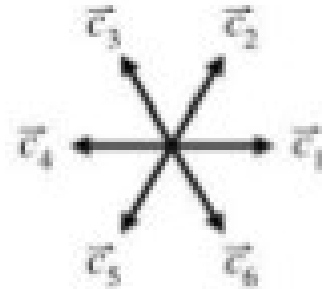
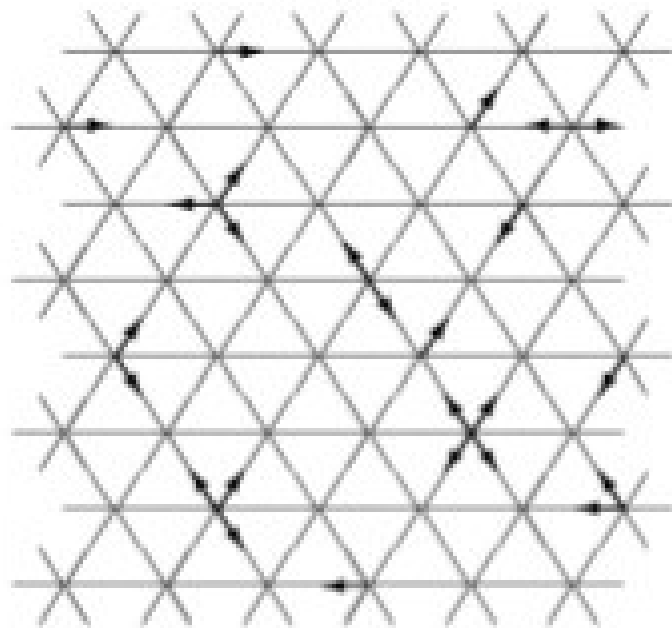


LATTICE BOLTZMANN METHOD

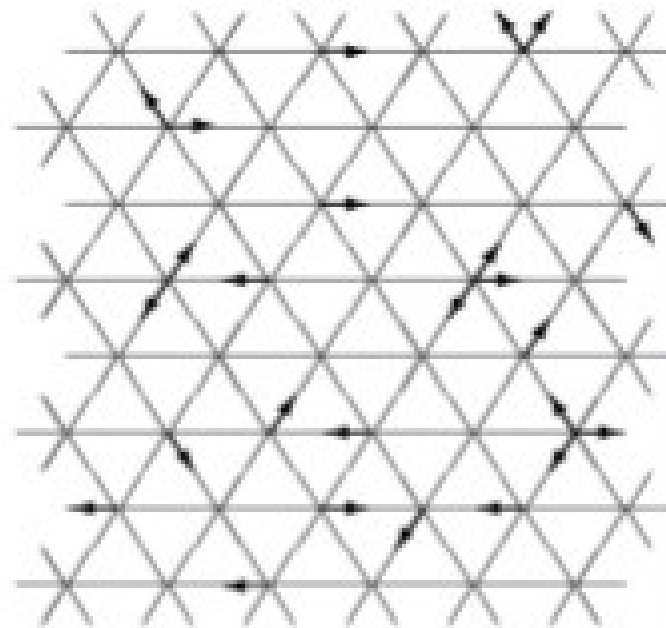
Denys Rybalka



Time t_n



Time $t_n + 1$



FHP: Model

It introduced in 1986 by Uriel Frisch, Brosl Hasslacher and Yves Pomeau

It is not deterministic

It supports 6 different velocities

Particle can move diagonally

More Realistic

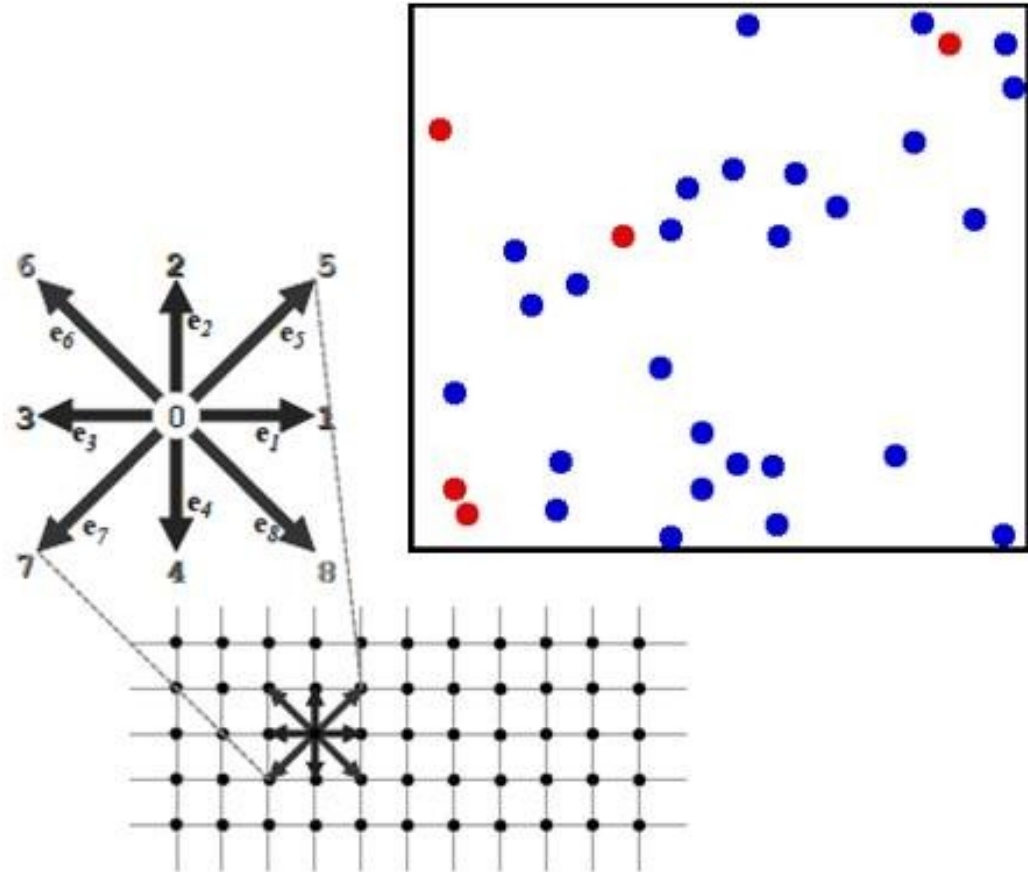
Difficult to Implement

LATTICE BOLTZMANN METHOD

Effective method for solving hydrodynamics equation via time evolution of the simple effective lattice model.

Each cell represents particle density in a discrete point.

Velocities are quantized to closest neighbors.



ALGORITHM

Continuous Boltzmann

equation
$$\frac{\partial f}{\partial t} + \frac{\mathbf{p}}{m} \cdot \nabla f + \mathbf{F} \cdot \frac{\partial f}{\partial \mathbf{p}} = \left(\frac{\partial f}{\partial t} \right)_{\text{coll}}$$

Discrete Boltzmann

equation
$$f_i^t(\vec{x}, t + \delta_t) = f_i(\vec{x}, t) + \frac{1}{\tau_f} (f_i^{\text{eq}} - f_i) \quad \text{- collision step}$$

$$f_i(\vec{x} + \vec{e}_i \delta_t, t + \delta_t) = f_i^t(\vec{x}, t + \delta_t) \quad \text{- streaming step}$$

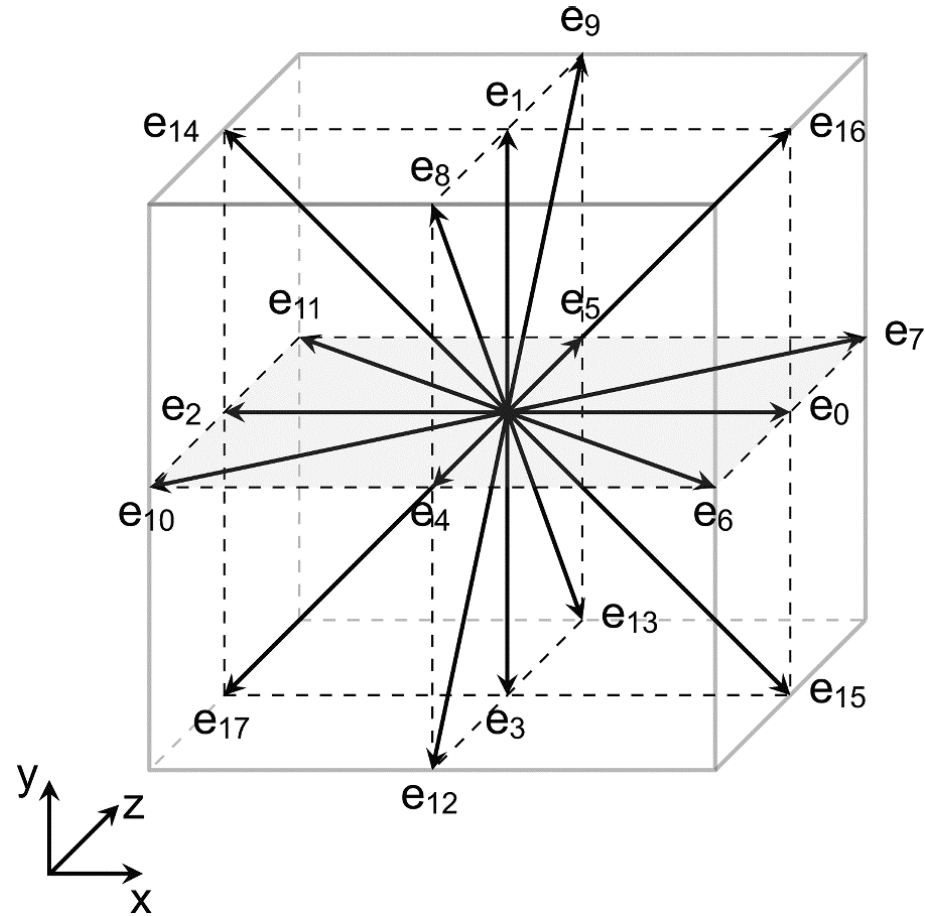
LATTICES AND THE DNQM CLASSIFICATION

Various possible lattices and velocities in general.

Usually DnQm model is used (like D2Q9, D3Q15 etc.), where

n - dimensionality

q - number of velocities



ADVANTAGES

Massive parallel capabilities

Microphysics

Multi-phase

Complex geometries and porous media.

Heat transfer and chemical reactions.

SOFTWARE

Advanced Simulation Library:^[17] Open source (AGPLv3) hardware accelerated multiphysics simulation software that utilizes LBM and supports, i.a., CPUs, GPUs, DSPs, FPGAs; (C++ API, internal engine in OpenCL).

El'Beem: free CFD code (GPL) which uses LBM

LBM-C: Open Source (GPLv2) CUDA code

Mechsys: Open source code includes lattice Boltzmann and several other numerical methods in C++.

OpenLB: Open source (GPLv2) library based on LBM, parallel, C++

Palabos: Open source (AGPL) parallel C++ code with a large spectrum of lattice Boltzmann models, including thermal, multi-phase, free-surface, and embedded particles.

Sailfish: Open Source LBM code (LGPL) for Graphics Processing Units (CUDA/OpenCL), with support for distributed multi-GPU simulations and various lattice Boltzmann

Taxila LBM: Open source (LGPL) lattice Boltzmann code from Los Alamos