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-Theoretic 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](https://arxiv.org/abs/1409.8227) (with some minor tweaks).

Graphs are drawn with the ‘neato’ component of graphviz.
Graph Browser

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

T. Hahn, Loopedia – A Database for Loop Integrals – p.7
Configuration Editor

Graph e12|e3|45|45|e1e

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|e1e

Database path: 2/4/7/e12|e3|45|45|e1e

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|e1 — Masses 110|10|00|0|11|1

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|e1: 110|10|00|0|11|1

Database path: 2/4/7/e12|e3|34|5|e5|e1/1/110|10|00|0|11|1

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

T. Hahn, Loopedia – A Database for Loop Integrals – p.10
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 P5 1 P6 1 P7 1

Order(s) in $\varepsilon$ (separate by comma, empty if n/a):

Reducible: unknown Number of master integrals:

Reference (arXiv:yyyymm.nnnnn or hep-ph/yyyymmnnn preferred, empty if n/a):

Authors:

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

Submit Reset
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|01|11|1 | P2=1,2 P3=2,
propagator powers not given default to 1, use eps=... and nmasters=... for per-line overrides):
\[ e11\,|\,e::n01|n1\,|\,n1 | P2=2\, P3=2 \]
\[ e11\,|\,e::n01|n1\,|\,n1 | P3=2\, eps=-1,0,1,2 \]
\[ e12|23|3|e::n00|11|1n1 | eps=0,1 \]
\[ e11|e2|e::001|n1|1n1 | P2=3 \]

Integrand type: Product of \((p^2 - m^2)^{-n}\)  
if other, please specify:

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

Reducible: unknown  
Number of master integrals:

Reference [arXiv:yy/mm.nnnn or hep-xx/yymmmmmmm preferred, empty if n/a]: hep-ph/0611236

Authors: Charalampos Anastasiou, Stefan Boerli, 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.

Submit  Reset

Submit:  Reset

T. Hahn, Loopedia – A Database for Loop Integrals – p.12
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.

**Submitter:** michel.martin@uclouvain.be

<table>
<thead>
<tr>
<th>Record</th>
<th>Non-standard propagator powers:</th>
<th>Orders in ε:</th>
<th>Dry run — not in database yet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1504335475.fuRH</td>
<td>P2=2 P3=2</td>
<td>0,1,2</td>
<td></td>
</tr>
<tr>
<td>1504335476.3AVB</td>
<td>P3=2</td>
<td>-1,0,1,2</td>
<td></td>
</tr>
<tr>
<td>1504335476.CVSs</td>
<td>P2=3</td>
<td>0,1</td>
<td></td>
</tr>
<tr>
<td>1504335476.ZcWD</td>
<td>P2=3</td>
<td>0,1,2</td>
<td></td>
</tr>
</tbody>
</table>

If this dry run was ok, press **Submit** to actually add the records to the database.
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: \( \text{db/L/ℓ/p/Nickel/s/Config/Visibility/Record} \)
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!