

SAGE Days 4

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Welcome to SAGE Days 4!

- This is a workshop aimed at **SAGE developers**.
- Afternoon talks each day: one from **the community** about what we should be doing, and one by **a developer** about what has been done.
- Daily intense **coding sprints** and **discussions**.
- **Goal:** Produce good **ideas** and good quality **code**.

Introduction to SAGE

SAGE: Open Source Mathematics Software

Our goal is to:

Create a high quality open source alternative to Magma, Maple, Mathematica, and MATLAB.

SAGE is:

- A **free distribution** of open source mathematics software,
- A **new mathematical software system** with a GUI and command line, and
- A **good way to use** all existing mathematical software together.

SAGE: Brief History

- **1965-2005:** Maxima, Singular, PARI/GP, GAP, GMP, etc.
- **Feb 24, 2005:** I released first version of SAGE. Initial goal was **freedom**; not write any more research papers that fundamentally depended on closed proprietary software.
- **2005:** Developers were me, David Joyner, David Kohel, Kyle Schalm, and Steven Sivek. Essentially we wanted to recreate a small subset of the Magma's functionality.
- **Feb 2006:** SAGE Days 1 – a lot more people got involved.
- **June 2007:** SAGE Days 4 – now; 148 subscriptions to the SAGE developer mailing list.

```

rank4:~/sage/web/0.1 was$ tar tvf sage-2005-02-24-0734-src-0.1.tar
2005-02-24 04:33:34 sage-2005-02-24-0734/
2005-02-24 04:27:59 sage-2005-02-24-0734/bin/
2005-02-24 04:12:42 sage-2005-02-24-0734/bin/gp
2005-02-24 04:27:59 sage-2005-02-24-0734/bin/sage
2005-02-24 04:10:29 sage-2005-02-24-0734/bin/pyrexc
2005-02-18 13:11:51 sage-2005-02-24-0734/README.txt
2005-02-24 04:07:35 sage-2005-02-24-0734/install/
2005-02-24 03:57:01 sage-2005-02-24-0734/install/src/
2005-02-24 03:56:47 sage-2005-02-24-0734/install/src/Python-2.4.tgz
2005-01-22 19:58:43 sage-2005-02-24-0734/install/src/gmpy-sources-10.zip
2005-01-22 19:02:19 sage-2005-02-24-0734/install/src/pari-2.2.9.alpha.tar.gz
2005-01-22 19:02:19 sage-2005-02-24-0734/install/src/Pyrex-0.9.3.tar.gz
2005-01-22 19:02:19 sage-2005-02-24-0734/install/src/readline-5.0.tar.gz
2005-02-19 09:32:42 sage-2005-02-24-0734/install/src/ipython-0.6.11.tar.gz
2005-02-24 04:24:12 sage-2005-02-24-0734/install/src/sage-0.1.tar.gz
2005-02-24 03:54:24 sage-2005-02-24-0734/install/src/gmp-4.1.4.tar.gz
2005-02-24 04:06:33 sage-2005-02-24-0734/install/Makefile
2005-02-24 04:27:54 sage-2005-02-24-0734/install/scripts/
2005-02-24 04:02:17 sage-2005-02-24-0734/install/scripts/install_ipython
2005-02-19 08:01:49 sage-2005-02-24-0734/install/scripts/ipythonrc
2005-01-23 18:21:20 sage-2005-02-24-0734/install/scripts/install_dir
2005-02-24 04:03:47 sage-2005-02-24-0734/install/scripts/install_gmp
2005-02-23 12:12:01 sage-2005-02-24-0734/install/scripts/doctest
2005-02-24 04:03:10 sage-2005-02-24-0734/install/scripts/install_python
2005-02-24 04:27:54 sage-2005-02-24-0734/install/scripts/install_scripts
2005-01-23 16:47:35 sage-2005-02-24-0734/install/scripts/install_gmpy
2005-02-24 04:22:53 sage-2005-02-24-0734/install/scripts/install_pari
2005-02-24 04:03:36 sage-2005-02-24-0734/install/scripts/install_sage
2005-02-24 03:52:43 sage-2005-02-24-0734/install/scripts/install_test
2005-02-24 03:47:22 sage-2005-02-24-0734/install/scripts/startup.py
2005-02-24 04:03:23 sage-2005-02-24-0734/install/scripts/install_readline
2005-02-24 04:02:56 sage-2005-02-24-0734/install/scripts/install_pyrex

```

SAGE: How it Works

SAGE is a combination of the following:

- The best **existing open source math programs** in many functional area: **number theory** (PARI), **group theory** (GAP), **commutative algebra** (Singular), and **symbolic computation** (Maxima).
- The best **open source math libraries**: **arithmetic** (GMP), **number theory** (NTL), **numerics** (gsl), **finite fields** (givaro), **linear algebra** (linbox, iml, and numpy), **graphics** (matplotlib and tachyon), etc.
- A **mainstream interpreter** (Python) and a GUI (the web-based SAGE notebook).
- **Interfaces** to all major math software.
- **Lots and lots of work** to put it all together, make it fast, **easy to install**, and fill in the **massive gaping holes** in functionality.

Demo

```
sage: factor(2^113 - 1)
3391 * 23279 * 65993 * 1868569 * 1066818132868207
```

```
sage: sin(x+y).trig_expand()
cos(x)*sin(y) + sin(x)*cos(y)
```

```
sage: R.<x,y> = QQ[]
sage: f = (x+y)^100
sage: len(str(f))
3402
```

```
sage: quit
Exiting SAGE (CPU time 0m0.15s, Wall time 1m14.64s)
Exiting spawned Maxima process.
```

Funding

The National Science Foundation has been the main source of funding for SAGE so far. Aplause to them.

- My **personal Algebra/Number Theory NSF grant** was just renewed (this was not directly for SAGE work.)
- The **NSF COMPMATH program** funded a **three-year SAGE postdoc** at UW.
- We have received very strong support for **workshops** by NSF, PIMS, IPAM, MSRI, etc., and I believe we will continue to do so.
- The **UW NSF/VIGRE grant** has very **generously funded** undergraduate work on SAGE.
- The SAGE funding model *must* be different than MAGMA's – we don't get a million dollars a year from grants and license fees, so lots of workshops and **volunteer** effort are critical right now.

SAGE Days Workshop Series

SAGE Days World Tour

- **SAGE Days 1 (Feb 2006):** San Diego “Introducing SAGE”
- **SAGE Days 2 (Sep 2006):** Seattle “Fast Arithmetic”
- **SAGE Days 3 (March 2007):** IPAM “Users / Developers”
- **SAGE Days 4 (June 2007):** Seattle “Developer Workshop”
- **SAGE Days 5 (Nov 2007):** Heilbronn Inst in Bristol, UK
“Cryptography” (organizers – me, M Albrecht, J Cremona).

Tentative work toward future SAGE Days in Cambridge (MA), Vancouver, Athens Georgia, Leiden, Barcelona, IPAM, Washington DC (AMS meeting), etc.

SAGE: Recent successes

Some recent technical successes of SAGE:

- **p -adic arithmetic** (David Roe)
- **Symbolic Calculus** (Bobby Moretti)
- **Optimized exact linear algebra** (Clement Pernet, Robert Miller, W Stein)
- **Mod 2 dense linear algebra** M4ri – method of four Russians (Martin Albrecht)
- **Fast multivariate polynomial arithmetic** (Martin Albrecht)
- **Graph isomorphism testing** (Robert Miller)
- **p -adic Arithmetic Geometry** (David Harvey, Robert Bradshaw, C. Wuthrich, Stein)

Publications that Use SAGE

- **My AMS GSM book** (GSM 79).
- A **popular book on the Riemann Hypothesis** I'm writing with Barry Mazur.
- D. Joyner and A. Ksir, *Automorphism groups of some AG codes* IEEE Trans. Info. Theory, vol 52, July 2006, pp 3325-3329.
- And much more is in the pipeline, e.g., David Joyner's popular **Rubik's cube book** will have SAGE code in it.

Developers

- SAGE now has **many developers** (148 people subscribe to sage-devel).
- The distributed open source model **scales well**, as much larger projects like the **Linux kernel** have definitely proven.
- The barrier to entry to be a SAGE developer is **lower** than many open source projects.
- I typically receive **more code each week** than I can merge into SAGE in one day of solid work. **This is good.**
- The referee system has been **very helpful**. It could be more focused, organized, better linking to journal articles, etc. — When the time is right.

Active SAGE Developers

The following **22 people** had hg patch bundles included in SAGE during the last month:

Martin Albrecht, Nick Alexander, Tom Boothby, Robert Bradshaw, Craig Citro, Nathan Dunfield, Jonathan Hanke, David Harvey, David Joyner, Josh Kantor, Emily Kirkman, David Kohel, Robert Miller, Joel B. Mohler, Bobby Moretti, Yi Qiang, David Roe, William Stein, Michel Van den Bergh, Justin Walker, Carl Witty, Christian Wuthrich

The **number of SAGE developers** has thus not grown too much in the last six months, though definitely much more code is being written now.

```
was@ubuntu:~/d/sage/sage$ cat *.py */*.py */*/*.py
287446
```

Download Statistics

Download stats for June 3 – 10, 2007 (last week) from sagemath.org and sage.math.washington.edu (combined).

Linux Binary	71
OS X Binary	75
Source	97
VMware (=Windows)	134
Total ...	377

- 1 This rate would be over 1500 downloads a month. (This doesn't count the six other mirror sites.)
- 2 The number of emails I get from new users keeps going up.
- 3 sage-support has 108 members.

Social Goals for SAGE 3.0 (Jan 2008)

These are the main social goals for SAGE 3.0 in order of priority.

- Have over **10,000 regular “quality” users** worldwide (as measured by downloads per month and active accounts on the public SAGE notebook).
- Have over **40 active developers** worldwide (as measured by unique patch contributors during any given month).
- Over **20 papers or books** that cite SAGE.

Technical Goals for SAGE 3.0 (Jan 2008)

These are the **main technical goals** for SAGE 3.0 in **order of priority**.

- 1 A stable robust **notebook server** that is secure, scalable, and easy for people to run themselves.
- 2 Greatly improve the **SAGE vmware virtual machine and OS X .app** (GUI, vmware tools, work on all processors).
- 3 **Numerical computation** (optimization, linear algebra, signal processing, better integration with scipy)
- 4 **3D graphics** in the notebook
- 5 Improve the **basic arithmetic and coercion model**
- 6 Easy-to-use **distributed computation**; **pickle/unpickle** almost anything robustly, quickly, etc.
- 7 Better **integration with R** (statistics)