TU Berlin
Advanced Topics from Scientific Computing
Winter Semester 2024/2025

Slide lecture 1

Jürgen Fuhrmann

juergen.fuhrmann@wias-berlin.de

# Me

- Name: Dr. Jürgen Fuhrmann (no, not Prof.)
- Affiliation: Weierstrass Institute for Applied Analysis and Stochastics (WIAS) Berlin;
  Deputy Head, *Numerical Mathematics and Scientific Computing*
- Email: **juergen.fuhrmann@wias-berlin.de**
- Course homepage:
  https://www.wias-berlin.de/people/fuhrmann/AdSciComp-WS2425/
- Experience/Field of work:
  - Numerical solution of partial differential equations (PDEs)
  - Development, investigation, implementation of finite volume discretizations for nonlinear systems of PDEs
  - Ph.D. on multigrid methods
  - Applications: electrochemistry, semiconductor physics, groundwater...
  - Software development:
    - WIAS code pdelib (http://pdelib.org)
    - Julia PDE solver package `VoronoiFVM.jl` (http://github.dom/j-fu/VoronoiFVM.jl) + package ecosystem
    - Languages: C, C++, Python, Lua, Fortran, Julia
    - Visualization: OpenGL, VTK, Makie.jl

# Admin stuff

- Lecture material will be available via https://www.wias-berlin.de/people/fuhrmann/AdSciComp-WS2425/
- All code examples and project assignments will be in Julia, either as notebooks or as Julia files. Things should work on Linux, MacOSX, Windows
- I will develop course projects on various topics in groups of 2-3 students. I will offer standard and advanced topics. The later are connected to my research projects.
- Portfolio exams will be based on course projects

# Intended aims and topics of this course

- Introduction to Julia as fresh approach to combine efficient computation with easy composability
- Focus on partial differential equation (PDE) solution
  - Solution of large linear systems of equations
  - Finite element and finite volume methods
  - Mesh generation
  - Nonlinear solvers
  - Automatic differentiation
  - Aspects of parallelization,Visualization
- Elements of Scientific Computing not covered:
  - Stochastic methods
  - Machine learning - but see the Course "Julia Programming for ML" by Adrian Hill, https://adrianhill.de/julia-ml-course/

# Standard topics

- These will involve the implementation of the numerical solution of a certain problem formulated as partial differentiation or system of PDEs, and a report on the implementation including the description of the methods used.

# Advanced topics

I am currently working in the following fields and look for interested students:

- Electrochemical systems (electrocatalysis experimentation, batteries, fuel cells, biological ion channels)
- Semiconductor devices and solar cells
- Geothermal flows, reactive flows in porous media
- Control volume finite elements and algebraic flux correction
- Tooling for Scientific computing: mesh generation, visualization

Upon interest I can formulate a course project based on one of these topics which may develop into a master thesis. In particular, my institute offers the possibility for female students to apply for the WIAS female master program.

# Lecture mode

- Variant A: “Classical”: in-person, Wed 16:00-18:00, material uploaded as Pluto notebooks, pdf, html
- Variant B: “Post-Covid”: online, material uploaded as Pluto notebooks, pdf, html, lectures recorded with occasional reuse of previous year’s video. In-Person consultation Wed 16:00-18.00.