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Interaction of two jets

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- The dihedron Ω defined by

(1) $\qquad \Omega \;=\; \{\, (x,\, y) \in \mathbb{R}^2 \,, \quad y > 0 \,, \quad x + y > 0 \,\}$

has a boundary $\partial\Omega \equiv \Gamma$ composed by three components according to the decomposition

(2) $\qquad \Gamma \;=\; \Gamma_m \;\cup\; \Gamma_1 \;\cup\; \Gamma_2 \,.$

This decomposition is presented and defined on Figure 1. For the portion Γ_m, we have a fixed boundary and the non penetration condition can be written as

(3) $\qquad u \bullet n \;=\; 0$

with a velocity field denoted by u and the external normal by n.

- The boundaries Γ_1 and Γ_2 have a linear measure equal to L and $2L$ respectively. They allow the injection of a warm gas denoted by W_1 and a cold gas W_2. The detailed scalar information for the physical state W_j is composed by the pressure p_j, the temperature T_j and eventually by the Mach number M_j. The gas is perfect with calorific capacities ratio γ

(4) $\qquad \gamma \;=\; 1{,}23.$

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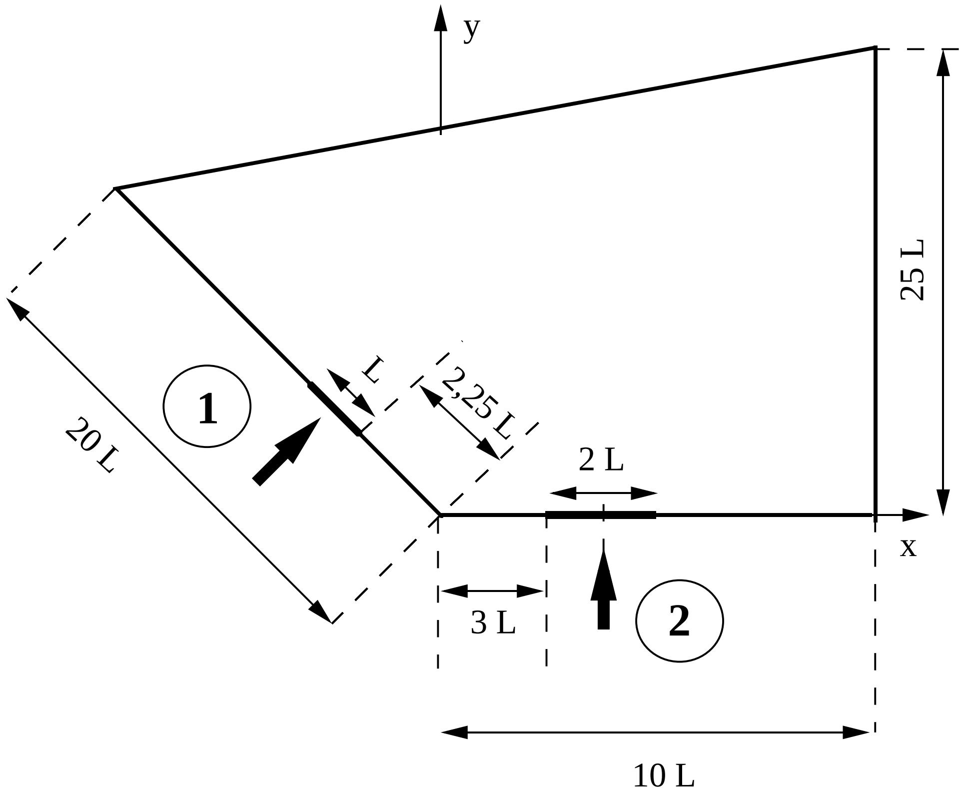

Figure 1. Physical problem and bounded domain Ω_1.

The equation of state can be written as

$$(5) \qquad p \;=\; (\gamma - 1)\,\rho T\,,$$

with the pressure field p expressed in bars (1 bar $=$ 10^5 Pascals in the International Unity System) and the temperature field T in Kelvins. The a nonstandard adimensionalization of the density is not discussed here. We are interested by the determination of the interaction of the two flows.

- The initial condition is composed by a uniform gas at rest, with pressure $p^{\rm ini}$ the half of one bar and the temperature $T^{\rm ini}$ of 853 Kelvins :

$$(6) \qquad p^{\rm ini} \;=\; 0{,}5\;, \qquad u^{\rm ini} \;=\; 0\;\;, \qquad T^{\rm ini} \;=\; 853\,.$$

- We are interested to study the intersection of the two jets for the following four test cases :

test case	p_1	T_1	M_1	p_2	T_2	M_2
1	25	2370	1,1	4	60	1,7
2	2,5	2370	1,1	4	60	null
3	2,5	2370	null	1,5	60	null
4	1	2370	null	1,5	60	null

In the previous table, the input velocity field is supposed to be normal to the boundary. Moreover, the value "null" for the input Mach number M_j indicates that the pressure p_j and the temperature T_j correspond to physical conditions for a null velocity. The input flow can be subsonic in this case and the input boundary conditions use only two given numerical parameters. For the different test cases, the physically realized state at the boundary Γ_j can be subsonic of supersonic. The given numerical data must be used carefully when applying the boundary condition.

- The problem is set in the unbounded domain Ω. The problem is discretized on **two** different bounded domains Ω_1 and Ω_2. The domain Ω_1 is presented on Figure 1. For the domain Ω_2, the dimensions $20\,L$, $10\,L$ and $25\,L$ have to be reduced by a factor of two, and become $10\,L$, $5\,L$ and $12,5\,L$ respectively. The domain Ω_2 is a zoom of the flow in the region of the interaction of the two jets. The boundary $\partial\Omega_j$ of the bounded domain Ω_j can be decomposed under the form

$$\partial\Omega_j \;=\; \big(\Gamma \cap \partial\Omega_j\big) \;\cup\; \Gamma_j^\infty \,. \qquad (7)$$

The numerical treatment on the artificial boundary Γ_j^∞ has to be discussed.

- The basic discretization uses 80 (respectively 160) meshes on the horizontal (respectively vertical) boundary and on the opposite line of the boundary. Recursive mesh refinements by a factor of 2 are sollicited, in order to determine numerical approximations that are independent of the discretization. The question is to know where the combustion process starts and to find the right pair for (domain, mesh) in order to make in evidence the points of maximal temperature and pression at the intersection of the two jets.