Numerical and experimental comparison of wetting on textured surfaces

Laboratory of Tribology and Dynamics of Systems

UMR 5513

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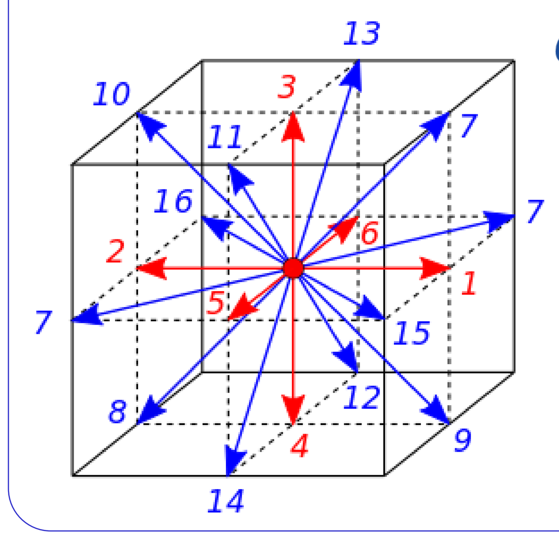
Numerical wetting using the Lattice Boltzmann Method

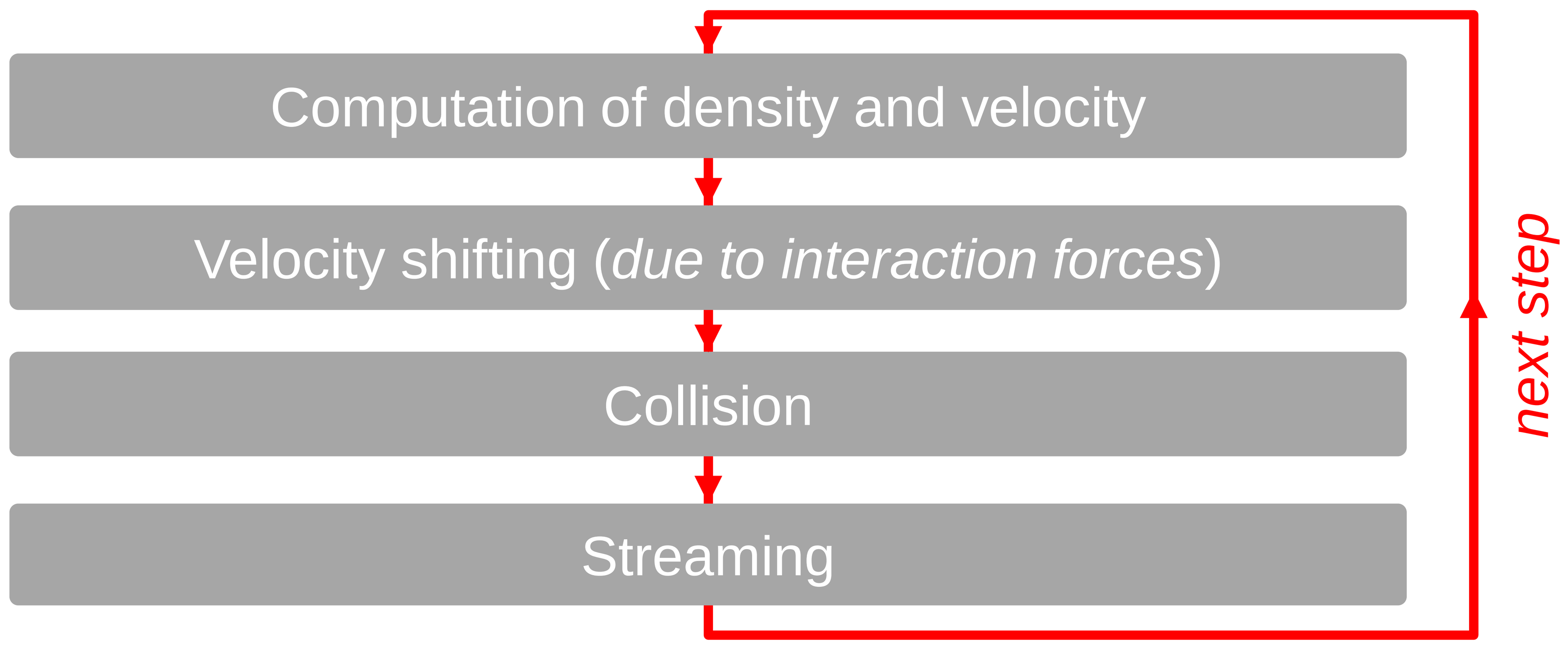
Continuous form of the Boltzmann equation

$$\frac{\partial f}{\partial t} + c\frac{\partial f}{\partial x} + \frac{F}{m}\frac{\partial f}{\partial c} = \Omega(f)$$



Velocities discretization

Scheme for 3 dimensions and 19 streaming directions



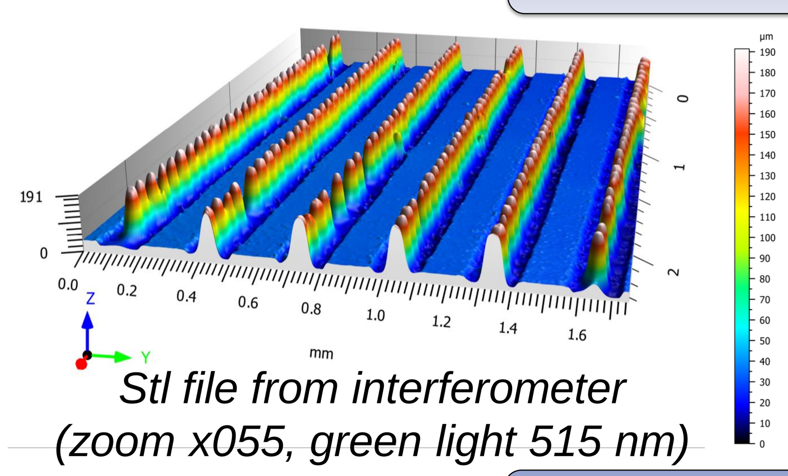
Streaming and collision algorithm for pseudo-potential LBM model

Comparison of wetting behaviors on textured surface

Experimental analysis

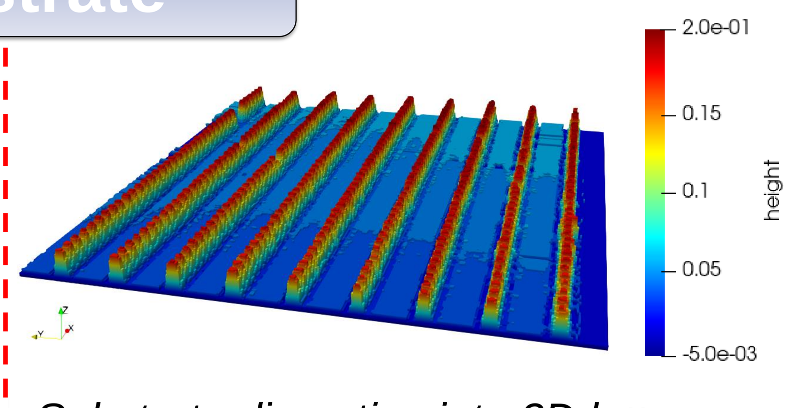
Substrate

Morphological characterization of the physical substrate (*size : 3 mm x 3 mm*)



Stl file from interferometer (zoom x055, green light 515 nm)

Numerical analysis



Substrate discretize into 3D lattices

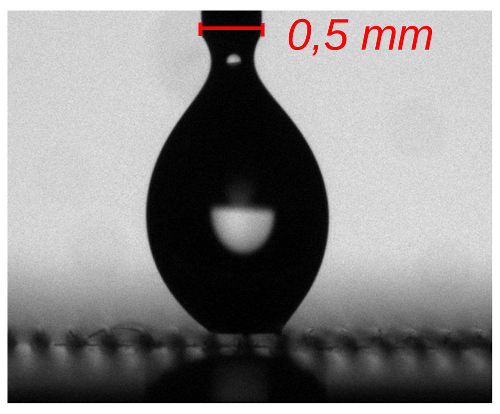
Substrates are discretized from physical surfaces

Composed of several cubes with sides equal to space discretization step (*10 µm*)

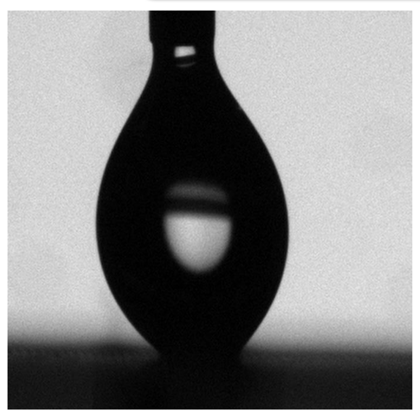
Initialization

Wetting characterization through a sessile drop experiments:

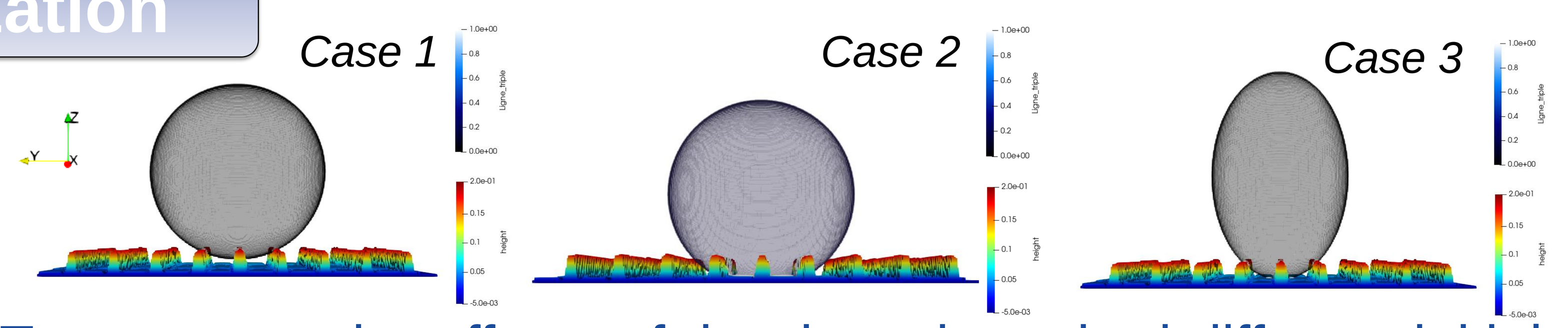
- Liquid = water (*3 µL*)
- Solid = PDMS



Transversal plan



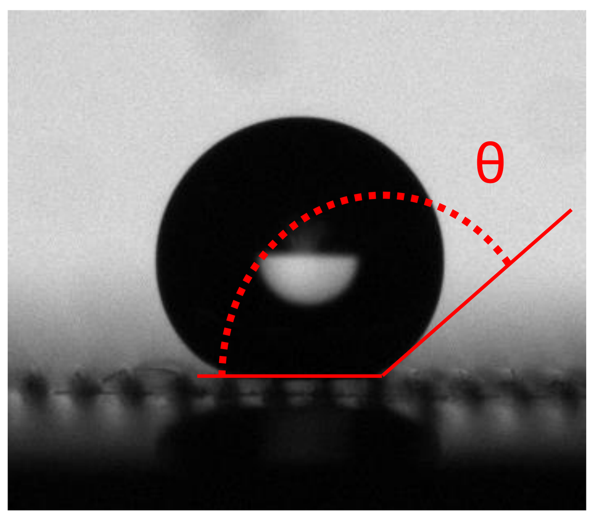
Longitudinal plan



To represent the effects of the deposit method different initial states are studied (*shape, position along z axis*)

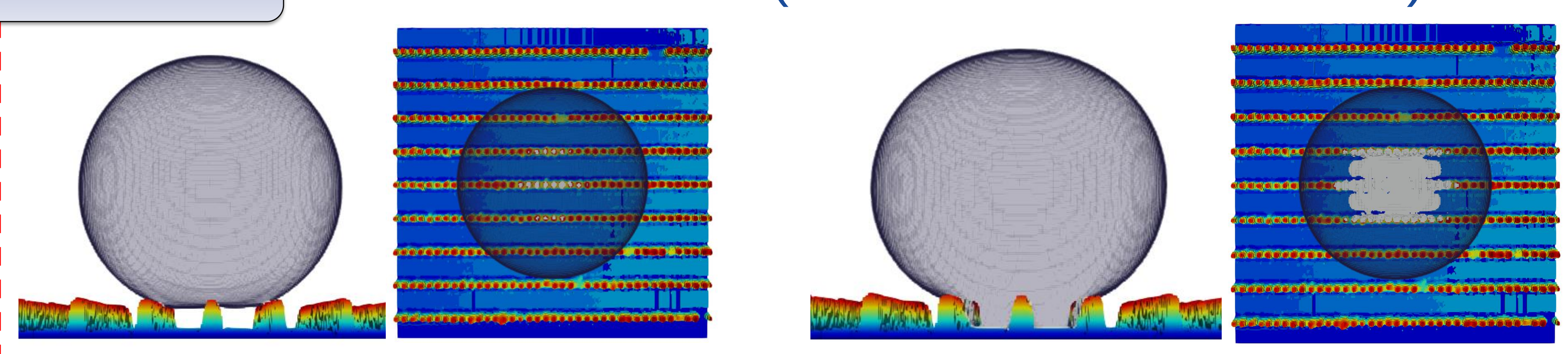
Final state

Contact angles θ along the 2 principal texture directions are measured



Contact angle along transversal plan

Different final states are observable depending on the initial state (Cassie-Baxter or Wenzel)



Case 1: Cassie-Baxter behavior *Case 2: Wenzel behavior*

Air below droplet and Liquid-Solid interface easily quantifiable

Experimental	*Results*	Numerical (*case 1*)
138°	*contact angles (longitudinal plan)*	153°
148°	*contact angles (transversal plan)*	159°
Cassie-Baxter	*wetting state*	Cassie-Baxter

- Results show a good prediction of wetting state and anisotropic behaviors
- The difference in values of around 10-15° can be explained by the numerical simplification (*density ratio = 1*)

Conclusions

- A lab-build numerical code to simulate 3D wetting on textured substrates is developed
- Contact angle is used to compare numerical and experimental data
- Anisotropic behaviors and wetting state are correctly simulated
- Simulation allows to access data hardly obtained experimentally

Perspectives

- **Enhance LBM pseudo-potential code to simulate higher density ratio and incorporate the effects of gravity
- Increase numerical resolution using supercomputer
- Predict wetting behavior to design new texture geometries

***Work in progress*

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