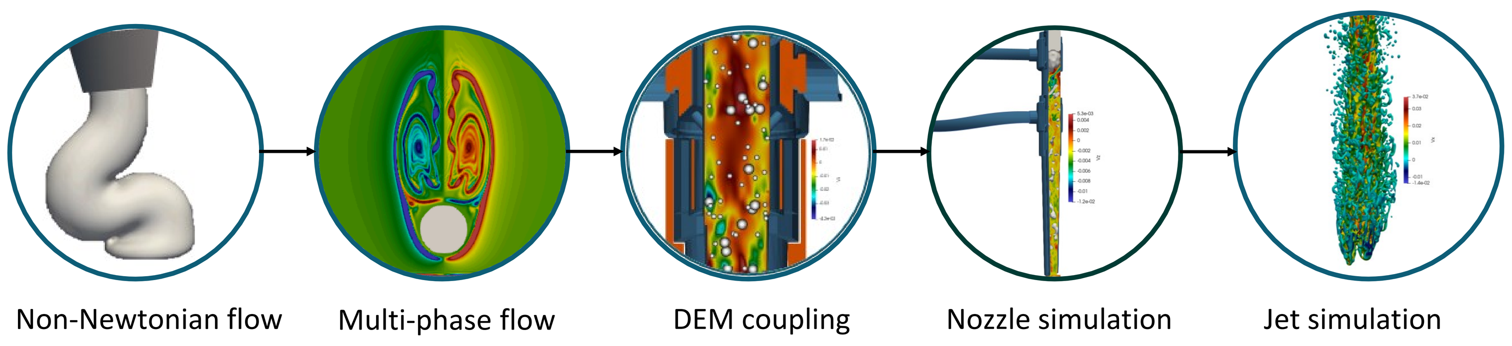


Fig 4: Evolution of multi-phase modelling

Project status



Elasto-plastic fluids with the Lattice Boltzmann Method

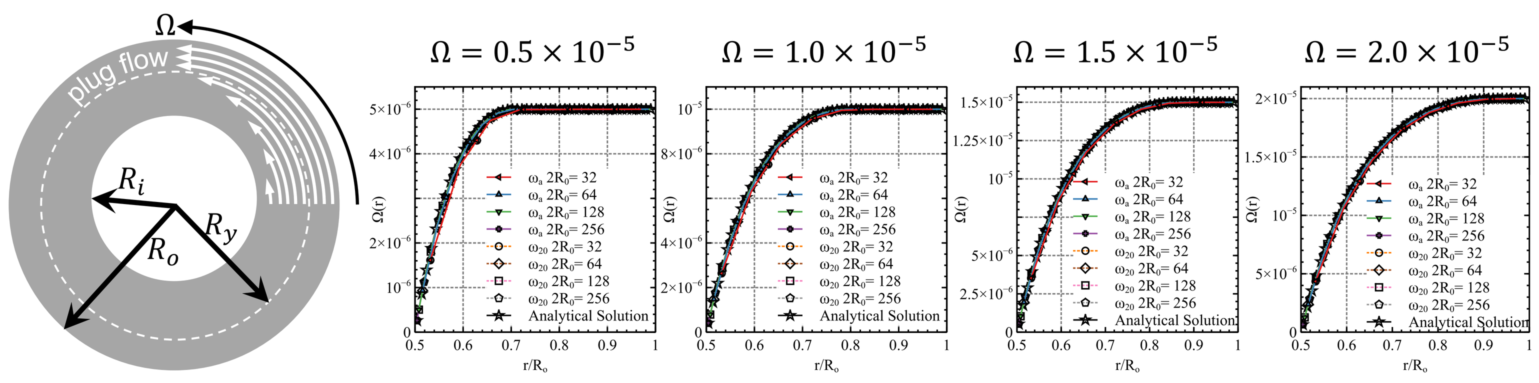


Fig 1: Taylor-Couette-Benchmark for Bingham fluid simulated with the developed lattice Boltzmann method

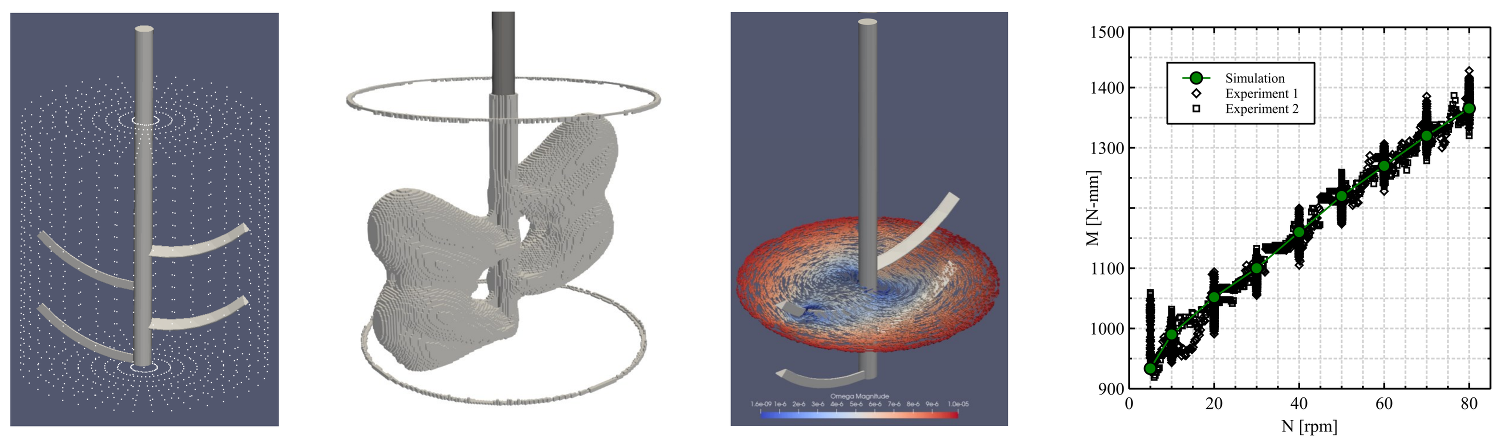


Fig 2: A virtual viscosimeter using an uncalibrated fishbone tool (a). The picture (b) shows the domain of concrete that is above the yield-stress, (c) shows the velocity field. Iterative parameter fitting was used to obtain viscosity and yield stress of the sample (d)

Discrete Element Lattice Boltzmann coupling

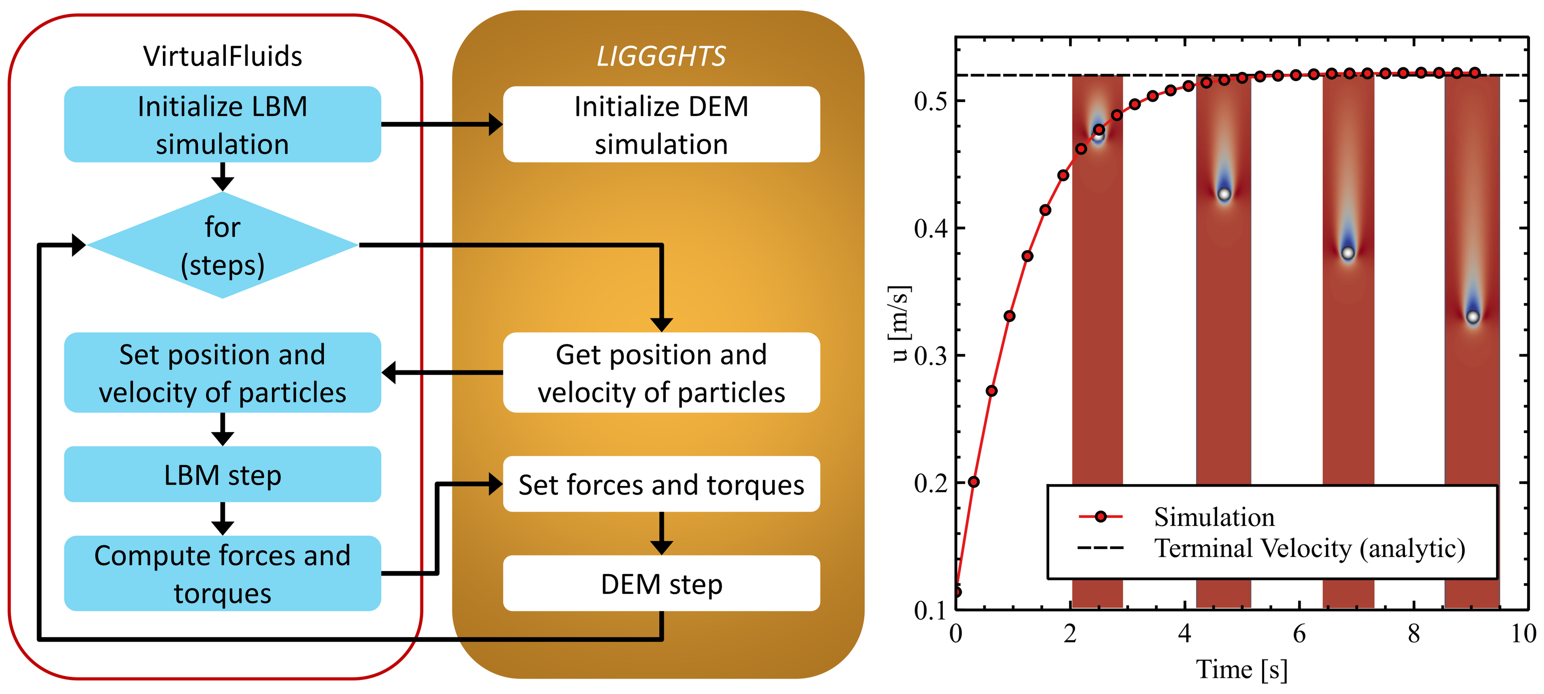


Fig 3: Flowchart of LBM-DEM coupling (left) Falling Sphere Benchmark (right)

Granular Particle Velocimetry

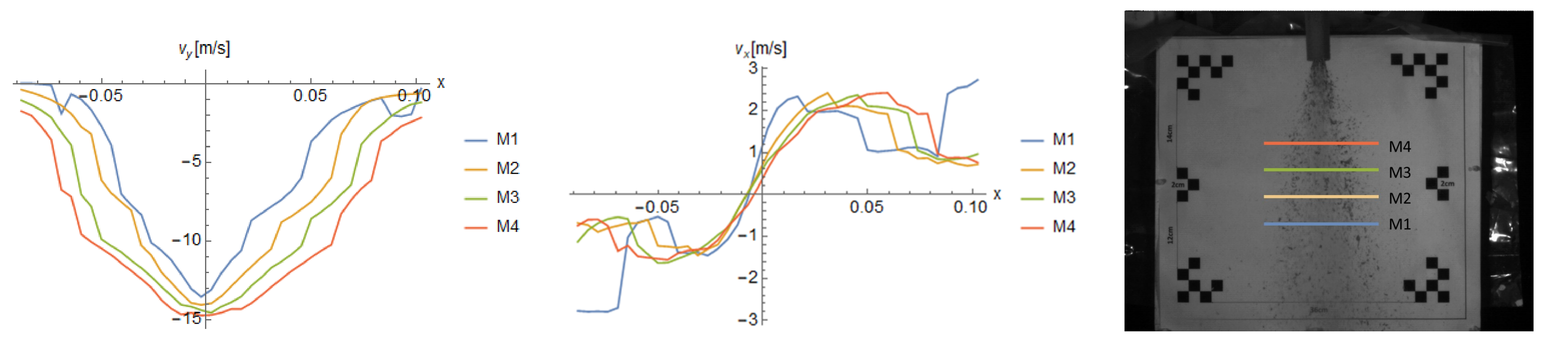


Fig 5: Measured vertical (left) and horizontal (middle) velocity obtained from image (right) correlation

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