

CFD – Lab

Preliminary Session

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Introduction to Grid-Based CFD

- theoretical background on fluid dynamics
- implementing two distinct approaches (C)
 - solving the Navier–Stokes equations
 - Lattice–Boltzmann method (maybe substituted by fluid-structure interaction)
- treating arbitrary geometries
- mpi parallelization

Project Work (topic chosen by the teams)

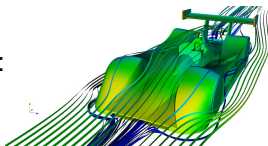
- adding heat transport
- adding turbulence model (RANS/LES)
- OpenMP
- free surfaces
- ...

Prerequisites

- programming skills in C
- basic numerical skills (e.g. Numerical Programming I)
- no preknowledge in fluid dynamics needed

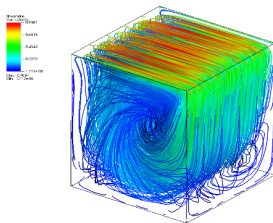
Motivation: NS... for WHAT???

- Describe the motion of fluid substances
- Obey general laws of continuum mechanics
- Widely used in different scientific areas :
 - Model of weather
 - Automobile, Airplane industry..
 - Medical science
 - Others:Geophysics, Chemistry, Astrophysics..



ParaView - Flow Around Car

NS: How does it work?

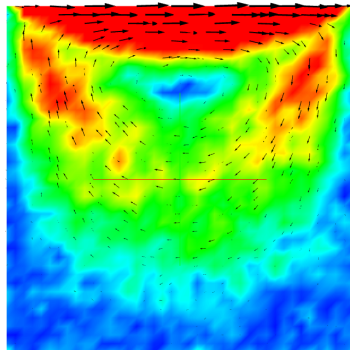


Driven cavity scenario in 3D

- Derived from Newton's second law
- A system of two partial differential equations
 - Equation of momentum
 - Continuity equation
 - Initial-boundary-value Problem

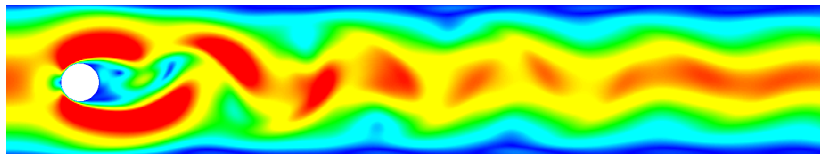
Motivation: LBM... for WHAT???

- **Mesososcopic** approach to fluid dynamics
 - allows to simulate fluids on smaller scales
 - widely used for the simulation of micro- and nanoflows
- **Local** scheme
 - efficient for simulations in complex geometries



Cavity on nanoscale with Brownian motion effects

LBM: How does it work?



Karman vortex street at $Re = 100$ simulated by LBM

- Based on **Statistical mechanics**
- Special finite difference discretisation of the **Boltzmann equation**
 - Compute probability for fluid molecules to have velocity v at position x and time t
 - Leads to an update scheme similar to **cellular automata** (Great for computer scientists :-)
 - Basic scheme (relatively) easy to implement (also in 3D!)
- In continuum (=macroscopic) limit: LBM \leftrightarrow Navier-Stokes

Whole lab is done in group work

- groups of 3
- oral examination for the whole group

Course of Action

1. lecture on the theoretical background
2. explanation of the task
3. programming
4. examination
5. GOTO 1

Examination compulsory

- one code handed in
- theoretical knowledge is tested
- questions concerning the implementation have to be answered
- **compulsory for each team member**

Registration

- registration with the *matching-system*
- starts today
- <http://docmatching.in.tum.de/>