# Sage-Combinat Free and Practical Software for Algebraic Combinatorics

## Nicolas M. Thiéry et al.<sup>1</sup>

Department of Mathematics, University of California, One Shields Avenue, Davis, CA 95616, U.S.A. Univ Paris-Sud, Laboratoire de Mathématiques d'Orsay, Orsay, F-91405; CNRS, Orsay, F-91405, France

### 1 Description

Sage [S<sup>+</sup>09] (http://www.sagemath.org) is a free open-source mathematics software system licensed under the GPL. It combines the power of many existing open-source packages (GAP [GAP99], Linbox, Singular [GPS98] to name a few) into a common Python-based interface.

The mission of Sage-Combinat itself (http://wiki.sagemath.org/combinat/) is to improve Sage as an extensible toolbox for computer exploration in combinatorics and algebraic combinatorics, and to foster code sharing between researchers in this area. As such, Sage-Combinat and its predecessor MuPAD-Combinat played an essential role in more than 50 publications.

In practice, Sage-Combinat takes the form of a collection of experimental extensions (patches), developed jointly by a growing community of researchers<sup>(i)</sup>, worldwide. Those extensions are intended to have a short life cycle, and to be merged into the Sage library as soon as they are mature enough. Hence, in a matter of months, most new features are made available to all Sage users. Those interested in the bleeding edge features can further download the experimental extensions by simply running Sage as sage -combinat install.

### 2 Software demonstration

During the software demonstration at FPSAC'09, we will present the prominent features of Sage for combinatorics and algebraic combinatorics, and discuss its design and development model. Afterward, we will run some informal tutorials during the evenings. For those interested in learning more or getting involved, there will also be a satellite workshop around Sage-Combinat and sister projects:

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<sup>(</sup>i) Nicolas Borie, Jason Bandlow, Daniel Bump, Adrien Boussicault, Vincent Delecroix, Tom Denton, Teresa Gomez-Diaz, Mike Hansen, Florent Hivert, Brant Jones, Sébastien Labbé, Gregg Musiker, Franco Saliola, Anne Schilling, Mark Shimozono, Lenny Tevlin, Nicolas M. Thiéry, Justin Walker, Mike Zabrocki, as well as, for MuPAD-Combinat and sister projects, Houda Abbad, Christophe Carré, Frédéric Chapoton, François Descouens, Ralf Hemmecke, Éric Laugerotte, Cédric Lecouvey, Patrick Lemeur, Robert Miller, Xavier Molinero, Jean-Christophe Novelli, Janvier Nzeutchap, Wang Qiang, Martin Rubey

\*-Combinat 09 July 25-29, RISC, Linz, Austria Free and Practical Software for Algebraic Combinatorics http://wiki.sagemath.org/combinat/fpsac09.

#### 3 Short history of \*-Combinat

Sage-Combinat started in 2000, under the name MuPAD-Combinat [HT04], as an open source library for the computer algebra system MuPAD [The96]. It took its roots in the projects ACE [Vei98],  $\mu$ -EC [Pro99], PerMuVAR [Thi], and progressively integrated CS [DDZ98], Symmetrica [KKL] Nauty [McK90] and lrcalc. The MuPAD platform was technically sound, and played its role very well for the first seven years. However, and as it was clear from the beginning, it suffered from not being open source. In particular, this hindered its dissemination, and the growth opportunities for both the users and developers community. This motivated our decision, in June 2008, to migrate the project to Sage, once this platform became mature enough, and despite the large overhead (100k lines of code to migrate). This migration allowed to almost double the community, in particular thanks to joining our efforts with the combinatorics on words project Sage-words.

The migration is on its way, and it is expected that, by FPSAC'09, most of the combinatorics code will be migrated, as well as part of the algebraic code.

#### 4 Features

From http://www.sagemath.org/tour.html:

Sage can be used to study general and advanced, pure and applied mathematics. This comprises a wide range of mathematics, including algebra, calculus, elementary to very advanced number theory, cryptography, numerical computation, commutative algebra, group theory, combinatorics, graph theory, exact linear algebra and much more. It combines various software packages and seamlessly integrates their functionality into a common experience. It is well suited for education, studying and research. The interface is a notebook in a web-browser or the command-line. Using the notebook, Sage connects either locally to your own Sage installation or to a Sage server on the network. Inside the Sage notebook you can create embedded graphics, beautifully typeset mathematical expressions, add and delete input, and share your work across the network.

Here are some of the features of Sage that are developed specifically by the Sage-Combinat project:

- Basic combinatorial classes: permutations, tableaux, ...
- Decomposable objects / Species
- Root systems and crystals
- Combinatorics on words
- (Non commutative) symmetric functions and related combinatorial (Hopf) algebras
- Easy definitions of new combinatorial (Hopf) algebras

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Other Sage features related to combinatorics include graphs (in particular via NetworkX), groups (via GAP), etc.

#### 5 Hardware requirements

Sage can be installed on most platforms, including Linux, Mac OS X, and Windows.

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