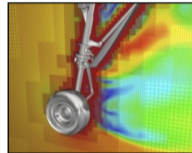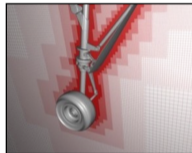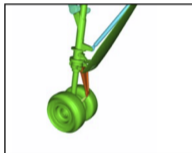# Embedded boundaries and Interfaces

IBM and turbulent aerodynamics

- ▶ Work done with ONERA, PhD of Benjamin Constant
- ▶ **Context**

- ▶ **IBM on non conformal meshes**
  - ▶ Uses automatically generated structured Cartesian grids
  - ▶ Ghost-cells direct forcing approach to set up boundaries conditions
- ▶ **Algebraic wall function for turbulent flows**
  - ▶ Avoid a prohibitive number of cells close to the boundaries

Embedded boundaries and Interfaces
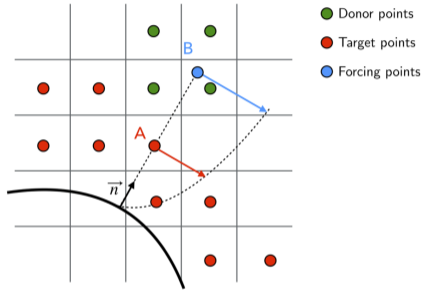
IBM and turbulent aerodynamics

Figure : Direct forcing on an IB target point (A) using its corresponding image point (B).

Classical IBM treatment

- One or two rows of target points

- The solution is computed at B using interpolation from donor points

- A Newton's method on the wall function gives the friction velocity used to compute the **tangential velocity** at A

- Normal velocity is computed using linear interpolation

- **Pressure** is directly extrapolated

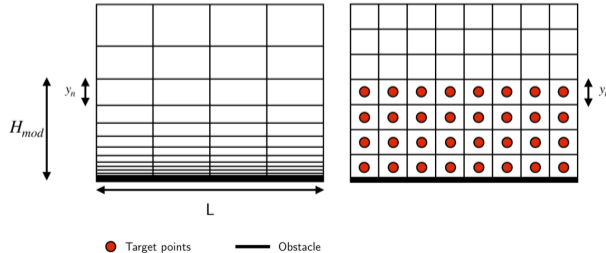- **Spalart pseudo-viscosity** is computed using the mixing length assumption

Embedded boundaries and Interfaces

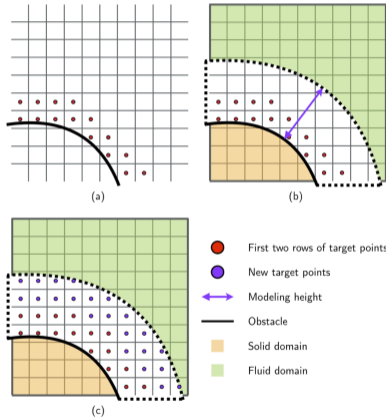**Observations with the classical treatment**

- ▶ Spurious oscillations on the wall
- ▶ Skin friction coefficient badly captured
- ▶ Grid refinement level change issues

Solution proposed

- ▶ Impose near-wall spacing and chose a target y^+ for image points
- ▶ Compute a modeling height H_{mod} using a flat plate approximation
- ▶ Define the number of target points according to H_{mod}

● Target points ▬▬▬ Obstacle

Embedded boundaries and Interfaces

(a)

(b)

(c)

Legend:
- ● First two rows of target points
- ● New target points
- ↔ Modeling height
- — Obstacle
- ▨ Solid domain
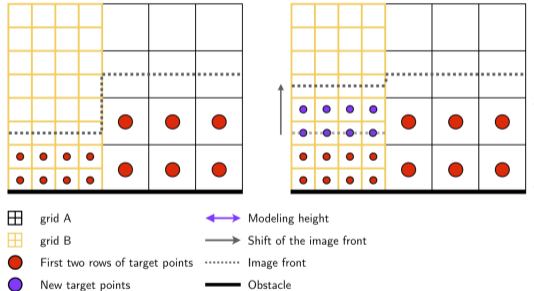- ▨ Fluid domain

Developments

- ▶ Impose near-wall spacing and chose a target y^+ for image points

- ▶ Compute a modeling height H_{mod}

- ▶ Define the number of target points according to H_{mod}
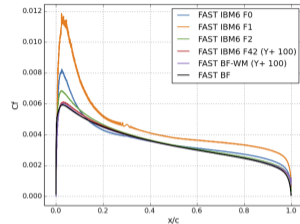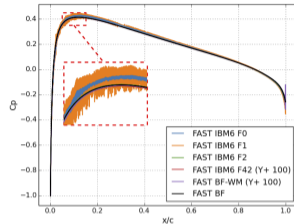
Publication

- ▶ JCP 435(2021) 110240
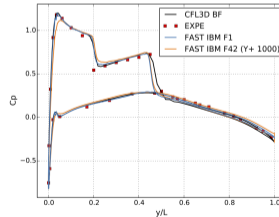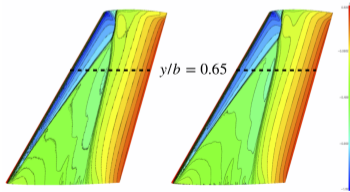
Embedded boundaries and Interfaces

▶ **Solves grid refinement level change issues**

⊞ grid A	◄──► Modeling height
⊞ grid B	──► Shift of the image front
🔴 First two rows of target points	⋯⋯ Image front
🔵 New target points	▬▬ Obstacle

Embedded boundaries and Interfaces

NACA0012 airfoil, Re = 6M, Ma = 0.15, $\alpha = 0^o$

$y/b = 0.65$

ONERA M6 wing, Re = 11.72M, Ma = 0.84, $\alpha = 3.06^o$