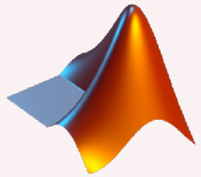
Introduction to Julia for High-Performance Computing

Carsten Bauer @ HLRS, Stuttgart

September 10, 2024

We don't always speak the same language

Domain Science



High-Performance Computing

Language Barrier

Julia aims to solve the "two-language problem”

Domain Science

High-Performance Computing

Gradual transition

”Julia: come for the syntax, stay for the speed”

nature

Learn about Julia (for HPC) and HPC (with Julia)

	Tuesday	Wednesday	Thursday	Friday
	Foundations	**Core**	**Node**	**Cluster**
09:00 - 10:45	Intro Onboarding	Type & Memory Optimizations	Multithreading	Distributed Computing
10:45 - 11:00	Break	Break	Break	Break
11:00 - 12:30	Fundamentals	Exercises	Exercises	Exercises
12:30 - 14:00	Lunch	Lunch	Lunch	Lunch
14:00 - 15:30	Specialisation & Abstraction	SIMD & Profiling	GPU Computing	Exercises
15:30 - 15:45	Break	Break	Break	Outro
15:45 - 17:00	Exercises	Exercises	Exercises	

Quick Live Survey

Julia’s Weaknesses

HPC with Julia is currently a niche.

Limited support by vendors and HPC centers

Opportunity to network, contribute and grow

Join us at conferences ...

... or in our monthly Zoom call

(open to everyone!)

Achieving
high performance
can be tricky.

Garbage collection

Type instabilities

No great way to produce (small) binaries.

Can impact workflow on clusters

Hampers integration into existing code bases

Julia's Strengths

Julia is interactive and convenient.

Powerful REPL, Jupyter, ...

Great math support

Best-in-class package manager

Software portability is as good as it gets

Laptop

```
➜  ~/myproject  tree
.
├── Manifest.toml
├── Project.toml
└── code.jl

0 directories, 3 files

➜  ~/myproject  cat Project.toml
[deps]
CUDA = "052768ef-5323-5732-b1bb-66c8b64840ba"
DifferentialEquations = "0c46a032-eb83-5123-abaf-570d42b7fbaa"
MKL = "33e6dc65-8f57-5167-99aa-e5a354878fb2"
MPI = "da04e1cc-30fd-572f-bb4f-1f8673147195"

➜  ~/myproject
```

HPC Cluster

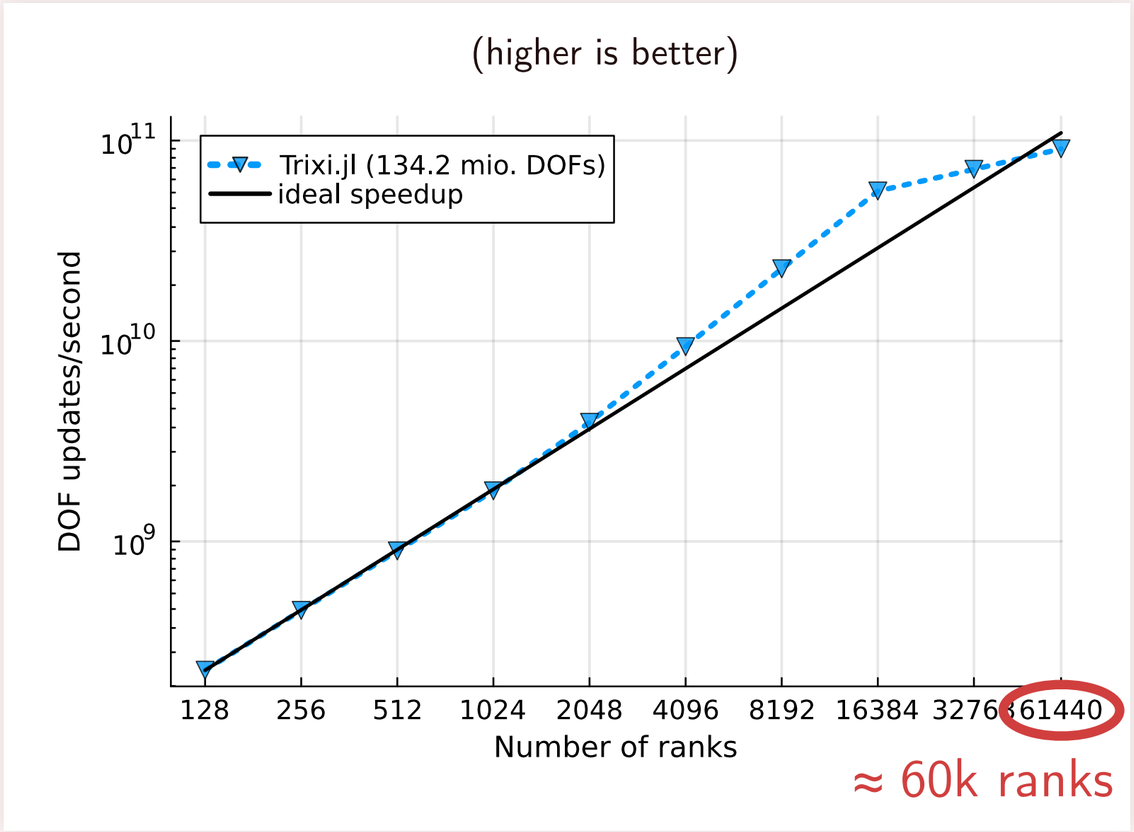
```
➜  bauerc@n2login3 myproject  julia --project
               _
   _       _ _(_)_     |  Documentation: https://docs.julialang.org
  (_)     | (_) (_)    |
   _ _   _| |_  __ _   |  Type "?" for help, "]?" for Pkg help.
  | | | | | | |/ _` |  |
  | | |_| | | | (_| |  |  Version 1.7.2 (2022-02-06)
 _/ |\__'_|_|_|\__'_|  |  Official https://julialang.org/ release
|__/                   |

(myproject) pkg> st
      Status `~/myproject/Project.toml`
➜ [052768ef] CUDA v3.11.0
➜ [0c46a032] DifferentialEquations v7.1.0
➜ [33e6dc65] MKL v0.5.0
➜ [da04e1cc] MPI v0.19.2
        Info packages marked with ➜ not downloaded, use `instantiat
e` to download

(myproject) pkg> instantiate
```

(Using **system software** is supported.)

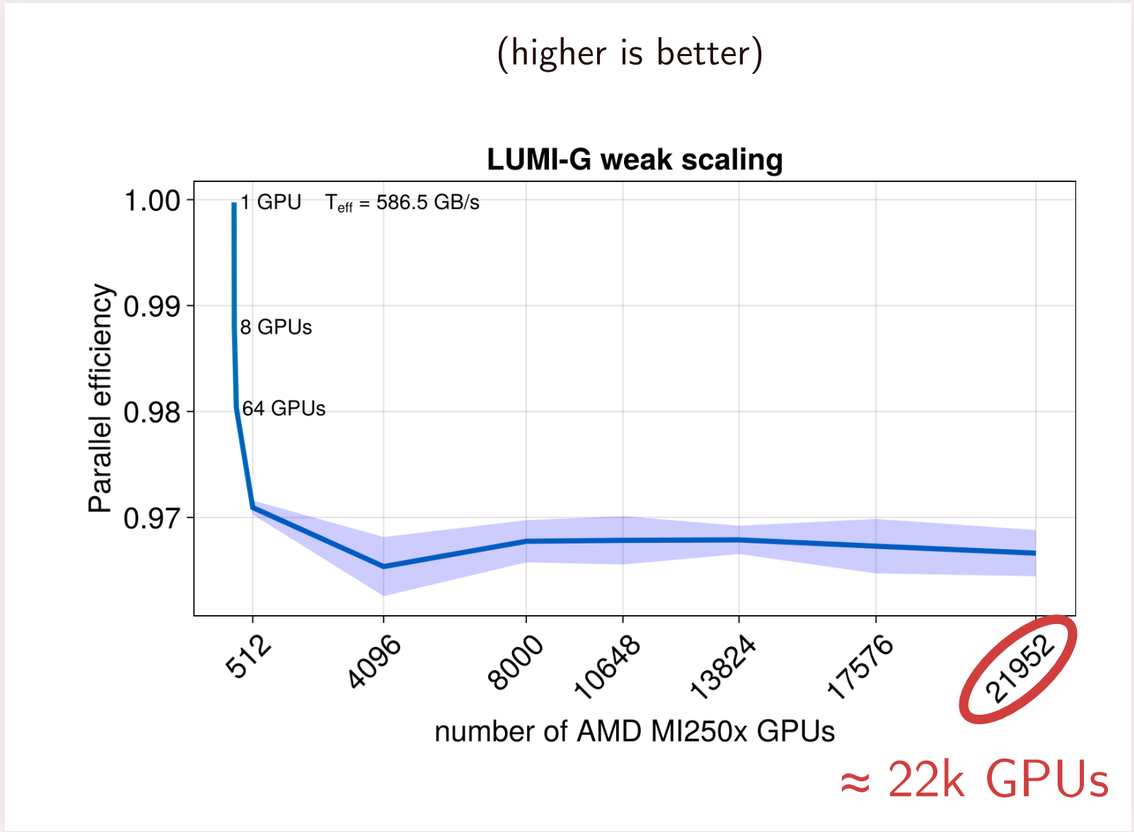
Julia code can be fast and scalable.

- Compilation via LLVM
- Great MPI support

Example: Good scaling of PDE codes



Trixi.jl (Multi-CPU)



ParallelStencil.jl (Multi-GPU)

Julia invites you to gradually delve deeper.

Transparent and open source

Julia is (mostly) written in Julia

Julia makes it easier to become a developer.