Lecture for BSc and MSc:

Hydrodynamics

Wintersemester 2025/26

Georg Wolschin
Universität Heidelberg
Institut für Theoretische Physik
http://wolschin.uni-hd.de

Dates and structure

- **Time: Mondays 9.15 - 11.00, Start: Mo 13.October 2025**
- **Lecture @ gHS, ITP, Philosophenweg 12, for BSc and MSc students.**
  Please inscribe only if you actually will attend the full semester, and plan to take part in the written test at the end of this term. (If you are inscribed and want to step back, please send an email to wolschin@uni-hd.de.)
- **Participation in the final test in Jan./Feb. 2026 only for registered participants.**
- **Prerequisites: Lectures on Quantum Mechanics, and if possible Statistical Physics (MKTP1).**
- **Language is english.**
- **Exercises will be given as homework problems.**
- **4 ECTS-Credit points for registered students who pass the final written test in 2026.**
- **Everybody is welcome to participate in the lecture, but only registered students can take the final test and receive CPs.**

Preliminary Program

1. Introduction
2. Ideal fluids
3. Viscous fluids
   - Navier-Stokes equation
   - Energy dissipation
   - Hagen-Poiseuille's law
   - Reynolds number, criterion for turbulence

4. Turbulence
   - Stability of stationary flow
   - Example: Turbulence in astrophysical environments
   - Nonstationary instabilities (Taylor-Couette, Raylewigh-Bénard)
   - Developed turbulence, Self-similarity (Nonlinearity, fractals, chaos)
   - Transition to turbulence without instability
   - Turbulent wake

5. Boundary layers
   - Laminar boundary layer
   - Turbulent boundary layer

6. Thermal conduction
   - Heat transport equation
   - Heat transport in incompressible media
   - Heat transport in infinite media
   - Convection

7. Diffusion
   - Diffusion in fluid mixtures
   - Brownian motion
   - Diffusion in relativistic systems: Heavy-ion collisions

8. Relativistic hydrodynamics

9. Astrophysical hydrodynamics

10. Hydrodynamics of superfluids
    - Basics
    - Hydrodynamic equations for HeII
    - Sound propagation in superfluids

Literature

D.J.Tritton: Physical Fluid Dynamics, Oxford University Press (1977)

L.D.Landau, E.M.Lifschitz: TPVI- Hydrodynamik, Akademie Verlag (1991)

D.J. Acheson: Elementary fluid dynamics, Clarendon/Oxford Applied Mathematics (1990)

T.E. Faber: Fluid dynamics for physicists, CUP (1995)

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W. Greiner, H. Stock: TP2A-Hydrodynamik, H. Deutsch (1991)

C. Godreche, P. Manneville (eds.): Hydrodynamics and nonlinear instabilities, CUP (2005)

A. Sommerfeld: Mechanik der deformierbaren Medien, Dieterich'sche Verlagsbuchhandlung, Wiesbaden (1947)

A.R. Choudhuri: The Physics of Fluids and Plasmas, CUP (1998)

R. Lüst: Hydrodynamik, BI Verlag (1978)

H.L. Swinney (ed): Hydrodynamic Instabilities and the Transition to turbulence, 2nd ed. Springer (1985)

S. Shore: An introduction to astrophysical Hydrodynamics, Academic Press (1992)

D. Michalas: Stellar Atmospheres, Freeman (1978)

P.H. Shu: The physics of astrophysics, Vol.II , Univ. Science books (1994)