LanHEP - a package for automatic generation of Feynman rules from the Lagrangian. Updated version 2.3.

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Abstract

This short note describes new features of the version 2.3 of the LanHEP software package; in particular, high spin particles and setting up the output tables format.

1 High spin particles

The particles with the spin 3/2 and 2 can be declared by means of `spinor3` and `tensor` statements. The syntax is the same as for old `scalar`, `spinor` and `vector` statements:

```
spinor3 g:(gravitino, mass Mgno=0.23).
tensor G:(graviton, mass MG=600).
```

2 Particle table format

New option allows to modify the format of the output particle table and to add new proprties (new columns in the table). The new format is set by means of `prtcformat` statement, for example, the default CompHEP table format can be set by:

```
prtcformat fullname:' Full   Name ',
           name:' p ',
           aname:' ap',
           spin2,color,mass,width, aux,
           texname:'  latex P name ',
           atexname:' latex aP name ' .
```

Each column of the table is described by the entry *prop:title=value*, where *prop* is the name of particle property, *title* is shown in the title line, and *value* is default value used if the property of specific particle is not set. **Important:** the width of *title* fixes the width of the table column, so it should be wide enough to contain records for this property for any particle. If not specified, property name is used as title, and blank space for default value.

There is a set of predefined properties (table columns) which exist in CompHEP by now plus the electric charge of a particle:

- `fullname` 'Long' particle name.

- `name` Particle name used in vertices table.
- `aname` Antiparticle.
- `spin2` Twice spin, integer 0—4.
- `mass` Particle mass.
- `width` Particle width.
- `echarge` Particle electric charge, integer or ratio $N/3$. The value is generated automatically if the `CheckEM(`*photon, coupling*`)` statement is used in the model file.
- `echarge3` Three times electric charge, integer.
- `color` Dimension of the color $SU(3)$ group representation (one of 1,3,8).
- `aux` Specify the particle as left or right fermion, boson in Feynman gauge (see CompHEP manual).
- `texname` LaTeX notation to be used for this particle.
- `atexname` Same for antiparticle. If not set, `bar{texname}` is used.

Besides these predefined properties, the user can introduce new ones. One can add, say, PDG particle number to the table:

```
prtcformat fullname:' Full   Name ',
           name:' p ',
           aname:' ap',
           spin2,color,mass,width, aux,
           pdg:'PDG ID',
           texname:'  latex P name ',
           atexname:' latex aP name ' .
```

Then the pair *prop value* can be written in the particle declaration statement:

```
scalar h:(higgs, mass Mh, pdg 123, width wh).
```

Another statement `prtcprop` can solve two problems. First, it can declare a property (or a few of them) which are not included in the particle table, but they still can be used in particle declarations for further use in the future. For example, one can declare `pdg` property:

```
prtcprop pdg.
```

and use it in the particle declarations even though CompHEP does not support this property now for future extensions. In this case, particle table format is not changed. Several properties can be listed, separated by comma.

Another problem is to set a new property for all particles in the model. There is no need to modify all particles declarations in the model, one can use statement like this:

```
prtcprop pdg:(h=123, g=124, f=125).
```

In this example h,g,f are some particles and the numbers are values of a property. Only new properties can be assigned to particles in this way, but not the predefined ones. If one wants to set, for example, the particle masses by this statement, new property (say `mymass`) should be declared and included into table format.

If some property is set to a number, a ratio, some particle or parameter name, then it can be used in the Lagrangian expressions as *(prop particle)*, e.g. electric charge can be used to describe quark-photon interaction:

```
lterm (echarge q)*EE*Q*gamma*q*A.
```

3 Lagrangian table setup

The format and content of the Lagrangian (vertices) table can be tuned by several options set by `option` statement:

`option` *opname*=*value*.

and by some command line options.

- `chepCFWidth` Width of Common Factor field, default is 50.
- `chepLPWidth` Width of Lorentz Part field, default is 600.
- `RemDotWithFerm` options (default value 1) tells LanHEP to replace $g_{\mu\nu}$ by $(\gamma_\mu\gamma_\nu + \gamma_\nu\gamma_\mu)/2$ in the vertices with fermions (CompHEP requirement). If this replacement is not neccessary put this option to 0.
- `ReduceGamma5` (default value 1) removes $(1 \pm \gamma_5)/2$ operators in the vertices with lefthand or righthand fermions (e.g. neutrinos) replacing them by 0 or 1. Put this option to 0 to keep projector operators in such vertices.
- `MultByI` (default value 0 for CompHEP output, 1 for LaTeX) In CompHEP tables, common i in the vertices is not shown, so imaginary unit appears only in the vertices with pseudoscalars. Setting this option to 1 allows to restore it, making ComHEP vertices the same as in textbooks.
- `WriteAll` (default 0) Setting this option to 1 makes LanHEP write into CompHEP table all vertices: 2-legs vertices, 1-legs ones (they can appear from incorrectly written Higgs potential) and also the vertices with more than 4 legs. The command line option `-allvrt` has the same effect.
- `MaxiLegs` allows to limit the number of legs in the vertices produced when `WriteAll` is active.
- `WriteColors` (default 0) Set this option to 1 to write color structure of vertices explicitely. Also the command line options `-colors` can be used.

When the `WriteColors` option is set to 1, color matrices and dot products are written in the Lorentz Part, e.g. QCD plus quark-photon interactions produces the following vertices file:

```
QCD
 Lagrangian
P1   |P2   |P3   |P4   |>   Factor   <|> dLagrangian/ dA(p1) dA(p2) dA(p3)
G    |G    |G    |     |gg            |m2.p3*m1.m3*F(c1,c2,c3)
     |     |     |     |               -m1.p3*m2.m3*F(c1,c2,c3)
     |     |     |     |               +m3.p1*m1.m2*F(c1,c2,c3)
     |     |     |     |               -m2.p1*m1.m3*F(c1,c2,c3)
     |     |     |     |               -m3.p2*m1.m2*F(c1,c2,c3)
     |     |     |     |               +m1.p2*m2.m3*F(c1,c2,c3)
G.C  |G.c  |G    |     |-gg           |m3.p2*F(c1,c2,c3)
Q    |q    |G    |     |gg            |L(c1,c2,c3)*G(m3)
Q    |q    |A    |     |ee/3          |c1.c2*G(m3)
G    |G    |G    |G    |gg^2          |m1.m3*m2.m4*F(c1,c2,c0)*F(c3,c4,c0)
     |     |     |     |               -m1.m4*m2.m3*F(c1,c2,c0)*F(c3,c4,c0)
     |     |     |     |               +m1.m2*m3.m4*F(c1,c3,c0)*F(c2,c4,c0)
     |     |     |     |               -m1.m4*m2.m3*F(c1,c3,c0)*F(c2,c4,c0)
     |     |     |     |               +m1.m2*m3.m4*F(c1,c4,c0)*F(c2,c3,c0)
     |     |     |     |               -m1.m3*m2.m4*F(c1,c4,c0)*F(c2,c3,c0)
```

Here q/Q is a quark, G – gluon , G.c – gloun ghost field, and A – photon. F stand for antisymmetric structure constants (D for symmetric ones), L – Gell-Mann matrices. The Lorentz part is shown one monomial per line just to make the expression fit into the page, usually there is one line per vertex (option `chepBreakLines` set to 1 to made this effect).