

# 3D shear-layer driven cavity flow with forcing term at $Re_{L_c} = 7826$

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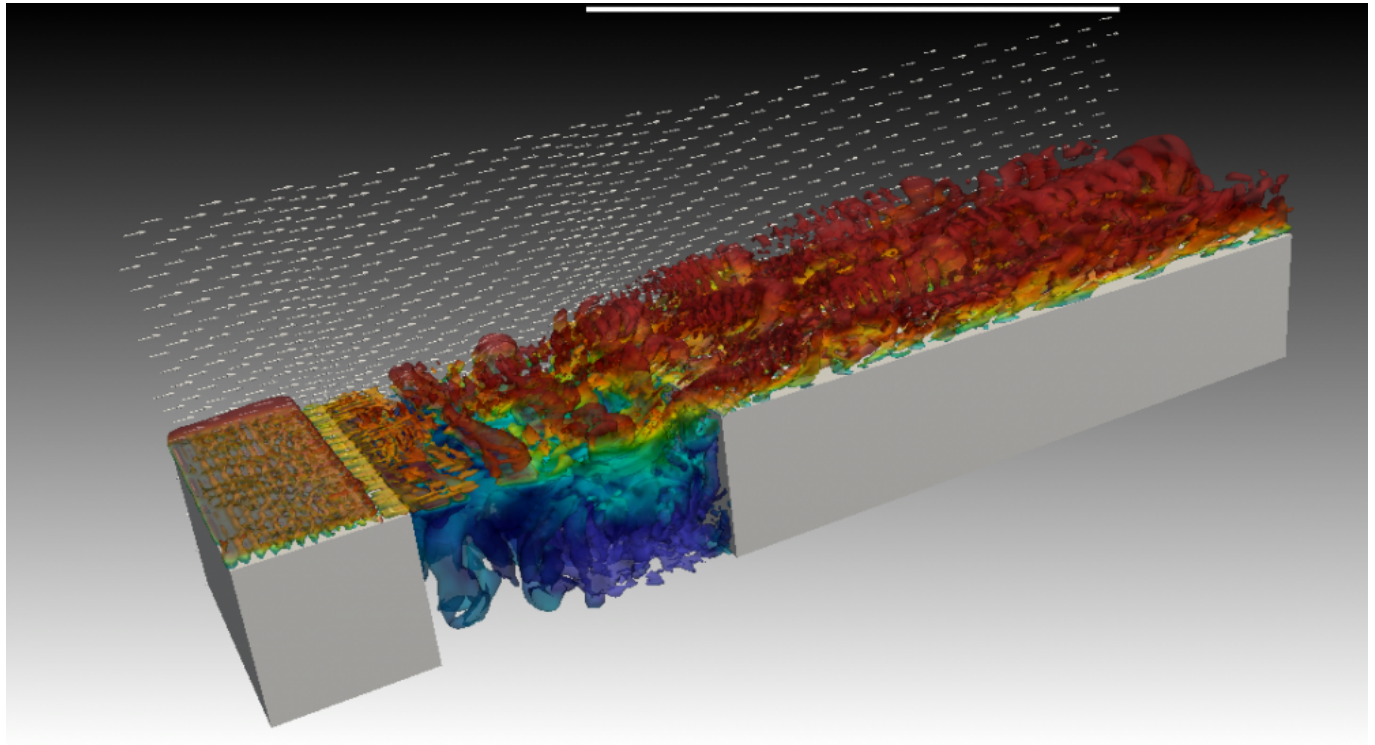
**Date** : July 2020

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

**Location** : DATABASE\_CAVITY3D\_R2\_RE7826\_PER1.0\_DNS/FORCINGTERM

**Status** : Free access

**Data size** : ~ 8.6 Go



[A video is available here](#)

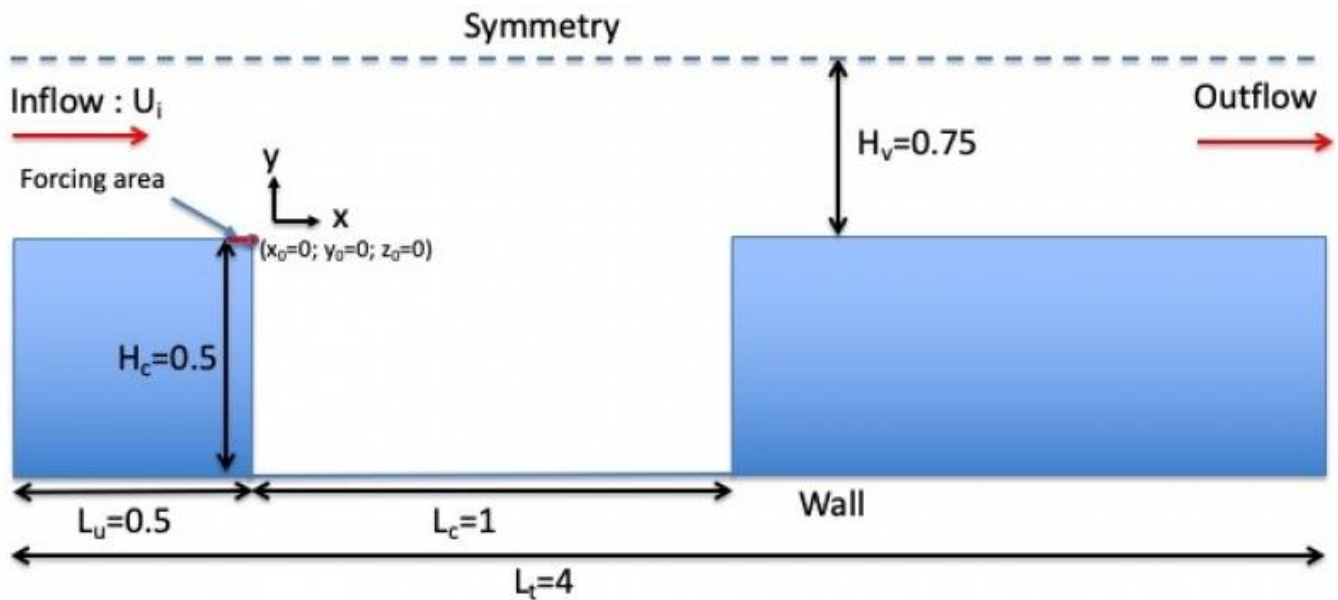
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## Simulation settings

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### 2D sketch



## Referential : cartesian geometry

1. axes :
  - $x(i)$  : downstream direction
  - $y(j)$  : normal direction
  - $z(k)$  : spanwise direction
2. origin :
  - $x_0 = 0$  : upstream edge of the cavity
  - $y_0 = 0$  : upstream edge of the cavity
  - $z_0 = 0$  : upstream edge of the cavity, at the mid-span location

## Reference scales

- Density : mass density of the fluid ( $\rho_0$ )
- Length : cavity length ( $L_c$ )
- Velocity : inlet bulk velocity ( $U_i$ )
- Dynamic viscosity : dynamic viscosity of the fluid ( $\mu_0$ )
- Reynolds number :  $Re_H = \frac{\rho_0 U_i L_c}{\mu_0} = 7826$

## Non-dimensionalised data

- velocity :  $U^* = \frac{U}{U_i}$
- density :  $\rho^* = \frac{\rho}{\rho_0} = 1$
- coordinates :  $x^* = \frac{x}{L_c}$ ,  $y^* = \frac{y}{L_c}$ ,  $z^* = \frac{z}{L_c}$

## Computational domain

1. **Domain scope**
  - Downstream direction ( $x$ ) :  $L^* = 4.0$
  - Normal direction ( $y$ ) :  $H_t^* = 1.25$
  - Spanwise direction ( $z$ ) :  $l^* = 1.0$

- upstream vein length :  $L_u^* = 0.5$
- cavity height :  $H_c^* = 0.5$

## 2. Boundary conditions

- Inlet : Blasius' profile at  $X_{in}^* = -0.5$ . Boundary layer thickness  $\delta^* = 8.75 \times 10^{-2}$
- Outlet : Orlansky's type at  $X_{out}^* = 3.5$
- Wall conditions : floor and cavity walls
- Periodicity : lateral ends of the domain (spanwise direction)
- Symmetry plan : top of the domain

## 3. Spatial resolution

- Grid :  $192 \times 128 \times 64$  per subdomain (1.572.864 cells over the domain)
- About cell-size
  - $\Delta x_{min}^* = 1.0 \times 10^{-2}$  quad  $\Delta x_{max}^* = 3.96 \times 10^{-2}$  (downstream direction)
  - $\Delta y_{min}^* = 7.5 \times 10^{-3}$  quad  $\Delta y_{max}^* = 1.45 \times 10^{-2}$  (normal direction)
  - $\Delta z_{min}^* = \Delta z_{max}^* = 1.5625 \times 10^{-2}$  (spanwise direction)

## Forcing term modeling

- Location : In front of the upstream edge of cavity
- Zone area : brick volume :  $0.1 \times 7.5 \times 10^{-3} \times 1$ , center located at :  $(-0.05, 3.75 \times 10^{-3}, 0)$
- forcing term modeled with the pseudo-penalty approach (Pasquetti et al., Applied Numerical Mathematics 58 (2008))
  - force applied in the zone area defined as :  $\vec{f} = \frac{U - U_i - U(i,j)}{\tau}$
  - $\tau \approx \delta t$  (the numerical time step)

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## Data Recording : information about data types

### • Time series from probes

- Physical quantities : velocity components along x, y and z directions (u,v,w) and pressure (p)
- 11 probes
- Time step = 0.0525 time unit
- Time range : 25.02 to 259.96 time units
- Locations (In vertical mid-plan at  $z=0.0$ )
  - $X_i=0.2, X_j=-0.3, X_k=0.0$
  - $X_i=0.5, X_j=-0.3, X_k=0.0$
  - $X_i=0.8, X_j=-0.3, X_k=0.0$
  - $X_i=0.1, X_j=0.05, X_k=0.0$
  - $X_i=0.5, X_j=0.05, X_k=0.0$
  - $X_i=0.9, X_j=0.05, X_k=0.0$
  - $X_i=1.0, X_j=0.05, X_k=0.0$

- File name (per physical quantity) : x\_ins\_YYYY.d with x= u,v,w,p and 'YYYY' the MPI subdomain ID
- **3D snapshots**
  - Instantaneous fields : velocity components in x, y and z directions (U,V,W) and pressure (P)
  - Recording rate : 0.25 time unit
  - Time range from 210.0 to 260.0 time units
  - File name : res\_XXXX\_YYYYYY.d (XXXX : MPI subdomain ID, YYYYYY : Time ID)
    - MPI subdomain ID: 0
    - Time ID : from 39 to 239
- **2D slices**
  - Instantaneous fields : velocity components in x, y and z directions (U,V,W) and pressure (P)
  - Recording rate : 0.05 time units
  - Time range from 210 to 260 time units
  - File name : slice\_n\_idir\_XXXX\_YYYYYY.d (n : slice number ID, idir : normal orientation= 1: x(i), 2: y(j), 3: z(k), XXXX : MPI subdomain ID, YYYYYY : Time ID)
    - MPI subdomain ID: 0
    - Time ID : from 1 to 1001
  - 8 slices
    - slice ID : 1 - normal orientation : spanwise - location :  $z=-3.390625 \cdot 10^{-2}$
    - slice ID : 2 - normal orientation : spanwise - location :  $z=-2.234375 \cdot 10^{-2}$
    - slice ID : 3 - normal orientation : spanwise - location :  $z=-7.8125 \cdot 10^{-2}$
    - slice ID : 4 - normal orientation : spanwise - location :  $z=7.8125 \cdot 10^{-2}$
    - slice ID : 5 - normal orientation : spanwise - location :  $z=2.234375 \cdot 10^{-2}$
    - slice ID : 6 - normal orientation : spanwise - location :  $z=3.390625 \cdot 10^{-2}$
    - slice ID : 7 - normal orientation : normal - location :  $y=-0.25$
    - slice ID : 8 - normal orientation : normal - location :  $y=0.03$
- **Statistics**
  - fields : (i,j : indexes of direction x, y or z)
    - Mean fields of velocity components ( $\langle U_i \rangle$ ) and pressure ( $\langle P \rangle$ )
    - Mean fields of quadratic quantities ( $\langle P^2 \rangle$ ,  $\langle U_i U_j \rangle$ )
  - Time average computation
  - Time startup = 210.0 time units
  - Time range per file = 50.0 time units
  - Total time range from 180.0 to 510.0 time units
  - file name : rst\_XXXX\_YYYYYY.d (XXXX : MPI subdomain ID, YYYYYY : Time ID)
    - MPI subdomain ID : 0
    - Time ID : 1

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## Database organisation

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**Data size** : ~ 8.6 Go

**Main directory :**

/vol/DATABASE\_MECA/DATABASE\_CAVITY3D\_R2\_RE7826\_PER1.0\_DNS/FORCINGTERM

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

**Directories & files**

```
/GRID : contains all ASCII files about grid setup
input data file      : data_meshgen.d
report on grid features : report_meshgen.d
grid files for sunfluidh: maillx.d, mailly.d, maillz.d
check files (ASCII)   : check_mesh_I.d, check_mesh_J.d, check_mesh_K.d
                        (3 columns : indices, cell-face coordinates,
cell size)
/DATASETUP           : ASCII files
input data file for sunfluidh : input3d.dat
velocity profile (Blasius' boundary layer) at the inlet :
inlet_velocity_profile.dat
/TIMESERIES : contains time series recorded over the time range
[200,513.3]
                ASCII files : x_ins_00000_full.d with x= u,v,w,p
/SNAPSHOTS : snapshots binary files res_XXXXX_yyyyyyy.d
/STATISTICS : statistics binary files rst_XXXXX_yyyyyyy.d
/RESTART_AR : backup/restart archive save.tar at 260.0 time units
```

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