Computational Physics II

Summer Semester 2025

Lecture Topics (Prof. Sebastiano Bernuzzi)

- **Programming**
  - Unix & Linux
  - Bash & Console navigation
  - Programming languages
  - Introduction to Python
  - Floating point representation
- **Solving equations and Linear systems**
  - Root finding: Bisection, Newton-Raphson, Secant
  - Direct methods: Gauss elimination, LU decomposition
  - Iterative methods: Jacobi, Gauss-Seidel, Successive-Over-Relaxation
- **Function representation, integrals, derivatives**
  - Polynomial approximation of function, interpolant
  - Runge phenomenon
  - Integrals: Riemann sums, Trapezoidal rule, Gaussian quadratures
  - Spectral methods: Orthogonal polynomial, Fourier basis
  - Interpolation: Lagrangian, Splines
  - Derivatives: finite differencing, spectral methods
- **Ordinary Differential Equations**
  - Initial Value Problems: well-posedness, stability and convergence
  - Euler scheme: stable/unstable vs explicit/implicit
  - Stability analaysis of ODE solvers
  - Runge-Kutta methods
  - Simplecting method: symplectic Euler, Störmer&Verlet
  - Boundary Value Problems: shooting method, solution with methods for linear systems
- **Fourier Transform**
  - Discrete Fourier Transform
  - Fast Fourier Transform
  - Solution of BVPs via FFT
  - Signal analysis
- **Monte Carlo methods**
  - Random variables and pseudorandom numbers
  - Multidimensional integration with MC
  - Random walks and Metropolis algorithm

Tutorials (Aurora Capobianco)

- Gymnastic with bash and Python
- Roots of complex functions and fractals
- Tridiagonal system solver: direct vs iterative methods
- Lagrangian Interpolation
- Finite differencing
- Kepler problem
- Ising 2D model