TP 10 : Flow around a cylinder in LBM

Cours de modélisation numérique

12 May 2023

The objective of this TP is to implement a simple Lattice Boltzmann model (LBM) in two dimensions. As an illustration, we are interested in the flow of a fluid around a cylindrical obstacle. This should result in the formation of a so-called *von Karman vortex valley*.

The model

We consider the system represented in figure 1. The system is periodic with respect to the horizontal coordinate while the walls at the top and bottom are sites following the so-called *bounce-back* dynamics. To make the system evolve, we impose on the left edge a constant velocity parallel to the x-axis

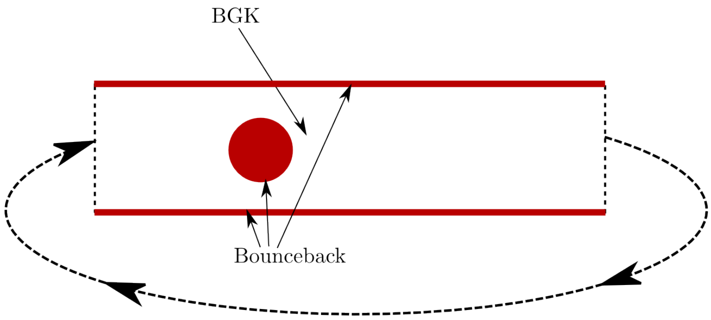

FIGURE 1 – Diagram of the system to be implemented

producing a left to right flow. In order to make the dynamics more interesting, a circular obstacle (also *bounce-back*) is placed in the tube.

Work to do

You will find on Moodle a complete LBM code dealing with the situation described above. You are asked to answer the following questions :

1. Which quantity seems to best characterize the problem ? Argue.
2. Vary this quantity to be able to observe turbulences (*Von Karman* vortices). From what value do they appear ?
3. Study qualitatively what happens when the obstacle is moved, duplicated, or modified (e.g., changing the cylinder to a parallelepiped).
4. Modify the code so that there are walls at the top and bottom, as shown in the figure : apply the dynamics of *bounce-back*. Then simulate the system without obstacles, and with the obstacles used in the previous questions. Comment.
5. Finally, assume that the domain width has N cells, the cylinder has a diameter of L cm, and the fluid is air at room temperature. Discuss a way to know the physical time that an iteration represents, knowing that we have the following relationship between the kinematic viscosity ν_{LB} in network units and the kinematic viscosity ν_{phys} in physical units : $\nu_{LB} = \nu_{phys} \cdot \Delta t/\Delta x^2$, with Δt the time step of the network and Δx the cell size.