

Sage: Creating a Viable Alternative to Magma, Mathematica, Maple and Matlab

<http://www.sagemath.org>

Martin Albrecht (M.R.Albrecht@rhul.ac.uk)

Information Security Group,
Royal Holloway, University of London

Open Knowledge Conference, London School of Economics,
15. March 2008

1 Motivation

2 Features

3 Epilogue

1 Motivation

2 Features

3 Epilogue

“Neubüser’s Law”

“You can read [some] Theorem and its proof in [some] book in the library [. . .] then you can use [that] Theorem for the rest of your life free of charge, but for many computer algebra systems license fees have to be paid regularly [. . .]. You press buttons and you get answers in the same way as you get the bright pictures from your television set but you cannot control how they were made in either case.

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**. Not applying these rules to computer algebra systems that are made for mathematical research [. . .] means **moving in a most undesirable direction**. Most important: Can we expect somebody to believe a result of a program that he is not allowed to see? Moreover: Do we really want to charge colleagues in Moldava several years of their salary for a computer algebra system?”

– J. Neubüser (1993) (he started GAP in 1986).

Why? II

WOLFRAMRESEARCH PRODUCTS PURCHASING FOR USERS ABOUT US OUR SITES

THE WOLFRAM WORLDWIDE WEB STORE



Mathematica 6
The World's Most Powerful Global Computing Environment

OPTIONS:

Mathematica Professional Download [3]

Select

Select

Windows - £2035.00

Macintosh - £2035.00

Linux x86/x86-64bit - £2035.00

HP-UX - £2545.00

IBM AIX - £2545.00

Linux Itanium - £2545.00

Solaris UltraSparc - £2545.00

Solaris x86 - £2545.00

[estimated download]

 **ADD TO CART**

 **ADD TO CART**

Recommended Products

Wolfram Education training--courses for everyone, beginner to expert, on all aspects of *Mathematica*

Application Packages

Books and References

Most Powerful Global Computing

Mathematica is a complete technical computing environment that seamlessly integrates numeric and symbolic computations, interactive document capabilities, an advanced programming language, and powerful connectivity.

The current version, *Mathematica* 6, introduces dynamic interactivity,

£2035

“Why You Do Not Usually Need to Know about Internals”

“Particularly in more advanced applications of **Mathematica**, it may sometimes seem worthwhile to try to analyze internal algorithms in order to predict which way of doing a given computation will be the most efficient. And there are indeed occasionally major improvements that you will be able to make in specific computations as a result of such analyses.

But most often the **analyses will not be worthwhile**. For the internals of **Mathematica** are **quite complicated**, and even given a basic description of the algorithm used for a particular purpose, it is usually **extremely difficult** to reach a reliable conclusion about how the detailed implementation of this algorithm will actually behave in particular circumstances.

– Mathematica Tutorial (2008)
<http://reference.wolfram.com>

on **[sage-devel]** mailing list:

This is like saying “you can read the statement of my theorems but not the proofs, because though you could sometimes greatly improve my theorems, their proofs are too complicated for you to understand and it wouldn’t be worth your time.” **If a pure research mathematician tried to make such claims, the mathematical community would not taken him seriously.**

– William Stein (**Sage** project leader) (29. May 2007)

... luckily, there are many high quality open-source software packages out there.

Neil Sloane

From: N. J. A. Sloane <XXXX@XXXXXXXXXXXX.XXX.XXX>

Date: 8 Nov 2007 06:28

Subject: Re: dumb question about installing pari-gp with fink

I would like to thank everyone who responded to my question about installing PARI on an iMAC.

The consensus was that it would be simplest to install sage, which includes PARI and many other things.

I tried this and it worked!

Thanks!

Neil

(It is such a shock when things actually work!!)

The Bottomline is:

- There are many excellent free and open-source mathematics software packages out there.
- However, these don't interact too well.
- Some suffer from “not invented here” syndrome and reinventing the wheel over and over again.
- Many, many specialised packages are leaders in their field but not embedded in some greater framework.

This is what **Sage** attempts to solve: Create a unified free, open-source mathematics package and liberate the mathematical sciences.

Mission Statement

Provide an open source, high-quality, and free viable alternative to **Magma**, **Mathematica**, **Maple** and **MATLAB**.

In other words: create a unified mathematics software package for algebra, calculus, elementary to very advanced number theory, cryptography, numerical computation, commutative algebra, group theory, combinatorics, graph theory, exact linear algebra and more.

To achieve this do not reinvent the wheel but **reuse** as much **existing building blocks** as possible and make sure the result is **rigorously tested**, **easy to modify** by the end user and **very well documented**.

Also create a **helpful environment** for users to get help (mailing-lists, irc-channel, workshops, coding sprints).

What is Sage?

Sage is a mathematics software package developed by a **worldwide** community of developers.

- 1 a **distribution** of the best free, open-source mathematics software available that is easy to compile or install from binaries.
- 2 an **interface** to most free and commercial mathematics software packages (e.g. Magma, Mathematica)
- 3 a **huge new library**, which uniformly covers the widest area of **functionality**, including several new implementations not yet found elsewhere.

Welcome to **Sage**:

```
-----  
| SAGE Version 2.10.3, Release Date: 2008-03-11 |  
| Type notebook() for the GUI, and license() for information. |  
-----
```

```
sage: 2 + 3  
5
```

1 Motivation

2 Features

3 Epilogue

A Distribution I

Arithmetic	GMP, MPFR, Givaro, MPFI
Commutative Algebra	PolyBoRi, SINGULAR (libSINGULAR)
Linear Algebra	LinBox, M4RI, IML, fpLLL
Cryptosystems	GnuTLS, PyCrypto
Integer Factorization	FlintQS, ECM
Group Theory	GAP
Combinatorics	Symmetrica
Graph Theory	NetworkX
Number Theory	PARI, NTL, Flint, mwrnk, eclib
Numerical Computation	GSL, Numpy, Scipy, ATLAS
Calculus, Symbolic Comp.	Maxima, Sympy
Statistics	R
User Interface	Sage Notebook, jsmath, Moin wiki, IPython
Graphics	Matplotlib, Tachyon, libgd, JMol
Networking	Twisted
Databases	ZODB, SQLite , Python pickle
Programming Language	Python, Cython (compiled)

Overall more than 70 packages are included and shipped with **Sage**.

A Unified Interface

- SAGE **interfaces to**: Axiom, GAP, GP/PARI, Kash, Macaulay2, Magma, Maple, Mathematica, MATLAB, Maxima, MuPad, Octave, Singular, etc.
- This gives SAGE a wide range of **functionality**.
- Unified **command completion and help**.

Example:

```
sage: x = gp('9+6')    # the GP/PARI math software
```

This fires up one copy of GP/PARI and sends the line 'sage[1] = 9+6' to it

```
sage: x, x.name()  
15, 'sage[1]'  
sage: x.factor()  
[3, 1; 5, 1]
```

Another Example:

```
sage: l.groebner_basis(algorithm='singular:slimgb')
```

The Interface is a General Purpose Language: Python

<http://www.python.org> and <http://www.cython.org>



- easy for you to define **your own data types** and methods on it (bitstreams, ciphers, rings, whatever).
- very clean language that results in **easy to read code**.
- a **huge number of libraries**: statistics, networking, databases, bioinformatic, physics, video games, 3d graphics, numerical computation (scipy), and serious “pure” mathematics (via Sage).
- easy to **use existing C/C++ libraries** from Python.
- **Cython** – an almost Python compiler.

On 11/1/07, Jack <XXXX.XXXXXXXXXX@XXXXX.XXX> wrote:

```
> Is it possible to fetch information from a database (say, PostgreSQL)
> with sage? If so, how is it done? If not, is there a workaround
> that people use?
```

Using Psycopg2 is the most popular way of using PostgreSQL from python,

see:

<http://www.initd.org/tracker/psycopg/wiki/PsycopgTwo>

...

Web-based Notebook Interface I

public notebooks available at <http://www.sagenb.org>

The screenshot shows a web browser window with the address bar at `http://localhost:8000/home/admin/15/`. The page title is "Copy of 2.5.1 dirichlet characters (SAGE)". The interface includes a navigation bar with links: `admin`, `Toggle`, `Home`, `Published`, `Log`, `Help`, and `Sign out`. Below this is a header for the notebook "2.5.1 dirichlet characters" with a timestamp "last edited on November 07, 2007 08:49 PM by admin". A toolbar contains buttons for "File...", "Action...", "Data...", "sage", "Print", "Use", "Edit", "Text", "Revisions", "Share", and "Publish". A "SAGE Tutorial" link is also present. Navigation links show "Previous: 2.5 Number Theory", "Up: 2.5 Number Theory", and "Next: 2.6 Linear Algebra".

The main content area is titled "2.5.1 Dirichlet Characters" and contains a paragraph: "A Dirichlet character is the extension of a homomorphism $(\mathbf{Z}/N\mathbf{Z})^* \rightarrow R^*$, for some ring R , to the map $\mathbf{Z} \rightarrow R$ obtained by sending those $x \in \mathbf{Z}$ with $\gcd(N, x) > 1$ to 0."

Below the text are three input boxes for code execution:

```
G = DirichletGroup(21)
list(G)
```

```
[[1, 1], [-1, 1], [1, zeta6], [-1, zeta6], [1, zeta6 - 1],
[-1, zeta6 - 1], [1, -1], [-1, -1], [1, -zeta6], [-1, -zeta6],
[1, -zeta6 + 1], [-1, -zeta6 + 1]]
```

```
G.gens()
```

```
([-1, 1], [1, zeta6])
```

```
len(G)
```

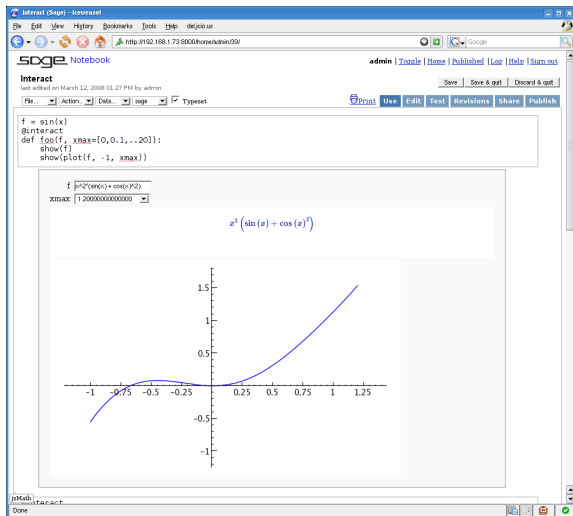
```
12
```

At the bottom, a message states: "Having created the group, we next create an element and compute with it."

- graphical user interface
- 2D plotting
- 3D interactive plotting
- \LaTeX typesetting
- web service (**AJAX**, SSL) inspired by Google Docs
- worksheet sharing
- worksheet up/down-load

Web-based Notebook Interface II

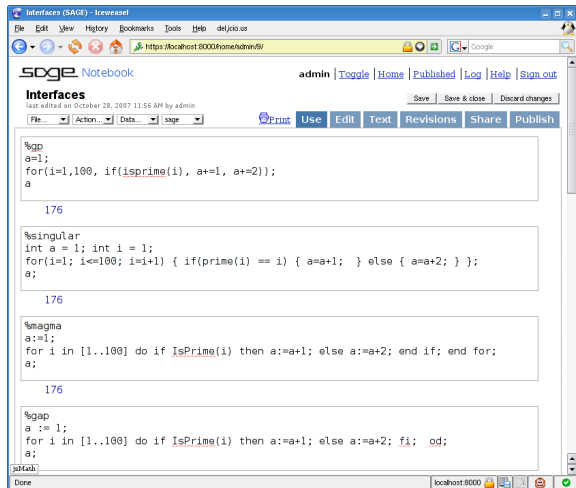
public notebooks available at <http://www.sagenb.org>



Web-based Notebook Interface III

public notebooks available at <http://www.sagenb.org>

A web interface to many mathematics software packages.



Examples:

- Pari
- Maxima
- Singular
- Gap
- Mathematica
- Maple
- ...

Live Demo

1 Motivation

2 Features

3 Epilogue

Mathematics software cannot only be used to analyse and generate knowledge, it **is** knowledge.

Sage source code is treated that way:

- Patch submission similar to submission to scientific journal.
- **Every** patch is refereed by at least one other developer.

Journal of Sage

JSAGE publishes high quality free open source refereed implementations of mathematical software as part of SAGE. To publish in JSAGE means that software you write becomes part of SAGE. Submissions from all areas of pure

and applied mathematics are encouraged. When possible, we strongly encourage JSAGE authors to also contribute corresponding mathematical research articles to these endorsed journals.

– <http://www.sagemath.org/jsage/>

Getting Started With Sage

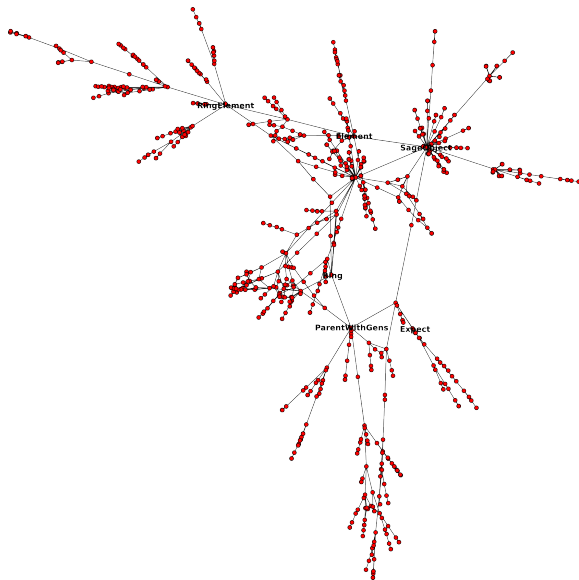
Ways to use Sage:

- download source; type 'make', wait, run (Linux, OSX, Solaris (soon))
- download binaries for a wide range of platforms
- download VMWare image (e.g. for Windows)
- try it online: <http://www.sagenb.org>

Documentation:

- **Sage** installation guide
- interactive tutorial
- comprehensive reference manual
- “How Do I Construct ...” manual
- **Sage** programming guide
- “Sage programming for Newbies” book
- <http://wiki.sagemath.org>

Questions?



Thank You!