# Introduction to Julia for High-Performance Computing

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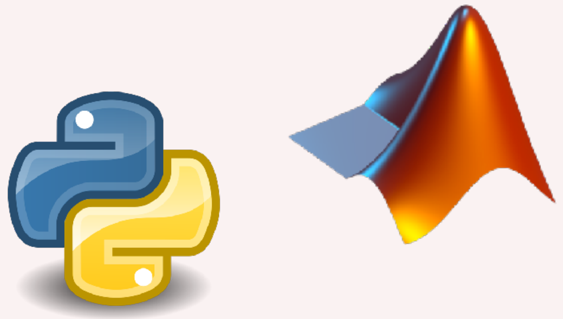
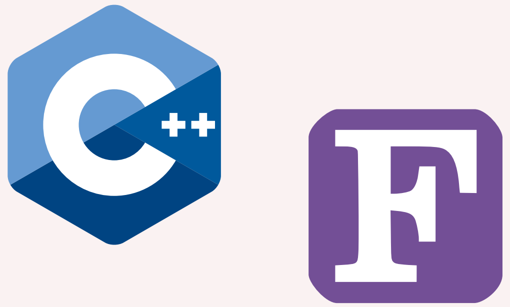
# We don’t always speak the same language

Domain Science

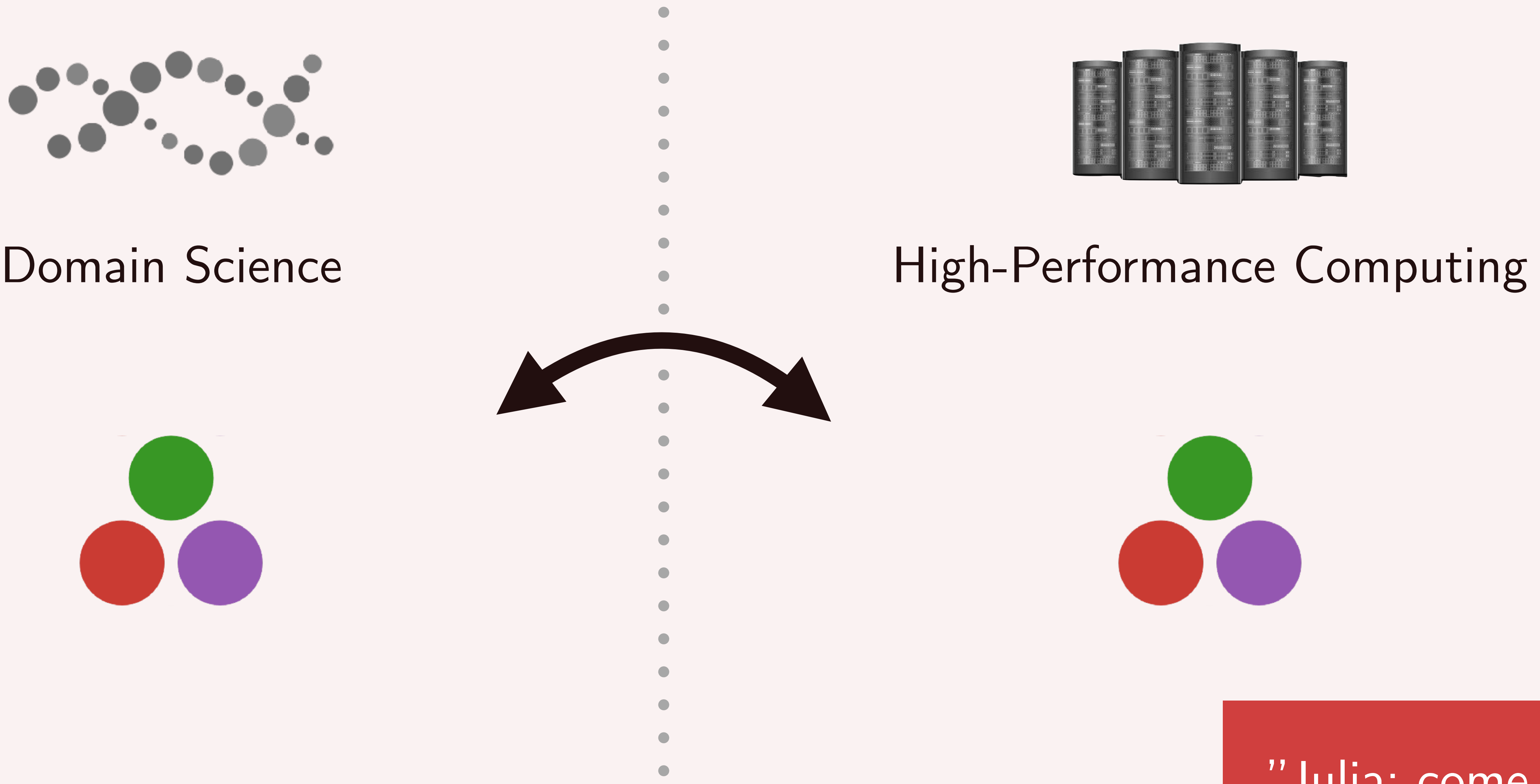


High-Performance Computing



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<br>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 Survey

https://etc.ch/wZaG

# Julia for HPC: Overview

# DISCLAIMER

# Julia’s Weaknesses

# HPC with Julia is currently a niche.

Limited support by vendors and HPC centers

Few people maintain many core packages

Still maturing

# Achieving high performance can be tricky.

Garbage collection

Type instabilities

Task-based multithreading

## No easy way to produce (small) shared libraries.

PackageCompiler.jl is currently your best bet

Hampers integration into existing code bases

# Julia’s Strengths

# Julia is interactive and convenient.

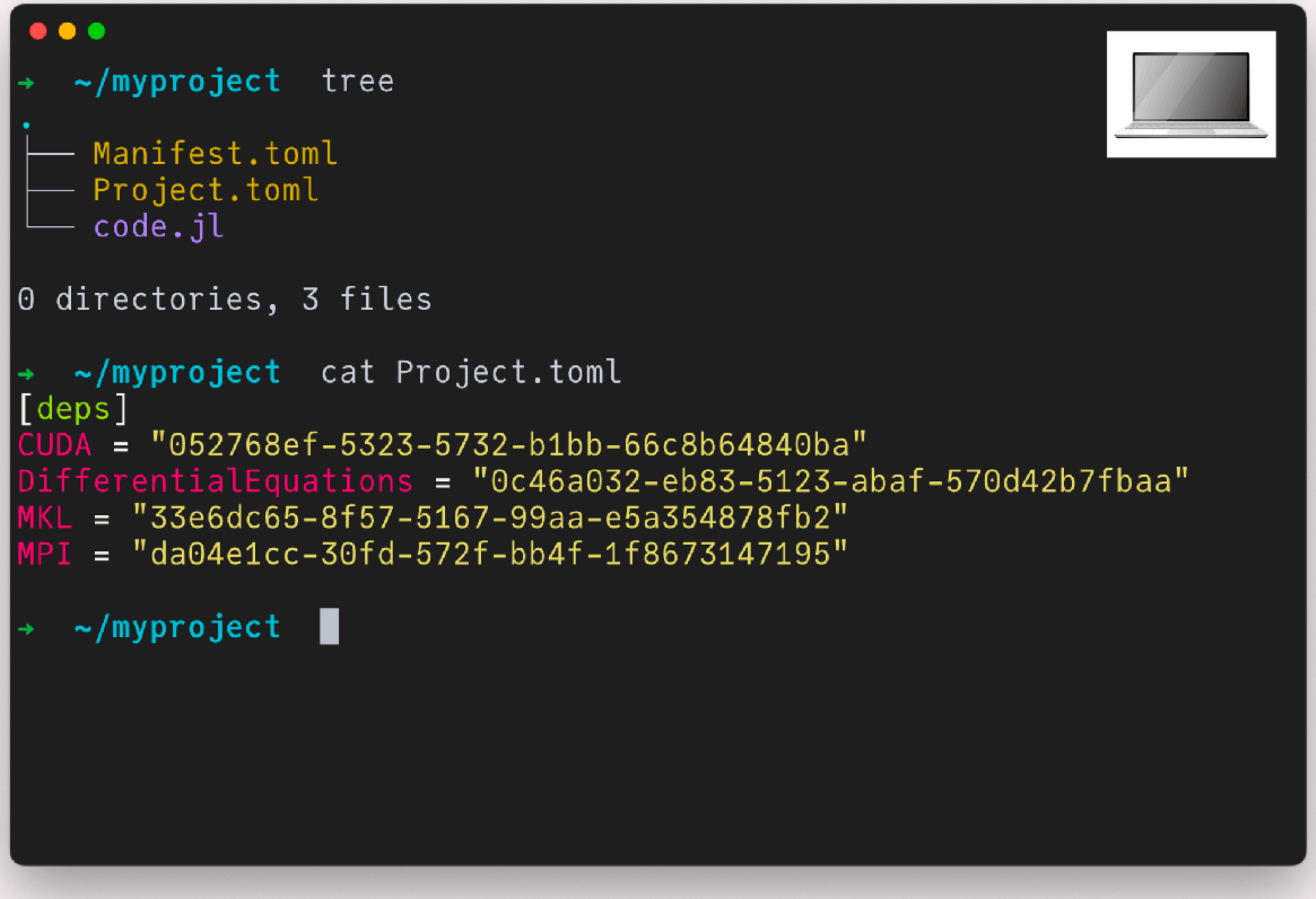
Powerful REPL, Jupyter, ...

Great math support

Best-in-class package manager

# Software portability is as good as it gets

Laptop



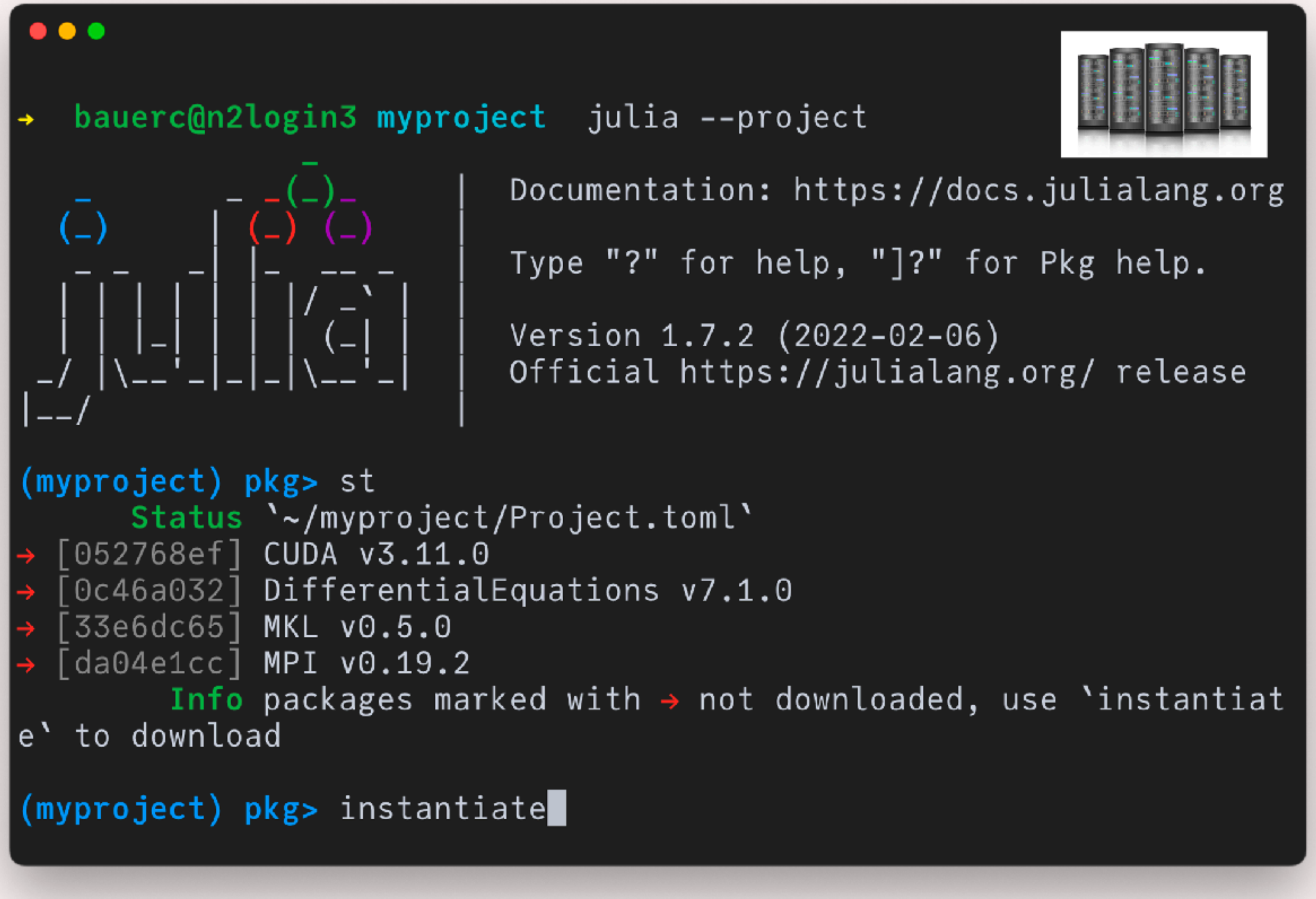
```
➜  ~/myproject  tree
.
├── Manifest.toml
├── Project.toml
└── code.jl

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.

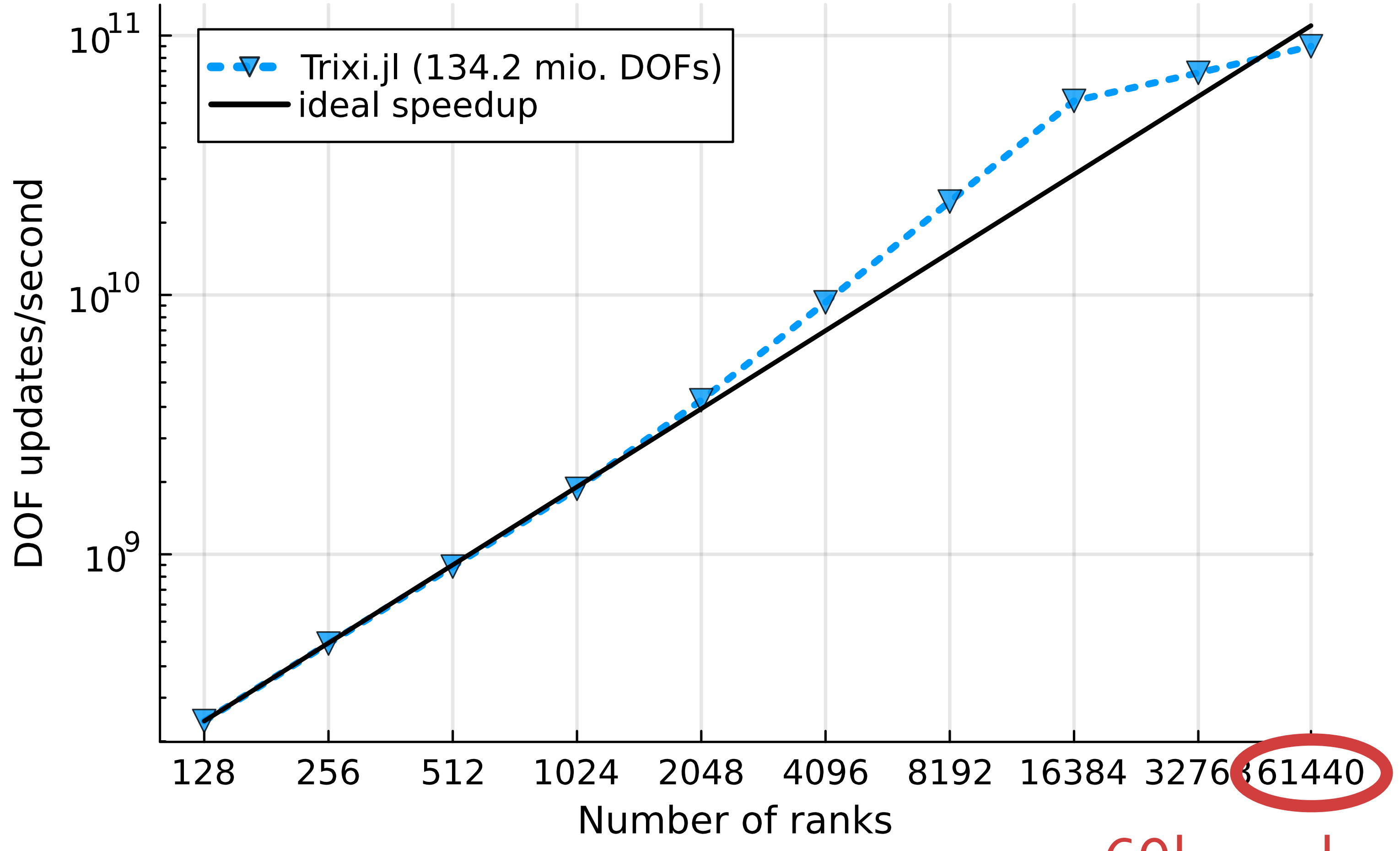
Type inference

Compilation via LLVM

MPI support

# Good scaling of PDE codes

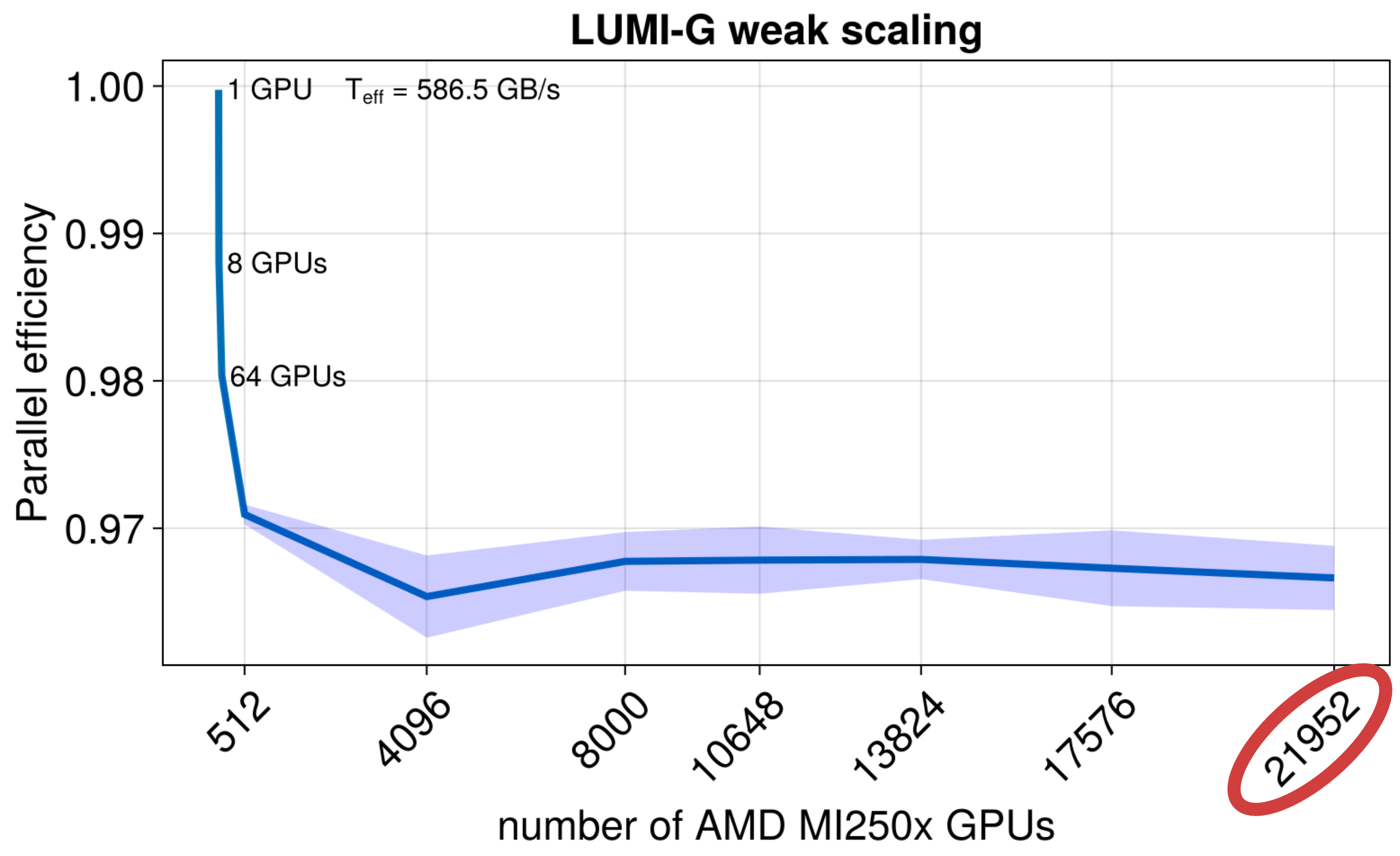
(higher is better)



≈ 60k ranks

Trixi.jl (Multi-CPU)

(higher is better)



≈ 22k GPUs

ParallelStencil.jl (Multi-GPU)

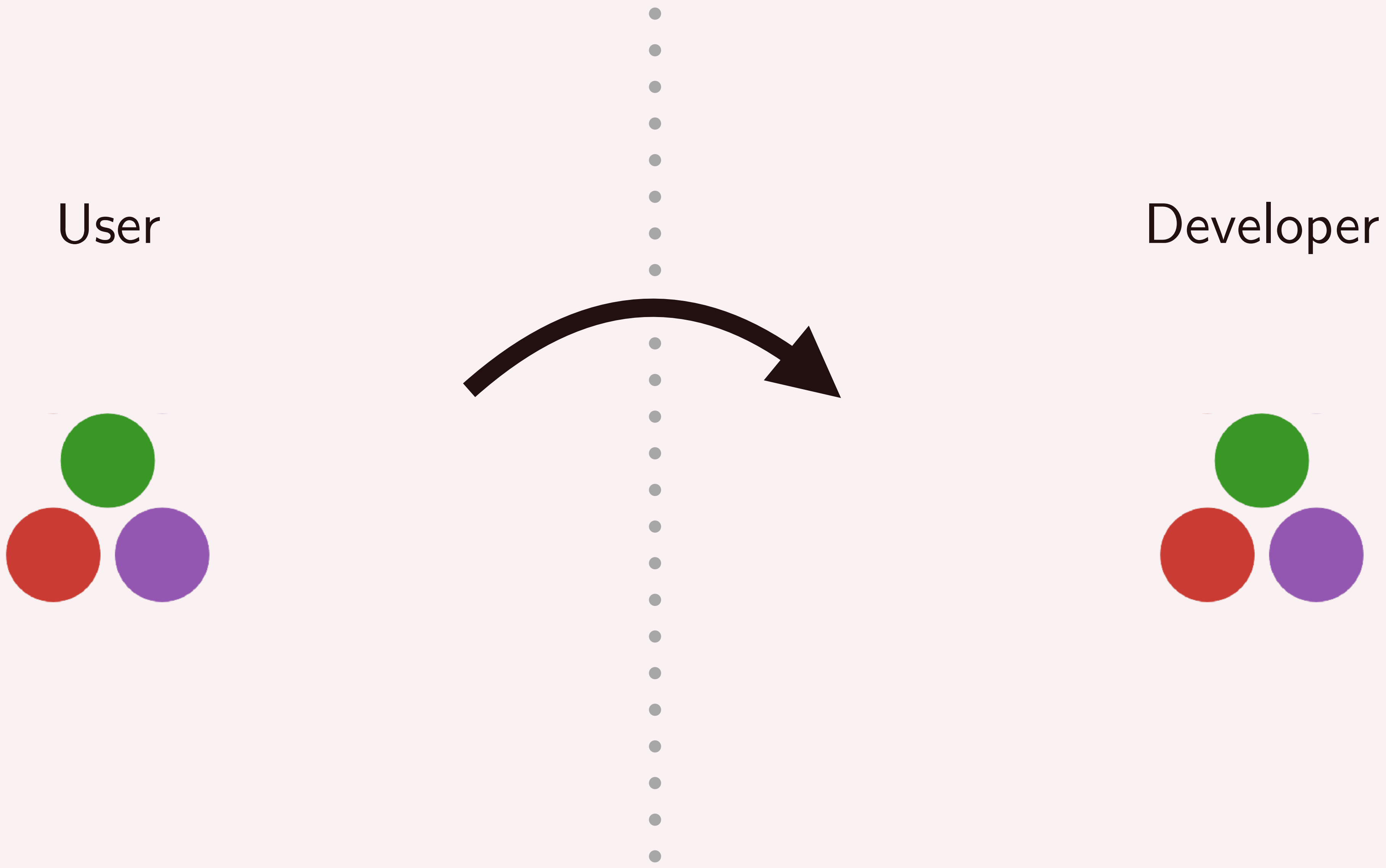
Julia invites you to gradually delve deeper.

Entirely open source

Julia is (mostly) written in Julia

Great introspection tools

# Julia makes it easier to become a developer.



User

Developer

Gradual transition

# A small but vibrant and welcoming community.

People with passion and drive

International
(NERSC, ORNL, CSCS, PC2, ...)

Opportunity to join and grow

# Join us at conferences ...

... or in our monthly Zoom call

(open to everyone!)