

Julia, GPU computing and Earth-system modelling

Session 1:
Introduction to Julia

Edinburgh, February 2026
Milan Klöwer and Simone Silvestri



Who are we?



Milan Klöwer

- PhD from Oxford, PostDoc at MIT (Julia...)
- NERC Independent Research Fellow at Oxford
- Building up my own research group on *climate modelling*
- Started Julia in 2017 (v0.6), definitely wrote bad code back then ...
- Not a core developer of Julia but wrote/maintain/contribute O(10-20) Julia packages
- HTML/JavaScript → Matlab → Python → Julia + sometimes Python

Who are we?



Simone Silvestri

- PhD from Delft, PostDoc at MIT (Julia...)
- Marie Curie Postdoc at Politecnico di Torino
- Started Julia in 2021 (v1.6)
- Passionate about computational fluid dynamics and high-performance computing
- Developer of numerous climate-related packages
- Fortran/C++/CUDA → Julia (no python whatsoever 😊)

Why do we care about programming languages?

The limits of our language are the limits of our world

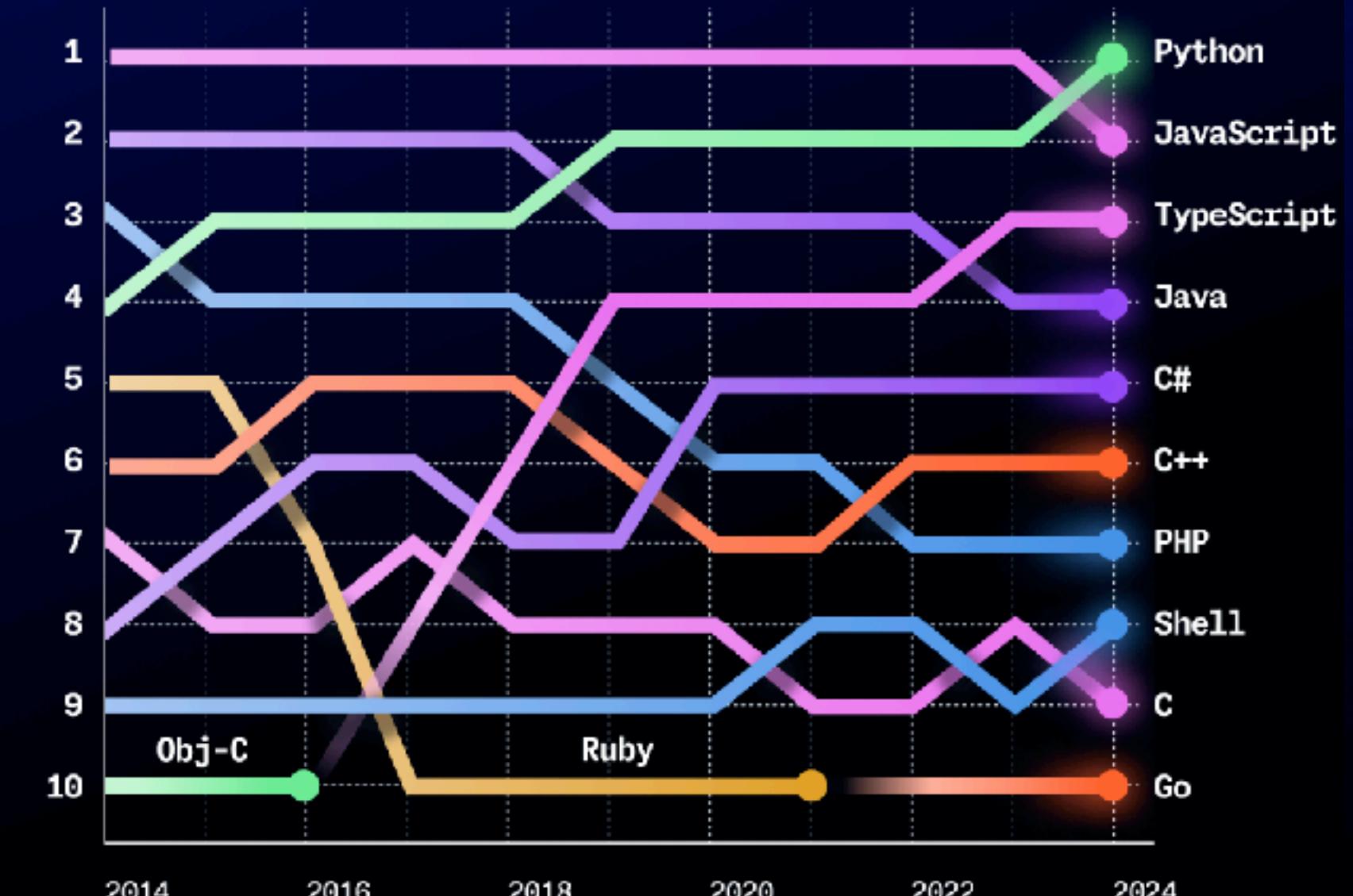
Wittgenstein, 1922

Why is Python successful?

- Speed but using C
- Easy, interactive
- Cross-platform
- Extensions and software stack
- Used for open-source

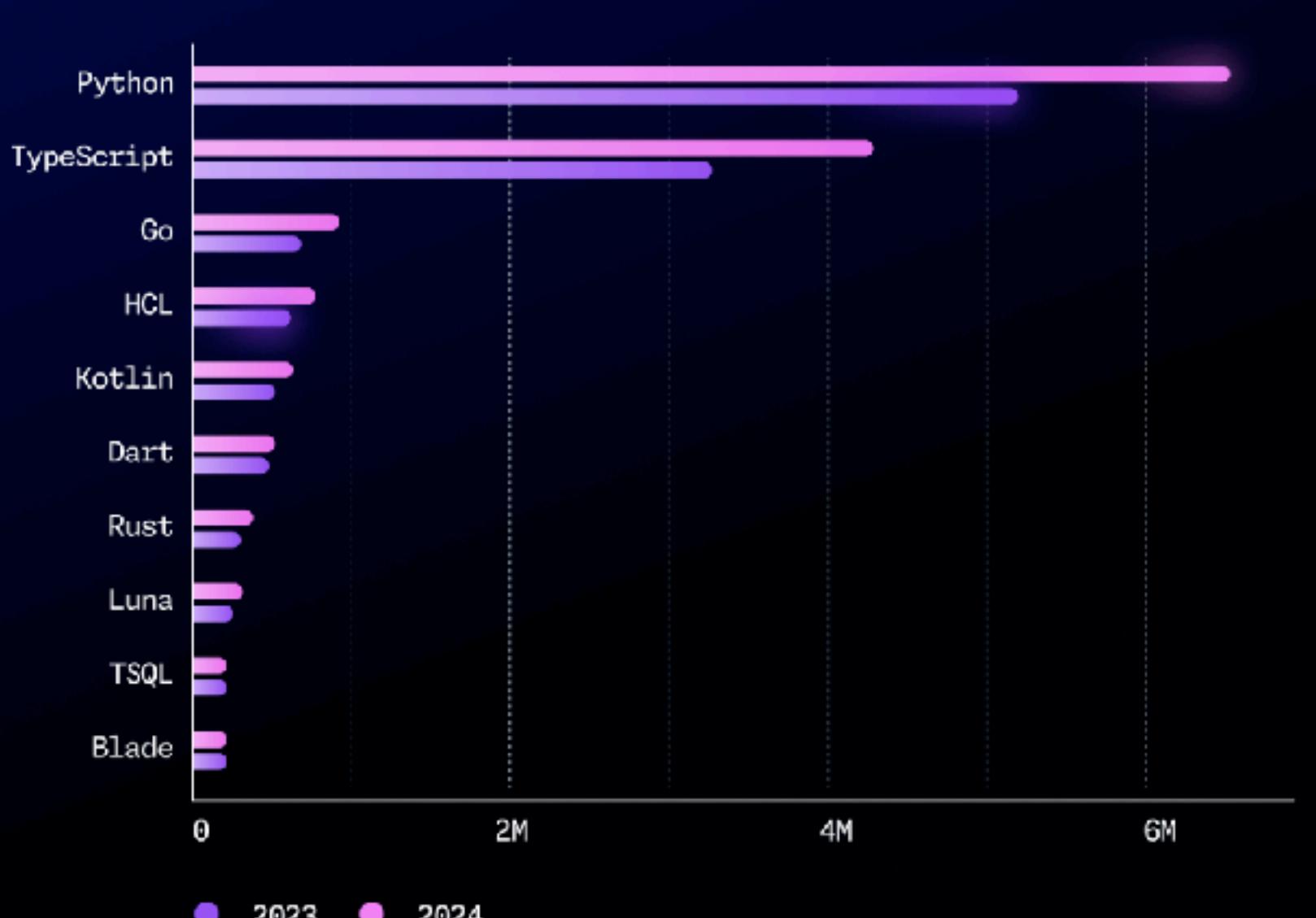
Top programming languages on GitHub

RANKED BY COUNT OF DISTINCT USERS CONTRIBUTING TO PROJECTS OF EACH LANGUAGE.



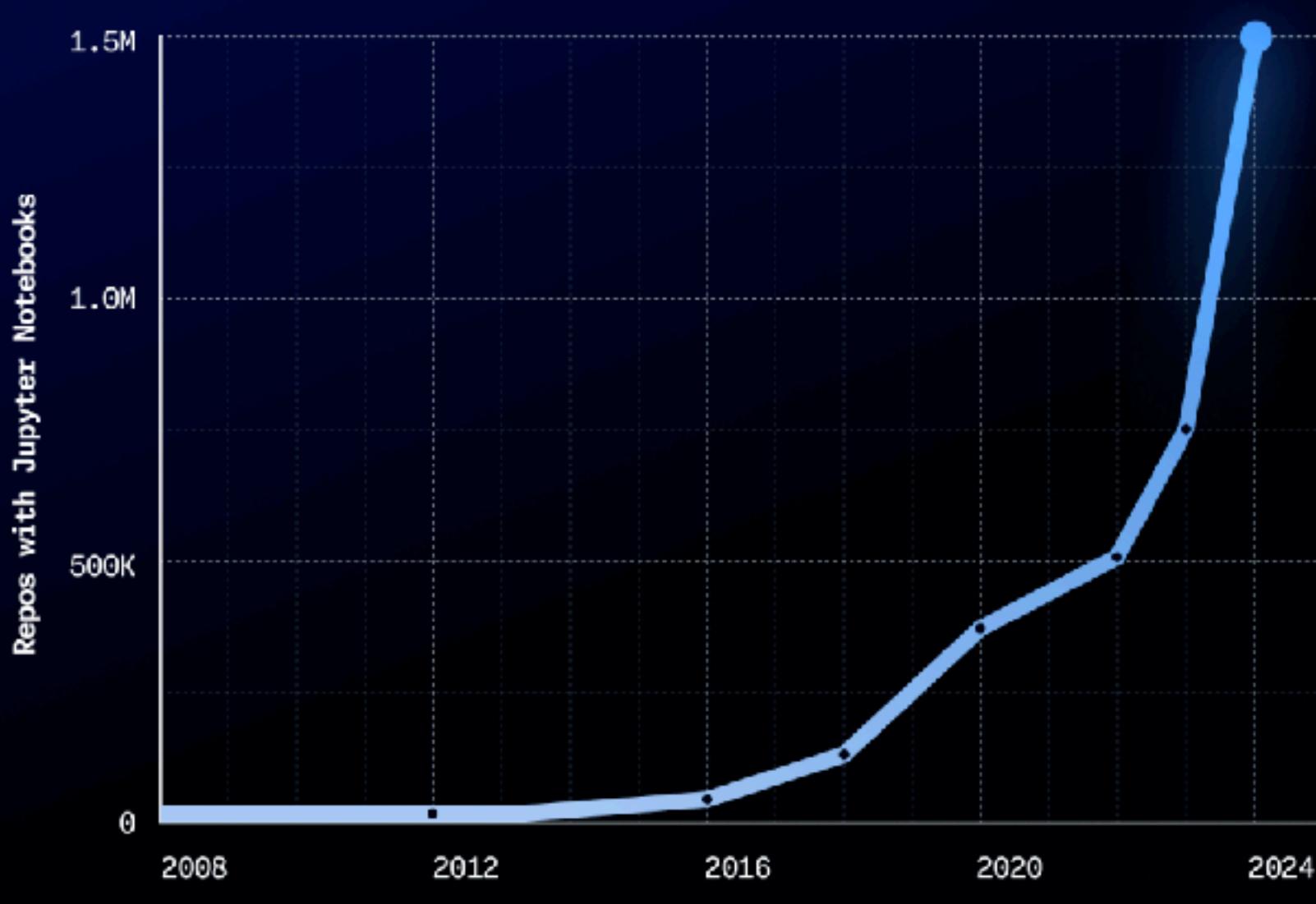
Top 10 fastest growing languages in 2024

TAKEN BY PERCENTAGE GROWTH OF CONTRIBUTORS ACROSS ALL CONTRIBUTIONS ON GITHUB.



Jupyter Notebook usage on GitHub

BY DISTINCT PUBLIC REPOSITORIES WITH AT LEAST ONE JUPYTER NOTEBOOK BY THE YEAR THAT THE REPOSITORY WAS CREATED.



Gen X: I can't learn another language

Gen Z:

The image shows a screenshot of the ChatGPT interface. At the top, the text "What can I help with?" is displayed next to the ChatGPT logo. Below this, a question is asked: "What programming languages do you speak?". Underneath the question are four buttons: "Attach", "Search", "Study", and "Create image". To the right of these buttons is a circular arrow icon with an upward-pointing arrow. The main content area below the question lists various programming languages.

What can I help with?

ChatGPT

What programming languages do you speak?

Attach Search Study Create image

I can work with and generate code in a wide range of programming languages, including:

Popular General-Purpose Languages

- Python
- JavaScript
- TypeScript
- Java
- C
- C++
- C#
- Go

The simplistic tool-bashing narrative

No tool-shaming! (Arfon Smith, 2024)



What is Julia?



- **modern** (2010s)
- **dynamic**
- **general-purpose**
- **compiled** (just-in-time, we'll cover that)
- **interactive** ("like Python") -> can be used in a REPL
- notebooks, like **Jupyter** (it's the "Ju") or Pluto (reactive!)
- **garbage collector**
- comes with its own (one!) **package manager**
- used for technical + **scientific computing**
- including **Machine Learning** and **Earth-system modelling** (that's us!)
- main paradigm is **multiple dispatch** (we'll cover that)

Why Julia? 😍

- **Explorable & Understandable**
- **Composability** (software that isn't meant to work together works together)
- **User-defined types** as fast as built-ins (much of Julia is written in Julia)
- Code **close to mathematics**
- Solves the **2-language problem**
- MIT licensed: free and **open source**

What is the 2-language problem?

You start out prototyping in one language (high-level, dynamic), but performance forces you to switch to a different one (low-level, static).

- For convenience use a scripting language (Python, R, Matlab, ...)
- but do all the hard stuff in an “old-school” language (C, C++, Fortran)

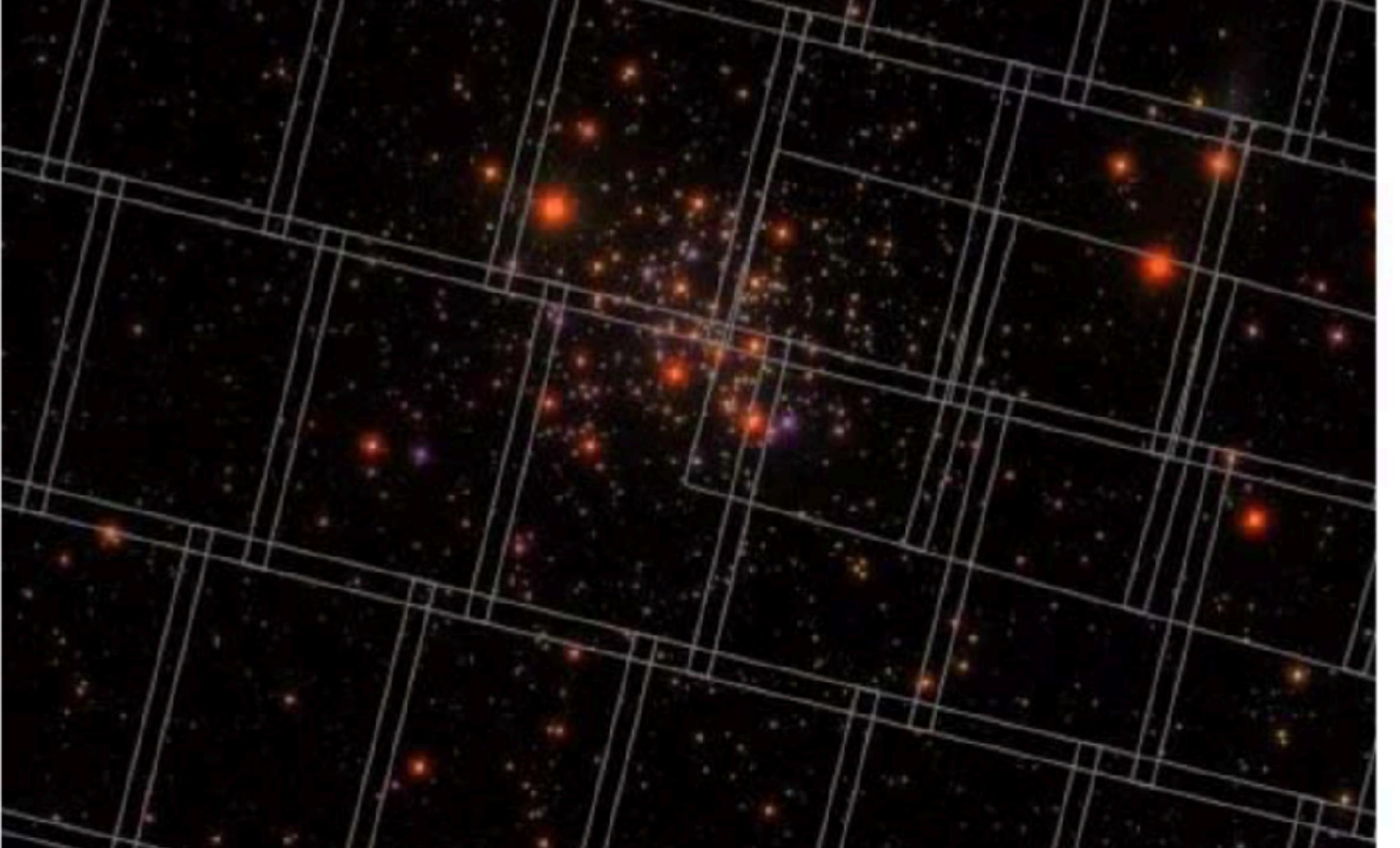
Pragmatic for many applications, but has drawbacks

- aren't the hard parts exactly where you need an easier language?
- creates a social barrier — a wall between users and developers
- “sandwich problem” — layering of system & user code is expensive
- prohibits full stack optimisations

High-performance computing

Multi-threading, distributed and GPU computing supported

Multi-processing with Distributed.jl



JuliaHub

PRODUCTS ▾ CUSTOMERS ▾ RESOURCES ▾ COMPANY ▾ PRICING ▾

HOME / BLOG

Julia Joins Petaflop Club

DATE PUBLISHED
Sep 12, 2017

CONTRIBUTORS
 Andrew Claster

SHARE
   

Berkeley, CA – Julia has joined the rarefied ranks of computing languages that have achieved peak performance exceeding one petaflop per second – the so-called ‘Petaflop Club.’

CONTACT US

```
using Distributed

# number of processors
addprocs(4)

# define calculation on each
@everywhere f(x) = x^2 - 2x - 1

# distribute calculation and reduce via +
@distributed (+) for i in 1:1000
    f(randn())
end
```

Threads, MPI.jl, CUDA.jl,
KernelAbstractions.jl,
AMDGPU.jl, Metal.jl,
Dagger.jl ...

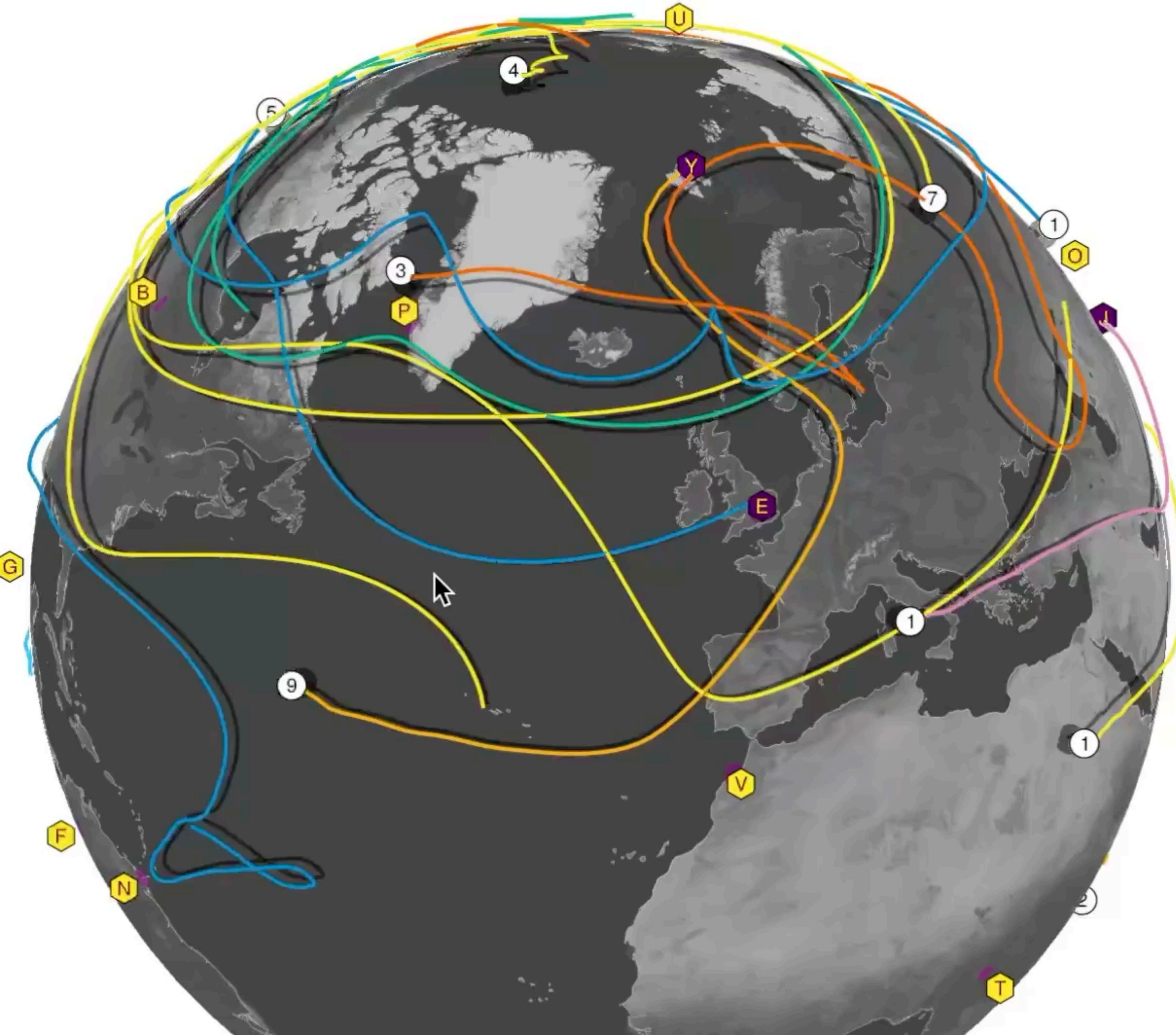
Tyler.jl



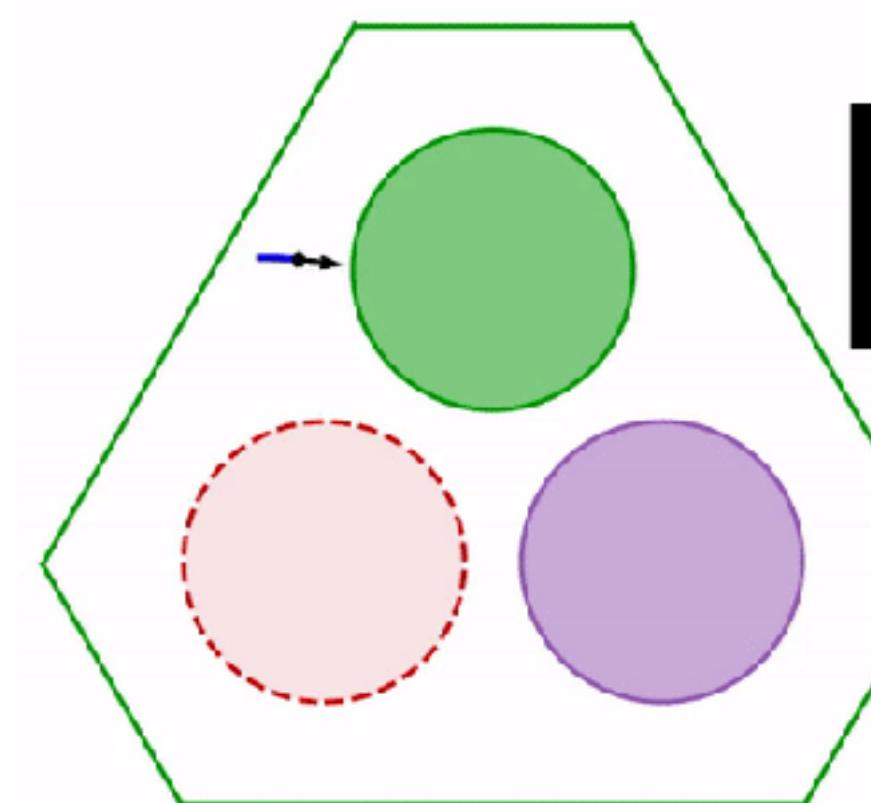
TravellingSailorProblem.jl

- Particle advection challenge
- Used in teaching
- Base on GeoMakie.jl and SpeedyWeather.jl

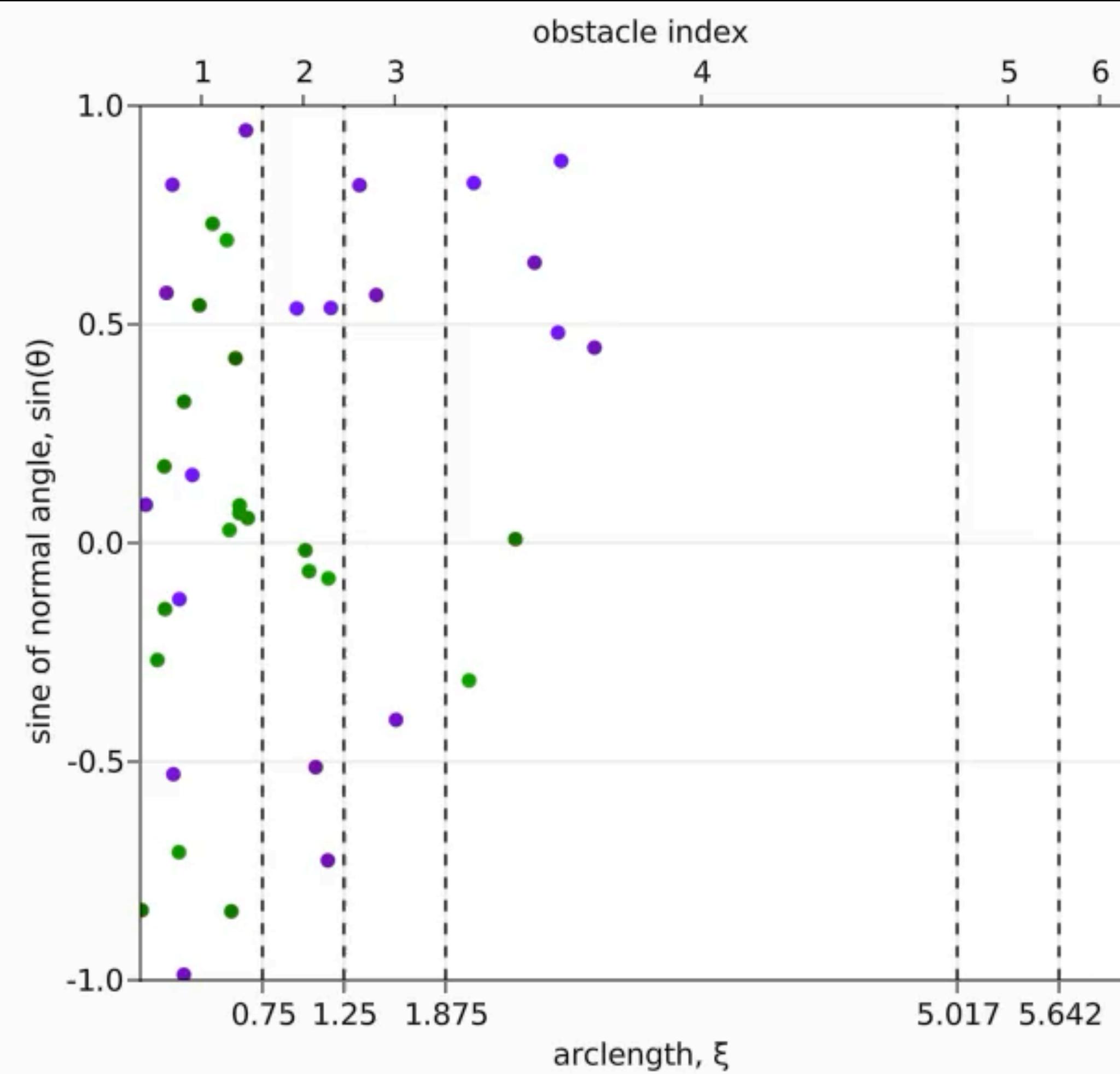
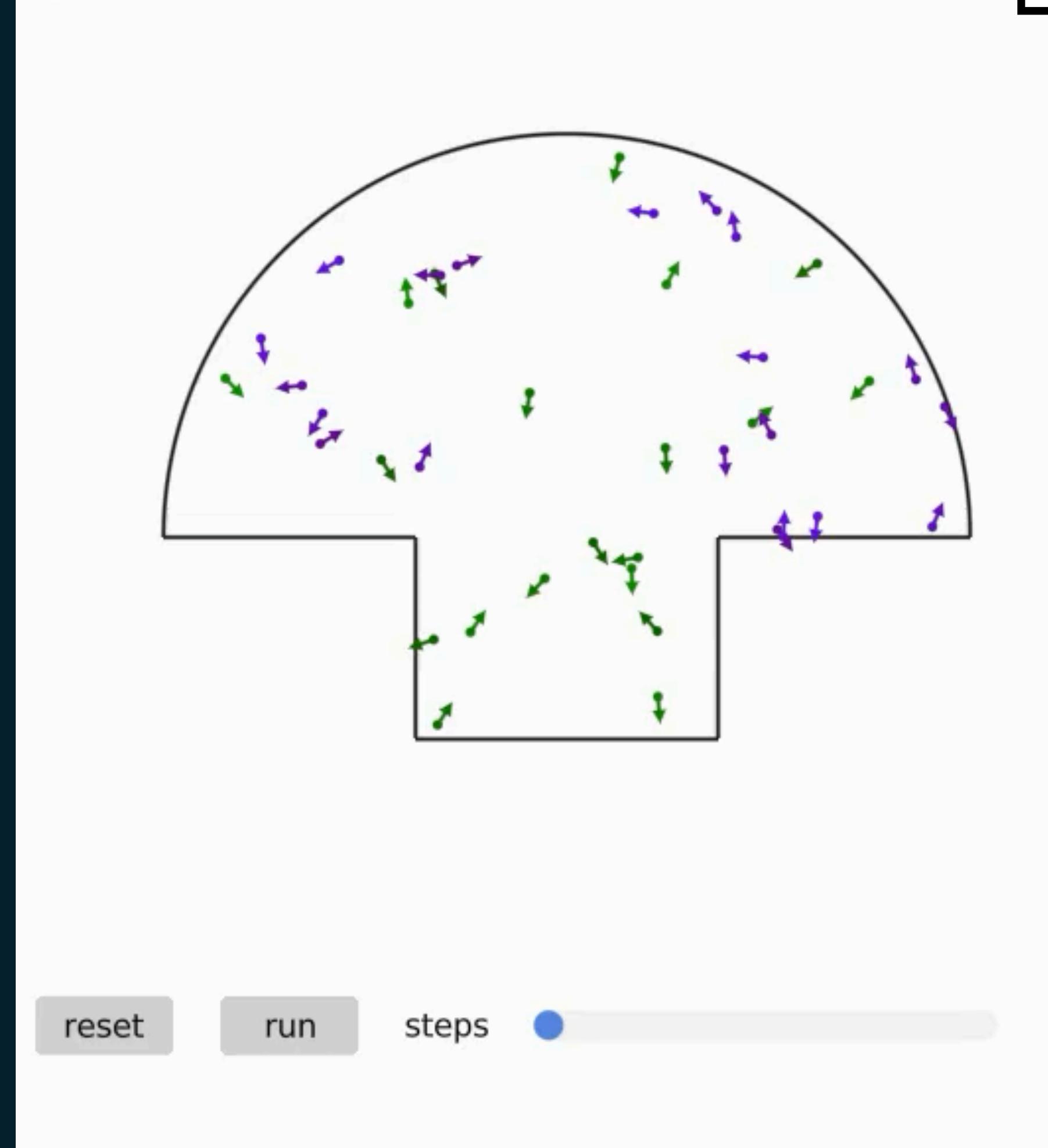
Anshul Singhvi,
Milan Klöwer



Dynamical Billiards.jl



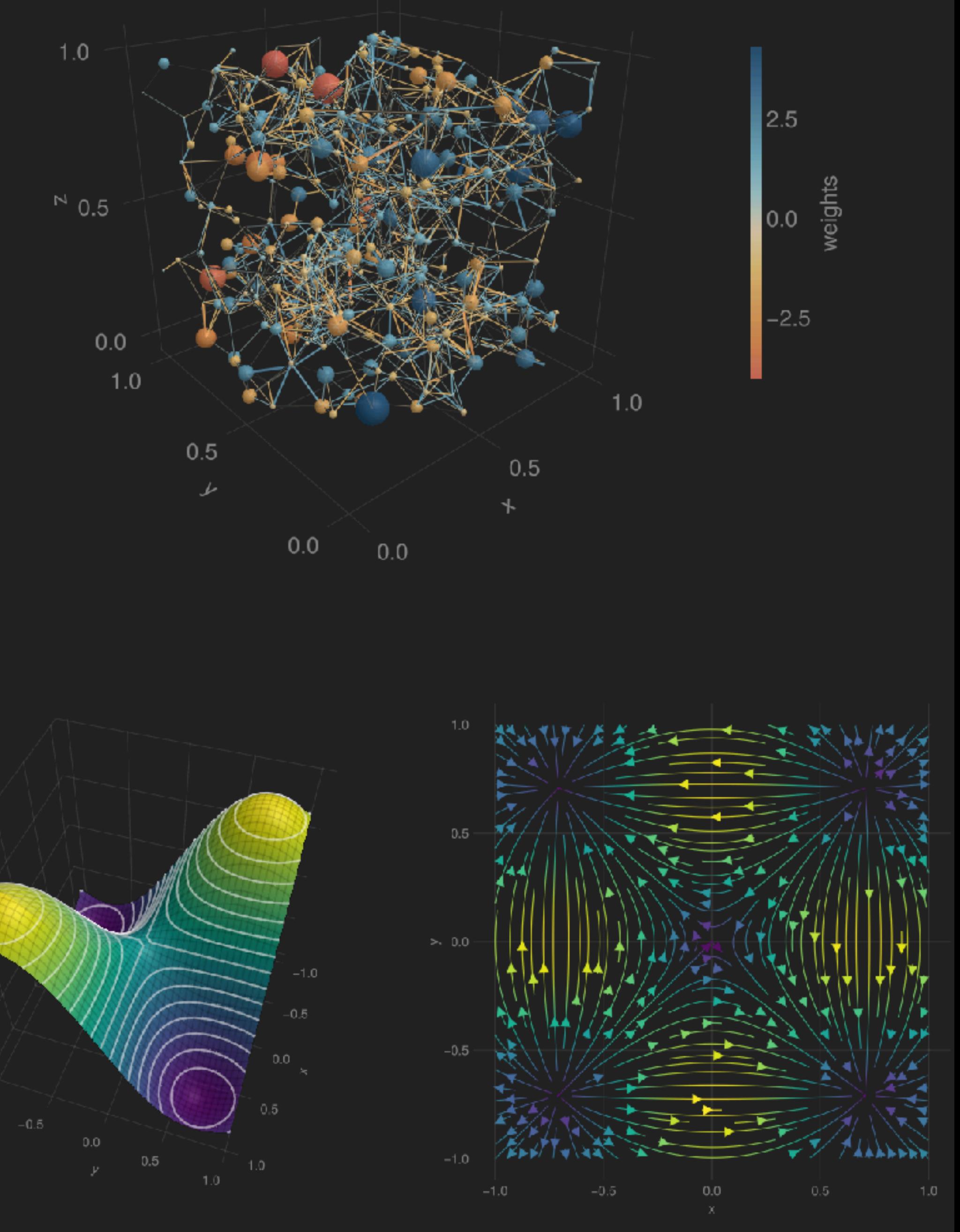
Makie





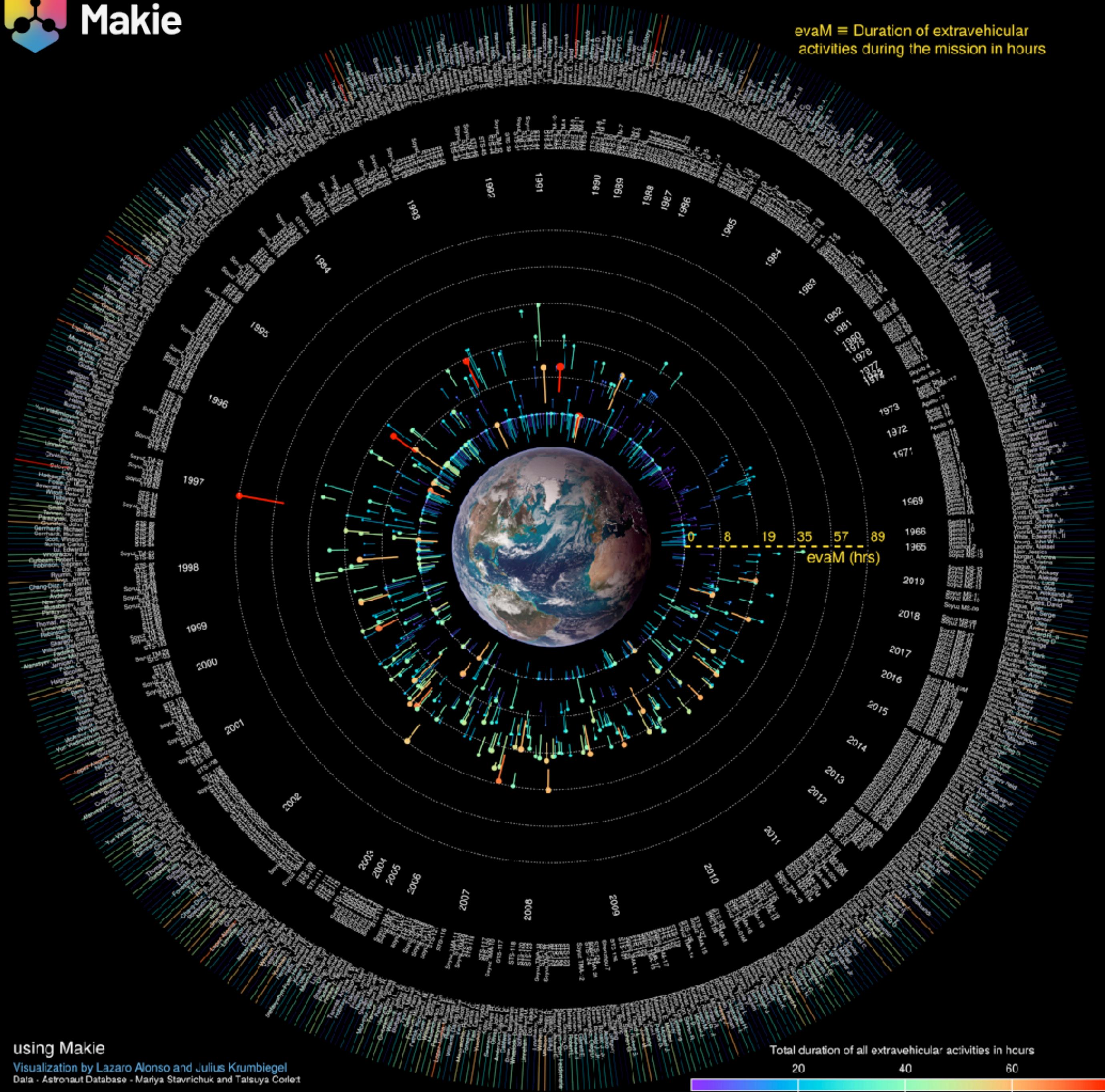
ASTRONAUTS' EXTRAVEHICULAR ACTIVITIES

evaM = Duration of extravehicular activities during the mission in hours



using Makie

Visualization by Lazaro Alonso and Julius Krumbeigel
Data - Astronaut Database - Mariya Stavrichuk and Tatsuya Corlet



Pluto.jl



Jupyter? Pluto — reactive notebooks in Julia

Grant Sanderson (3Blue1Brown)

```
+ A = 2x2 Matrix{Float64}:
  -0.4  -1.0
  1.0   0.41
  • A = [-0.4  -1.0
         1.0   0.41]  ...
+ points =
▶ [(1.0, 0.0), (0.996, 0.01), (0.991916, 0.020001
  • points = integrate_ODE(A, 50.0)

3
2
1
0
-1
-2
-3
-3  -2  -1  0  1  2  3
  plot(points)
```

```
+ # returns two vectors of n successively smaller images
+ # The second images have markings where the seam is cut out
+ carved, marked_carved = shrink_n(img, n_examples);
+ @bind n Slider(1:length(carved))
shrunken by 171:
  • hbox(img, carved[n], sy=size(img))
```

