

## 2D flow around a heated square-cylinder - $Re_h = 50$ , $Ra = 5 \cdot 10^6$



A heated square-cylinder is placed in a channel flow

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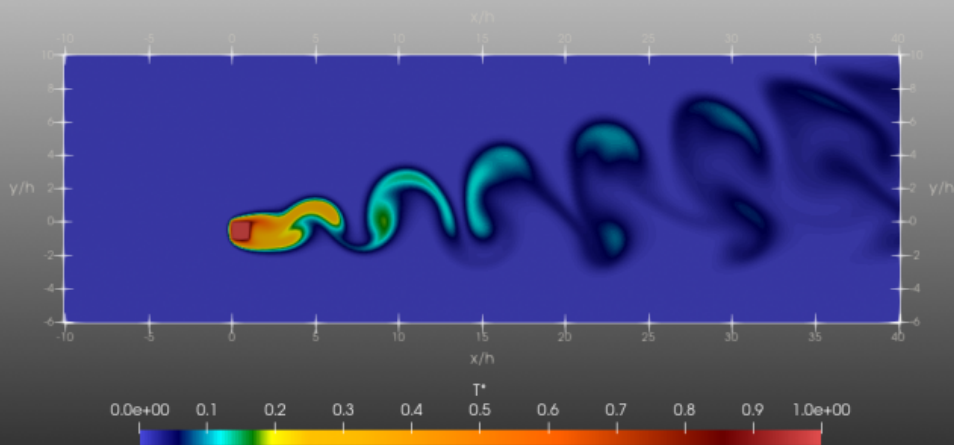
**Date** : June 2019

**Simulation type** : DNS ([Sunfluidh code](#))

**Location** : /DATABASE\_2DFLOW\_AROUND\_HEATED\_SQUARECYLINDER\_DNS

**Status** : Free access

**Data size** : ~ 3 Gb



[A video is available here](#)

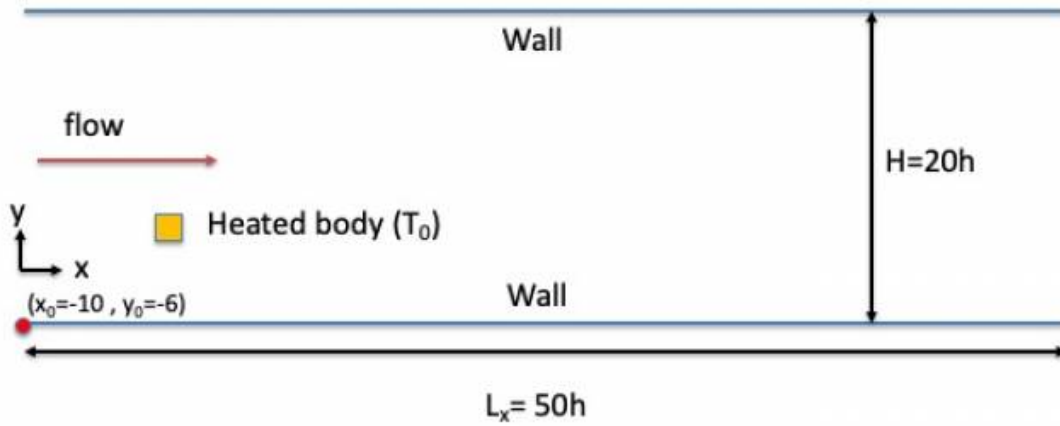
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### Simulation settings

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## 2D sketch



### Referential : cartesian geometry

1. axes :
  - $x(i)$  : downstream direction
  - $y(j)$  : normal direction
2. origin : lower left corner of the computational domain
  - $x_0 = 10h$
  - $y_0 = -6h$

### Reference scales

- Density : mass density of the fluid ( $\rho_0$ )
- Lengths : cylinder size ( $h$ ) and  $H_u = 10h$  the distance between the domain's top and the square-cylinder's top.
- Velocity : velocity at inlet ( $U_0$ )
- Dynamic viscosity : dynamic viscosity of the fluid ( $\mu_0$ )
- thermal diffusivity : ( $\kappa_0$ )

- Reynolds number :  $Re_H = \frac{\rho_0 U_0 h}{\mu_0} = 50$
- Rayleigh number :  $Ra = \frac{\rho_0 \beta g \Delta T H_u^3}{\mu_0 \kappa_0} = 5 \cdot 10^6$

## Non-dimensionalised data

- velocity :  $U^* = \frac{U}{U_0}$
- density :  $\rho^* = \frac{\rho}{\rho_0} = 1$
- coordinates :  $x^* = \frac{x}{h}$ ,  $y^* = \frac{y}{h}$
- temperature :  $T^* = \frac{T - T_c}{T_h - T_c}$  ( $T_h$  and  $T_c$  are respectively the temperature imposed at the cylinder's walls and the temperature at the inlet and channel's walls)

## Computational domain

### 1. Domain scope

1. computational domain size (channel flow)
  - Downstream direction(x) :  $L_x^* = 50.0$  (upward part  $L_u = -10$ , downward part  $L_d = 40$ )
  - Normal direction (y) :  $L_y^* = 20.0$
2. heated square cylinder
  - size:  $h^* = 1$
  - temperature  $T_h^* = 1$

### 1. Boundary conditions

- Inlet : imposed pressure uniform velocity ( $U_0 = 1$ )
- Outlet : Orlansky type
- Bottom and top conditions : walls at ( $T_c^* = 0$ )

### 2. Spatial resolution

- mesh size :  $512 \times 256$  (131.072 cells)
- About cell-size
  - $\Delta x^*$  : from  $0.03125$  to  $0.723$  (downstream direction)
  - $\Delta y^*$  : from  $0.03125$  to  $0.187$  (normal direction)

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## Data features

### • Time series

- from probes
  - Physical quantities : velocity components along x and y directions (u,v) and pressure (p)
  - 1 probe
  - Time step =  $2 \cdot 10^{-2}$  time unit
  - Time range : 400 to 600 time units
  - Location :  $X_i = 3.5$ ,  $X_j = 0.0$
  - File name (per physical quantity):  $x\_ins\_00000.d$  with  $x = u, v, p$

- about cylinder motion
  - center position as a function of time (ASCII file `ibm_position01.dat`)
  - cylinder velocity as a function of time (ASCII file `ibm_velocity01.dat`)
  - global force components applied to the cylinder (ASCII file `ibm_force01.dat`)
  - force contributions exerted on the moving cylinder (ASCII file `ibm_force_contribution01.dat`, the four last columns can be ignored)
- **3D snapshots**
  - Instantaneous fields : velocity components in x, y and z directions (U,V), the pressure (P) and the phase function related to the body motion (TRACE)
  - Recording rate : 0.4 time unit
  - Time range from from 200.0 to 600.0 time units
  - File name : `res_xxxxx_yyyyyyy.d`
    - MPI subdomain ID: 0
    - Time ID : from 3 to 502

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## Database organisation

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**Data size** : ~ 7 Gb

**Main directory** : `/vol/DATABASE_MECA/DATABASE_2DFLOW_AROUND_OSCILLATING_CYLINDER_DNS`

For more details about files, see the [wiki doc of Sunfluidh](#)

Intermediate directories (four cases of study)

- $St = 0.95$  and  $A = 0.2$  - directory : `CAS_F0.95_A0.2`
- $St = 0.95$  and  $A = 0.5$  - directory : `CAS_F0.95_A0.5`
- $St = 1.20$  and  $A = 0.2$  - directory : `CAS_F1.2_A0.2`
- $St = 1.20$  and  $A = 0.5$  - directory : `CAS_F1.2_A0.5`

Endpoint directories & files

```
/DATASETUP      : ASCII files
                  input data file for sunfluidh : input3d.dat
/GRID            : ASCII files
                  input data file           : data_meshgen.d
                  grid files for sunfluidh: maillx.d, mailly.d, maillz.d
/SNAPSHOTS       : snapshots binary files res_xxxxx_yyyyyyy.d
/TIMESERIES      : ASCII files
                  u_ins_00000.d , v_ins_00000.d and p_ins_00000.d
(timeseries of the velocity components and pressure from probe)
                  ibm_position01.dat, ibm_velocity01.dat (about cylinder
motion)
                  ibm_force01.dat, ibm_force_contribution01.dat (about
forces exerted on the cylinder)
```

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