

# GAMES 201

## Advanced Physics Engines 2020: A Hands-on Tutorial

# 高级物理引擎实战2020

(基于太极编程语言)

Yuanming Hu

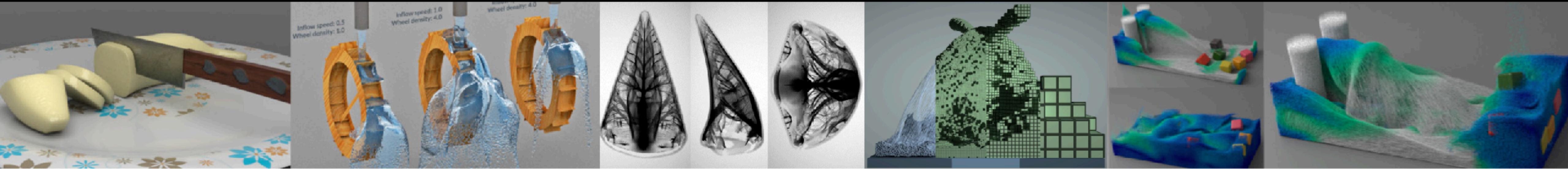
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MIT CSAIL

 Taichi  
Programming Language



# Logistics

- ◆ Taichi v0.6.8

- 国内安装请考虑使用豆瓣源~

- ◆ Homework 0可以继续提交

- 优秀作品：<https://zhuanlan.zhihu.com/p/146520831>

- 神秘礼物

- 作业1下周发布

- ◆ python v.s. ipython

- ◆ Jupiter notebook

# 论坛提交作业的几个小问题

- ◆ 代码格式化 yapf + PEP8

- ◆ 论坛中贴代码 (Markdown)

```
```python
```

```
import taichi as ti
```

```
```
```

- ◆ 展示结果

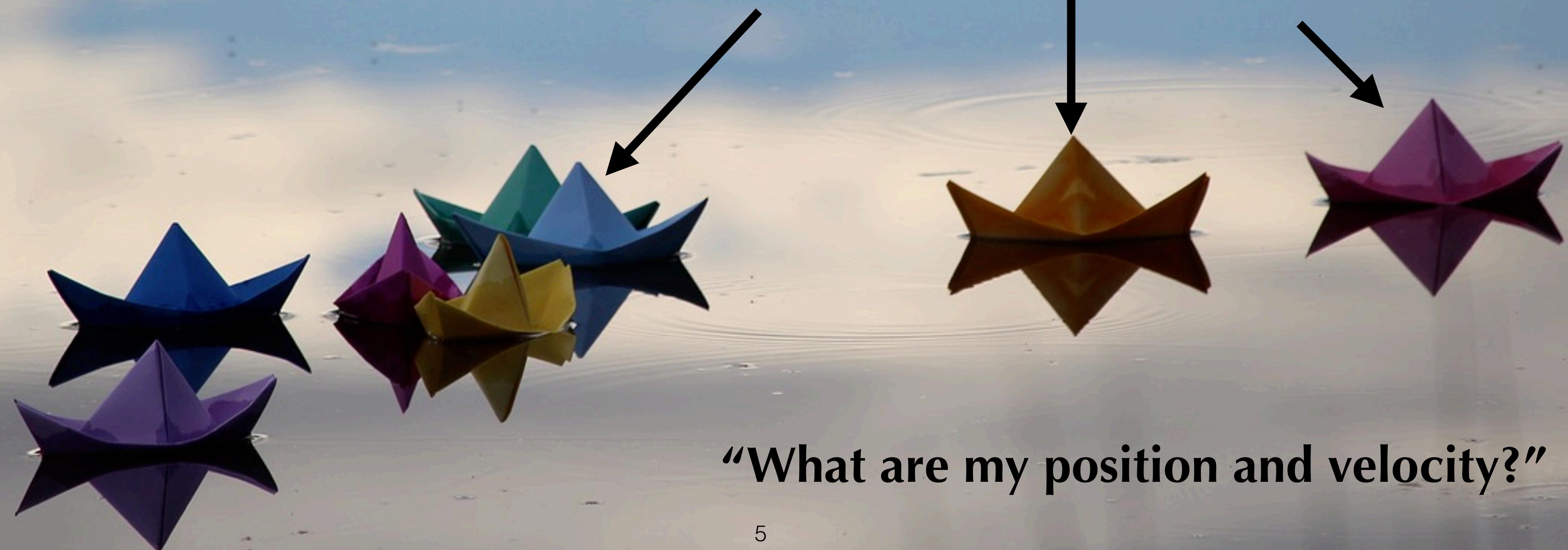
- 输出gif (这节课最后会提到细节)

- ◆ Faster compilation:

```
ti.core.toggle_advanced_optimization(False)
```

# **Lagrangian v.s. Eulerian: Two Views of Continuums**

# Lagrangian View



# Eulerian View

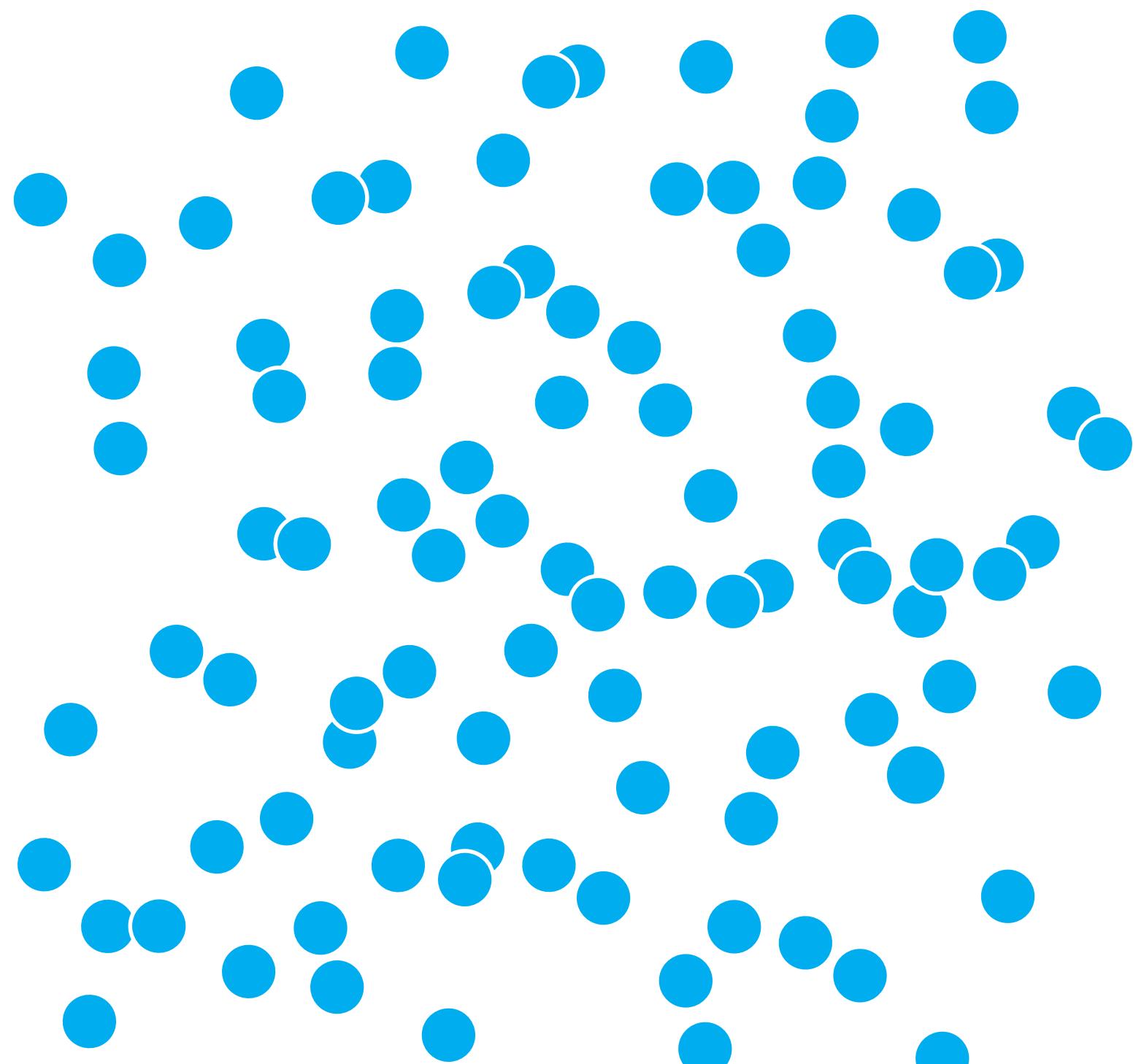
“What is the material velocity passing by?”



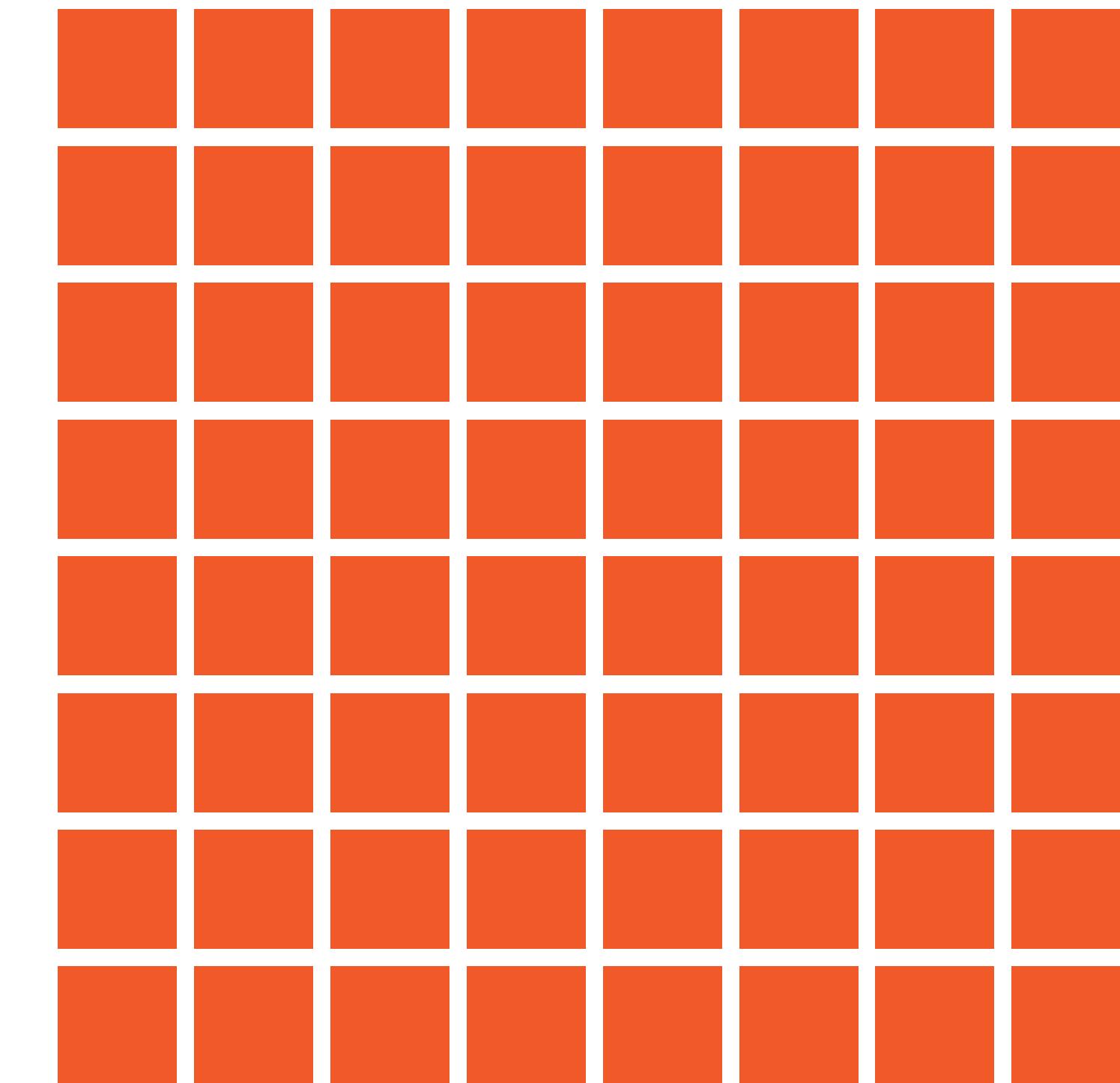
Still sensors that never moves

<https://www.peakpx.com/15/gray-wooden-pillar-lot-on-body-of-water>

# Continuum Simulation

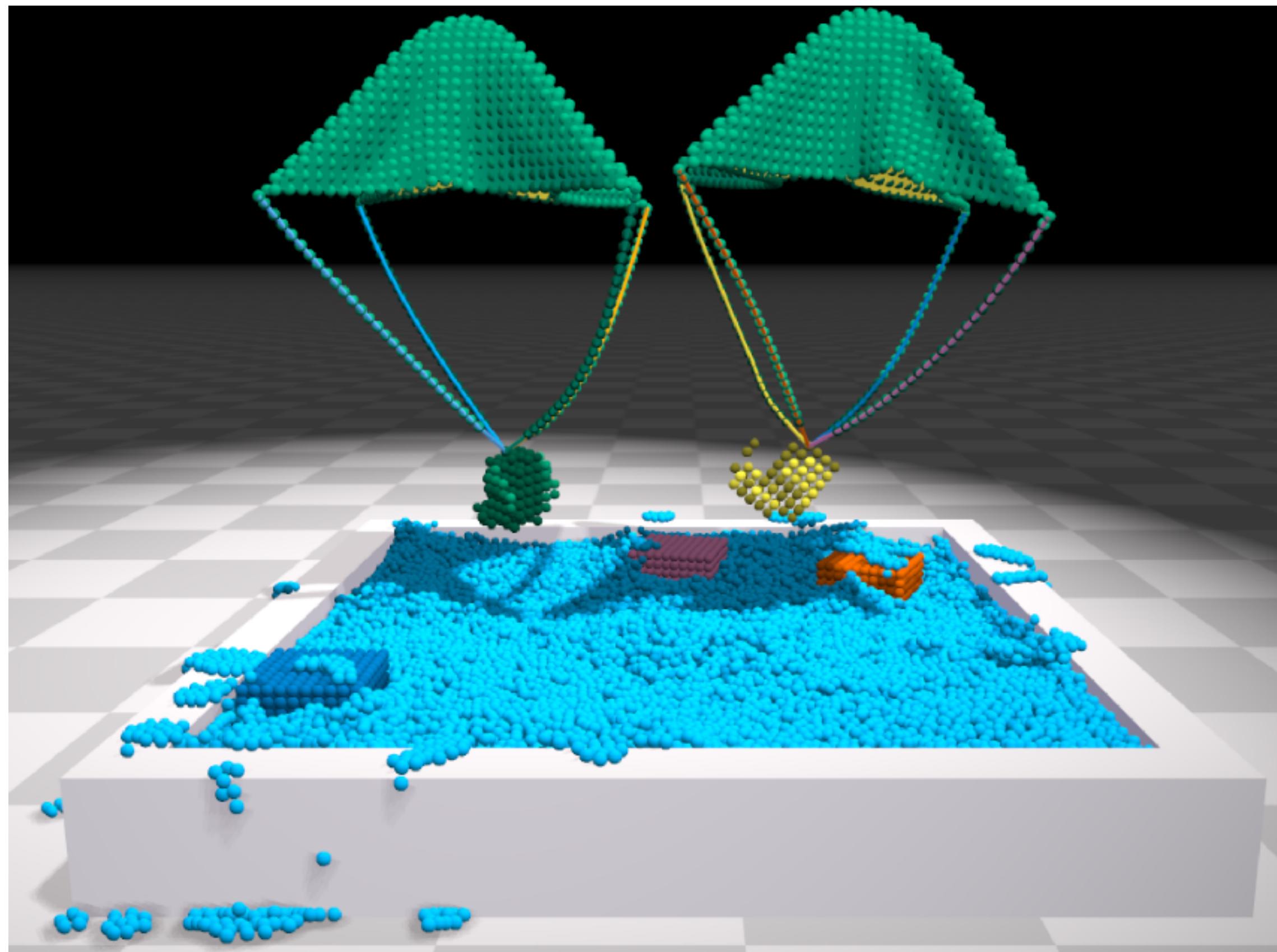


Lagrangian representation



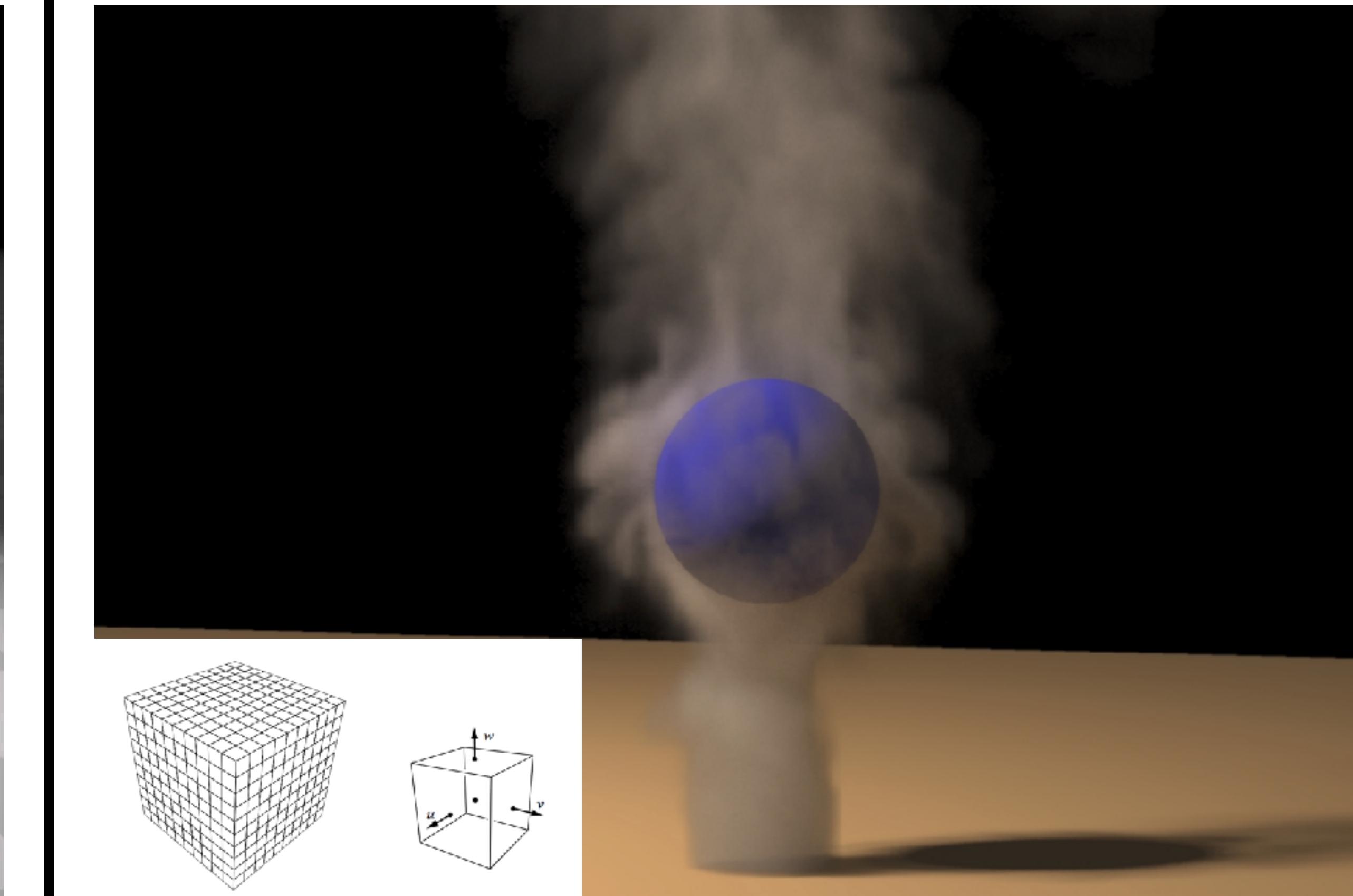
Eulerian representation

# Continuum Simulation



Lagrangian representation

[Macklin et al. 2014,  
Unified Particle Physics for Real-Time Applications]

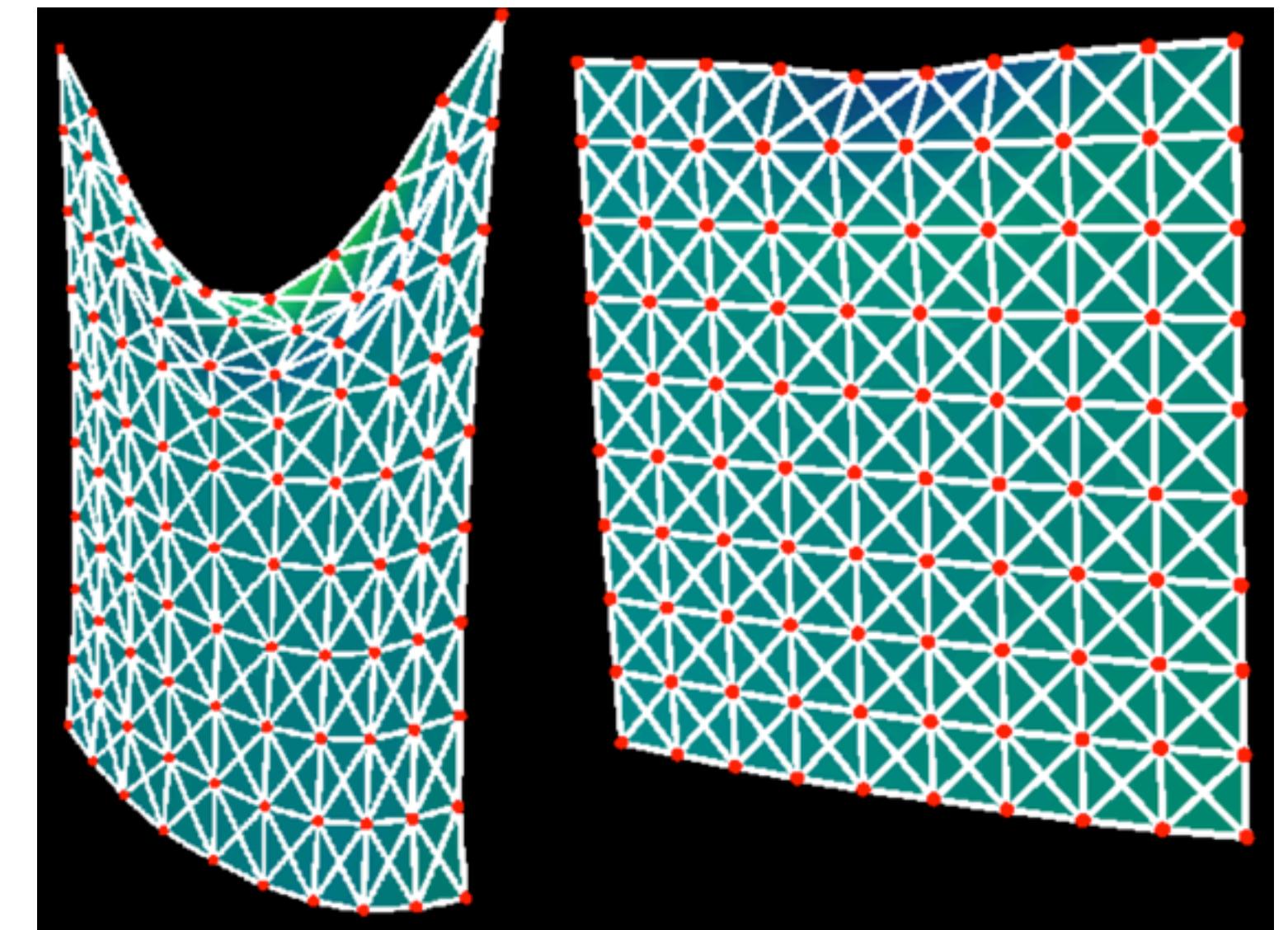
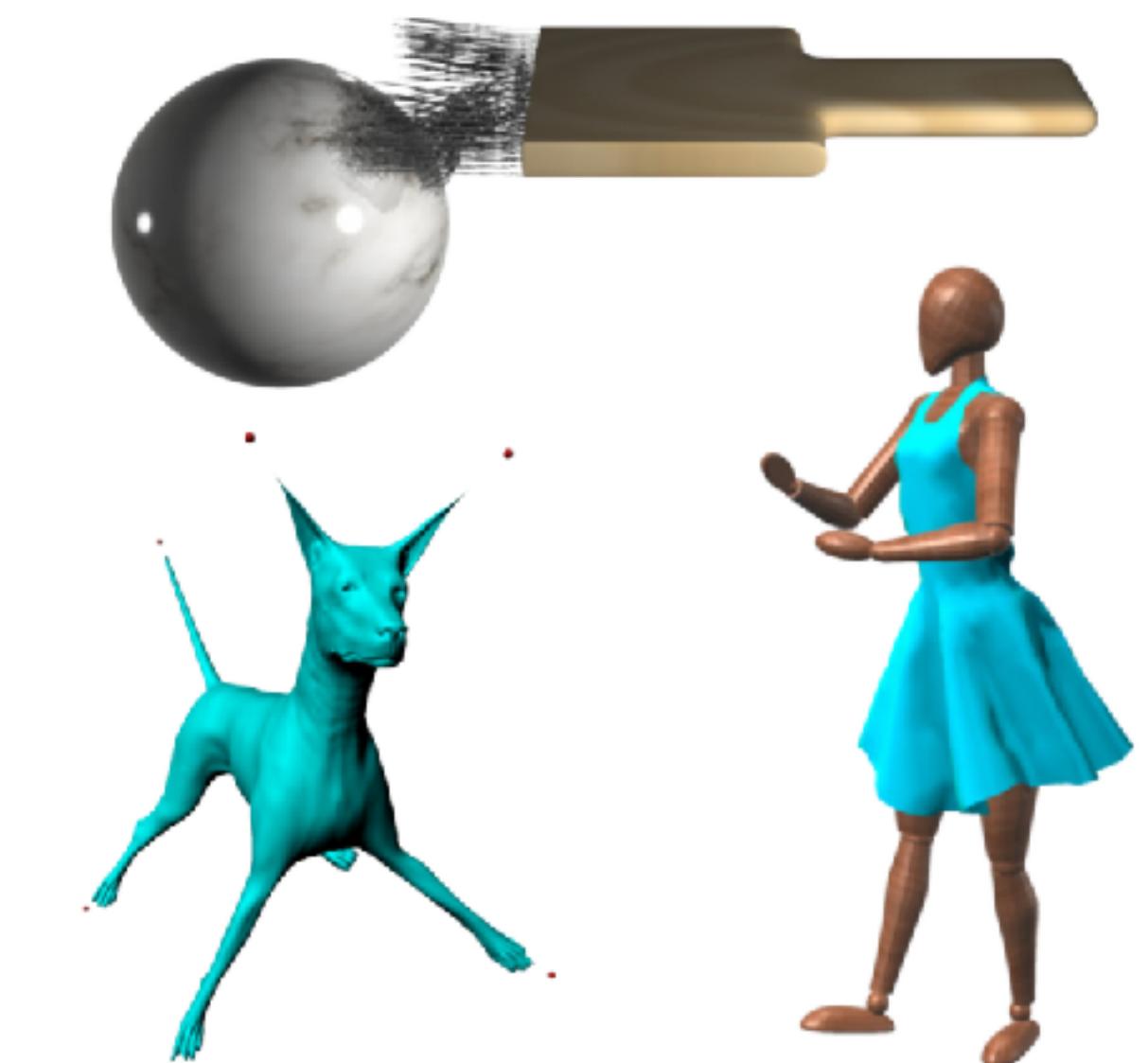


Eulerian representation

[Fedkiw 2001, Visual Simulation of Smoke]

# Mass-Spring Systems

- ♦ **Extremely simple**
- ♦ **But very useful!**
  - Cloth
  - Elastic objects
  - ...



Fast Simulation of Mass-Spring Systems, Liu et al.  
<https://www.cs.utah.edu/~ladislav/liu13fast/liu13fast.html>

<https://graphics.stanford.edu/~mdfisher/cloth.html>

# World of Goo



retry

0 of 8 collected menu

<https://www.nintendo.com/games/detail/build-a-bridge-switch/>

# Build a Bridge!





Lagrangian  
Simulation  
Approaches

Yuanming Hu

Modelling  
Physical  
Systems

Mass-spring  
systems

Time integration

Lagrangian fluid  
simulation:  
Smoothed  
particle  
hydrodynamics

# Lagrangian Simulation Approaches

## Mass-Spring Systems and Smoothed Particle Hydrodynamics

Yuanming Hu

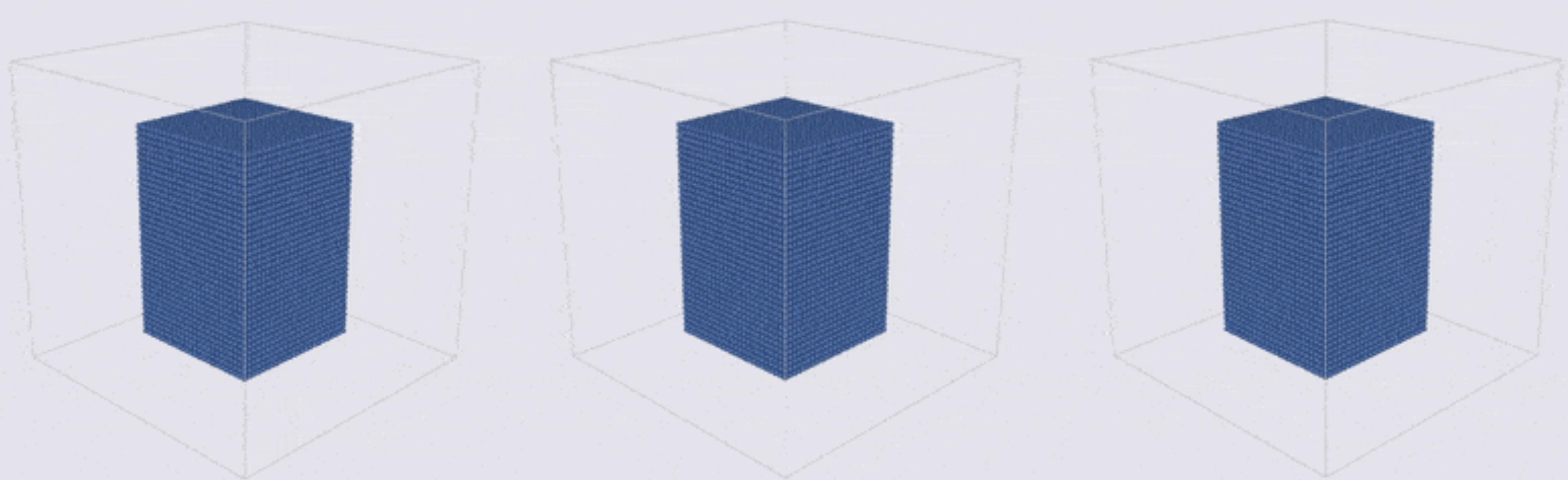
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June 8, 2020

# C++ Fluid Particles (by Xiao Zhai)

- ♦ **Smoothed Particle Hydrodynamics (SPH) implemented with C++ and CUDA**
  - Weakly Compressible SPH
  - Position-Based Fluids
  - Divergence-Free SPH
  - ...
- ♦ <https://github.com/TroyZhai/CPP-Fluid-Particles>

# C++ Fluid Particles (by Xiao Zhai)

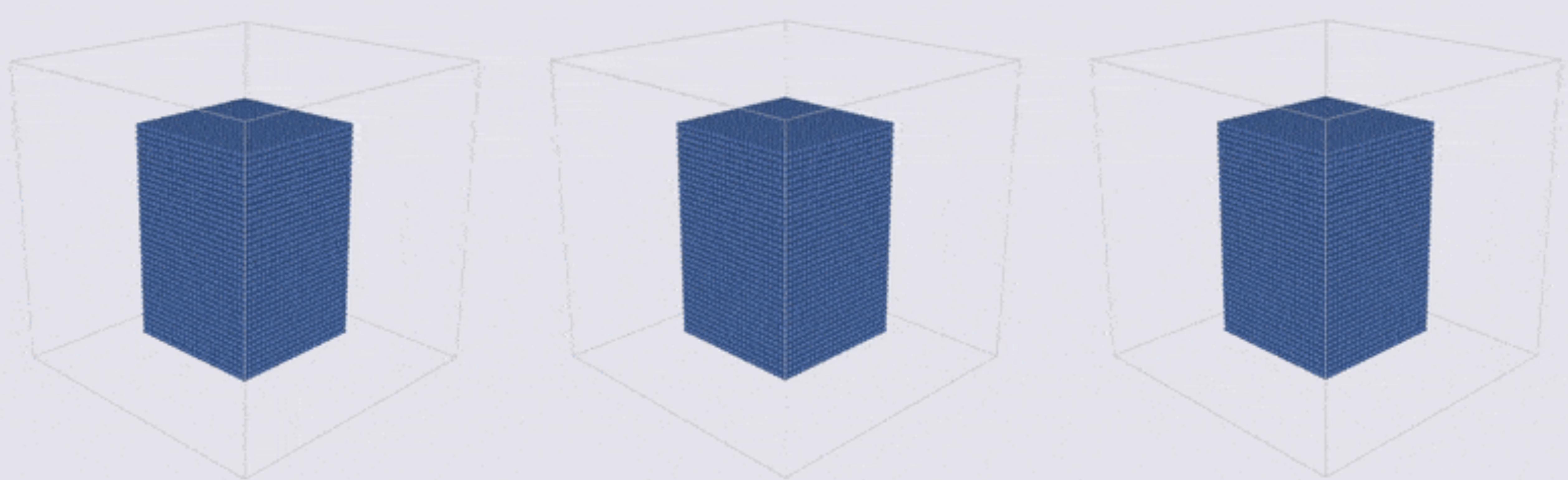


**WCSPH**

**DFSPH**

**PBD**

# C++ Fluid Particles (by Xiao Zhai)

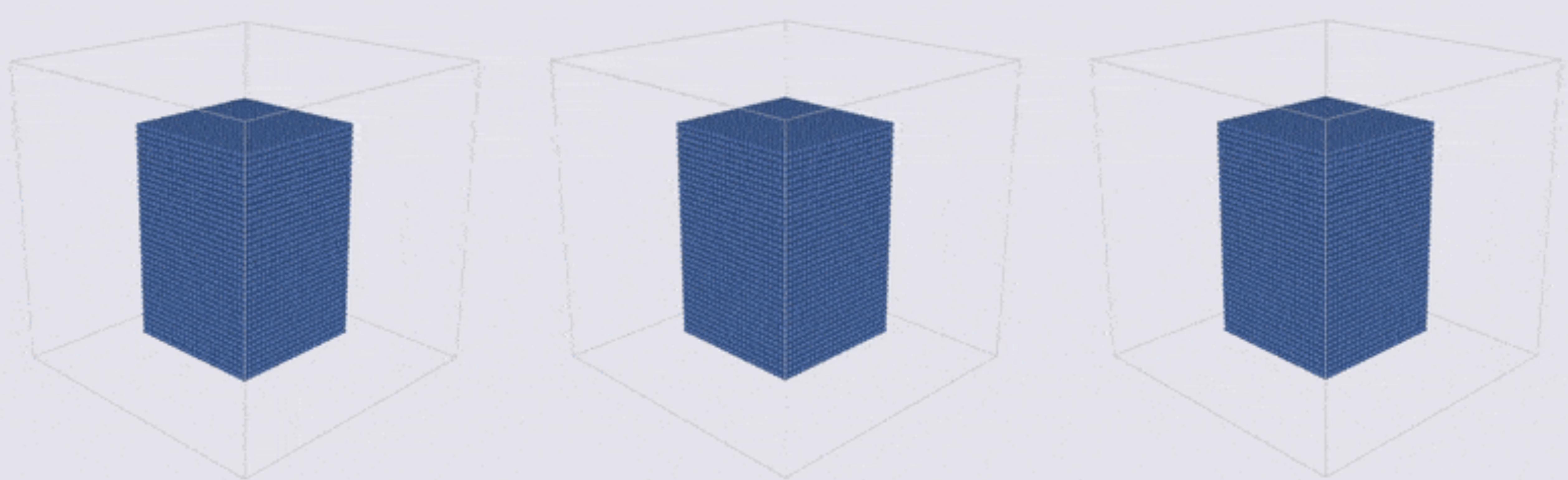


**WCSPH**

**DFSPH**

**PBD**

# C++ Fluid Particles (by Xiao Zhai)



**WCSPH**

**DFSPH**

**PBD**

# Interlinked SPH Pressure Solvers for Strong Fluid-Rigid Coupling

C. Gissler<sup>1,2</sup>, A. Peer<sup>1</sup>, S. Band<sup>1</sup>, J. Bender<sup>3</sup>, M. Teschner<sup>1</sup>

<sup>1</sup>University of Freiburg, Germany

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The end

**Questions are welcome!**