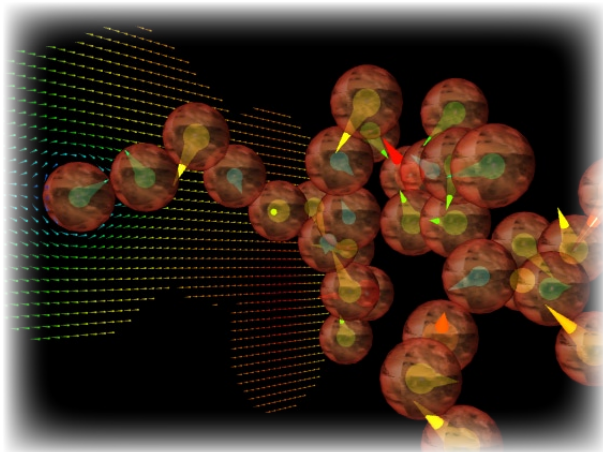
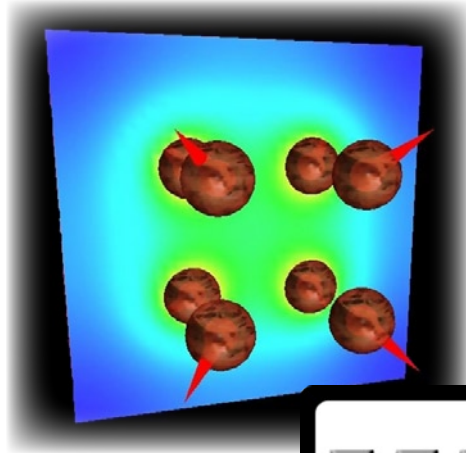
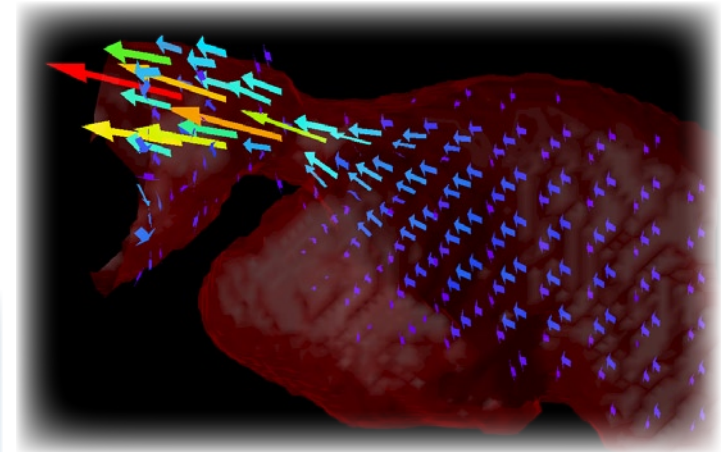


# Software Concepts of the waLBerla project



**waLBerla**



# Software Concepts of the waLBerla project



## Software Concept of a Widely Applicable Lattice Boltzmann Solver

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### waLBerla

waLBerla is a widely applicable Lattice Boltzmann solver from Erlangen

- Efficient and extensible
- Usable for a wide range of applications
- Available for teaching and Bachelor-, Diploma and Master theses

### The Lattice Boltzmann Algorithm

- A method to simulate fluid flows
- Alternative approach to classical Navier Stokes
- Regular grid with a fixed number of directions
- Time step and cell size are normalized
- Optimized implementation/parallelization possible
- The common 3D model (D3Q19):

During one time step:

- Stream:** Movement of fluid particles during one time step along their respective directions
- Collide:** Fluid particle collisions during movement are calculated

Stream from adjacent cells → Perform collision → Store DFs and continue with next cell.

## Basics of the Lattice Boltzmann Method

## Project features

- Description language
- Visualization
- Test and validation
- ...

### Features

- Grid refinement
- Input parameters via description language
- Visualization with open source software

- Parallelization for shared and distributed memory
- Logging and debugging functionality
- Internal benchmarking and performance measurements
- Test suite for validation and verification

### Concepts

**Patches:** Patches can be handled in parallel due to the little dependence on neighboring patches.

**Grid refinement:**

- High resolution only where necessary
- Grid refinement in each patch possible
- Refinement divides patches into smaller ones

**Debugging:** For debugging an arbitrary number of cells can be monitored.

**Polymorphic patches:**

- In simple regions primitive patches can be used, which can be highly optimized for performance
- Complicated regions (e.g. free surfaces, particles or boundary) can be processed by specialized patches

**Parallelization:**

- A communicator object handles the data exchange between patches
- Communicator enables MPI communication
- Type of communication (shared memory/MPI) is transparent for patches

**Input parameters:** (Screenshot of a configuration file)

## Software Concepts

- Polymorphic patches
- Grid refinement
- Parallelization
- ...

## Project environment

### Environment

- C++
- OpenMPI
- Subversion

## Current applications

### Applications

<ul style="list-style-type: none"> <li>Free surfaces</li> </ul> <p>VoF Free Surface Method. Accurate foam simulation including film rupture and disjoining pressure.</p>	<ul style="list-style-type: none"> <li>Moving obstacles</li> </ul> <p>Simulation of moving obstacles including aggregation and rupture.</p>	<ul style="list-style-type: none"> <li>Charged colloids</li> </ul> <p>Investigation of agglomeration processes in colloidal suspensions stabilized by electrostatic charges.</p>	<ul style="list-style-type: none"> <li>Blood flow</li> </ul> <p>Efficient calculation of hemodynamic values in blood vessels, especially in a stenosis or an aneurysm.</p>	<ul style="list-style-type: none"> <li>Free surfaces and FSI</li> </ul> <p>Sophisticated free surface method with fluid-fluid as well as fluid-structure interaction.</p>
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