A Feynman graph selection tool in GRACE system

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Abstract

We present a Feynman graph selection tool 	exttt{grcsel}, which is an interpreter written in C language. In the framework of GRACE, it enables us to get a subset of Feynman graphs according to given conditions.

1 Introduction

Using an automatic Feynman graph calculation package, we can generate the information of all Feynman graphs for given processes. Sometimes it is necessary to select graphs from the set of all graphs by some conditions. However, it is not so easy to select them correctly by hand when a huge number of graphs is involved, such as higher order corrections or SUSY processes.

A program 	exttt{grcsel} selects out a subset of Feynman graphs from the set of graphs, generated by GRACE\textsuperscript{[1]}, according to given selection conditions. The output information of selected graphs is written in the same format as that of the original set. This enables us to generate Feynman amplitudes within GRACE in the same procedure as for all graphs. So we can perform cross section calculation, gauge invariance check, event generation and so on for the selected ones. 	exttt{grcsel} helps us:

1. to find decay-graphs and evaluate signal/background ratio,
2. to check the accuracy of approximated calculation,
3. to confirm precision of the calculation,
4. to reduce the calculation time,
5. to develop kinematics routine.

2 Overview of 	exttt{grcsel}

	exttt{grcsel} consists of three parts: a steering-part defines basic functions of graph selections and reads input files, an interpreter-part parses and evaluates commands, and a utility-part handles subsets of particles, vertices and graphs.

Once a physics process and the order of calculation are fixed, Feynman graphs are generated by 	exttt{grc} program with specified Feynman rules described in physics model file\textsuperscript{[2]}. The information on graphs generated are stored in a file named 	exttt{out.grf} (we call the format of this file \texttt{.grf} format).

	exttt{grcsel} reads the physics model file and 	exttt{out.grf} and selects graphs according to a kind of propagator, characteristics of graph topology, a type of vertex or a graph number. 	exttt{grcsel} outputs those selected graphs in the same format as 	exttt{out.grf}. Successively this
output file can be used as the input to source code generation for Monte Carlo integration or event generation. We can also use grcsel again reading output of previous execution of grcsel. The schematic view of how grcsel works in GRACE system is shown in Fig. 1.

2.1 Running grcsel

Graph selection starts by the program grcsel:

```
grcsel
```

This program requires out.grf file by default. The graph selection commands are read through standard input, which may be given interactively or by a script file. With a script file where grcsel commands are prepared, we can redirect that file:

```
grcsel < command.in
```

To use another input .grf format file, e.g. out1.grf, instead of out.grf, we can add the filename after grcsel command as:

```
grcsel out1.grf < command.in
```

2.2 grcsel command

In a script file there are a series of grcsel commands such as declaration of variables and basic functions to specify the selection conditions or operators. grcsel has 14 basic functions in total. Three of them return a subset of graphs in accordance with specified selection condition and two functions output set of graphs. They are summarized in Table 1.

| Function  | Description                                      |
|-----------|--------------------------------------------------|
| cutprop   | Select graphs with a specified propagator.       |
| selvlegs  | Select graphs with a vertex consisting specified particles. |
| selvertex | Select graphs with a specified vertex.           |
| outgset   | Output a set of graphs.                         |
| renumgset | Renumber and output a set of graphs.             |

In grcsel, graphs, particles or vertices are treated as elements of a set of type gset, pset or vset, which are defined as a set of graphs, particles or vertices, respectively. Set variables have to be declared at first with their types. Operations on sets are available and are shown in Table 2.

| Operator | Function         |
|----------|------------------|
| &        | Set intersection |
| |      | Set union        |
| ^        | Complement of set |

Table 1: Basic functions to select and output graphs.

Table 2: set operators
3 Example

In the following example, graphs with $\nu_e$ propagator connected to the initial electron and final $W^-$ are selected among graphs of $e^+e^- \rightarrow W^+W^-\gamma$ process. Selected graphs are output into a file named out1.grf.

```plaintext
% e+ e- --> W+ W- Photon
% out1.grf : with neutrino propagator
% at the vertex of initial electron and
% final W-.
%

gset gs0, gs1;
gs0 = ~[];  % all graphs
gs1 = cutprop(gs0, ['nu-e'], [0,3]);
outgset('out1.grf', gs1);
quit;
```

In Fig. 2 selected graphs are shown.

4 Remarks

grcsel has been developed in the framework of GRACE 2.1.7.4. It can handle tree and 1-loop graphs and it supports standard and MSSM physics model. grcsel is included in a distribution kit of GRACE 2.1.7.4.

Acknowledgments

We wish to thank the members of MINAMITATEYA collaboration for continuous discussions and many kinds of support. We are also grateful to express our sincere gratitude to Prof. Y.Shimizu for the valuable suggestions and continuous encouragements. Authors appreciate Prof. Y.Watase for the encouragements. This work was supported in part by the Grant-in Aid (No. 12680363, 10640285, 10680366 and 11440083) of Monbu-sho, Japan.

References

[1] MINAMI-TATEYA group: GRACE manual. KEK Report 92-19.
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A program \texttt{grcsel} selects out a subset of Feynman graphs from the set of graphs, generated by GRACE\cite{grace}, according to given selection conditions. The output information of selected graphs is written in the same format as that of the original set. This enables us to generate Feynman amplitudes within GRACE in the same procedure as for all graphs. So we can perform cross section calculation, gauge invariance check, event generation and so on for the selected ones. \texttt{grcsel} helps us:

\begin{itemize}
  \item[1.] to find decay-graphs and evaluate signal/background ratio,
  \item[2.] to check the accuracy of approximated calculation,
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Once a physics process and the order of calculation are fixed, Feynman graphs are generated by \texttt{grc} program with specified Feynman rules described in physics model file\cite{phys}. The information on graphs generated are stored in a file named \texttt{out.grf} (we call the format of this file \texttt{.grf} format).

\texttt{grcsel} reads the physics model file and \texttt{out.grf} and selects graphs according to a kind of propagator, characteristics of graph topology, a type of vertex or a graph number. \texttt{grcsel} outputs those selected graphs in the same format as \texttt{out.grf}. Successively this
GRACE system

grc
(Graph generator)

grcsel
(Graph selection tool)

Model file
SM or MSSM

out.grf
(.grf format file)

Post Graph generation
- Source code generation
- Monte Carlo integration
- Event generation

Figure 1:

output file can be used as the input to source code generation for Monte Carlo integration or event generation. We can also use grcsel again reading output of previous execution of grcsel. The schematic view of how grcsel works in GRACE system is shown in Fig. 1.

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