Open Boundaries: Inlet and Outlet Conditions

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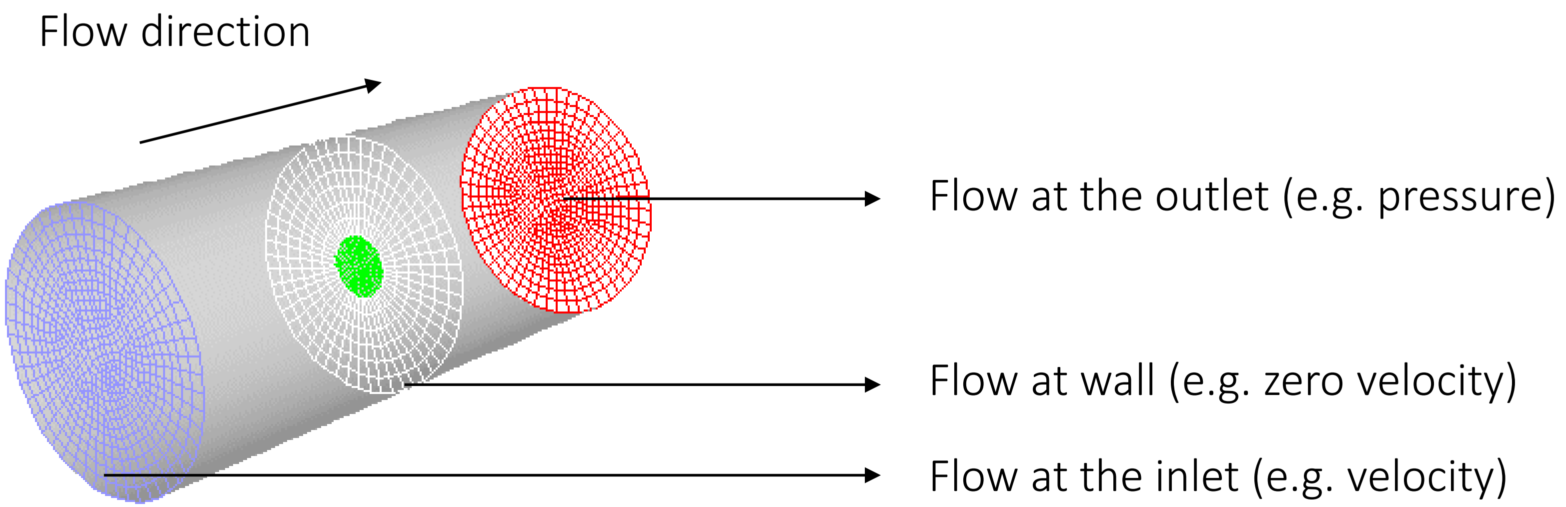
Outline

- Theoretical Background
- DualSPHysics Implementation
- Applications
- Ongoing Developments

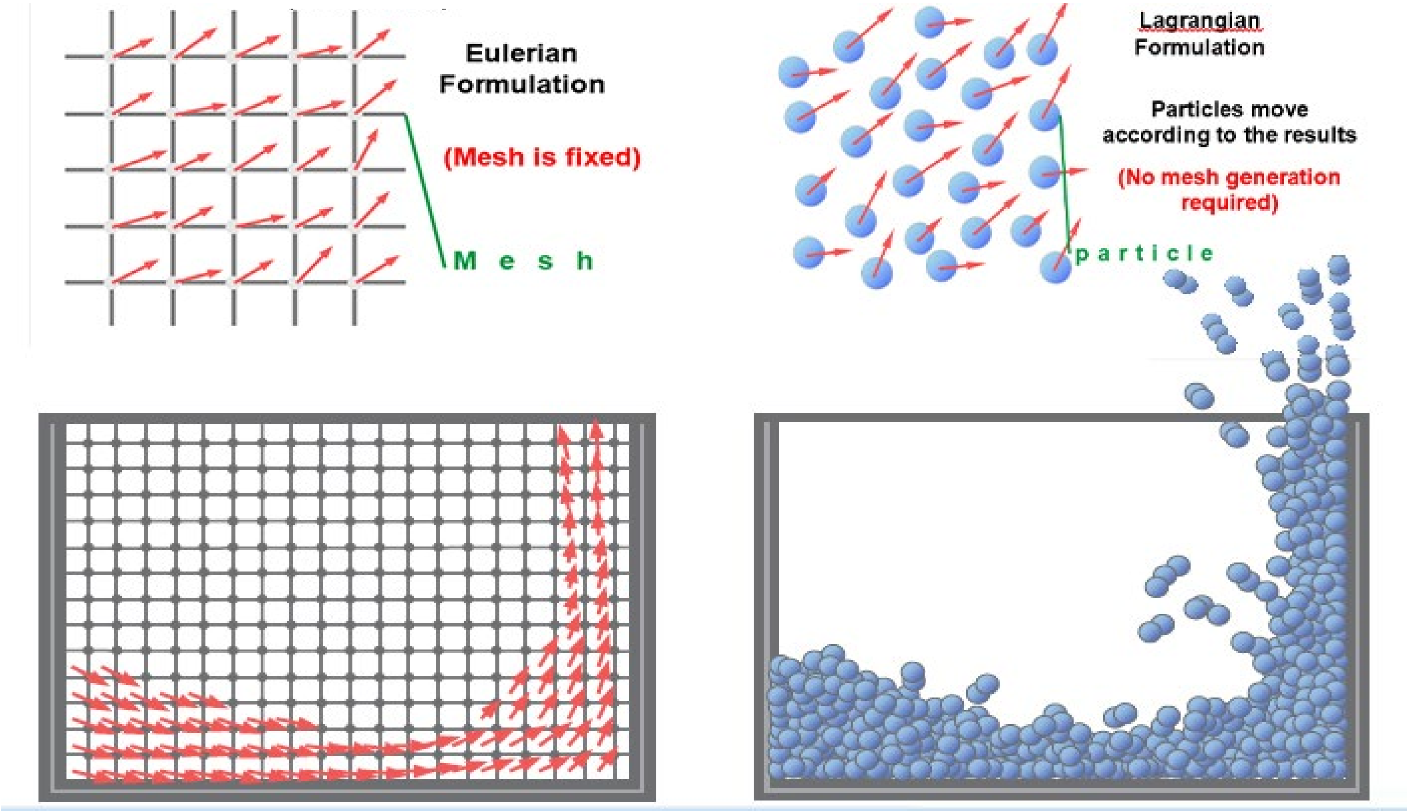
Importance of BCs

- Boundary conditions are a required component of the mathematical model
- Specify fluxes into the computational domain, e.g. mass, momentum, and energy
- Boundaries direct motion of flow



Modelling Boundaries

Generally Easier



Generally Harder

Source: Powersys solutions

SPH and Boundaries

GC#1: Convergence, consistency and stability

Leaders: J.J. Monaghan, D. Violeau and R. Vignjevic

GC#2: Boundary conditions

Leaders: A. Souto-Iglesias and J-C. Marongiu

GC#3: Adaptivity

Leaders: B.D. Rogers and R. Vacondio

GC#4: Coupling to other models

Leaders: D. Le Touzé, S. Marrone and C. Altomare

GC#5: Applicability to industry

Leaders: J-C. Marongiu and M. De Leffe

Approaches to Inflow/Outflow

- Unified Semi-Analytical Open Boundary Conditions
- Open Boundary Conditions via Mirror Particles
- Open Boundary Conditions via Buffer Regions ☑

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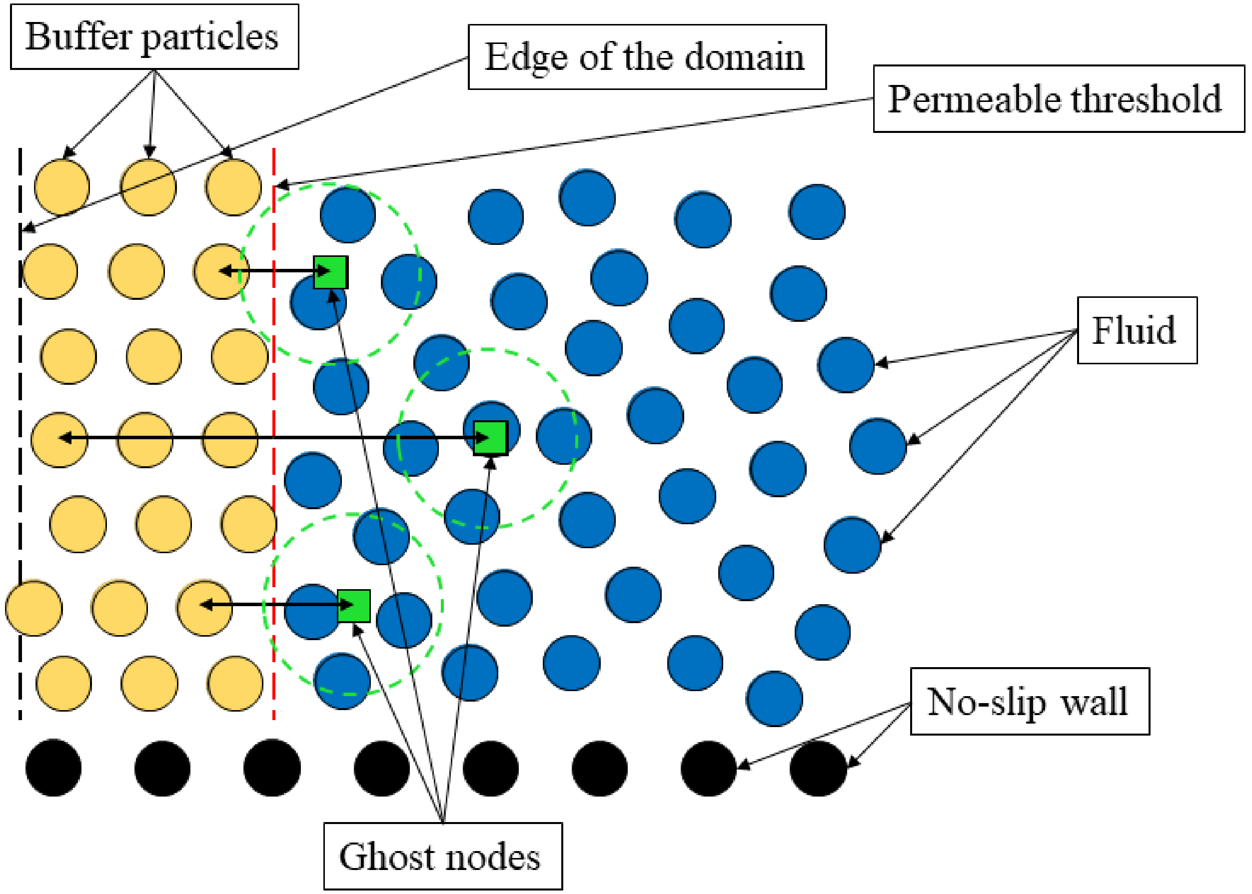
DualSPHysics Implementation



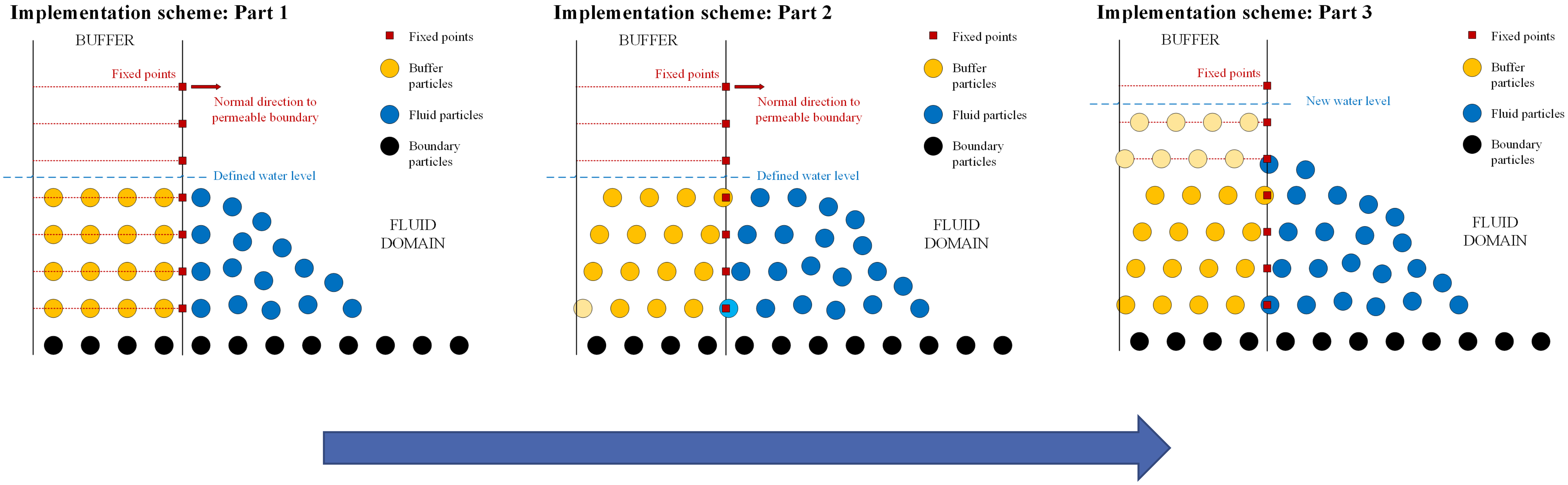
- Ghost nodes are *positioned* by mirroring along the normal distance to OBPs

- Standard SPH interpolation + correction to *retrieve* first order accuracy and consistency

  (Liu and Liu, 2006)

- Properties of the ghost nodes are *mirrored back* to OBPs (2nd order approx.)

DualSPHysics Implementation



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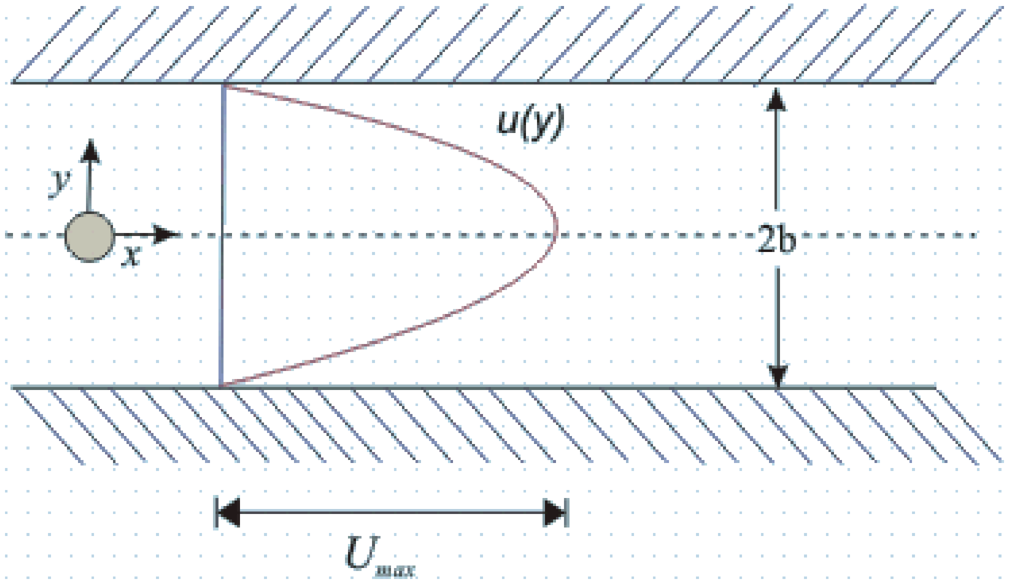
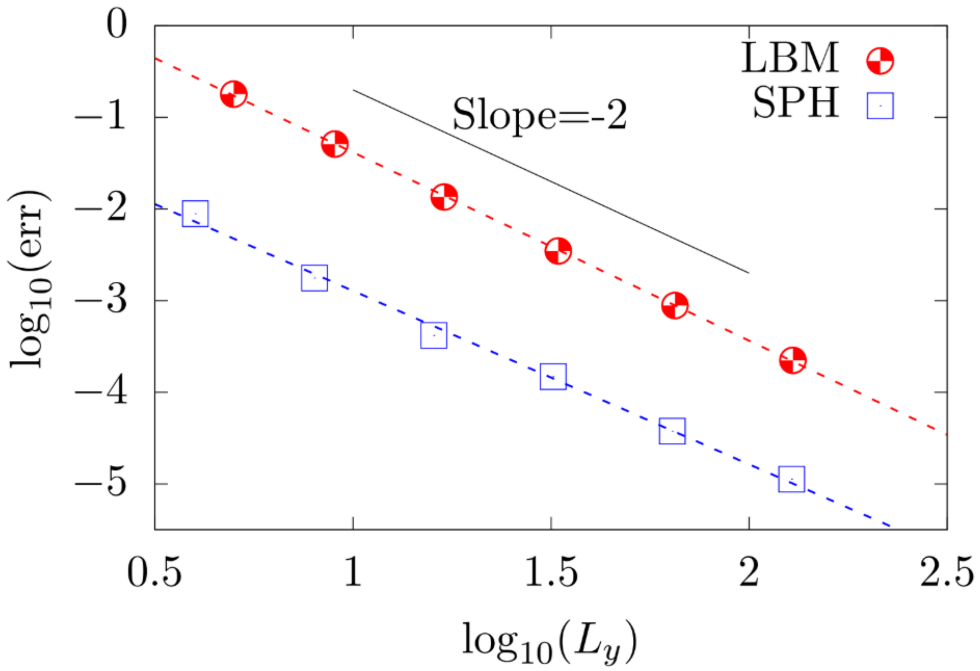
Internal Flow



Sketch of the 2-D Poiseuille flow problem

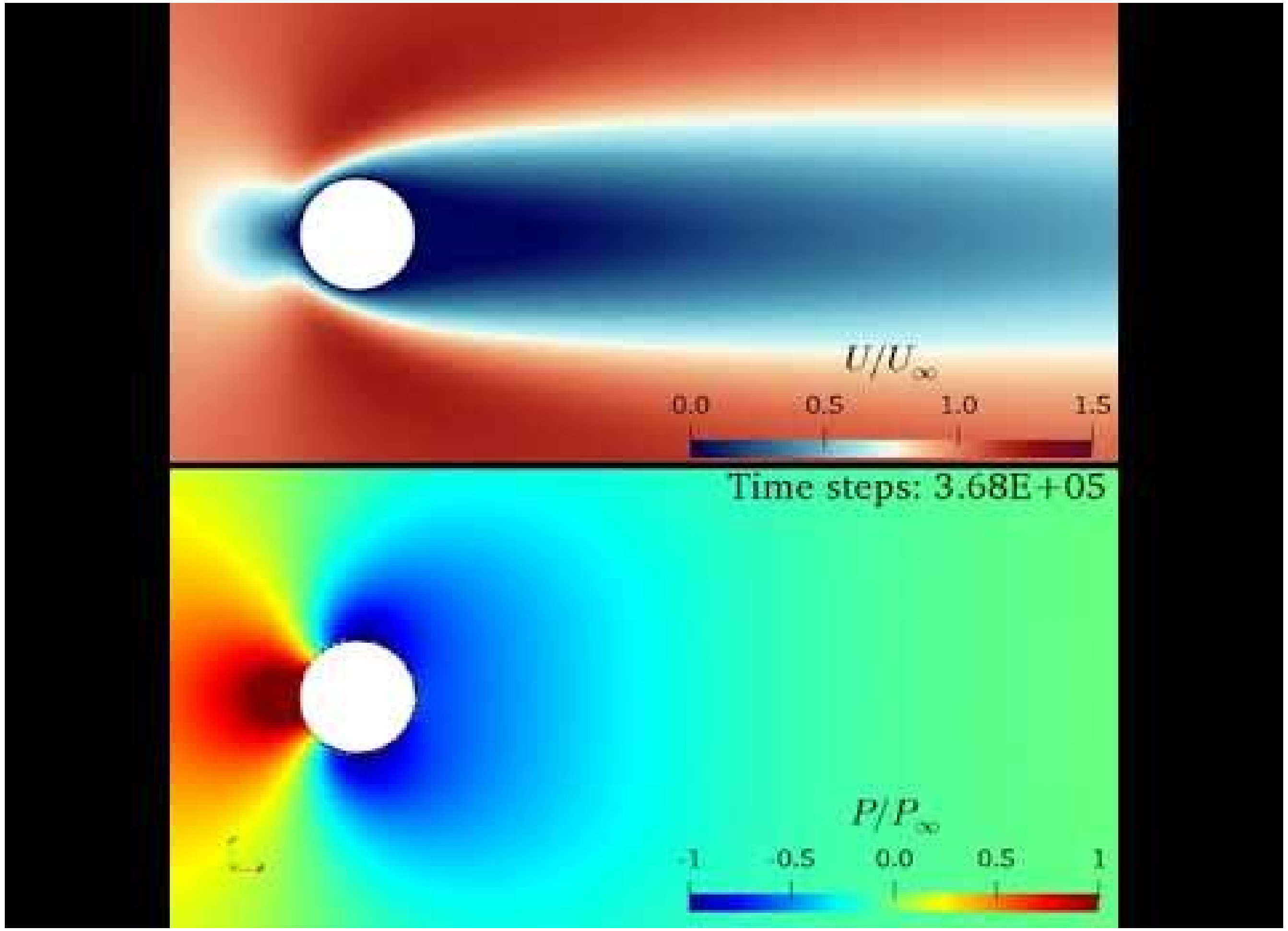


L-2 norm of the error wrt the analytical solution

Tafuni, A. and De Rosis, A. Paper in preparation

External Flow

- Re = 20
- VELOCITY
  - Imposed at inlet
  - Extrapolated at outlet
- DENSITY
  - Imposed at inlet
  - Extrapolated at outlet



Tafuni, A. et al. 2018, CMAME

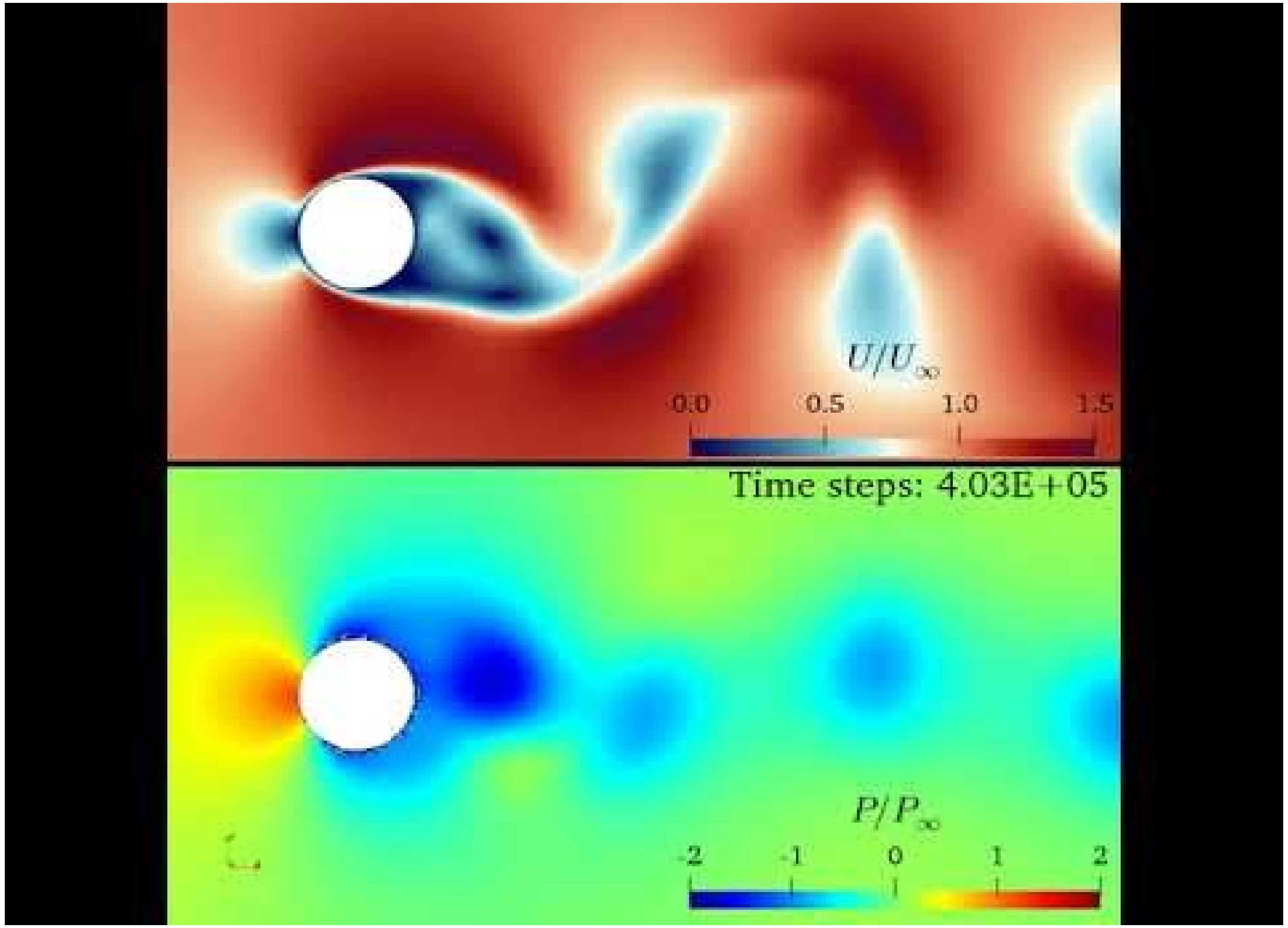
External Flow

- Re = 200

- VELOCITY
  - Imposed at inlet
  - Extrapolated at outlet

- DENSITY
  - Imposed at inlet
  - Extrapolated at outlet

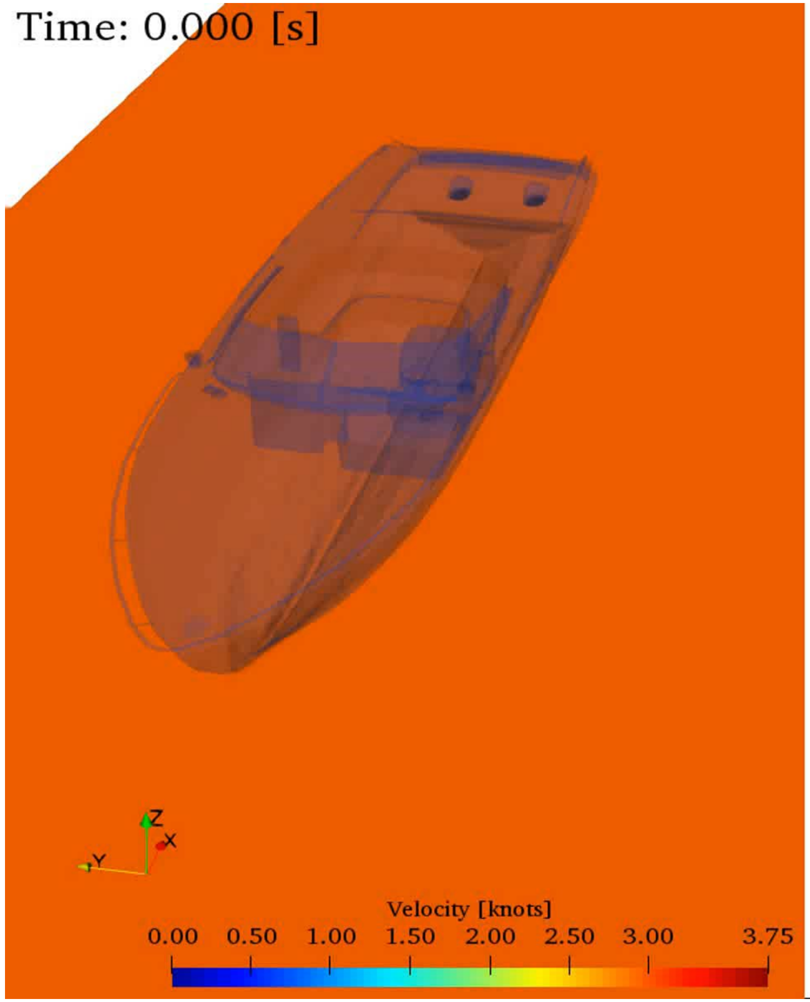
Tafuni, A. et al. 2018, CMAME

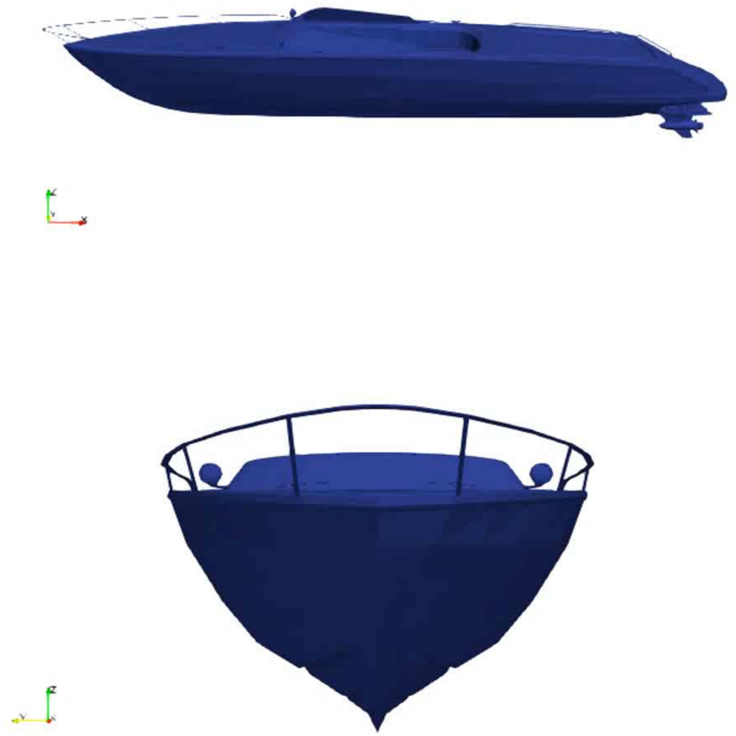


3-D Free Surface Flow

DualSPHysics + Project Chrono

- Boat is hinged at its center of gravity
- Inflow/outflow condition simulate flow past the boat
- Chrono applies the proper forces to the boundary particles so that the boat is not carried away with the fluid





Ongoing research

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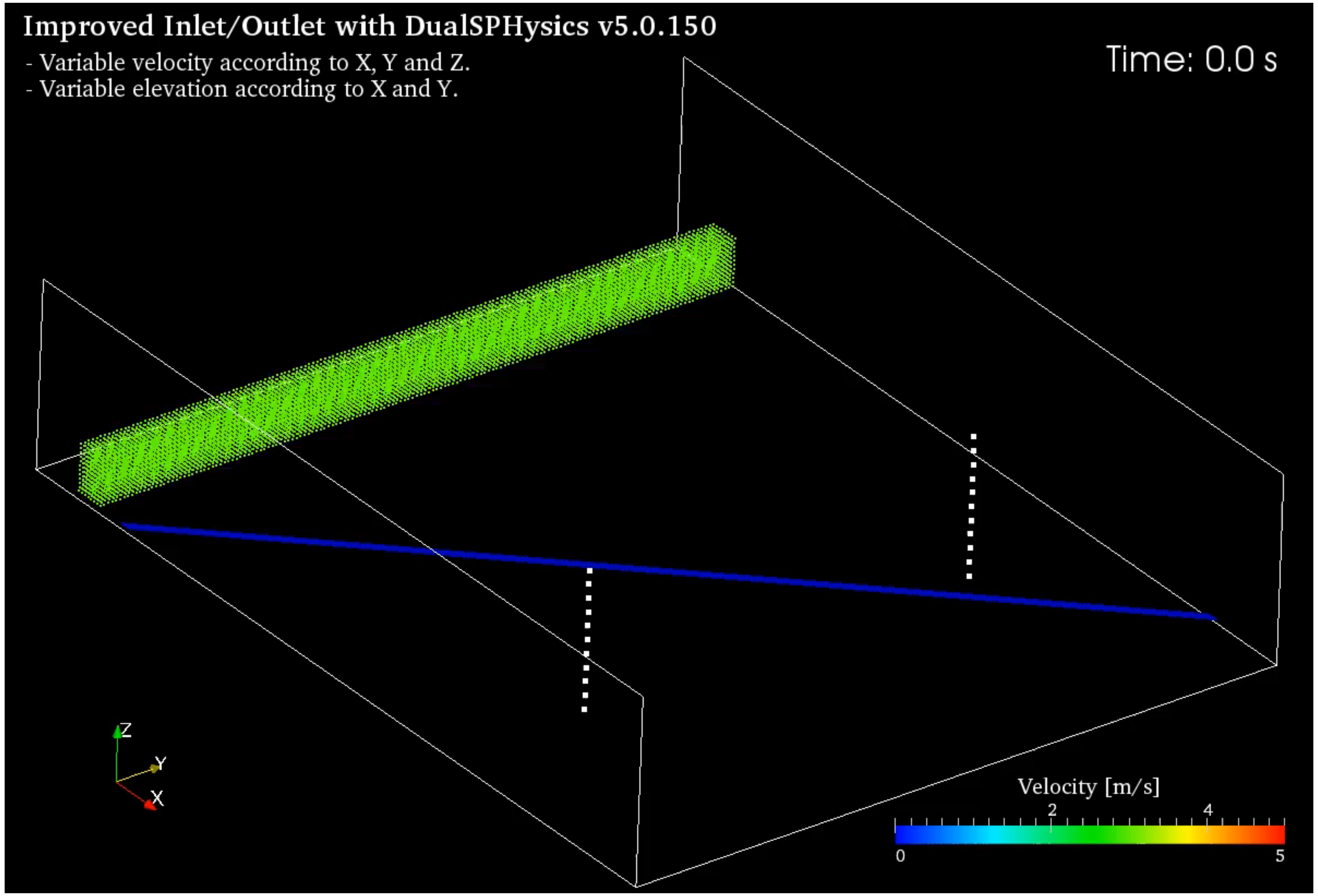
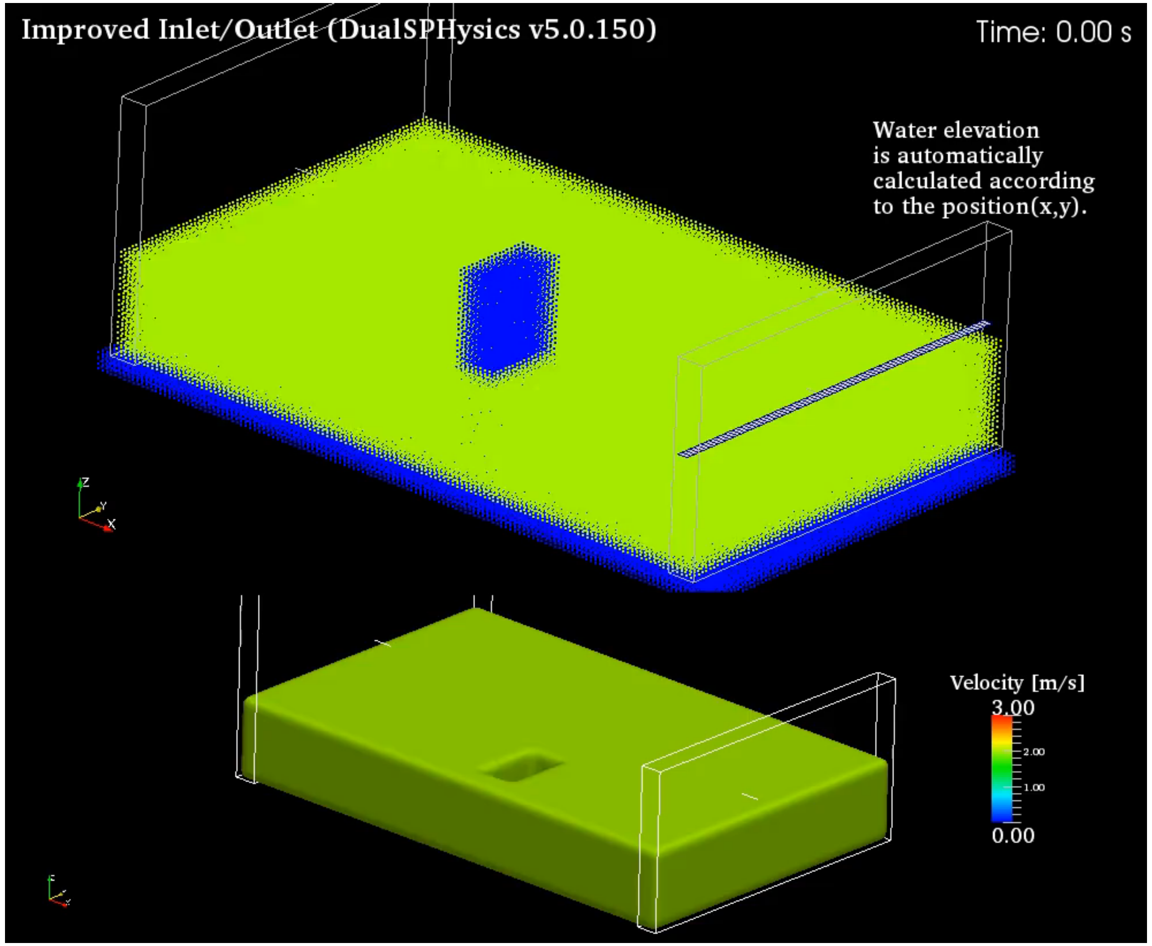
Advanced Features



Ongoing research

Advanced Features



Ongoing research

Conclusion

- Boundary treatment is not straightforward in SPH
- DualSPHysics incorporates open boundaries based on the buffer region formulation
- The I/O formulation has been applied to several validated 2-D and 3-D flows
- It takes some time plus experience to set up boundary conditions properly; in some cases, further code development is requred

DualSPHysics Wiki

Home

Alejandro J. C. Crespo edited this page on Apr 7, 2020 · 54 revisions

DualSPHysics is based on the Smoothed Particle Hydrodynamics model named SPHysics.

The code is developed to study free-surface flow phenomena where Eulerian methods can be difficult to apply, such as waves or impact of dam-breaks on off-shore structures. DualSPHysics is a set of C++, CUDA and Java codes designed to deal with real-life engineering problems.

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https://github.com/DualSPHysics/DualSPHysics/wiki

Thank you

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