Module 2

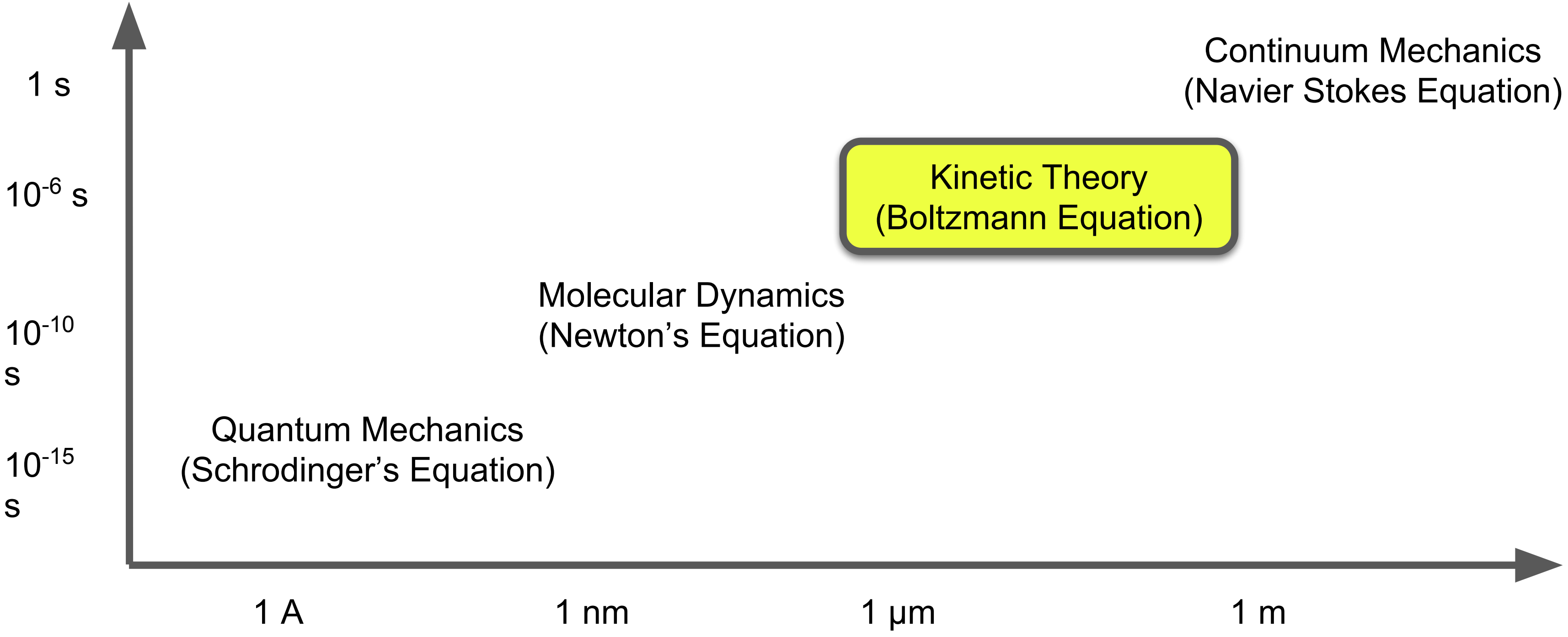
The Lattice Boltzmann Method, Biofluids, and GPUs

Recap

- Fluid mechanics is everywhere
- So far, we have studied classical fluid flows from the continuum perspective
  - Newtonian fluid
  - Incompressible flows
  - Rayleigh-Benard convection
- Calculations performed using an HPC code (Drekar)
- Mainly worked with the finite element method for spatial discretization
- Simulations run on CPUs on the Odyssey supercomputer

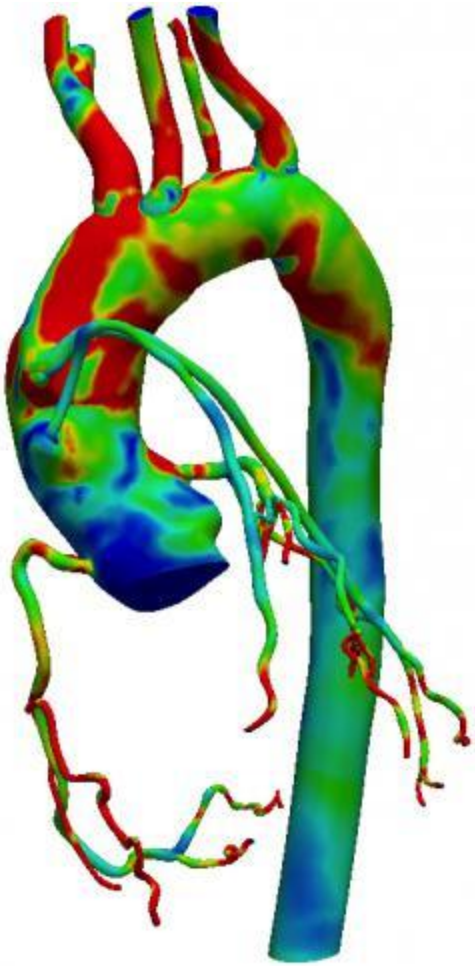
Next steps

- Go beyond continuum description
- One step lower is the meso-scale



Applications

- Multiphase flow
- Cellular flows
- Biofluids
- Rarefied gas
- ...



Basic Ideas Behind the Lattice Boltzmann Method

- Goal: Find the distribution function
  - Distribution of particles in space and time with a given velocity
  - 7-dimensional (1 time, 3 space, 3 velocity)
  - Moments of the distribution function provide properties of the fluid
    - e.g. density and velocity
- The distribution function is governed by the Boltzmann equation
  - *Very* hard to solve analytically
- Navier-Stokes equations can be derived from the Boltzmann equation
  - Kinetic $\longrightarrow$ Continuum

Computing with the LBM

- Numerically solving the Boltzmann equation has advantages over numerically solving the Navier-Stokes equations
  - No need to worry about the nonlinear term
- The Lattice Boltzmann method is amenable to parallelization
- LBM with GPUs has led to significant speed-up
- You will work with the MUPHY code
  - GPU / CPU code for LBM simulations
  - MUPHY: A parallel MUlti PHYsics/scale code for high performance bio-fluidic simulations

Where We're Going

Today and Thursday: Introduction to the LBM

Next week: Basic LBM implementation, CUDA

Two weeks and beyond: Run MUPHY and work on 2nd project

Schedule