A Fresh Approach to Technical Computing

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Julia computing

NUMFOCUS
OPEN CODE = BETTER SCIENCE

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Numerical languages

What's the deal with these?

- specialized for **numerical** work

Matlab

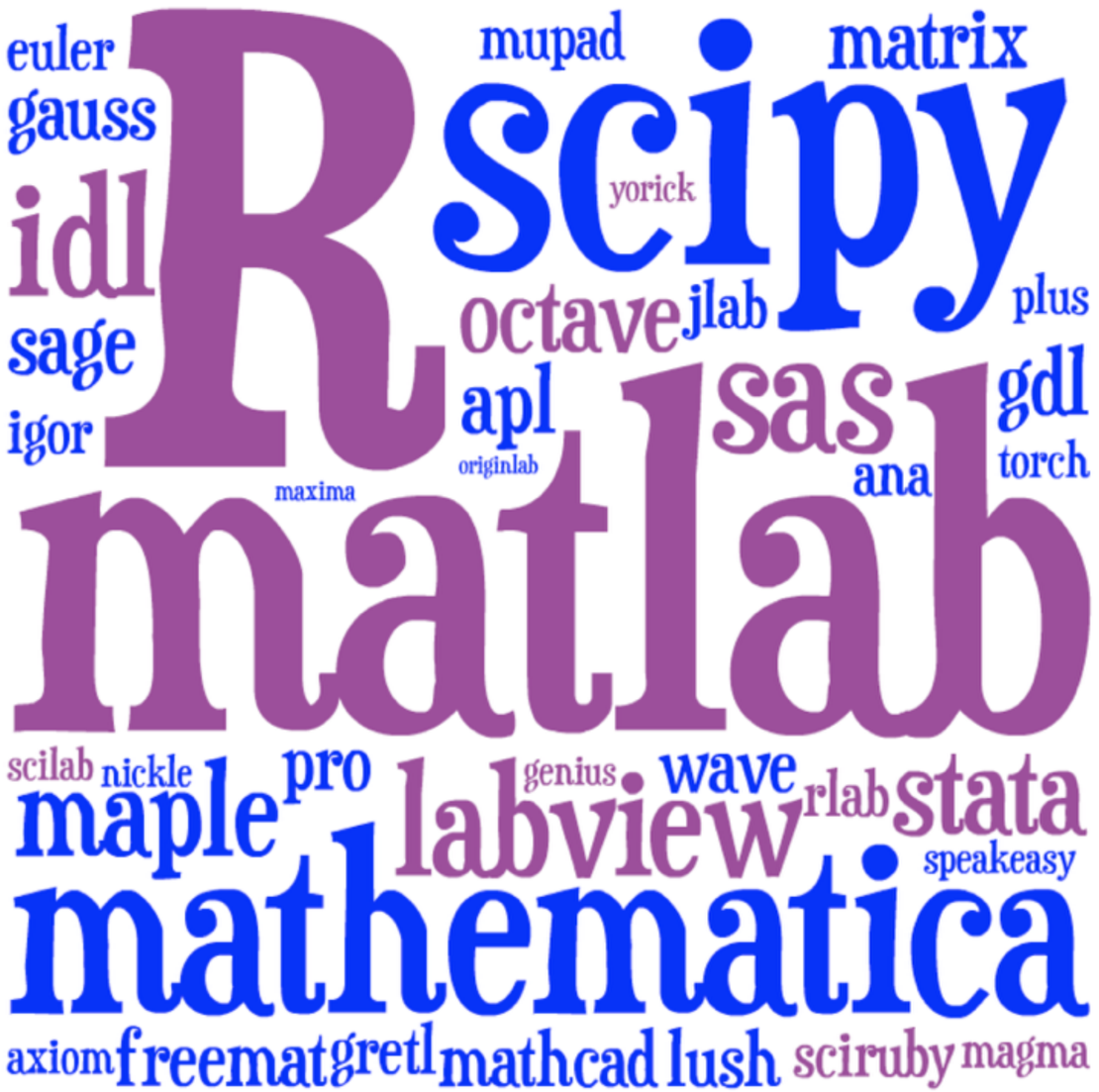
- everything is a complex matrix

R (and S before it)

- allow "NA" values everywhere
- data frame as basic data type

Mathematica

- symbolic rewriting everywhere



So… is Scheme numerical?

R^{6}RS spec:

- **20% numerical**
- (C99 is similar)

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Are we doing it wrong?

Numerical languages are strangely diverse

General languages are strangely numerical

This doesn’t seem quite right.

Julia: a new approach

Stop making numbers **special**

All numeric types are **user-defined**

(Some of them are just defined for you)

The challenge

What does it take

to make numbers **just another type**

and still do real **numerical work?**

Numeric operations

Operations like **+**, *****, **[ ]**, ****

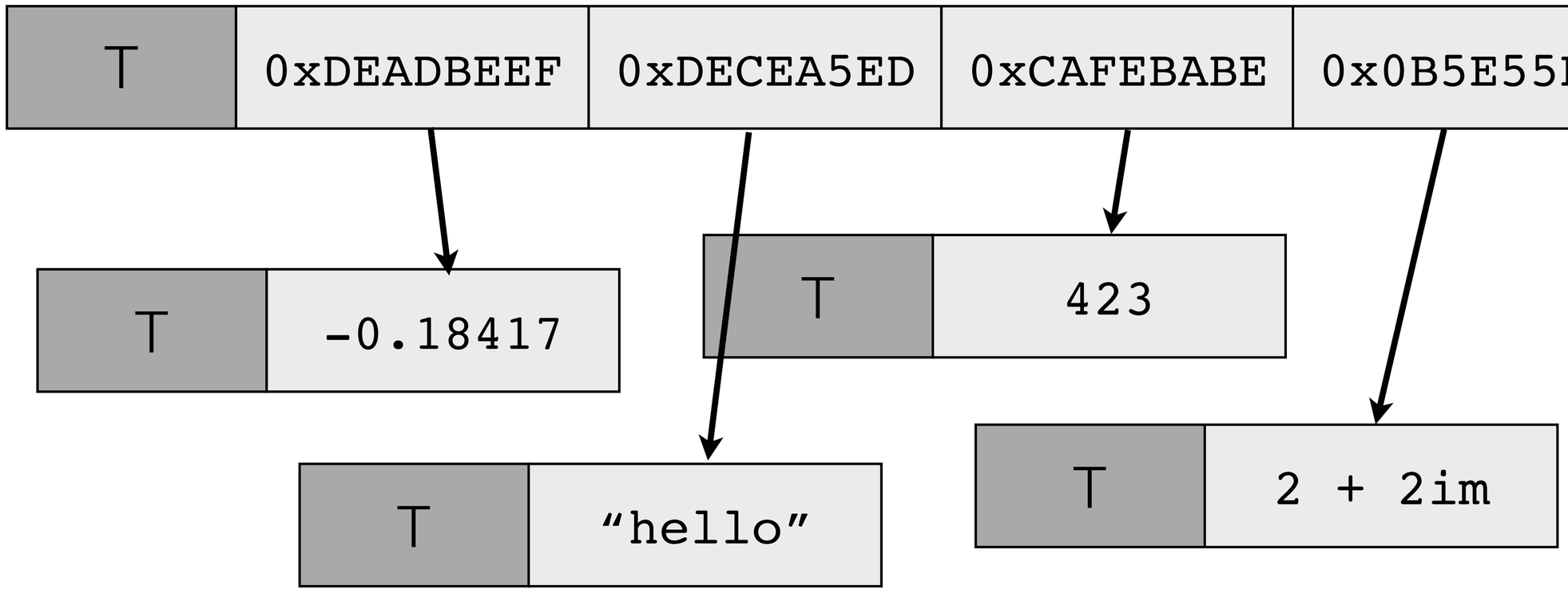
- **unusually polymorphic** – often not normal functions
- behavior depends on **all arguments** not just first
- **extensibility** to new numeric types $\iff$ *the expression problem*

We need **multiple dispatch**

- but if ops like **`Int+Int`** and **`Float64*Float64`** are generic
- generic functions had better be **blazingly fast** (basically free)

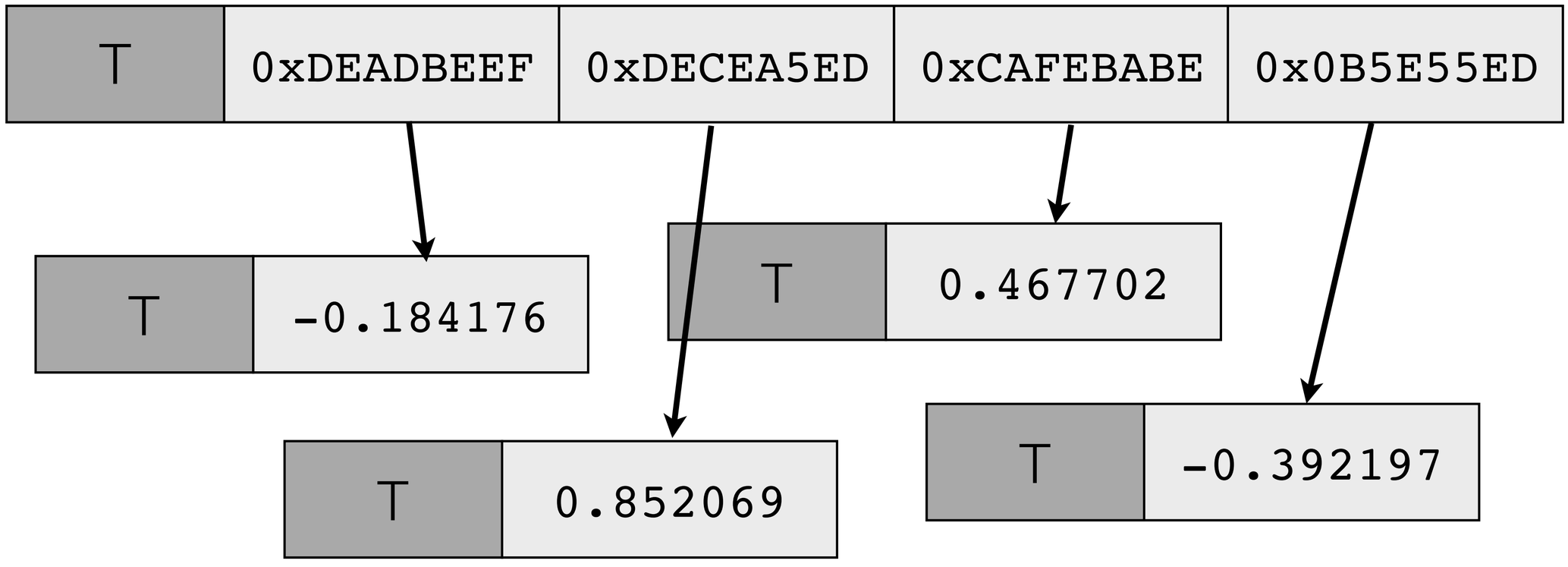
Arrays

```
[-0.18417, “hello”, 423, 2 + 2im]
```



Arrays

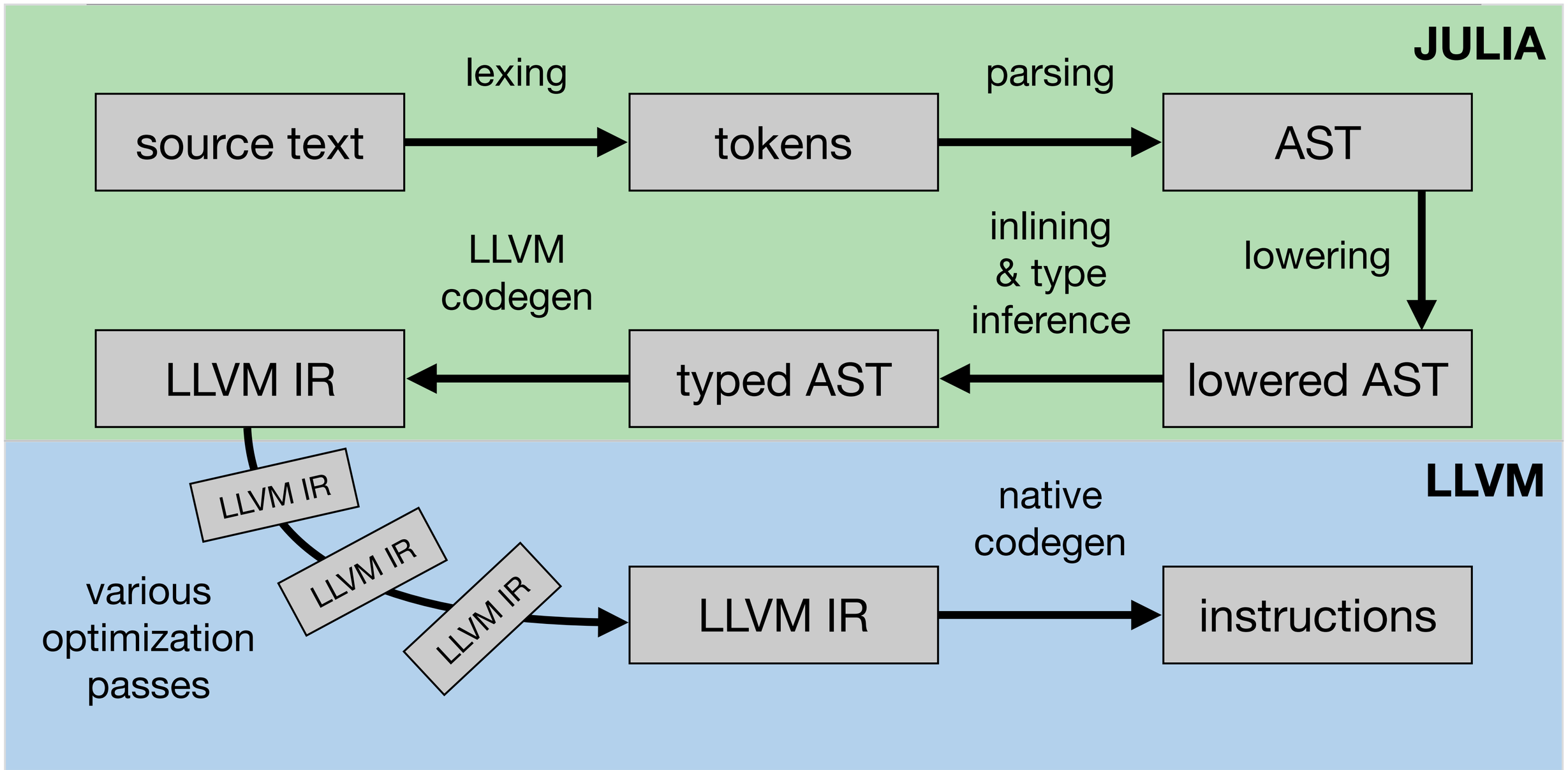
```
Any[-0.18417, 0.85206, 0.46770, -0.39219]
```



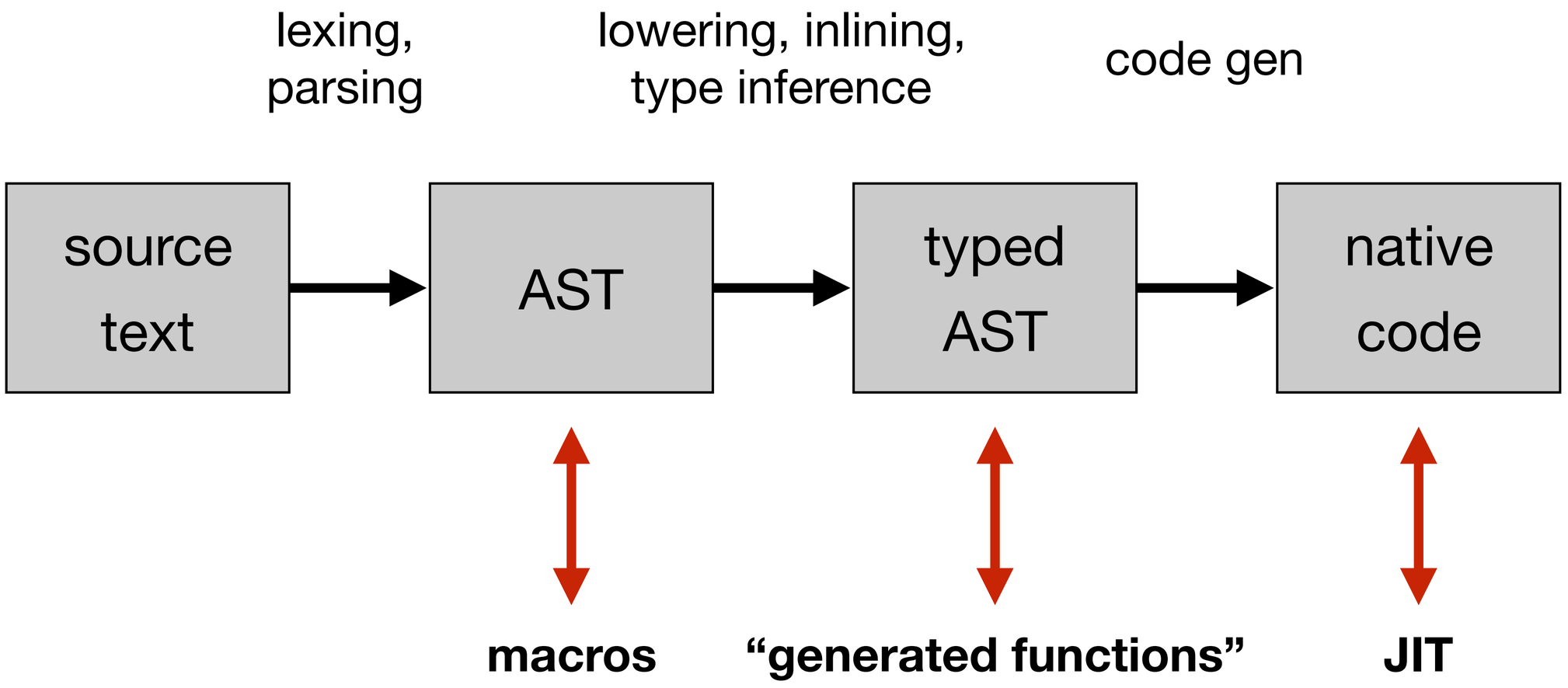
Staged programming

Allowing the programmer to generate code at various points in the compilation process

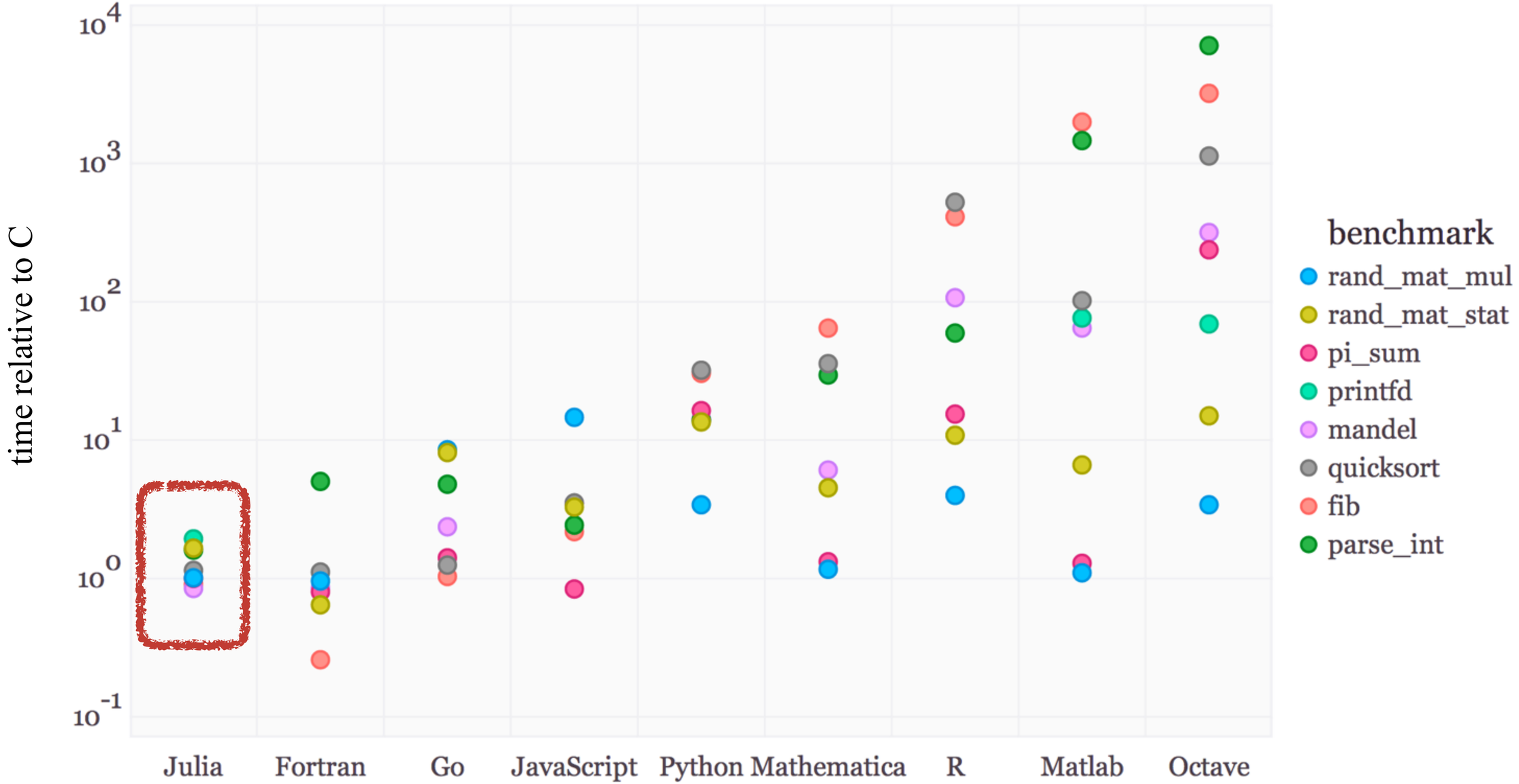
From Source to Machine Code



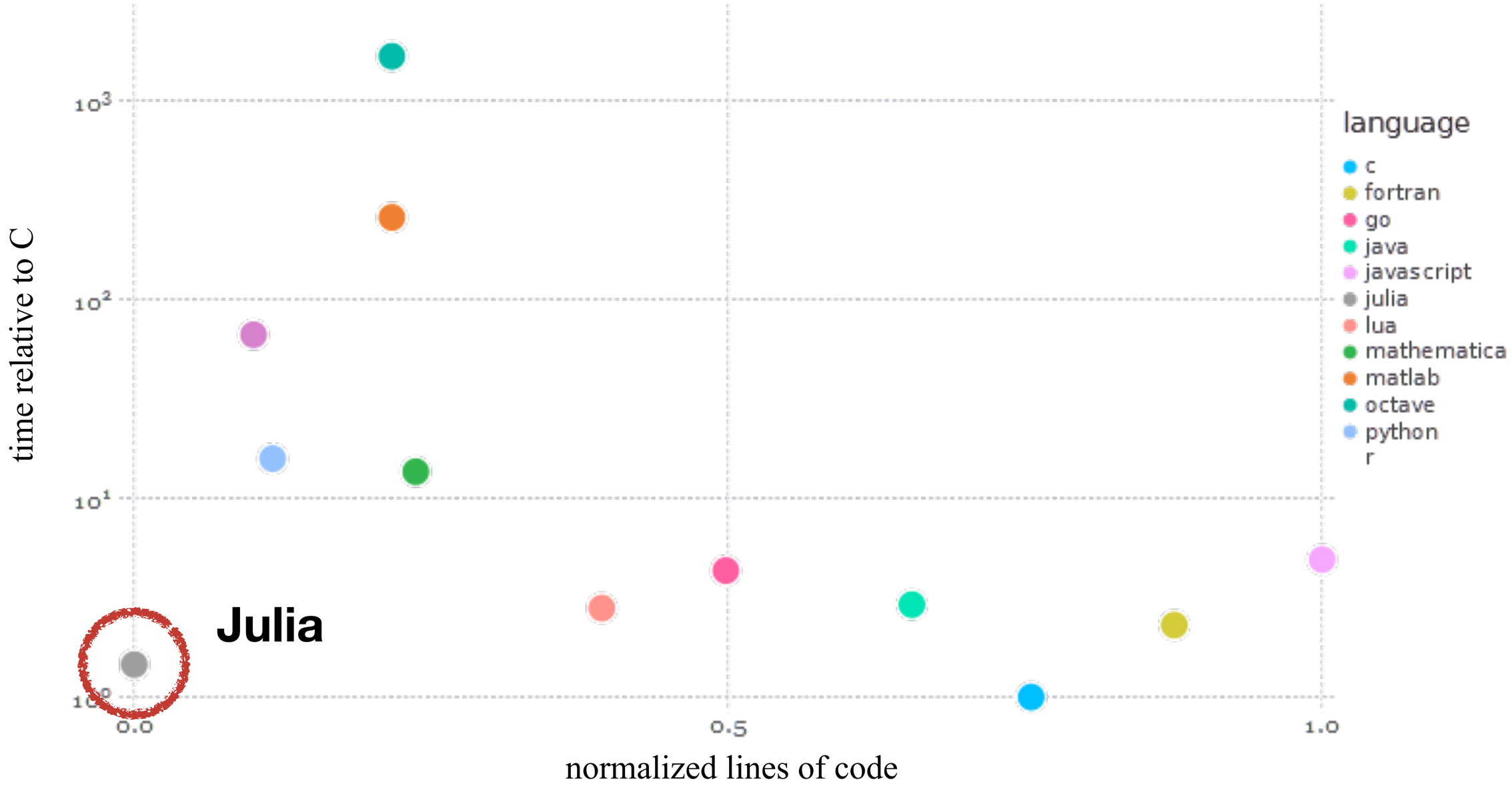
Hooking into compilation



Speed


time relative to C
10^4
10^3
10^2
10^1
10^0
10^{-1}
Julia
Fortran
Go
JavaScript
Python
Mathematica
R
Matlab
Octave
benchmark
rand_mat_mul
rand_mat_stat
pi_sum
printfd
mandel
quicksort
fib
parse_int

Speed vs. Productivity



Demos & Examples

- Simple generic programming: **nextfib**
- Interactive visualization: **Julia set**
- Efficient custom types: **Kakuro**
- Multiple dispatch: **notebook, promotion system**
- Macros & metaprogramming: **Horner & evalpoly**
- Generated functions: **nloops, Savitsky-Golay smoothing**