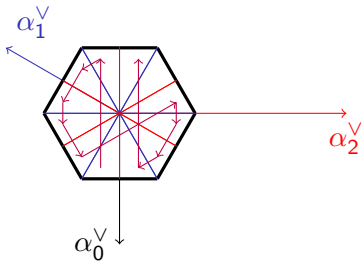


# Sagemath

(Free Software for Mathematics)

<https://sagemath.org>



With slides from Nicolas Thiéry, Franco Saliola, Florent Hivert, Dan Drake, William Stein, ...

Sage is free software

# Sage is free software

“Mission: Creating a viable free open source alternative to  
Maple™, Mathematica™, Magma™ et MATLAB™”

...

## Sage is free software: the GNU definition

A program is free software if the program's users have the four essential freedoms:

- 0 The freedom to run the program as you wish, for any purpose.
- 1 The freedom to study how the program works, and change it so it does your computing as you wish. Access to the source code is a precondition for this.
- 2 The freedom to redistribute copies so you can help your neighbor.
- 3 The freedom to distribute copies of your modified versions to others. By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

See <https://www.gnu.org/philosophy/free-sw.en.html>

Sage is free software: free as in “free beer”

## Sage is free software: free as in “free beer”

- ▶ No need to be in a rich laboratory to be able to use it
- ▶ Technical and administrative simplicity
- ▶ Can be used by students at home
- ▶ Remote computation, large scale deployment
- ▶ Non discrimination
- ▶ Free access to non academics
- ▶ Free access in developing countries

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But the production has a cost: *nothing prevents the rich to contribute.*

## Sage is free software: free goes beyond free

- ▶ english: free means more than free
- ▶ français : libre signifie plus que gratuit
- ▶ en arabe : ?
- ▶ en kabyle : ?



## Sage is free software: access to the source code

*“You can read Sylow’s Theorem and its proof in Huppert’s book in the library . . . then you can use Sylow’s Theorem for the rest of your life free of charge, but for many computer algebra systems license fees have to be paid regularly . . . .*

*With this situation two of the most basic rules of conduct in mathematics are violated: In mathematics information is passed on **free of charge** and everything is laid open for checking.”*

— J. Neubüser (1993)  
(GAP founder in 1986)

## Sage is free software: access to the source code

- ▶ Teaching
- ▶ Reproducibility of scientific results
- ▶ Proof checking
- ▶ Control over the hypothesis, models and algorithms
- ▶ Analysis of bugs and unexpected behavior

# Sage is free software: mutualization

Build the bike instead of reinventing the wheel:

Arbitrary precision arithmetic	MPIR (GMP), MPFR, MPFI, NTL
Algebra	GAP, Maxima, Singular, Givaro
Algebraic geometry	Singular, Macaulay2*
Arithmetic geometry	FLINT, PARI/GP, NTL, ecm
Courbes elliptiques et fonctions L	ECLib, mwrank, ratpoints, SYMPOW, Lca
Symbolic computation	Pynac, Maxima, Sympy, giac*
Exact linear algebra	Linbox, IML
Numerical calculations	Blas (Atlas), Numpy, LAPACK
Numerical calculations	GSL, Scipy
Combinatorics	Symmetrca, Lrcalc, PALP, Coxeter 3, Che
Graph theory	NetworkX, Cliquer, Buckygen*, graphviz*, cvxopt, PPL, glpk, CBC*
Group theory	GAP
Game theory	Gambit*
Statistics	R, Rpy, pandas*
Cryptography	pycrypto, cryptominisat*

(\* optional)

... and more!

## Sage is free software: mutualization

- ▶ about 400k lines of code or doc
- ▶ about 7000 classes
- ▶ about 7000 functions
- ▶ Rich mathematical content: categories, combinatorics, graphs, number theory, ...
- ▶ Many new algorithms

*Share the development to focus on the code specific to your own research.*

## Sage is free software: mutualization



me

1 developer

1k lines of code

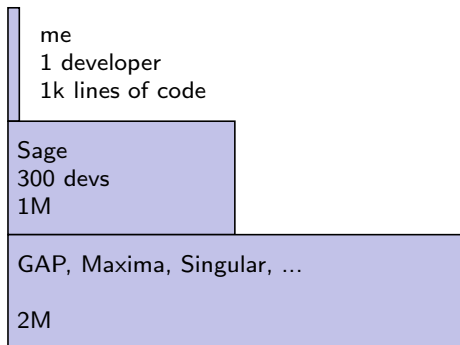
*On the shoulders of a giant.*

## Sage is free software: mutualization



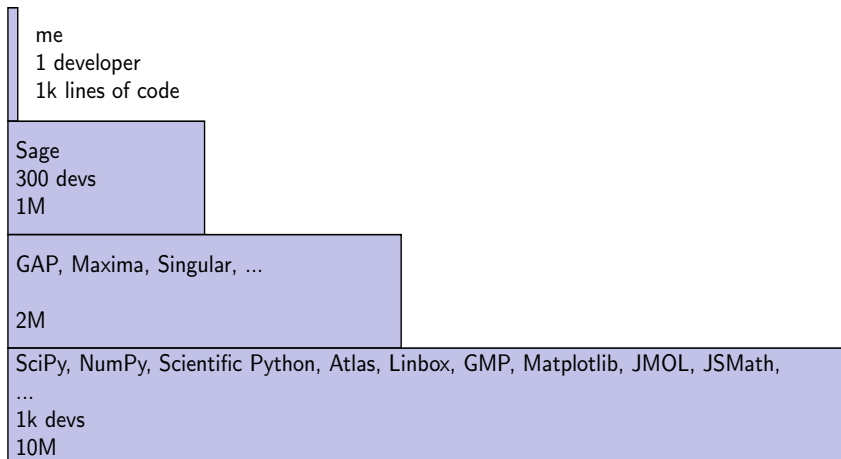
*On the shoulders of a giant.*

## Sage is free software: mutualization



*On the shoulders of a giant.*

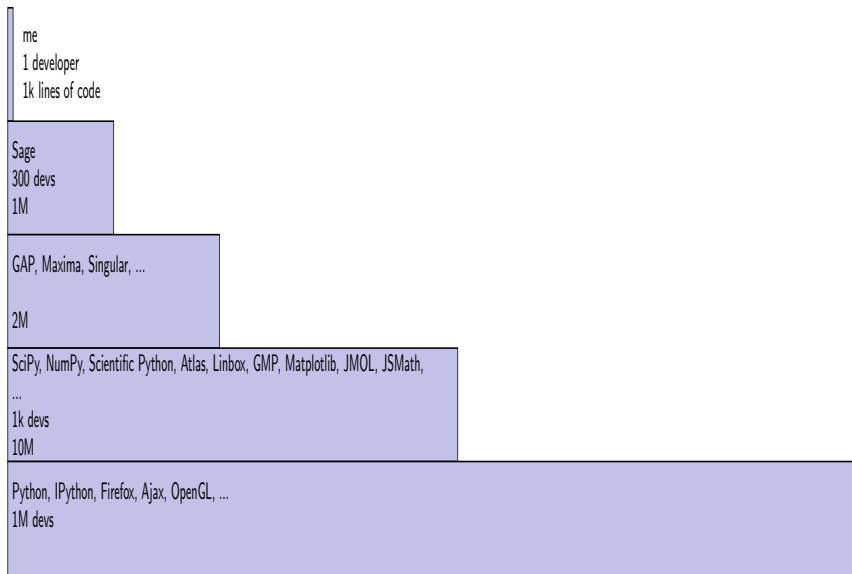
## Sage is free software: mutualization



*On the shoulders of a giant.*



# Sage is free software: mutualization



*On the shoulders of a giant.*

## Sage is free software: in both directions

Freedom to improve and publish one's improvements

- ▶ Adaptation to local needs (dialects, conventions)
- ▶ Specific developments
- ▶ Bug fixes
- ▶ Empowering of users
- ▶ Mutualisation of efforts
- ▶ Importance of communities

## Sage is free software: in both directions

- ▶ A tarball on your webpage far is better than nothing, as easy as:
  - ▶ `tar czvf my-code.tgz my-code/`
  - ▶ `scp my-code.tgz my-lab:my-homepage/.`
- ▶ public git repository
- ▶ pip/R/gap/npm/... package
- ▶ integration into a low-level library
- ▶ integration into Sage

## Sage is free software: in both directions

Beyond the tarball that rots on your webpage.

- ▶ Your code will be read (at least once), and even used!
- ▶ Compilation problems on strange machines will be dealt with.
- ▶ Your code enters a collective world, and will be maintained if it is good (or trashed).
- ▶ The future PhD candidates in your field can position themselves with respect to your work, and build on top of it.
- ▶ Note: it is important to let the permanent researchers do the well-known code and maintenance, so that PhD and postdoc can focus on their own research and algorithms.
- ▶ Remember that Python is only the interface language, if you have a fast optimized library written in C (for example), it also can enter Sage or one of the specialized libraries it uses.

Sage is free software: incomplete and buggy

[https://trac.sagemath.org/sage\\_trac/ticket/10923](https://trac.sagemath.org/sage_trac/ticket/10923)

# Sage is free software: community

Sage is developed by its users (outdated map).



More than 500 people contributed to Sage already.

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# Sage is free software: community

## *Websites and mailing-lists*

<https://www.sagemath.org/> (download Sage)

<https://ask.sagemath.org/> (get help and report bugs)

<https://doc.sagemath.org/> (documentation and tutorials)

<https://wiki.sagemath.org/> (organization and Sage days)

<https://trac.sagemath.org/> (development process)

<https://git.sagemath.org/> (source code repository)

## *SAGE DAYS (Usually one week)*

Developpers: an opportunity to exchange ideas directly.

Newcomers: an opportunity to start, and bootstrap a community (tutorial sessions, demonstrations, stats reports,...).



## Various ways to in install Sage

- ▶ windows : download and unpack the **cygwin** build
- ▶ **mac** : download and unpack the .app.dmg file
- ▶ **linux** : get it from your distro apt get install sagemath, sage-on-gentoo, archlinux,...
- ▶ **docker** image
- ▶ build from **source** : make
- ▶ live **self-replicating bootable USB key** : so that all your student have the same version of softwares (LaTeX, math softwares, editors, compilers...), robust to internet cuts  
<https://sagedebianlive.metelu.net/>
- ▶ **online** : <https://cocalc.com> cloud, or served by your university (or my laptop)

## Various ways to interact with Sage

- ▶ Command line
- ▶ Jupyter notebook
- ▶ Direct use within a  $\text{\LaTeX}$  file: `\usepackage{sagetex}`
- ▶ As a library for Python scripts:  
`from sage.all import *`
- ▶ Live demo on your webpage:  
<https://sagecell.sagemath.org>