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Cadabra2: computer algebra for field theory revisited

Kasper Peeters[1]

1 Durham University

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Software

- Review
- Repository
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Summary

Field theory is an area of mathematics required in a wide range of theoretical physics problems, from general relativity to high-energy particle physics and condensed matter theory. Symbolic computations in this field tend to be difficult to do with mainstream computer algebra systems, because the required algorithmic functionality is often simply not available, but also because the standard notation tends to hide a lot of implicit mathematical structure which cannot easily be represented. `Cadabra2` is an open source computer algebra system specifically written for the solution of tensor field theory problems. It enables manipulation of Lagrangians, computation of equations of motion, analysis of symmetries and so on in an interactive notebook interface, using an input format which closely resembles standard mathematical notation, combined with a familiar Python environment to manipulate expressions.

The core of `Cadabra2` consists of a set of algorithms for tensor field theory written in C++, which are in part based on functionality of an earlier version of the software (Peeters, 2006, 2007). These algorithms take care of specific tensor aspects of computer algebra, such as dummy indices, implicit coordinate dependence, implicit index lines and commutativity properties. All standard scalar algebra is handed off to a scalar backend, currently either Sympy (Meurer, 2017) or Mathematica (Wolfram Research Inc., 2018). The core is accessible from Python, using a wrapper built using pybind11 (Jakob, Rhinelander, & Moldovan, 2017). At the highest level there is a custom pre-processor which enables input in a mixture of LaTeX for mathematical expressions and Python for expression manipulation. The user interface consists of a command-line client, as well as a graphical cell-based notebook built using gtkmm, with TeX-driven maths typesetting. The software builds and runs on Linux, macOS and Windows.

`Cadabra2` has been used to derive or verify results in a variety of recent papers, in areas such as supergravity (Butter, Novak, & Tartaglino-Mazzucchelli, 2017; Geissbühler, 2011), cosmology (Malik & Wands, 2009), applications of the string/gauge theory correspondence (Buchel, Myers, Paulos, & Sinha, 2008; Christensen, Hartong, Obers, & Rollier, 2014; Koile, Kovensky, & Schvellinger, 2015), and general relativity (Durkee, Pravda, Pravdová, & Reall, 2010), to name a few. The software is supported by an on-line Q&A forum, a collection of tutorials and on-line manual pages, and has an active user base. The source code for `Cadabra2` has been archived to Zenodo with the DOI listed in (Peeters, 2018).

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