

# Master Thesis Experiment Report II

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## Abstract

Experiment report on the PDFs of a bounceback-node and his neighboring site before and after the collision.

## 1 Context

We are running a Lattice-Boltzmann experiment on a branching lattice. The lattice size is 201x301 and the branching is illustrated in Figure 1. The color scheme represents the defined flags : purple for open parts, blue for bounceback nodes, and yellow for inside obstacles. The purple parts flow normally, the bounceback nodes flow and have a point-based bounceback condition during collision and there is no update inside the obstacles.

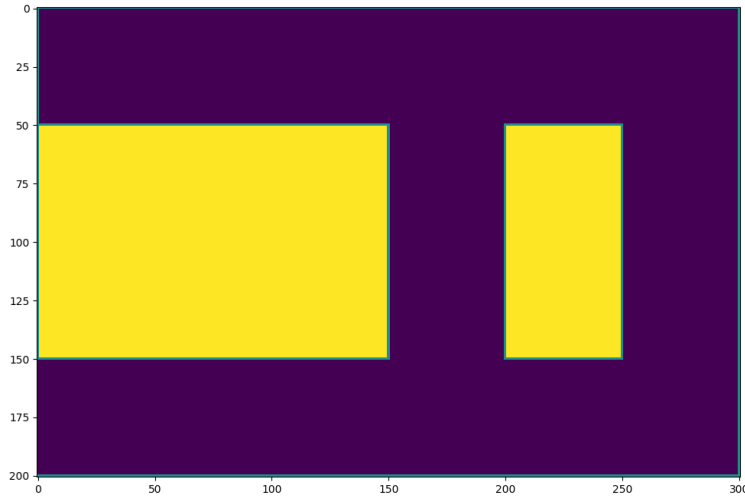


Figure 1: Flags for the branch system of the lattice

The streaming step is made by brute force, going through every node and updating those that have a flag open path or bounceback. The particle density functions are divided into two categories : particles incoming on a node (fin) and particles going out of a node (fout). Both of these have indexes associated with their directions which are represented in Figure 2.

The upper left open path is defined as an inlet (right in front of the bounceback node to avoid leaks made by the cyclic behavior of the streaming step) following the Zu-He method, and the lower left is defined as an outlet.

## 2 Problem

When running the experiment long enough, the bounceback nodes see a constant increase in velocity compared to their neighboring nodes. This phenomena is illustrated in Figure

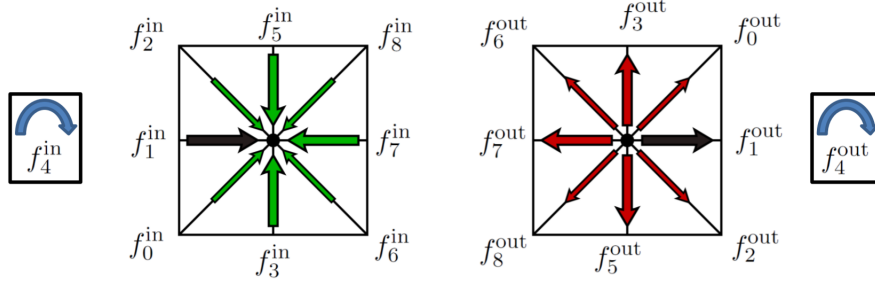


Figure 2: Directional velocity in a D2Q9 lattice for  $f_{in}$  and  $f_{out}$

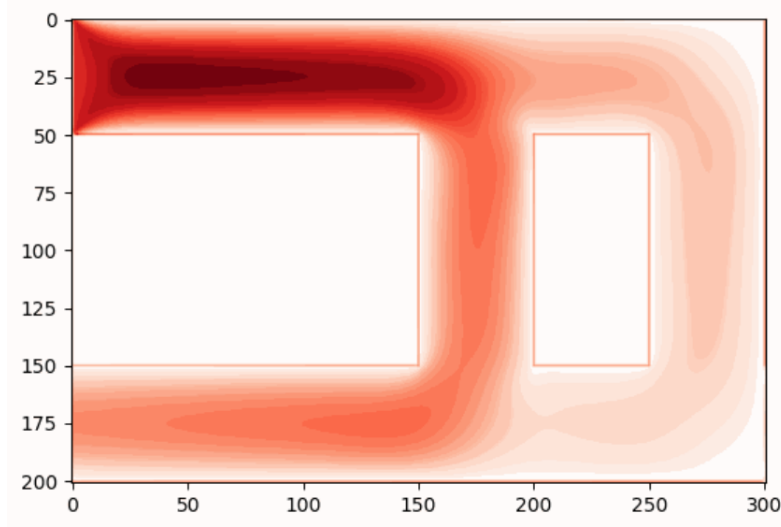


Figure 3: Norm of the velocity over each node of the lattice at 10000 iterations

### 3 Experiment

We want to assess what is happening inside a bounceback node during the collision process. To do so we checked the directional PDFs for 4 points : one bounceback node and it's three nodes above. Formally :

1. The 3 points above the bounceback node before propagation :  $f_{out}[:,49,49]$ ,  $f_{out}[:,50,49]$ ,  $f_{out}[:,51,49]$
2. the bounceback node after streaming and before collision :  $f_{in}[:,50,50]$
3. the bounceback node after collision :  $f_{out}[:,50,50]$

The simulation has run for approximately 2000 iterations (enough to see the phenomena appear).

### 4 Results

A snippet of the results are shown in Figure 4. For further clarity the results of iteration 1865 have been re-drawn in Figure 5.

We can observe that the PDFs have propagated in an incorrect direction in the bounceback node. Analysis is required on the streaming step to assess where the inconsistency comes from.

### 5 Conclusion

There is an incorrect flow of particles that come from one node into another bounceback one. We need to analyze the specifics of the code to better understand the source of the error.

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0.12550983, 0.03084209, 0.12452146, 0.03146291]), array([0.03192565, 0.12648029, 0.03129182, 0.12548704, 0.50192448,
0.1254777, 0.03083407, 0.12448904, 0.03145481])) | [0.03194192 0.11111111 0.02777778 0.12551921 0.44444444 0.11111111
0.03083407 0.11111111 0.02777778] | [0.02777778 0.11111111 0.03083407 0.11111111 0.44444444 0.12551921
0.02777778 0.11111111 0.03194192]
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0.12548141, 0.03083481, 0.12449244, 0.03145576])) | [0.03194297 0.11111111 0.02777778 0.12552283 0.44444444 0.11111111
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0.03083555 0.11111111 0.02777778] | [0.02777778 0.11111111 0.03083555 0.11111111 0.44444444 0.12552642
0.02777778 0.11111111 0.03194402]
1868 | [array([0.03194507, 0.12655609, 0.03131052, 0.12556208, 0.50222579,
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0.12548872, 0.03083628, 0.12449913, 0.03145762])) | [0.03194507 0.11111111 0.02777778 0.12552998 0.44444444 0.11111111
0.03083628 0.11111111 0.02777778] | [0.02777778 0.11111111 0.03083628 0.11111111 0.44444444 0.12552998
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0.03083701 0.11111111 0.02777778] | [0.02777778 0.11111111 0.03083701 0.11111111 0.44444444 0.12553352
0.02777778 0.11111111 0.03194611]

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Figure 4: PDFs for three nodes, from iteration 1865 through 1869

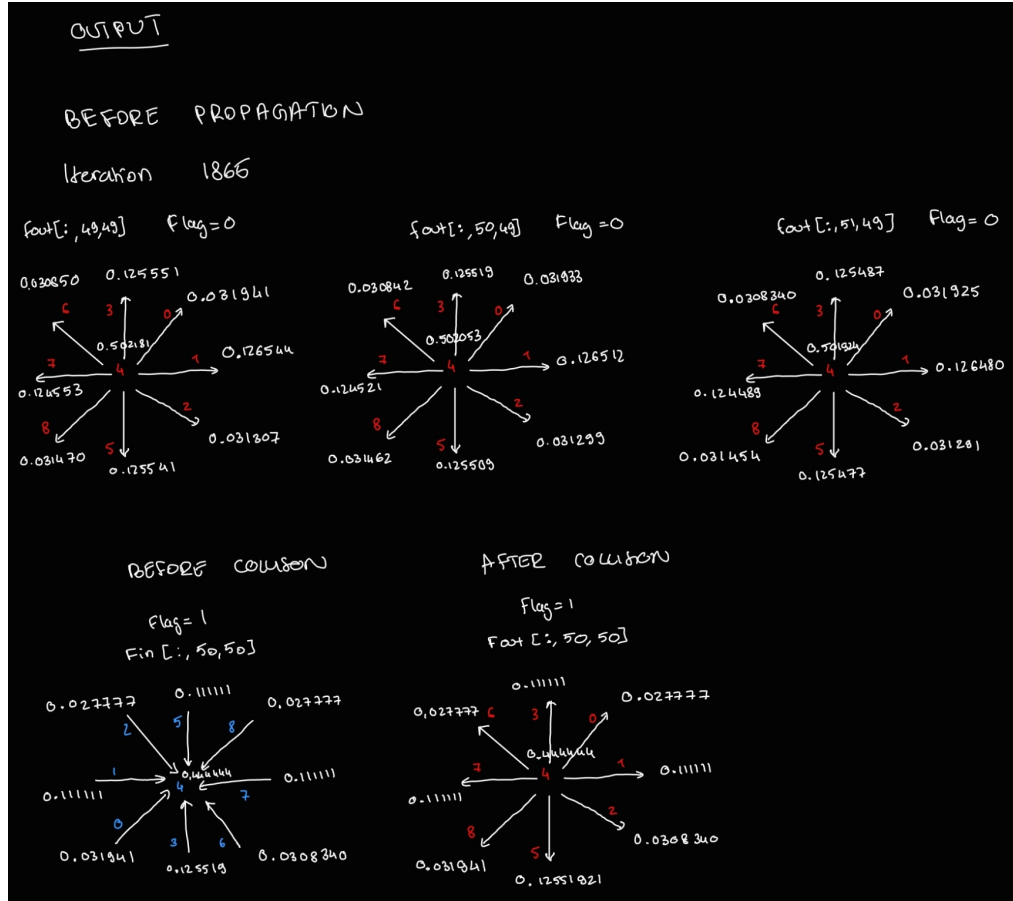


Figure 5: PDFs for three nodes at iteration 1865, simplified view