

Navier-Stokes at High Reynolds Numbers



Motivation: turbulence on the nanoscale

- ▶ “Planckian fluid” on the nanometer scale. Fermi-liquid guised Reynolds gives order:

$$Re = \frac{\sqrt{2}}{y_7} \circ \frac{L_a}{l_\mu} \cdot \frac{v_{tr}}{v\mu} \cdot \frac{\mu}{k_B T}$$

- ▶ Expressing length and velocity in natural units:

$$Re = \frac{\mu}{k_B T}$$

- ▶ Strange Metal at 1K, $Re = 100\ 000\ 000 v_{tr} / v_\mu$
- ▶ YBCO at $T=100K$, just above critical: $Re = 10\ 000 v_{tr}/v_\mu$
- ▶ Turbulent flows in a nanoscale system!

Can we solve this with Engineering techniques?

- ▶ Benefit:
 - ▶ different materials
 - ▶ different spatial arrangements
 - ▶ Rapidly posing problems
- ▶ Drawbacks:
 - ▶ Makes assumptions to simplify problem
 - ▶ Slower code (framework overhead)
- ▶ Conclusion?

Direct Navier Stokes

- ▶ Industry-standard: Prediction-Projection method
 - ▶ (simplified) “U star” $\sim u(t+dt)$ “predict Navier-Stokes”
 - ▶ Use to calculate $p(t+dt)$ “Solve Continuity”
 - ▶ Then update $u(t+dt)$ “Project Navier-Stokes”
- ▶ C++14/OMP: Cluster optimization
- ▶ However:
 - ▶ Stability issues
 - ▶ Very hard to implement
 - ▶ Assumptions build into core of process
 - ▶ This is an instate for Physics, not CFD

Results: Engineering CFD

- ▶ (Movie time)

Results: Lattice Boltzmann Method (SPTCM school)

- ▶ Gallery time

What now?

- ▶ direct NS solver:
 - ▶ Implementation taken care of
 - ▶ Focus holo/hydro, not CFD
- ▶ Pose problems (e.g. candle flame)
- ▶ ... Next sprint:
 - ▶ Candle flame
 - ▶ Global vs local measurements of turbulence?
 - ▶ Near-boundary local measurements?