Tutorial sheet 14

summary list of discussion topics

- Which idealizations underlie the description of a macroscopic many-body system as a continuous medium? What is the Knudsen number?
- How is local thermodynamic equilibrium defined?
- What are the Lagrangian and Eulerian descriptions of fluid motion?
- What is mechanical stress? the (Cauchy) stress tensor? How is a fluid defined?
- What are the strain rate tensor, the rotation rate tensor, the vorticity vector? How do they come about and what do they measure?
- What do the following characterizations of flows mean?
  - compressible/incompressible
  - vorticity-free
  - laminar
  - steady
  - isentropic
  - subsonic/supersonic. How is the Mach number defined?
- What is the Reynolds transport theorem (and its utility)?
- Which quantities are used to describe the motion of a fluid?
- What are the basic equations governing the dynamics of perfect fluids? What are the boundary conditions?
- What is the Bernoulli equation? Which examples of application do you know?
- What is Kelvin's circulation theorem? What does it imply for the vorticity?
- What is a potential flow? What are the corresponding equations of motion?
- What is a sound wave? How do you derive the corresponding equation of motion? How is the speed of sound defined? What happens when the amplitude of the wave becomes large?
- What are the fundamental equations governing the dynamics of non-relativistic Newtonian fluids? What are the boundary conditions?
- Do you know simple examples of steady flows of non-relativistic Newtonian fluids?
- How can one reformulate the Navier–Stokes equation in dimensionless form? What is dynamical similarity?
- How is the Reynolds number defined?
- Which modifications due to viscosity affect the dynamics of vorticity? of sound waves?

- Turbulence in fluids: what is it? why does it require a Reynolds number larger than some critical value to develop?
- In fully developed turbulence, what are the mean flow, the fluctuating flow, the Reynolds stress tensor, the energy cascade?
- Convective heat transfer: what is the Rayleigh–Bénard convection? Describe its phenomenology. Which effects plays a role?
- What are the fundamental equations of the dynamics of a relativistic fluid?
- What is the relation between the energy-momentum tensor of a perfect relativistic fluid and its internal energy, pressure, and four-velocity? How is the latter defined?
- In the case of a flowing dissipative relativistic fluid, what is the Eckart frame? the Landau frame?
- What do the denominations "first-order", "second-order" dissipative fluid dynamics stand for?