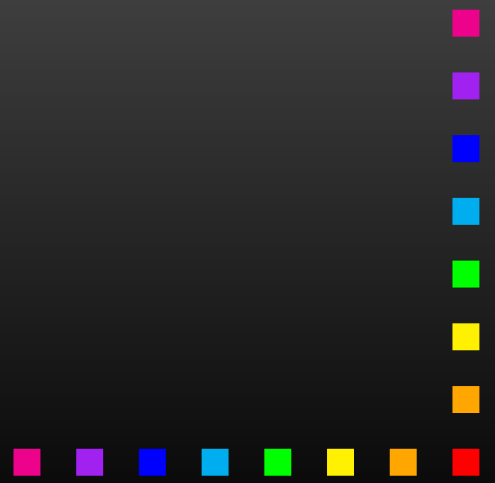
Loopedia - A Database for Loop Integrals

Thomas Hahn

in collaboration with
C. Bogner, S. Borowka, G. Heinrich, S. Jones, M. Kerner,
A. von Manteuffel, M. Michel, E. Panzer, V. Papara



Introduction

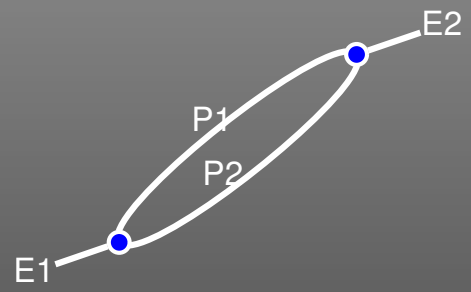
- Researchers in HEP enjoy **privileged bibliographic access** thanks to arXiv & SPIRES.
- But: **Indexing only by 'traditional' metrics:** author, title, year of publication, etc.
- Interesting for loop calculators: find all papers which **refer to graph X,** where X is specified in some graph-theoretical way.
- Ideally: store also available results.
- This new database is now available:

  loopedia.org

Graph-Theory Inputs

The Topology can be entered as

- an Edge List, e.g. `(e,0) (0,1) (0,1) (e,1)`
- an Nickel Index, e.g. `e11|e|`



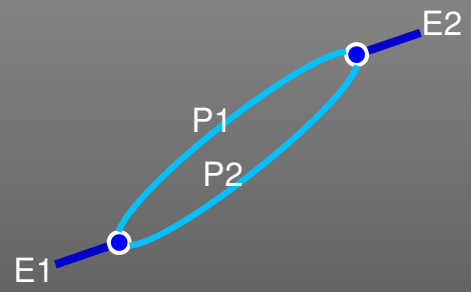
Edge List has some latitude, can also put e.g.

- `x a  a b  a b  b y`
- ```
  Topology[2][
    Propagator[Incoming][Vertex[1][1], Vertex[3][3]],
    Propagator[Outgoing][Vertex[1][2], Vertex[3][4]],
    Propagator[Loop[1]][Vertex[3][3], Vertex[3][4]],
    Propagator[Loop[1]][Vertex[3][3], Vertex[3][4]] ]
  ```
  ```

Graph-Theory Inputs

The Configuration is appended to the topology as

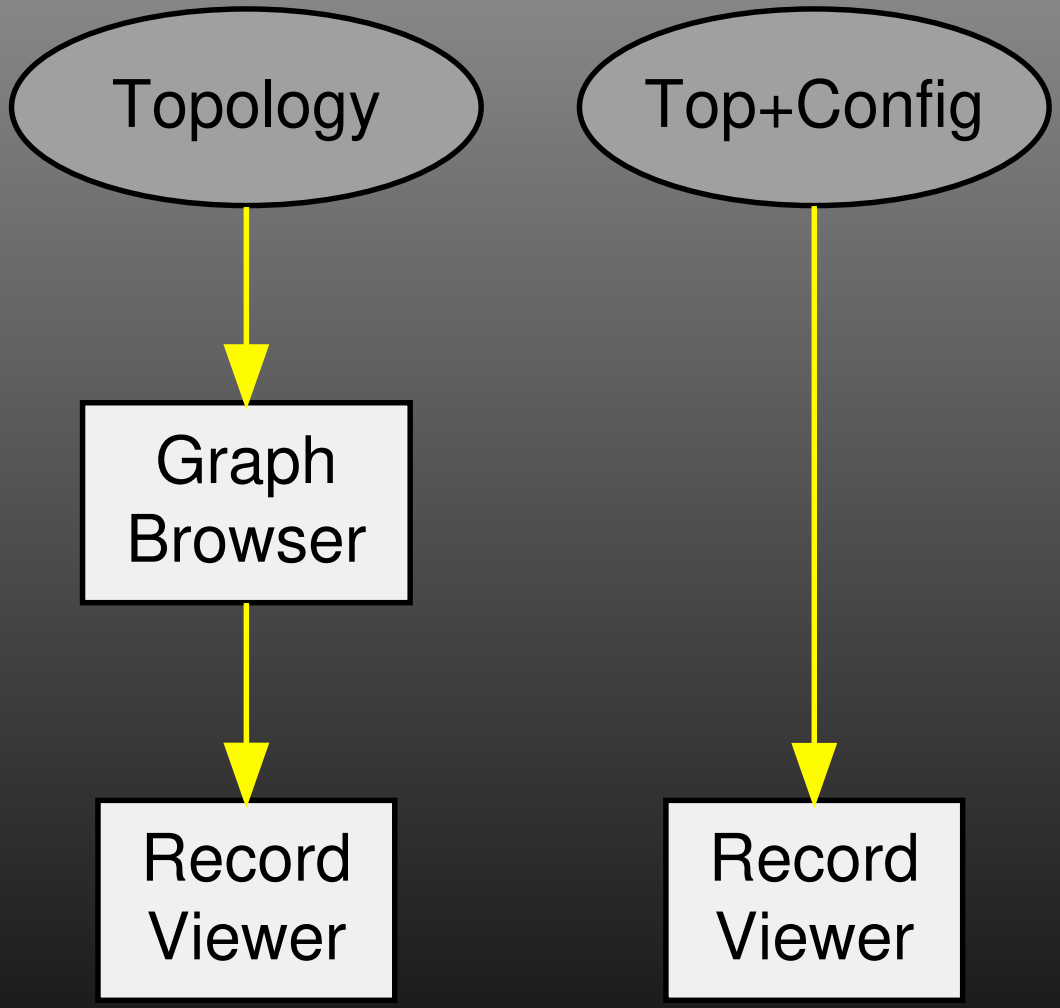
- an Extended Edge List, e.g.
  `(e,0|n) (0,1|1) (0,1|1) (e,1|n)`
- a Colored Nickel Index, e.g. `e11|e|:n11|n|`
  - `z` = any mass scale (including zero),
  - `n` = non-zero mass scale,
  - `0` = zero,
  - `1...9 a...y` = definite non-zero mass scale.



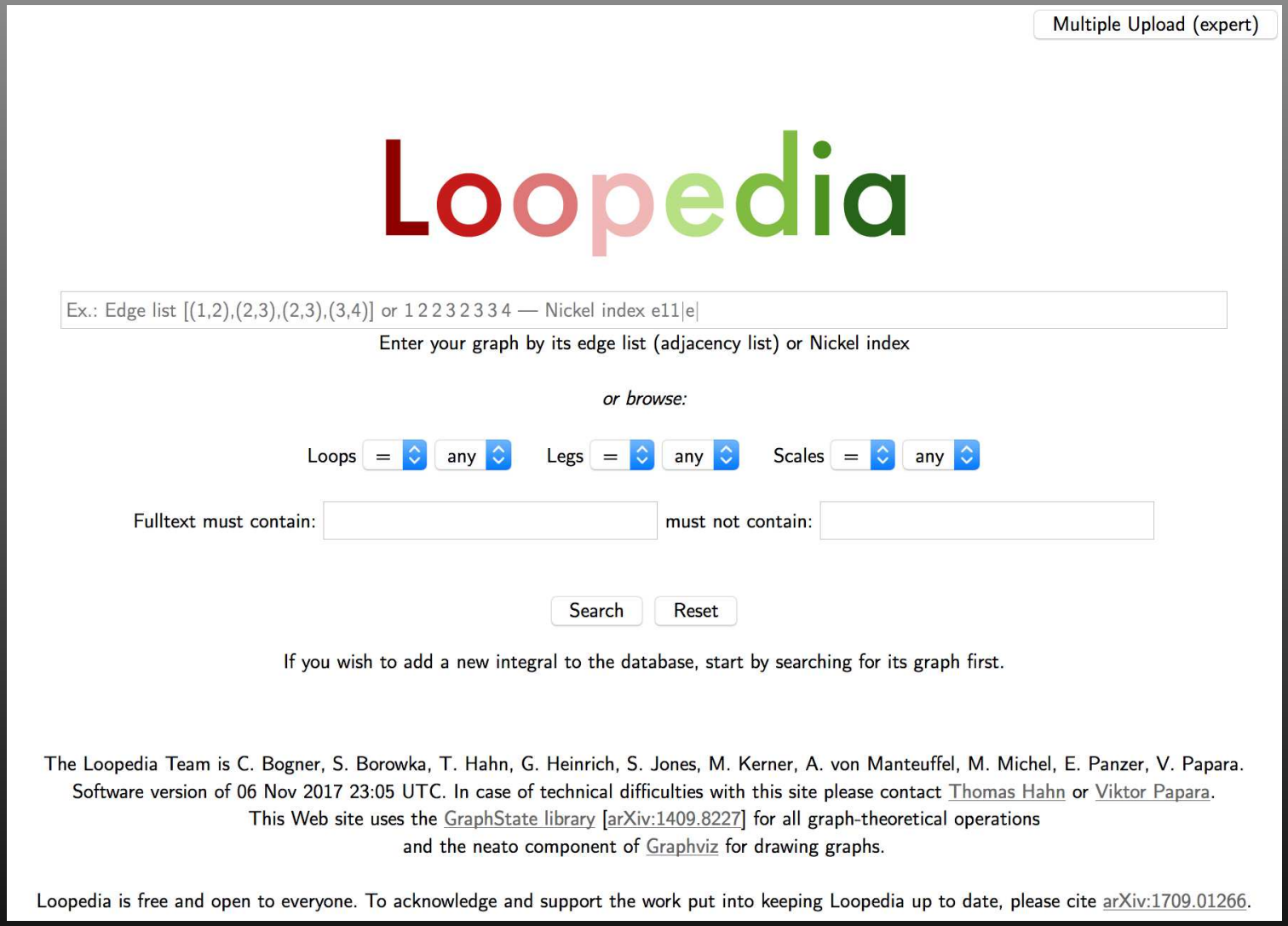
All graph-theory objects are handled by the GraphState library arXiv:1409.8227 (with some minor tweaks).

Graphs are drawn with the 'neato' component of graphviz.

Flow Chart

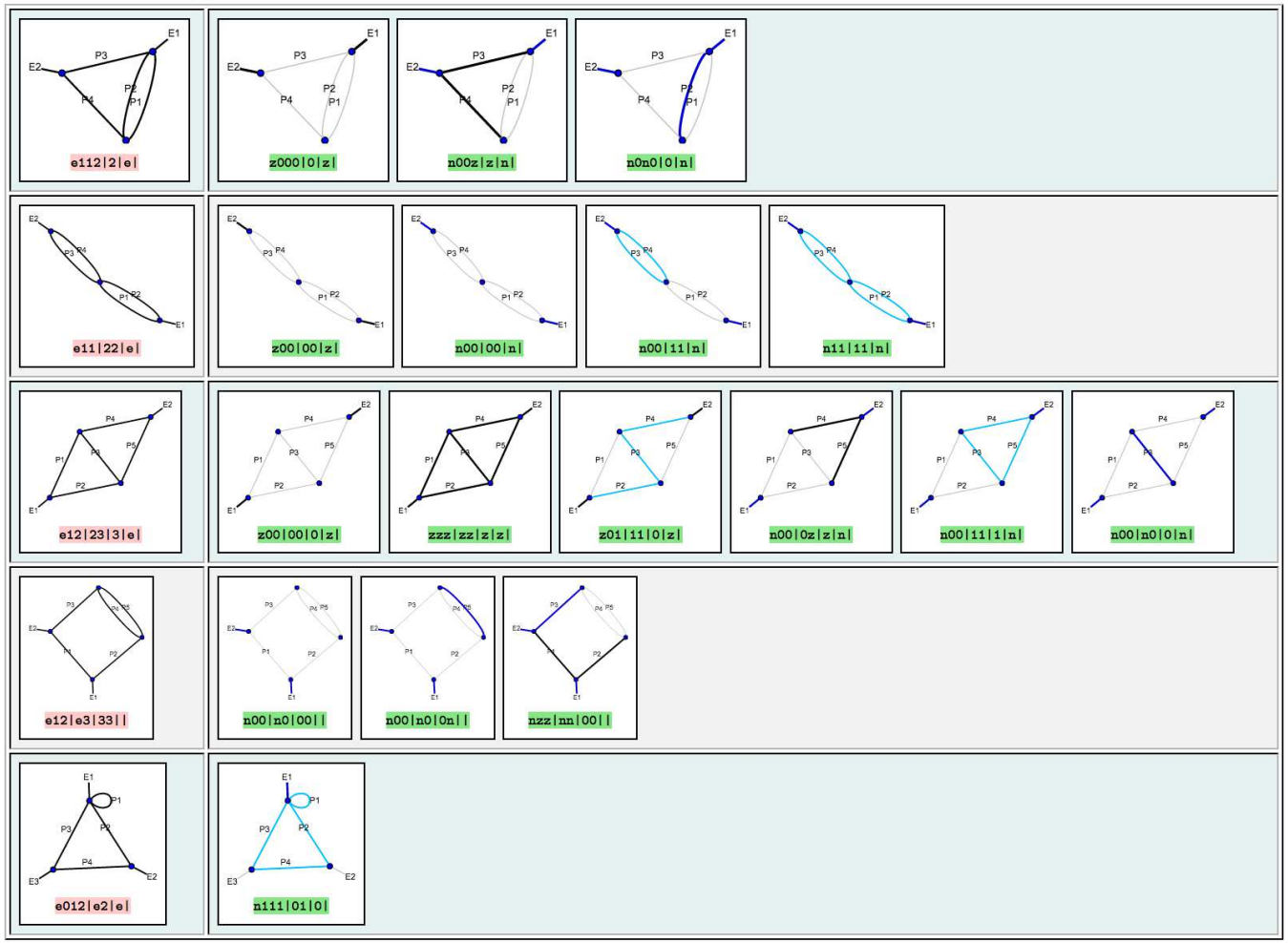

Topology
Top+Config
Graph Browser
Record Viewer
Record Viewer

Start Page


Multiple Upload (expert)
Loopedia
Ex.: Edge list [(1,2),(2,3),(2,3),(3,4)] or 1 2 2 3 2 3 3 4 — Nickel index e11|e
Enter your graph by its edge list (adjacency list) or Nickel index
or browse:
Loops = any
Legs = any
Scales = any
Fulltext must contain:
must not contain:
Search
Reset
If you wish to add a new integral to the database, start by searching for its graph first.
The Loopedia Team is C. Bogner, S. Borowka, T. Hahn, G. Heinrich, S. Jones, M. Kerner, A. von Manteuffel, M. Michel, E. Panzer, V. Papara.
Software version of 06 Nov 2017 23:05 UTC. In case of technical difficulties with this site please contact Thomas Hahn or Viktor Papara.
This Web site uses the GraphState library [arXiv:1409.8227] for all graph-theoretical operations
and the neato component of Graphviz for drawing graphs.
Loopedia is free and open to everyone. To acknowledge and support the work put into keeping Loopedia up to date, please cite arXiv:1709.01266.

Graph Browser

Results for all loops, all legs, all scales — Row 11»



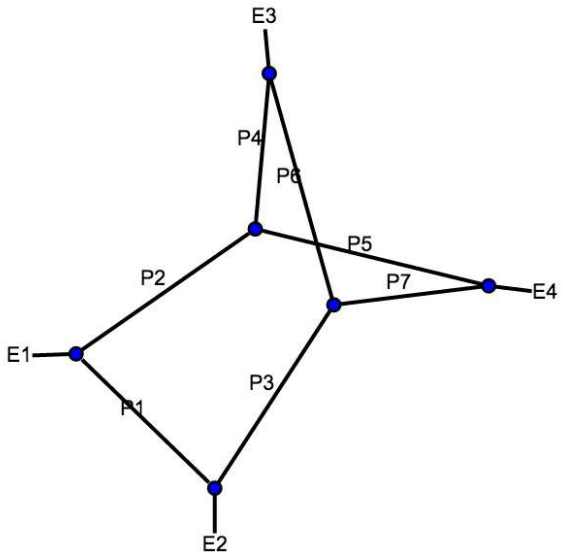
Prev Next Show 5 rows per page Home

Configuration Editor

Graph `e12|e3|45|45|e|e|`

Edit • : • | Edit • | Browse • : * | Home

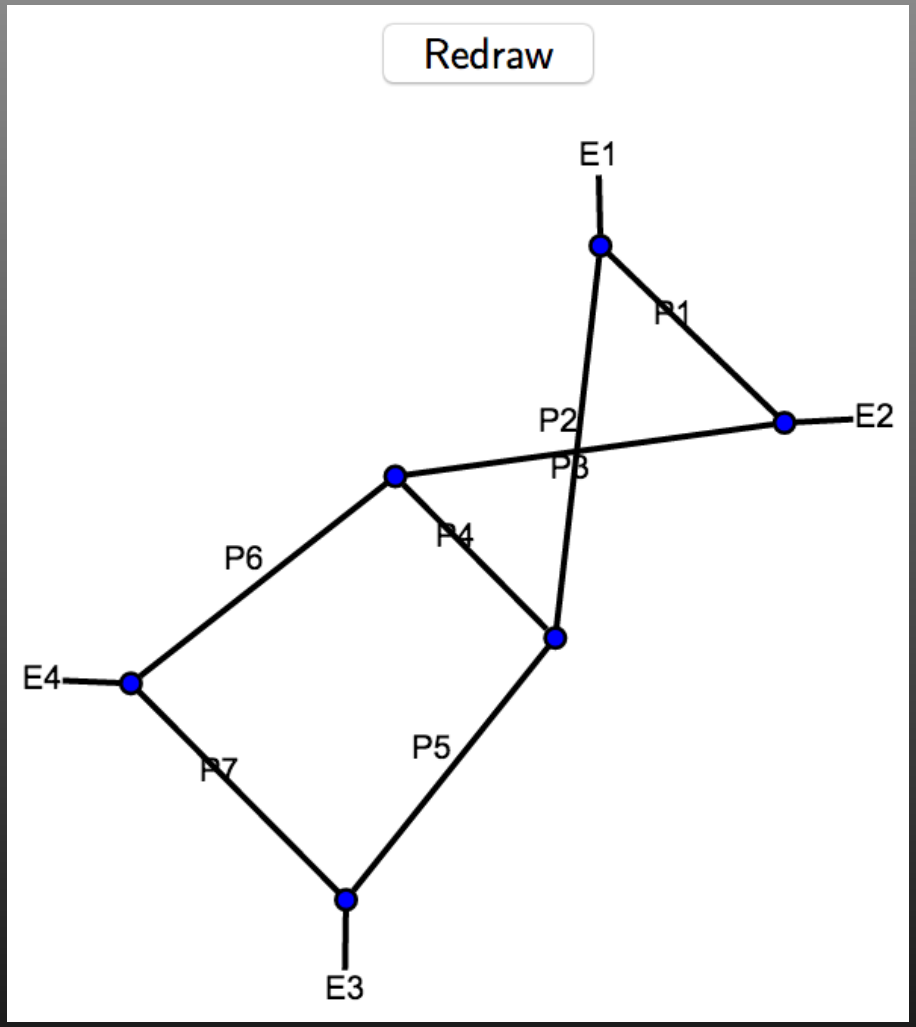
Edge list:	`(e,0) (0,1) (0,2) (e,1) (1,3) (2,4) (2,5) (3,4) (3,5) (e,4) (e,5)`
Nickel index:	`e12|e3|45|45|e|e|`
Database path:	`2/4/7/e12|e3|45|45|e|e|`



Propagator P1	any m
Propagator P2	any m
Propagator P3	any m
Propagator P4	any m
Propagator P5	any m
Propagator P6	any m
Propagator P7	any m
External Leg E1	any q^2
External Leg E2	any q^2
External Leg E3	any q^2
External Leg E4	any q^2

Choose Configuration

Redraw an 'Ugly' Graph



Record Viewer

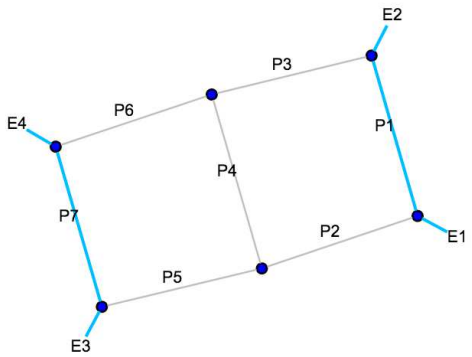
Graph `e12|e3|34|5|e5|e|` — **Masses** `110|10|00|0|11|1|`

Edit • : • | Edit • | Browse • : * | Home

Edge list: `(e,0|1) (0,1|1) (0,2|0) (e,1|1) (1,3|0) (2,3|0) (2,4|0) (3,5|0) (e,4|1) (4,5|1) (e,5|1)`

Nickel index: `e12|e3|34|5|e5|e|:110|10|00|0|11|1|`

Database path: `2/4/7/e12|e3|34|5|e5|e|/1/110|10|00|0|11|1|`



Propagator P1	m = m1
Propagator P2	m = 0
Propagator P3	m = 0
Propagator P4	m = 0
Propagator P5	m = 0
Propagator P6	m = 0
Propagator P7	m = m1
External Leg E1	$q^2 = m1^2$
External Leg E2	$q^2 = m1^2$
External Leg E3	$q^2 = m1^2$
External Leg E4	$q^2 = m1^2$

Choose Configuration

Reference: arXiv:1612.05609

Description: The authors compute the planar 2-loop box master integrals involved in QQ → QQ, where QQ are massive external quarks using the method of differential equations.

Submitter: sophia.borowka@cern.ch

Record `1482239373.Z1Fv`
added 20 Dec 2016 13:09 UTC
last modified 23 May 2017 14:07 UTC

New Record Form

Integrand type: Product of $(p^2 - m^2)$^-n if *other*, please specify:

Propagator powers (the n in $(p^2 - m^2)^{-n}$ for which result is valid, separate by comma if necessary, leave empty if n/a):

P1 1 P2 1 P3 1 P4 1

Order(s) in ε (separate by comma, empty if n/a):

Reducible: unknown **Number of master integrals:**

Reference (arXiv:*yymm.nnnnn* or hep-*xx*/*yymmnnn* preferred, empty if n/a):

Relevant equations in reference:

Authors:

Description (package URL, dimension computed in, type of functions, Euclidean/physical kinematics, weight, free text, etc.):

Submitter (e-mail):

Additional material (PDFs not on arXiv, Mathematica/Maple/FORM/Python/Fortran programs, etc.):

Browse... No file selected.
Browse... No file selected.
Browse... No file selected.

Submit Reset

Multiple Upload

Add record for multiple graphs

CNickels and non-standard propagator powers

(One graph per line, format e.g. `e12|e3|34|5|e5|e|:110|10|00|0|11|1| P2=1,2 P5=2`,
propagator powers not given default to 1, use `eps=...` and `nmasters=...` for per-line overrides):

```
e111|e|:n011|n| P2=2 P3=2
e111|e|:n011|n| P3=2 eps=-1,0,1,2
e12|23|3|e|:n00|11|1|n| eps=0,1
e112|e2|e|:0011|01|n| P2=3
```

Integrand type: Product of $(p^2 - m^2)$^-n if *other*, please specify:

Order(s) in ε (separate by comma, empty if n/a): 0,1,2

Reducible: unknown **Number of master integrals:**

Reference (arXiv:*yymm.nnnnn* or hep-*xx*/*yymmnnn* preferred, empty if n/a): hep-ph/0611236

Relevant equations in reference:

Authors: Charalampos Anastasiou, Stefan Beerli, Stefan Bucherer, Alejandro Daleo, Zoltan Kunszt

Description (package URL, dimension computed in, type of functions, Euclidean/physical kinematics, weight, free text, etc.):

The authors give the two-loop master integrals for Higgs production via a massive quark and a squark loop.

Submitter (e-mail): michel.martin@uclouvain.be

Additional material (PDFs not on arXiv, Mathematica/Maple/FORM/Python/Fortran programs, etc.):

Browse... No file selected.
Browse... No file selected.
Browse... No file selected.

Submit Reset

Multiple Submit

Submission overview

Reference: hep-ph/0611236
Authors: Charalampos Anastasiou, Stefan Beerli, Stefan Bucherer, Alejandro Daleo, Zoltan Kunszt
Description: The authors give the two-loop master integrals for Higgs production via a massive quark and a squark loop.
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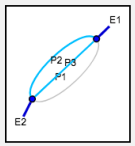
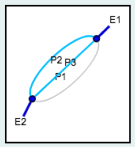
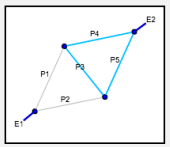
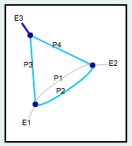
	e111|e|:n011|n| **Non-standard propagator powers:** P2=2 P3=2 **Orders in ε:** 0,1,2	Dry run — not in database yet	**Record** 1504335475.fuUH edit delete
	e111|e|:n011|n| **Non-standard propagator powers:** P3=2 **Orders in ε:** −1,0,1,2	Dry run — not in database yet	**Record** 1504335476.3AVB edit delete
	e12|23|3|e|:n00|11|1|n| **Orders in ε:** 0,1	Dry run — not in database yet	**Record** 1504335476.CVSs edit delete
	e112|e2|e|:0011|01|n| **Non-standard propagator powers:** P2=3 **Orders in ε:** 0,1,2	Dry run — not in database yet	**Record** 1504335476.ZcWO edit delete

If this dry run was ok, press Submit to actually add the records to the database.

Back Home

Database Setup

Database realized as

- an `index.cgi` bash script in a CGI environment
- that uses the Unix filesystem as database (like iTunes),
- indexed by the `mlocate` utility.

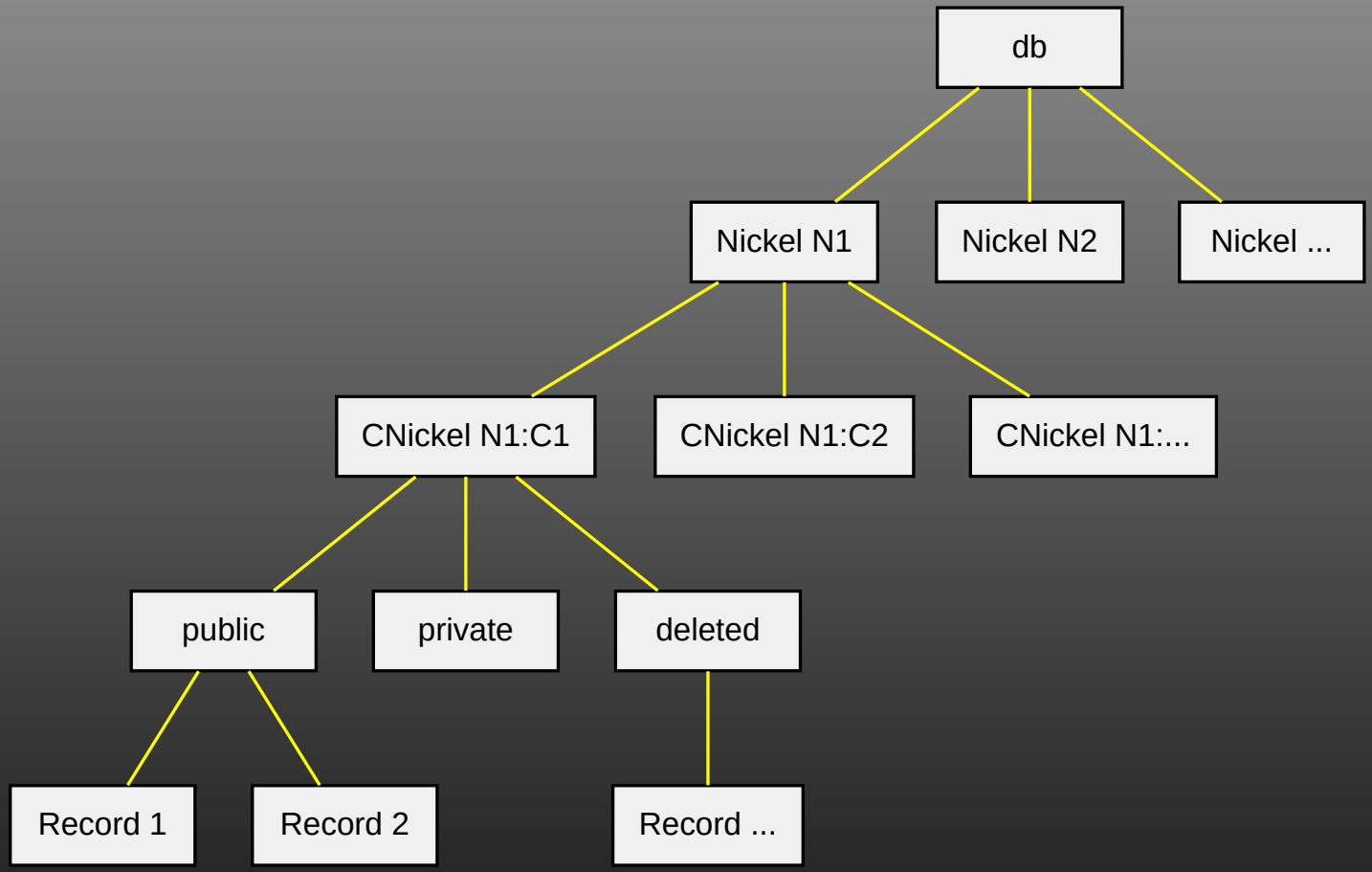
Internal tools used:

- `unescape.c`, `formdecode.c` - parsing CGI input
- `token.c`, `djb2hash.c`, `recfind.c` - token generation, hashing, finding
- `loopedia.py` - interfacing with GraphState

External tools used:

- GraphState [mod] (https://pypi.python.org/pypi/GraphState)
- mlocate [mod] (https://github.com/msekletar/mlocate)
- graphviz (http://graphviz.org)

Database Structure



Full DB path: $\mathrm{db}/L/\ell/p/$**Nickel**$/s/$**Config**/**Visibility**/**Record**

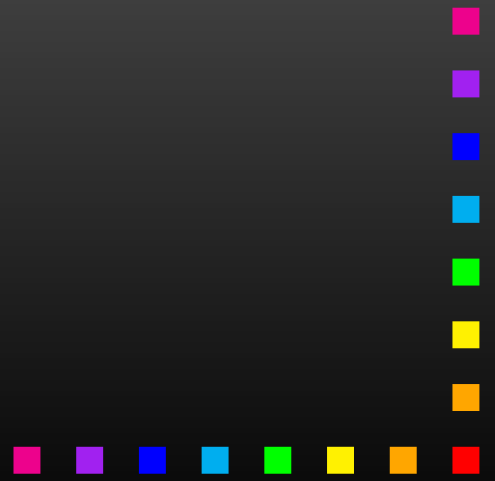
Summary

Loopedia is a new database for loop integrals

- indexed by graph-theoretical properties,
- can hold bibliographic but also other information, e.g. results in some machine-readable format,
- slim CGI design, Unix filesystem doubles as database,
- filling database task for researchers,
- still pretty much work in progress.

Please try it out and give us feedback!

Part II: MathLink



MathLink programming

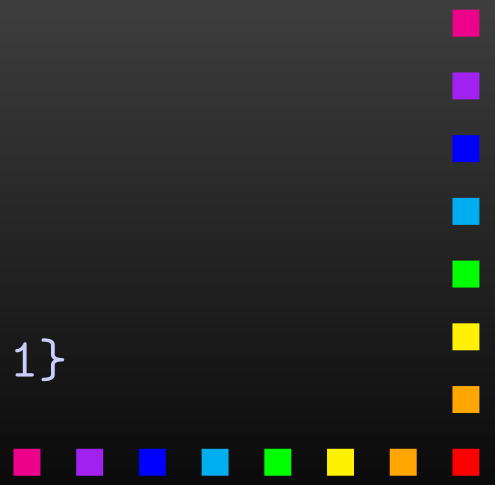
MathLink is Mathematica's API to interface with C and C++.
J/Link offers similar functionality for Java. (There's more.)

A MathLink program consists of three parts:

a) Declaration Section

```
:Begin:
:Function: a0
:Pattern: A0[m_, opt___Rule]
:Arguments: {N[m], N[Delta /. {opt} /. Options[A0]],
   N[Mudim /. {opt} /. Options[A0]]}
:ArgumentTypes: {Real, Real, Real}
:ReturnType: Real
:End:

:Evaluate: Options[A0] = {Delta -> 0, Mudim -> 1}
```

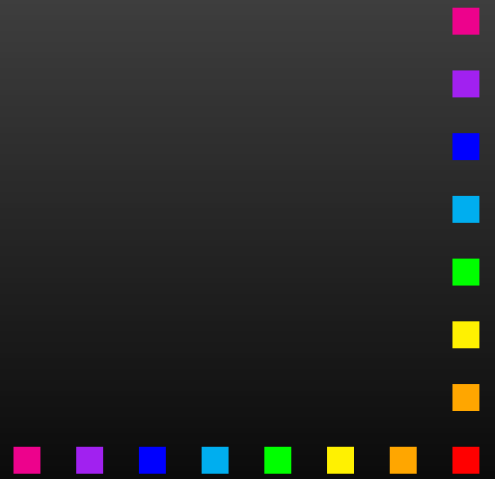


MathLink programming

b) C code implementing the exported functions

```
#include "mathlink.h"

static double a0(const double m,
    const double delta, const double mudim) {
  return m*(1 - log(m/mudim) + delta);
}
```



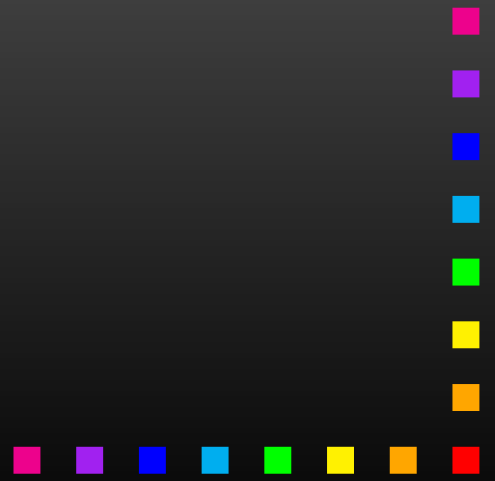
MathLink programming

c) Boilerplate main function

```
int main(int argc, char **argv) {
  return MLMain(argc, argv);
}
```

Compile with `mcc` instead of `cc`.
Load in Mathematica with `Install["program"]`.

For even more details see arXiv:1107.4379.



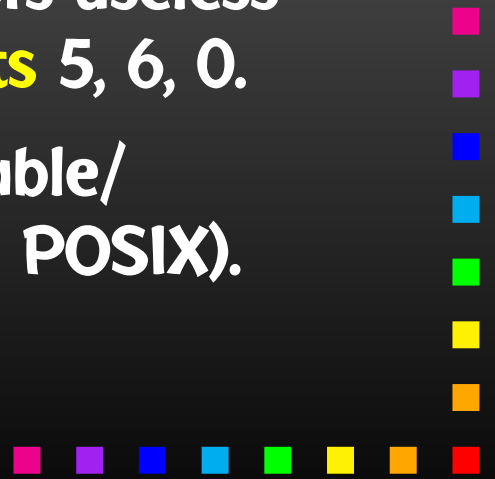
Recent Problems

arXiv:1107.4379 gives details on how to set up thread to listen on stdout and send output back to Mathematica.

No error/warning messages reported on Cygwin + gfortran.

Careful analysis:

- Mathematica closes stdin, stdout, stderr before launching MathLink executable.
- libgfortran startup considers closed descriptors useless and refuses to allocate workable Fortran units 5, 6, 0.
- Workarounds using e.g. FIFO pipes not desirable/ straightforward (Windows FIFO API not fully POSIX).



Solution

- First Try: open stdout, then `exec` self:

```
stdoutorig = dup(1);
if( stdoutorig == -1 && getenv("LTRESPAWN") == NULL ) {
  openstdout();
  putenv("LTRESPAWN=1");
  execv(argv[0], argv);
  exit(1);
}
```

  Downside: Spurious terminal window opens (why?).

- 'Squeeze in' before libgfortran constructor runs:

```
static void __attribute__((constructor(4711)))
    make_sure_stdout_is_open() {
  if( fcntl(1, F_GETFD) == -1 ) openstdout();
}
```

Summary

- MathLink is Wolfram Research's API for interfacing Mathematica to C/C++ (and everything that links to C/C++).
- Generally straightforward but many caveats beyond pure C/C++ (mixed languages, Cygwin).
- Copy-&-paste "Cookbook recipes" for most issues. Standard Unix build on Linux, MacOS, Windows.
- Details in arXiv:1107.4379.
- But: API very stable over time, statically linked executables work 'forever'.
- Recently solved two issues with Cygwin + gfortran.