



Multiphase implementation on a parallel 2D/3D Lattice Boltzmann solver using GPGPUs

Technical Presentation

José Oliveira

Cranfield University
School of Aerospace, Transport and Manufacturing

July 2017

- 1 Introduction
- 2 Multiphase Lattice Boltzmann Methods
- 3 Result
- 4 Future work



Lattice Boltzmann Method

Applications

What is the Lattice Boltzmann Method?

LBM is a fluid flow simulation method capable of solving CFD problems.

- Incompressible and isothermal flows
- Mesoscopic approach
- Model evolution of time
- Commonly used in automotive industry
- Great candidate for parallel programming

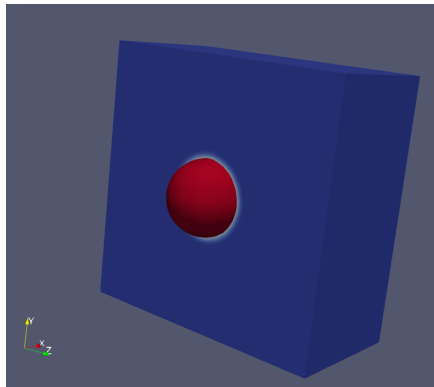
Multiphase flow in Lattice Boltzmann

Multiphase can simulate flows
in different states

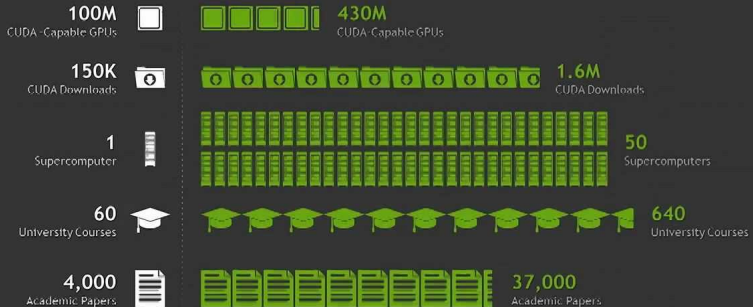
- Solid / Liquid
- Liquid / Liquid
- Gas / Solid
- etc.

Used in

- Problems controlled by surface tension
- Oil industry
- Bubble dynamics
- Fluid management in space



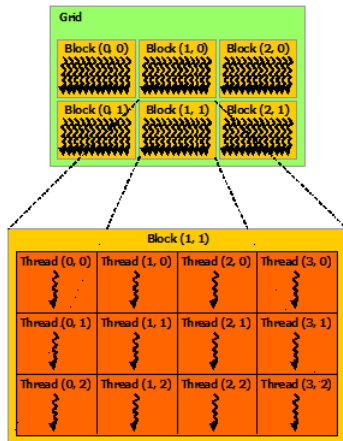
Growth of GPU Computing



2008 2013

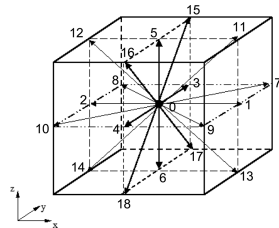
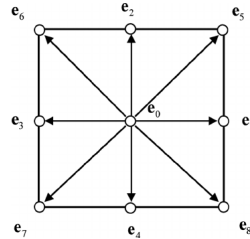
Main differences from CPU programming

- Different memory structure (registers, shared, constant and global memory)
- Many concurrent threads



Iterative method, analogous from 2D to 3D

- 1 Collision
- 2 Streaming
- 3 Boundary conditions
- 4 Macro-variable update
- 5 Residuals



Simulates interaction between a red and blue fluid.

- Single phase collision
- Perturbation
- Recoloring

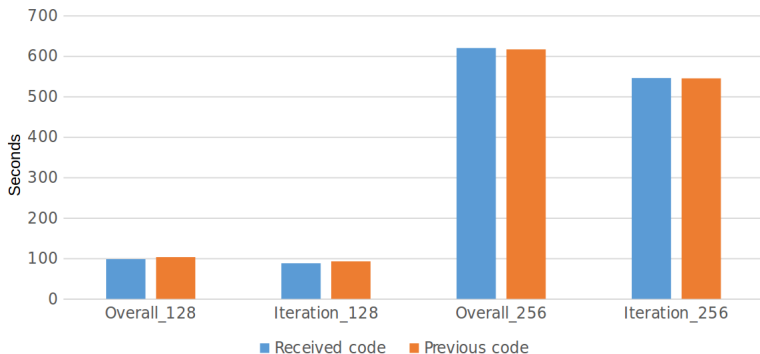
Plans for implementation:

- 1 2D case
 - Serial
 - Validation
 - Parallel
 - Validation
- 2 3D case

Results

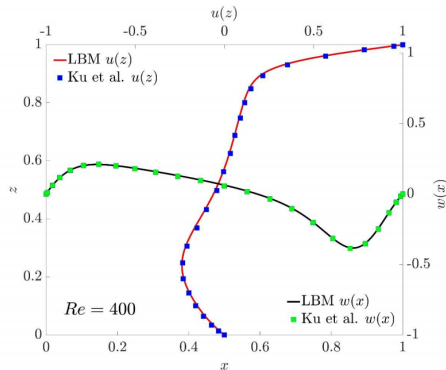
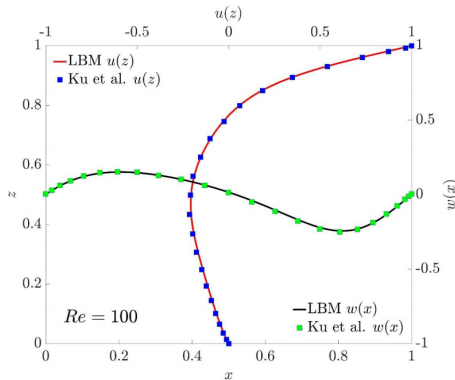
Previous solver

Runtimes



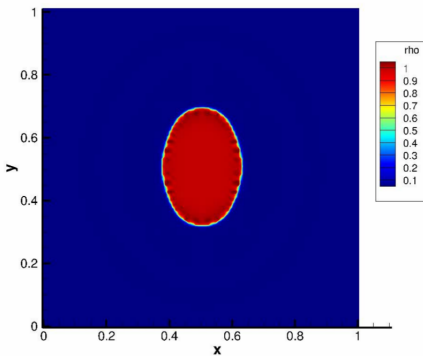
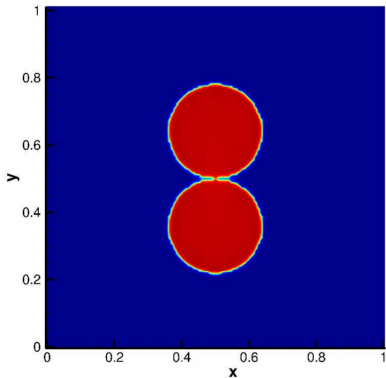
Previous solver

Validation

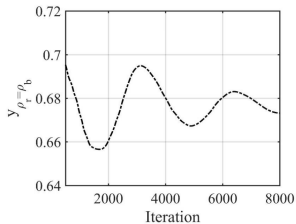


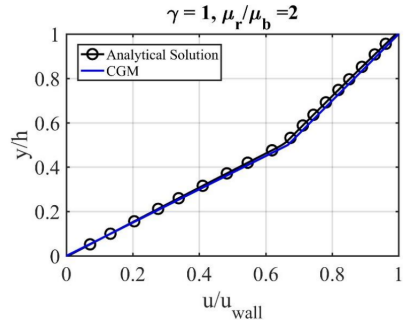
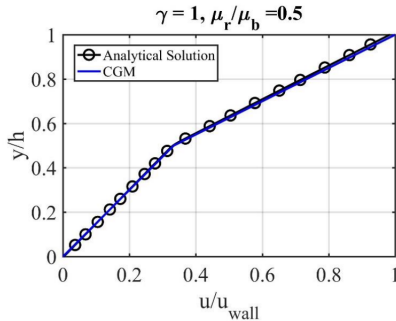
Validation

Coalescence and oscillation



γ	Error (%)
1	4.81
10	0.56
40	0.93
75	0.16





Validated by Antonio González, MSc CFD Thesis at Cranfield University

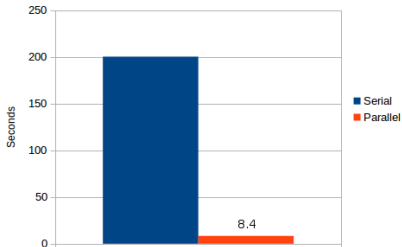


Memory usage

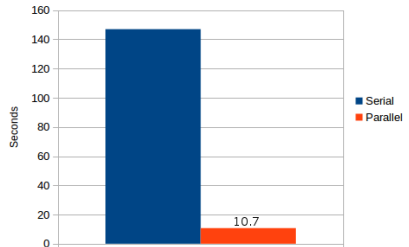
Type	Nodes	Single precision (MB)	Double Precision (MB)
2D_128	16384	21,8	33,6
3D_128	2097152	1725	2785
2D_256	65536	47,97	83,95
3D_256	16777216	9637	18091

Performance

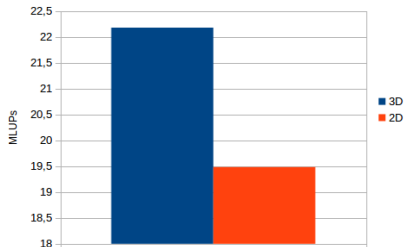
2D Color Gradient over 10000 iterations



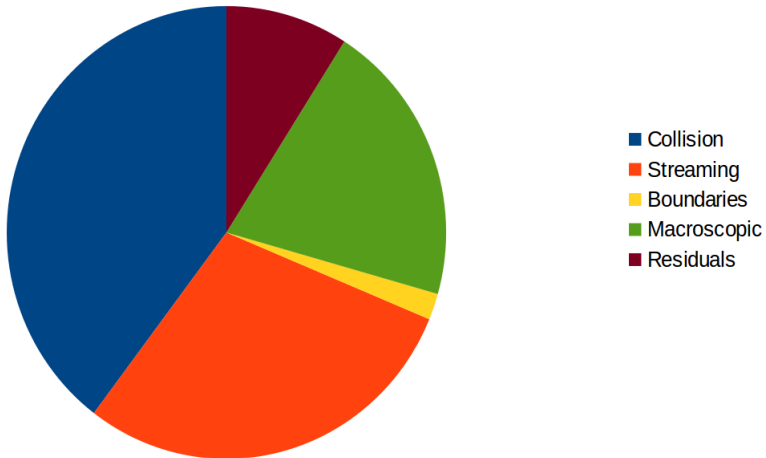
3D Color Gradient over 20 iterations



Color Gradient over 10000 iterations



3D Color Gradient sub-steps runtimes



- Implement higher order Color Gradient
- Improve memory usage/performance
- Validate 3D solver
- Finish writing thesis

	July		August		
	24 - 27	27 - 01	2 - 8	9 - 15	15 - 18
High Order CG					
3D Validation					
Optimisation					
Writing					

Thank you!