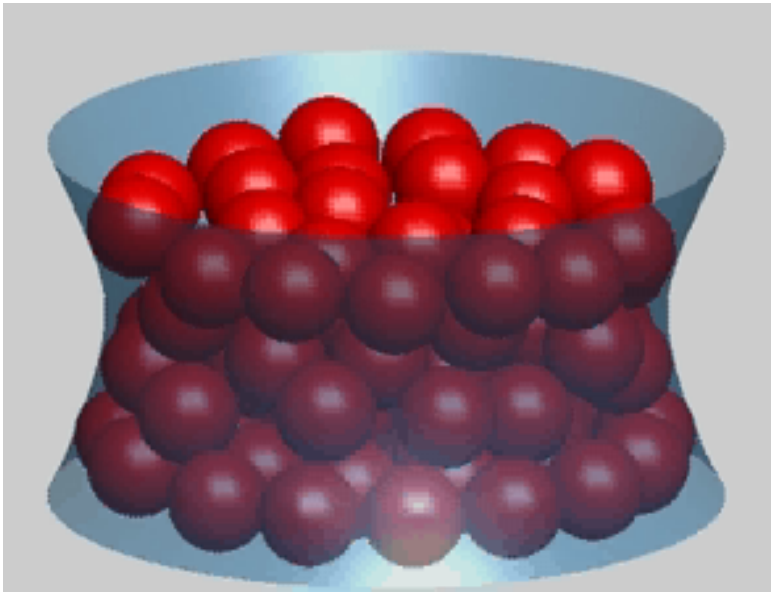
Interfaces: with and without particles



Jeffrey F. Morris
Mark D. Shattuck
City College of New York

Sidney Nagel
University of Chicago

the City College of New York
OF THE CITY UNIVERSITY OF NEW YORK

THE UNIVERSITY OF CHICAGO

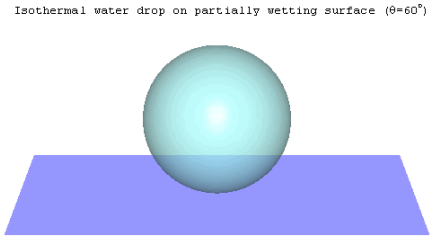
NSF-PREM 2013

Director's Meeting

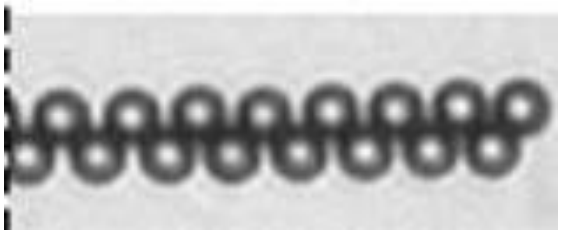
PREM Focus Areas

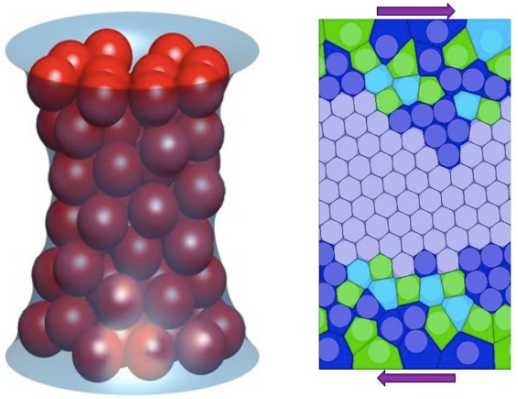
IRG = Integrated Research Group

- IRG1 Vapor-liquid and gas-liquid systems
  - Koplik, Watkins, T. Lee, Shattuck, Morris (Maldarelli)
  - Nagel, Zhang, Jaeger



- IRG2 Novel assembly processes
  - Kretzschmar, Tu, John, Koplik
  - Talapin, K.-Y. Lee, Witten, Jaeger





- IRG3 Particulate materials
  - Morris, Shattuck, Koplik, T. Lee
  - Jaeger, Nagel, Dinner

Particles at Surfaces

Ilona Kretzschmar, Ray Tu --- Ka Yee Lee, Binhua Lin

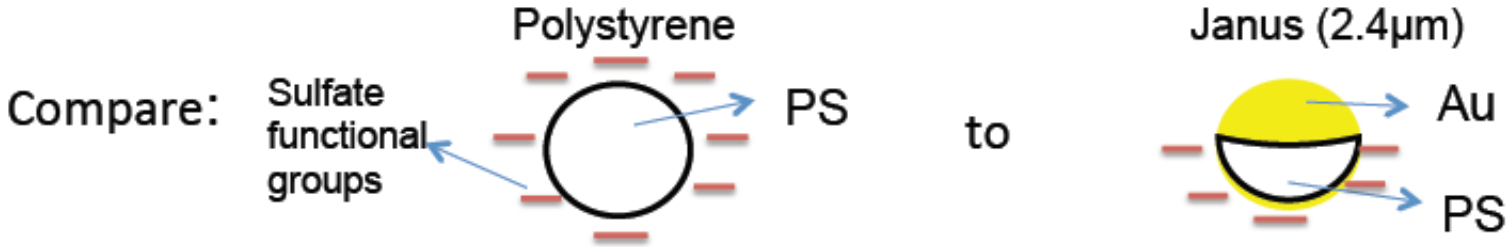
Applications → drug delivery, catalysis, sensors, stabilization of foams and emulsions

UofC: K. Y. Lee + Lin labs

Wrinkle-to-fold transition in polyester films (Lee) & gold nanoparticle trilayers (Lin)

CCNY: Kretzschmar + Tu labs

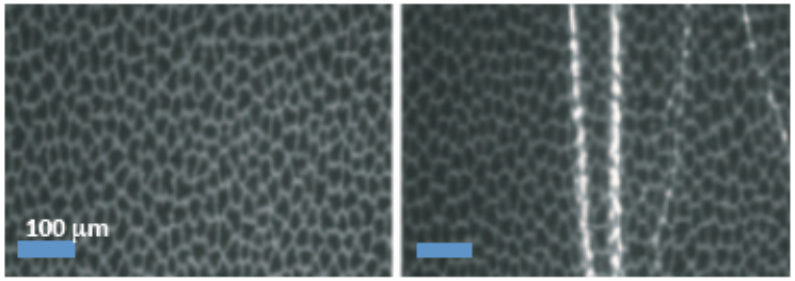
nm- & µm- sized particles



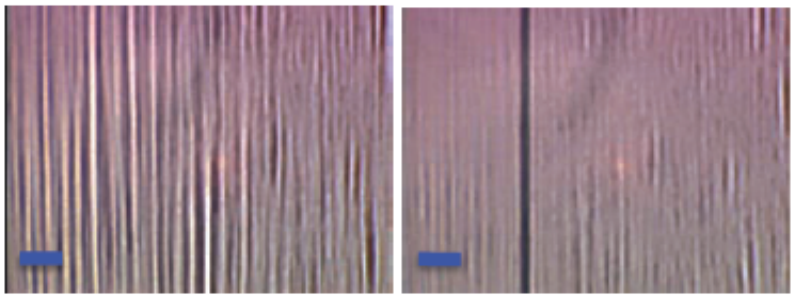
µm complements Å and nm scale at UofC: confirm universality?

Partnership on the Dynamics of Heterogeneous and Particulate Materials DMR 0934206

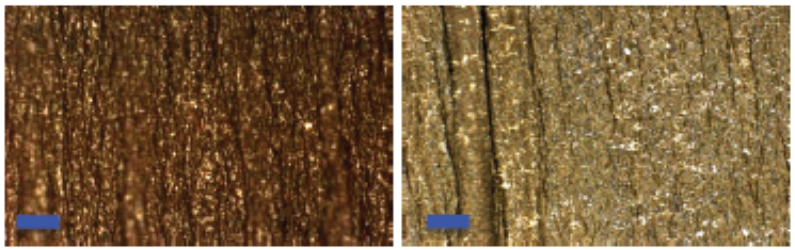
Wrinkle-to-fold transition



Model Lung Surfactant Monolayer
Flat to folds (2 nm thick)



Gold Nanoparticle Trilayer
Wrinkles to folds (15 nm thick)



Polystyrene Particle Monolayer
Wrinkles to folds (2.4 μm thick)
(J. Lenis & I. Kretzschmar, unpublished)

Wrinkles Folds.

Wrinkles → folds observed over 3 decades of size

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Drop impact and splash

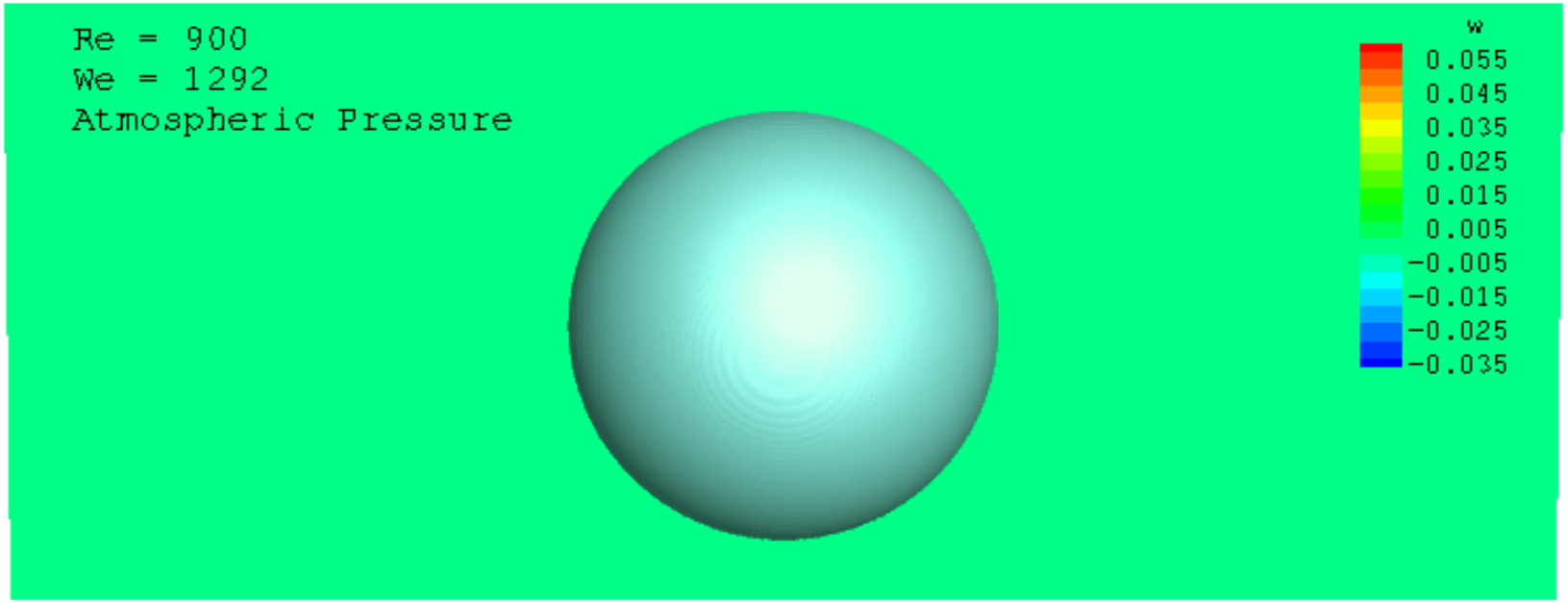
Taehun Lee, Joel Koplik, Jeff Morris, Charles Watkins -- CCNY
Sid Nagel, Wendy Zhang -- Chicago

Observations (Chicago group):
Drops splash on smooth surface at atmospheric P

Splash vanishes at 1/3 atmospheric P
(e.g. for water or ethanol drops)

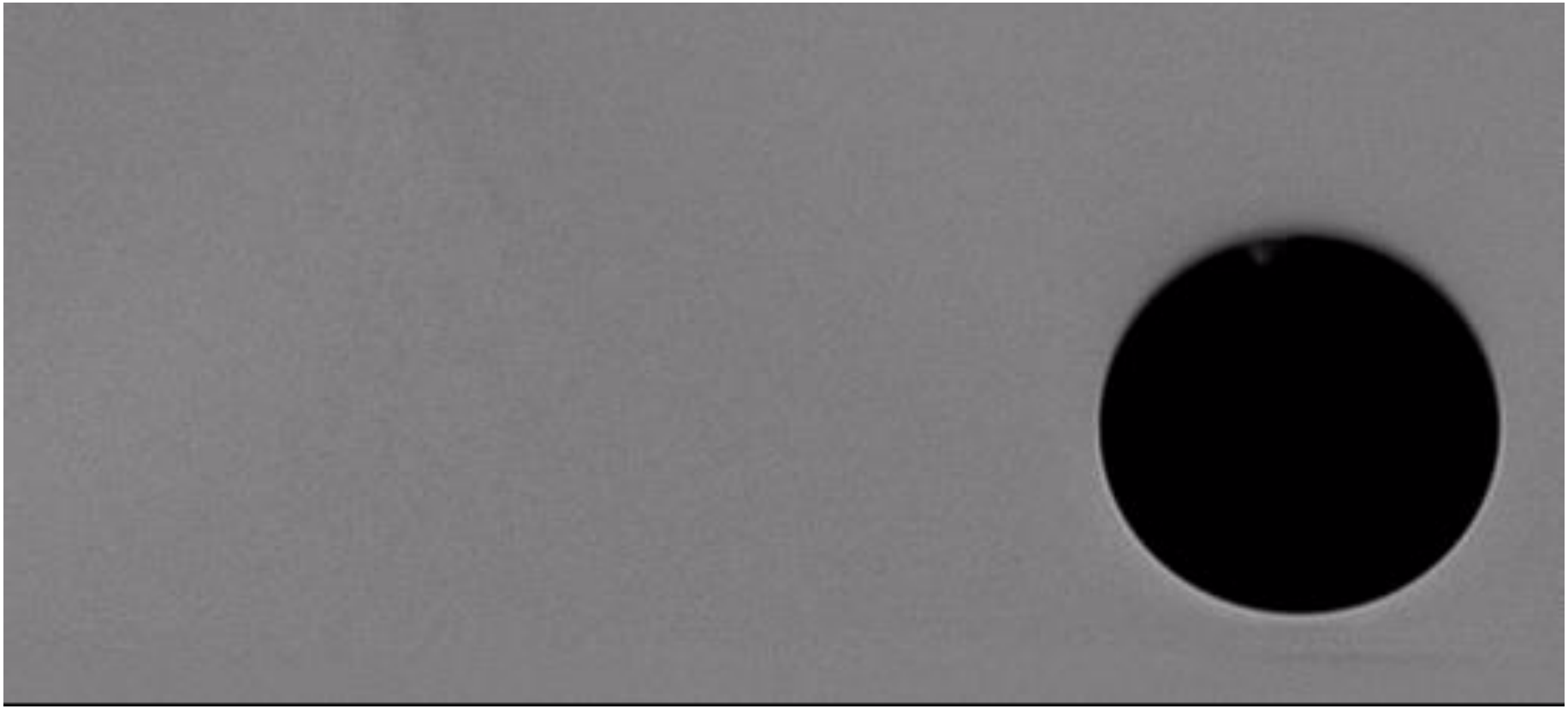
Question:
How can air cause a splash?

Splash (simulation)



Lattice-Boltzmann Simulations, Taehun Lee, CCNY

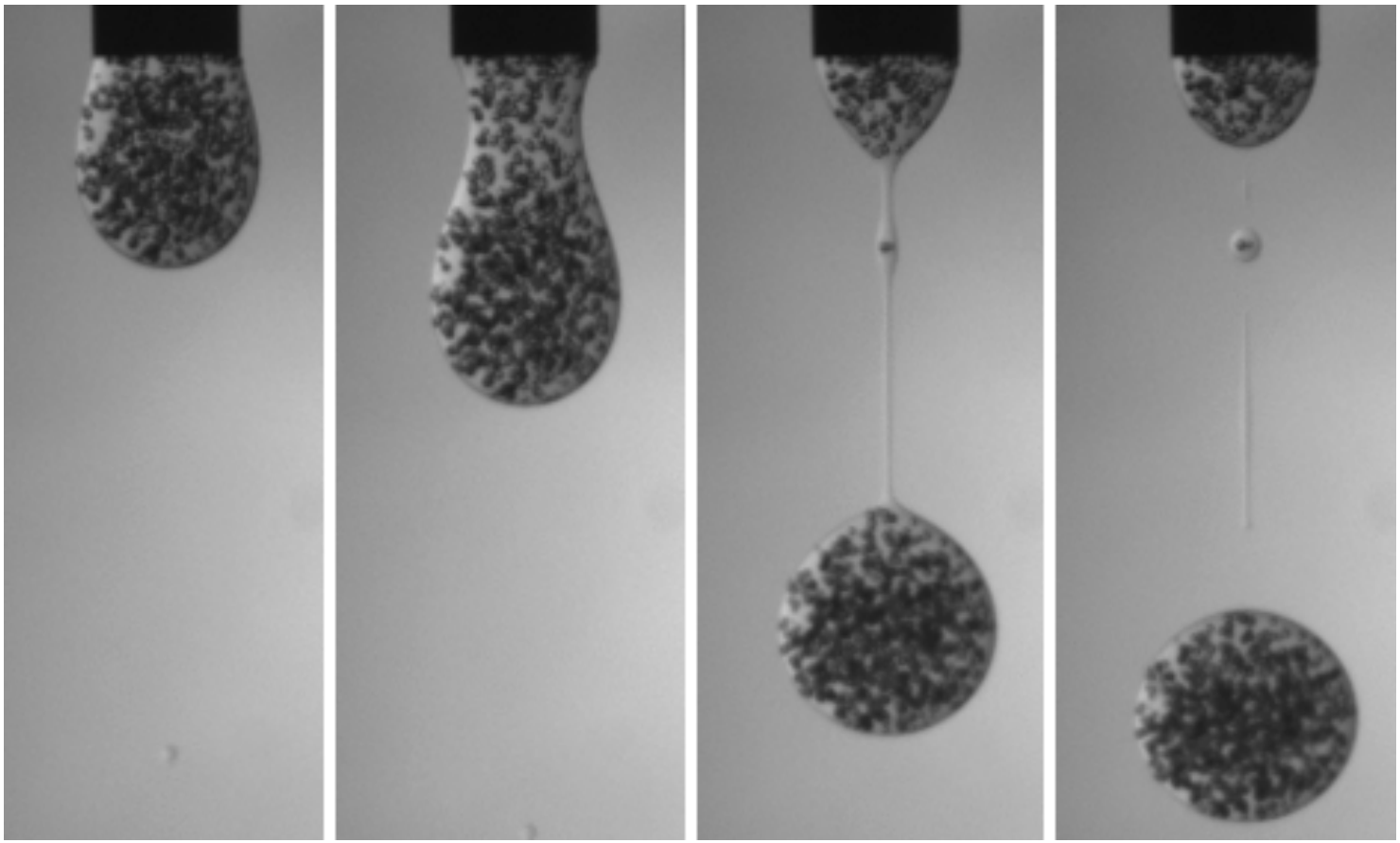
Splash (experiment)



Experiments: Irmgard Bischofberger, Chicago

Dilute Particle Laden Drop

Roy Furbank, Jeff Morris



Particle-laden flows

Jeff Morris, Mark Shattuck, Taehun Lee --- Heinrich Jaeger, Wendy Zhang

Droplet breakup

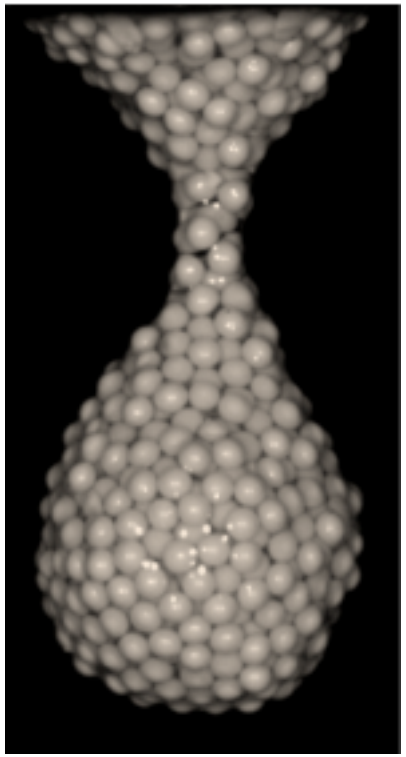
UofC: Nagel, Zhang on Newtonian fluids CCNY: Morris on dilute suspensions

Geometry and Dense Suspensions

Both liquid and particles determine pressure and structure:

Meniscus moves particles ←→ Particles scaffold for meniscus

Neck (singularity) retains memory of initial conditions.



UofC: Jaeger Quasi-static Experiments

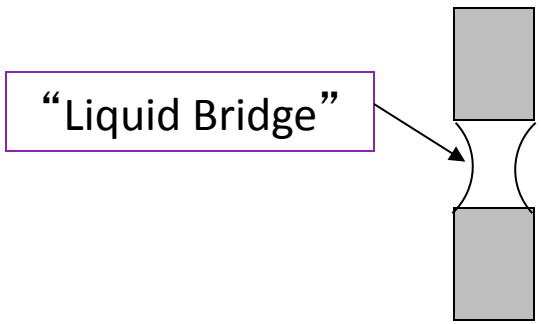
Measure pressure while controlling geometry

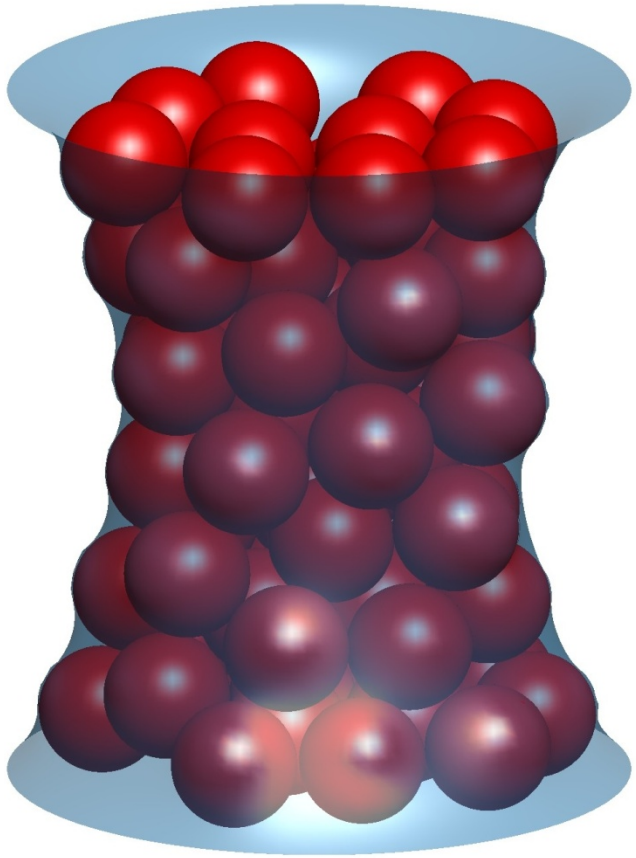
Tensile Test: How do particle positions create stress-strain curve?

How to relate packing geometry to pressure generated?

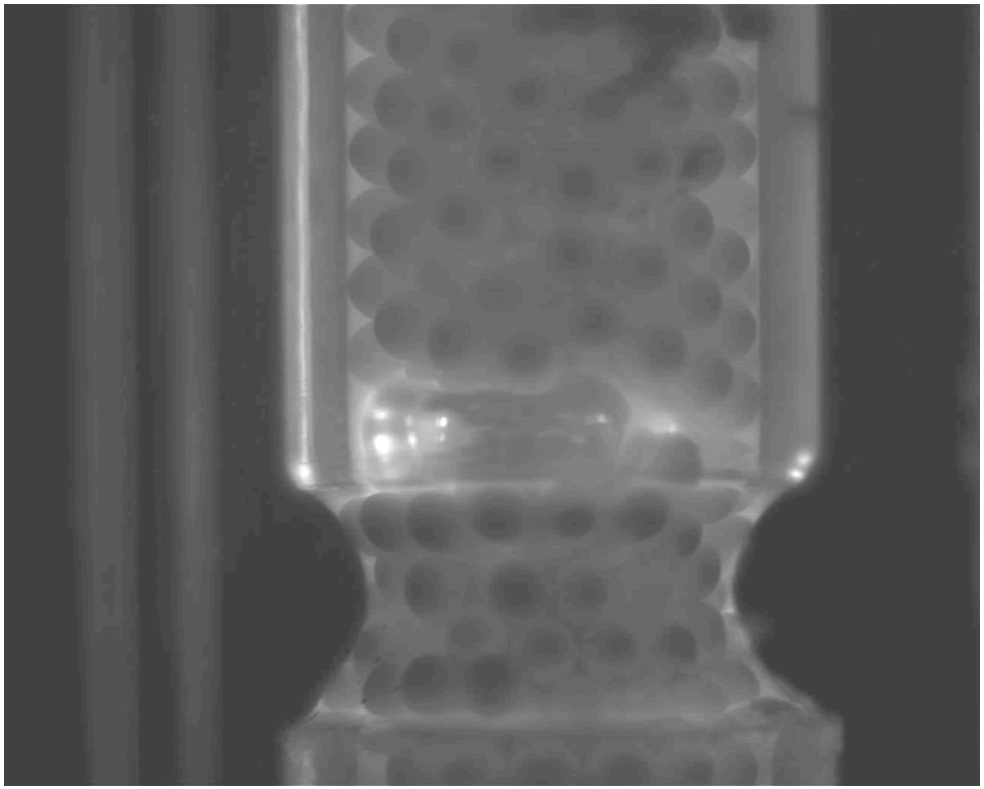
Particle-Laden Liquid Bridge

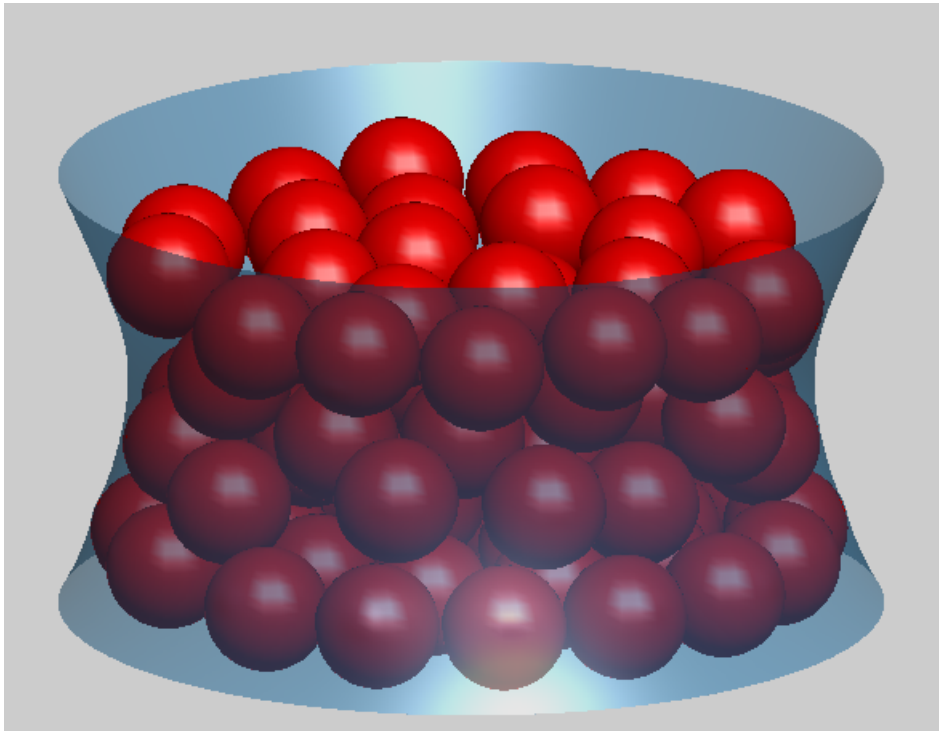
Mark Shattuck CCNY; Marc Miskin Heinrich Jaeger Chicago





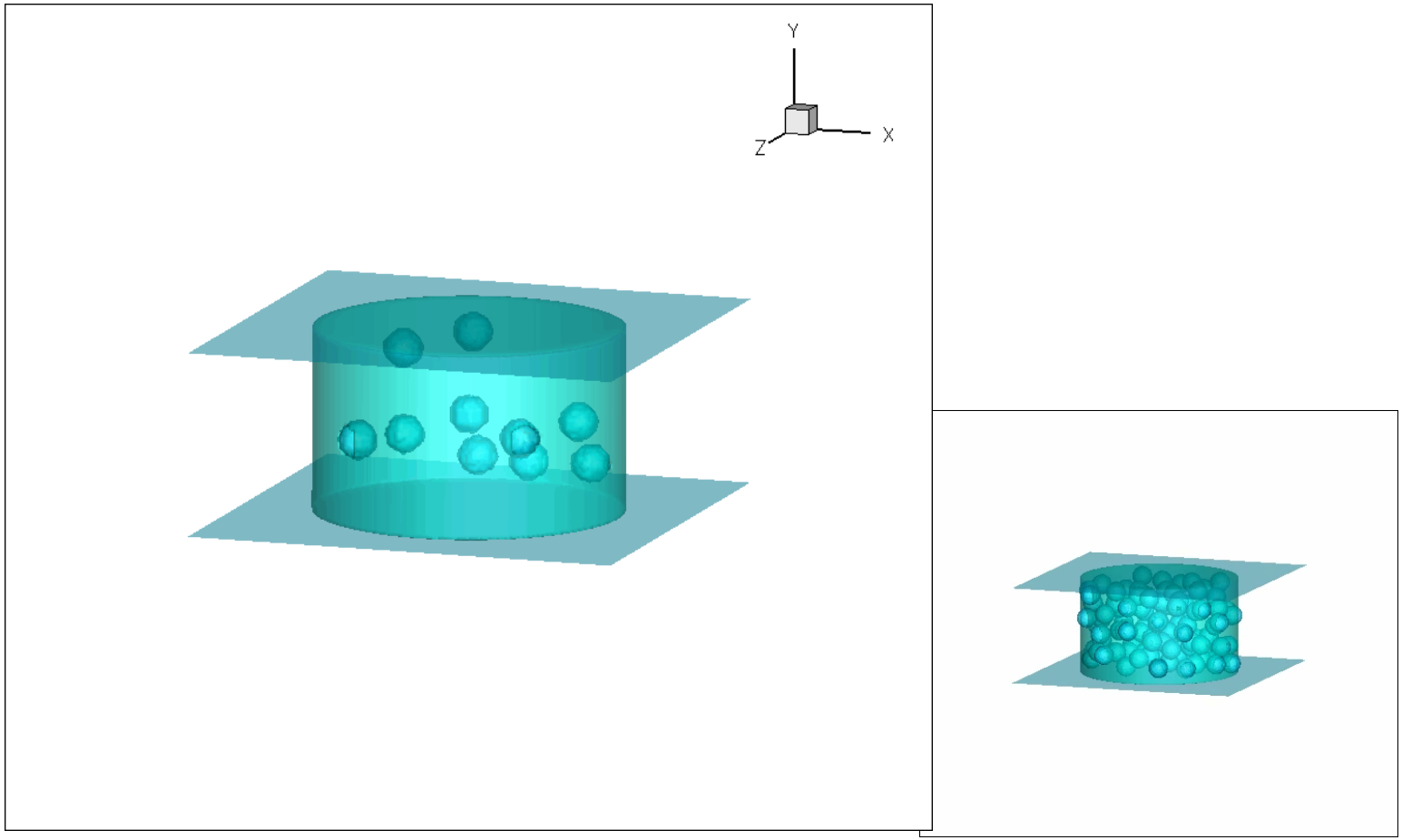
Comparison with Experiment



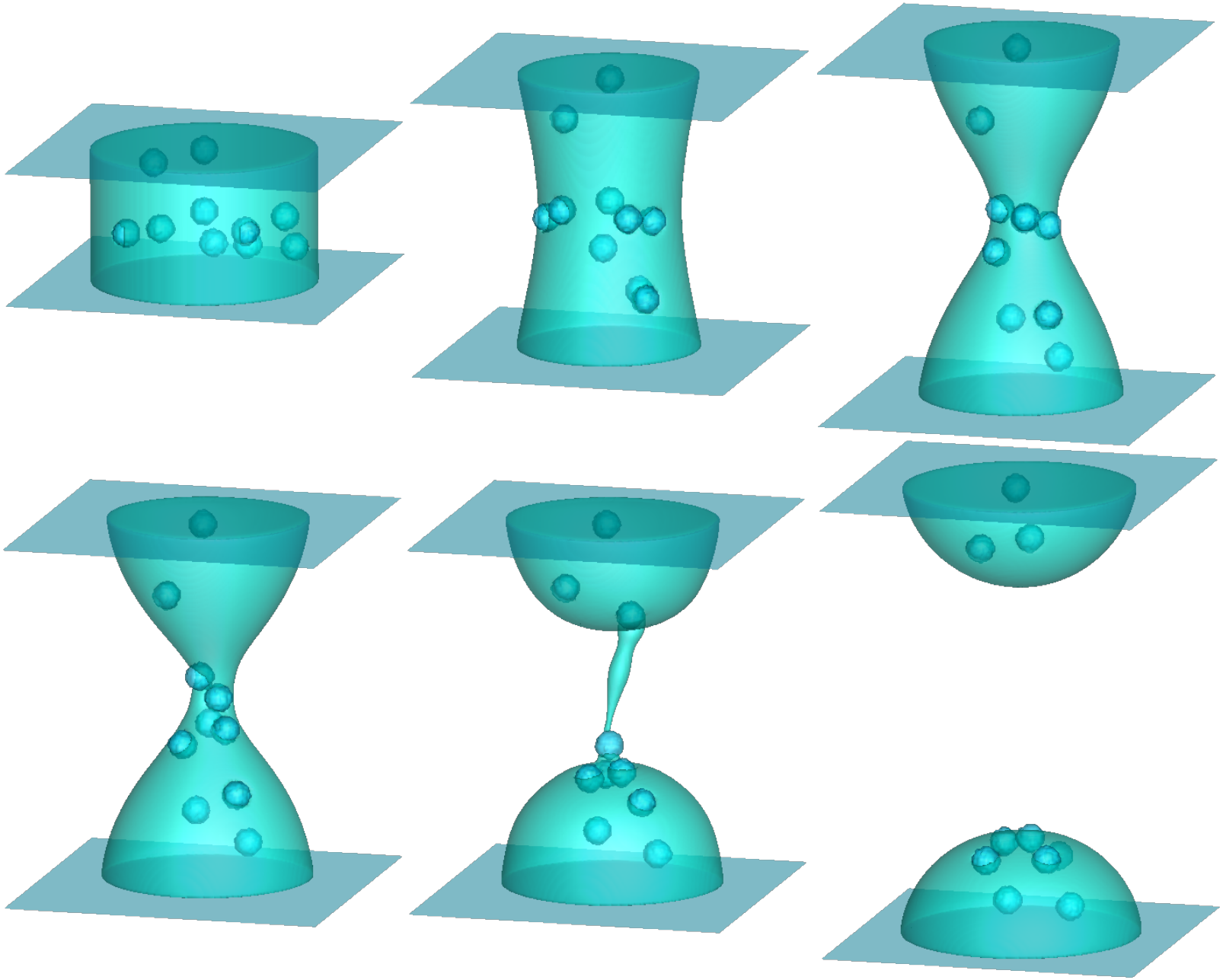


Lattice-Boltzmann Liquid Bridge

Kevin Connington, Taehun Lee, Jeff Morris CCNY



Dilute Liquid Bridge



Summary

- Interfaces play a significant role in materials development: assembly processes, deposition, coatings

- Splash phenomena remain poorly explained: simulations suggest consideration of *vorticity in the gas (!?)*; beautiful observations in simulation and experiments

- Three-phase flow solver developed: provides access to role of particles in drop formation/impaction processes.