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Phase-field Simulation of Droplet Wetting and Impact Phenomena

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Motivation and goal

- Urea solution spray-wall-interaction in exhaust gas tailpipe
- Simulation of individual droplet wetting and impact on wall
- Simulation of liquid film formation on wall
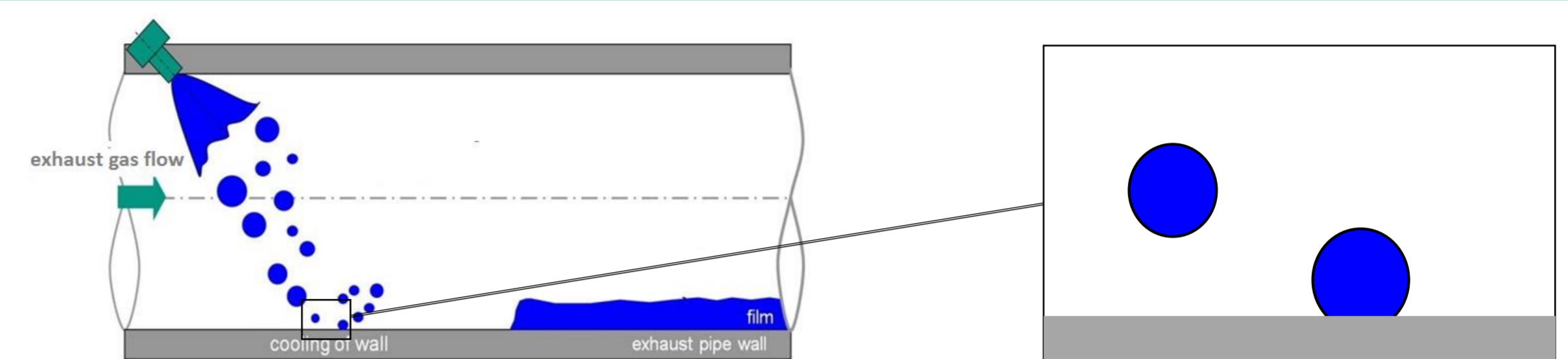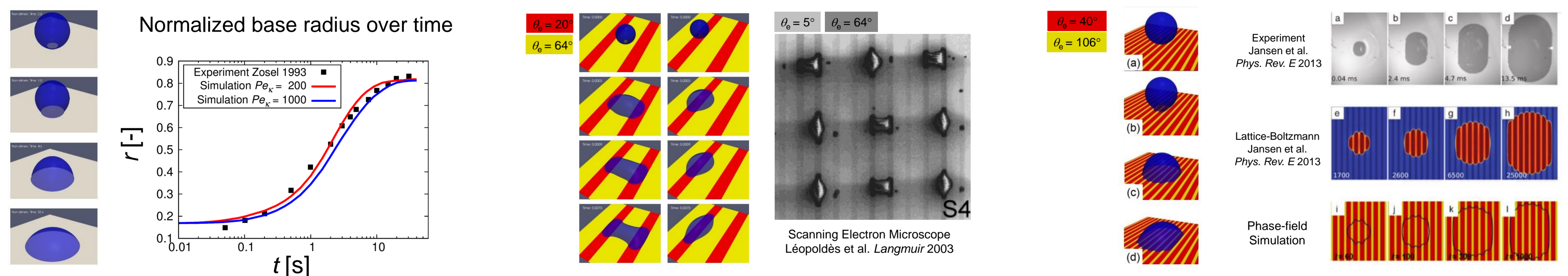

Numerical method and code

Phase-field method

- An interface-capturing method where interface is treated as being of certain thickness (also called "diffuse-interface method")
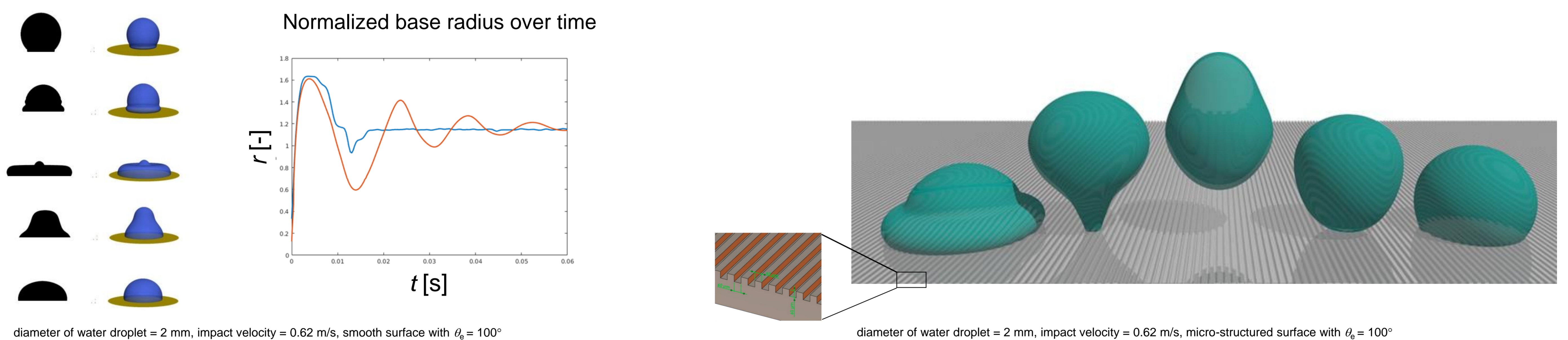- Especially suited for moving contact line problem

phaseFieldFoam

- A novel OpenFOAM solver implementing a Cahn-Hilliard based phase-field method coupled with Navier-Stokes equations
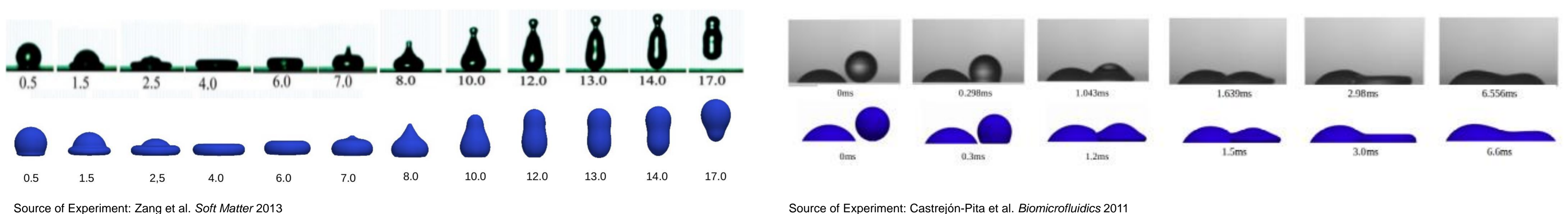- Developed by the authors (Marschall and Cai)

Droplet deposition on homogeneous and chemically-patterned surface

Normalized base radius over time

- Experiment Zosel 1993
- Simulation Pe_K = 200
- Simulation Pe_K = 1000

Scanning Electron Microscope
Léopoldès et al. *Langmuir* 2003

Experiment Jansen et al. *Phys. Rev. E* 2013

Lattice-Boltzmann Jansen et al. *Phys. Rev. E* 2013

Phase-field Simulation

Droplet impact on smooth and micro-structured surface

Normalized base radius over time

diameter of water droplet = 2 mm, impact velocity = 0.62 m/s, smooth surface with θ_e = 100°

diameter of water droplet = 2 mm, impact velocity = 0.62 m/s, micro-structured surface with θ_e = 100°

Work-in-progress: rebound and coalescence

Source of Experiment: Zang et al. *Soft Matter* 2013

Source of Experiment: Castrejón-Pita et al. *Biomicrofluidics* 2011

Further steps

- Evaporation of droplet
- Heat Transfer btw. droplet and wall
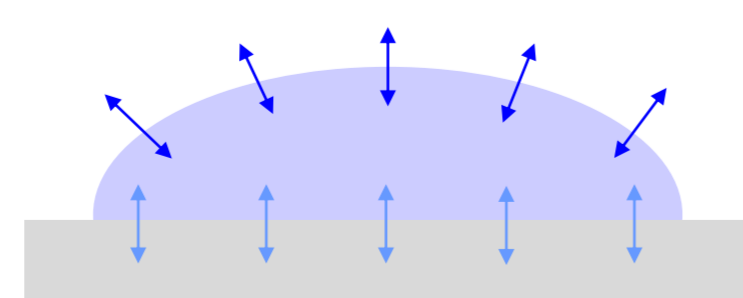
Acknowledgement

References

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- Cai, Dissertation, 2016, Karlsruher Institut für Technologie
- Cai, Wörner, Marschall and Deutschmann, *Catalysis Today* 2016, 273: 151–160.
- Fink, Bernard, Marschall, Wörner, Frohnapfel and Cai, *Jahrestreffen der ProcessNet Fachgruppe CFD* 2017, Dresden