

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



A heated square-cylinder is placed in a channel flow

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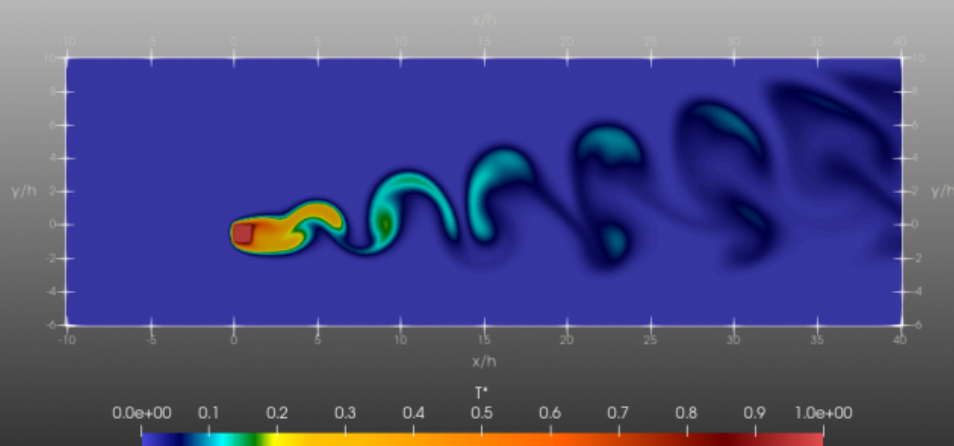
**Date** : June 2019

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

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

**Status** : Free access for laboratory members, on request for external members

**Data size** :  $\sim 1$  Gb



[A video is available here](#)

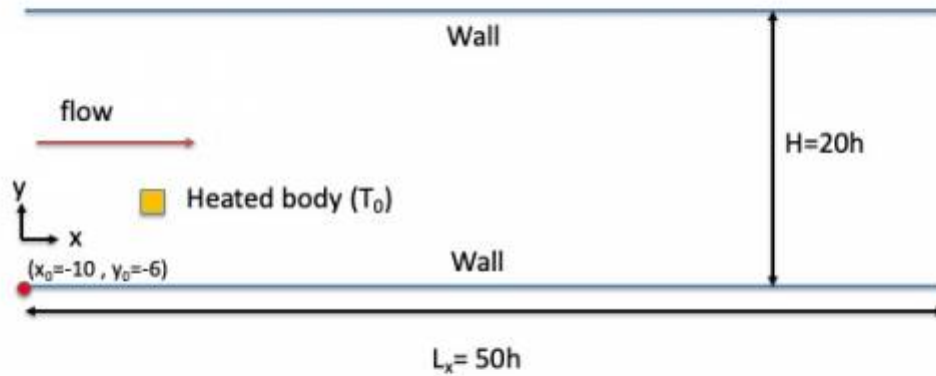
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## Simulation settings

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

## 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

- 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) :  $H^* = 20.0$
- heated square cylinder
  - size:  $h^* = 1$
  - wall 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

- Physical quantities : velocity components along x and y directions (u,v) and pressure (p)
- 1 probe
- Time step=  $\approx 6 \times 10^{-2}$  time unit (irregular time step)
- Time range : 250 time units
- Location :  $X_i = 20.0$ ,  $X_j = 2.0$
- File name (per physical quantity):  $x\_ins\_00000.d$  with  $x = u, v, t$

### • 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 : 1 time unit
- Time range from 20.0 to 250.0 time units

- File name : res\_XXXXX\_YYYYYYY.d
  - MPI subdomain ID: from 0 to 3 (case with MPI domain decomposition)
  - Time ID : from 0 to 250

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## Database organisation

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**Data size** : ~ 3 Gb

**Main directory** : /vol/DATABASE\_MECA/DATABASE\_2DFLOW\_HEATED\_SQUARRECYLINDER\_DNS

Directories & files

```
/DATASETUP      : ASCII files
                  input data file for sunfluidh : input3d.dat (and
input3d.dat_mpi4 for the case with MPI domain decomposition)
/GRID           : ASCII files
                  input data file           : data_meshgen.d
                  grid files for sunfluidh: maillx.d, mailly.d, maillz.d
(sequential case)
                  mesh.tar (archive containing
grid files for a domain decomposition with 4 MPI processes)
/SNAPSHOTS      : snapshots binary files res_XXXXX_YYYYYYY.d
/SNAPSHOTS_MPI4 : snapshots resulting from a domain decomposition with 4
MPI processes
/TIMESERIES     : ASCII files
                  u_ins_00000.d , v_ins_00000.d and t_ins_00000.d
(timeseries of the velocity components and temperature from probe)
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