

## A Feynman diagram analyzer DIANA: recent development \*

M. Tentyukov,<sup>a†</sup> J. Fleischer<sup>b</sup>,

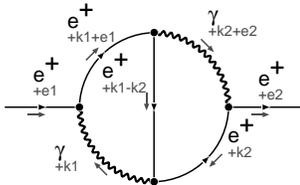
<sup>a</sup>BLTP JINR, Dubna, Russia

<sup>b</sup>Universität Bielefeld, Fakultät für Physik, Bielefeld, Germany

New developments concerning the extension of the Feynman diagram analyzer DIANA are presented. We discuss new graphic facilities, application of DIANA to processes with Majorana fermions and different approaches to automation of momenta distribution.

The project called DIANA (DIagram ANAlyzer)[1] for the evaluation of Feynman diagrams was started by our group some time ago. It was already used to calculate several processes [2]. The recent development<sup>1</sup> of this project will be shortly described below.

The pictorial representation of diagrams described in [3] includes three different kinds of postscript files. Now one more kind is available, the encapsulated postscript file containing particle lines together with momenta flows. Particle identifiers now can be depicted by different fonts, sizes and colours:



DIANA has several features to support simple algorithmic Feynman rules for interactions with Majorana fields, elaborated by Denner *et al* [4]. The basic idea is the following: a new keyword in the model description of propagators and vertices is introduced. Its default value `fflow` may be changed by the directive `fermion number flow = newkw`. This identifier is supposed to take the values 0, -1 or 1.  $\pm 1$  stand for Dirac fermions and 0 for all other par-

\*Supported by INTAS-CERN 99-0377

†Supported by DFG under the project FL 241/4-2

<sup>1</sup>For details look at

<http://www.physik.uni-bielefeld.de/~tentukov/diana.html>

ticles. For vertices it will be -1, if at least one incident line has -1. The assignment of these values is performed by DIANA.

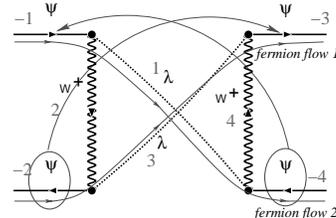
For example, the Lagrangian  $\bar{\lambda}\Gamma\psi W^- + \bar{\psi}\Gamma\lambda W^+$ , ( $\psi=f$  – Dirac fermion,  $\lambda=1$  – Majorana fermion,  $W^\pm=(\mathbf{W}_p, \mathbf{W}_m)$  – charged vector,  $\Gamma$  is a Gamma matrix) in terms of a DIANA model reads in terms of propagators

```
[Wp, Wm; a; ww(num, ff=fflow, fn=fnum); 0]
[f, F ; f; ff(num, ff=fflow, fn=fnum); 0]
[l, l ; l; ll(num, ff=fflow, fn=fnum); 0]
```

and vertices

```
[l, f, Wm; ; lfWm(num, ff=fflow, fn=fnum)]
[F, l, Wp; ; FlWp(num, ff=fflow, fn=fnum)] .
```

Process  $(\psi, \bar{\psi}) \rightarrow (\psi, \bar{\psi})$ , diagram “number 3”:



Generated FORM input:

```
G Rq =
spl(-3, ff=1, fn=1)*spl(-4, ff=-1, fn=2)*
(-1)*FlWp(3, ff=1, fn=1)*ll(3, ff=0, fn=1)*
FlWp(2, ff=-1, fn=1)*lfWm(4, ff=-1, fn=2)*
ll(2, ff=0, fn=2)*lfWm(1, ff=1, fn=2)*
ww(1, ff=0, fn=0)*ww(4, ff=0, fn=0)
*spr(-2, ff=-1, fn=1)*spr(-1, ff=1, fn=2);
```

Topologies [1] are represented in terms of ordered pairs of numbers like (*fromvertex*, *tovertex*). All external legs have negative numbers.

Sometimes the number of topologies is too large such that it is impossible to assign momenta to the lines in all topologies “by hand”.

Of course, momenta can be introduced automatically. The user may specify loop momenta via the macro `\loopmomenta` in the “create” file, e.g. `\loopmomenta(k1,k2,k3)`, and DIANA will assign momenta automatically using “*k1*”, “*k2*” and “*k3*” as the loop integration momenta.

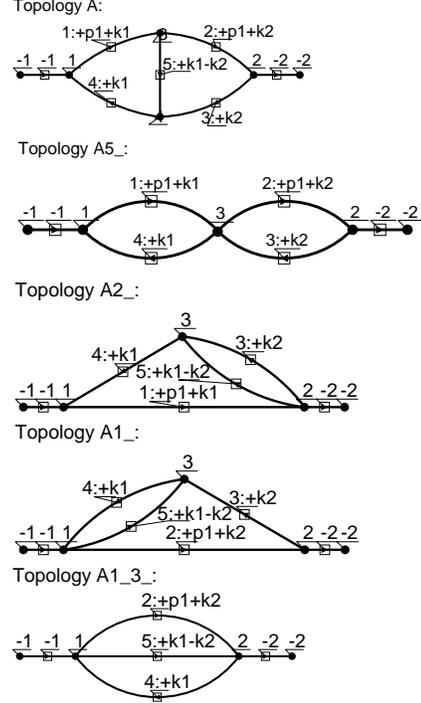
Sometimes it is important to keep some definite lines free from the external momenta. If the users specifies `SET _MARK_LOOP=YES` in the “create” file, the topology editor will be invoked in a special mode, and the user can point out which lines should carry bare integration momenta. All remaining momenta will be assigned automatically.

Sometimes it is necessary to use more sophisticated distribution. For example, the user may want to use his favorite momenta like  $k - p_1$ ,  $k - p_2$ ,  $k - p_3$ , etc. assigned to some definite lines (see e.g. [5]). For such cases, DIANA provides a possibility to define momenta only for the virtual lines, and the full set of topologies will be defined from these “internal” topologies attaching the external legs. Momenta for internal parts are defined in terms of combinations of loop momenta ( $k$  in the above example) and some “abstract” tokens ( $p_1, p_2$  etc.), and for each topology DIANA may express these tokens in terms of external momenta.

Another example: often topologies are generated by more complicated (“generic”) ones by scratching lines. In such cases one wants to stick to the momenta introduced for the lines which are kept. E.g. the user investigates the generic topology

```
genericctopology A =
(-2,2)(-1,1)(1,3)(3,2)(2,4)(4,1)(3,4):
p1+k2,p1+k1,k1,k2,k2-k1.
```

Then DIANA will generate topologies form this one by scratching lines in the following manner:



## REFERENCES

1. M. Tentyukov, J. Fleischer, *Comput. Phys. Comm.* **132** (2000) 124.
2. J. Fleischer *et al*, *Phys. Lett.* **B459** (1999) 625; J. Fleischer, O. V. Tarasov and M. Tentyukov, *Nucl. Phys. Proc. Suppl.* **89** (2000) 112; F. Jegerlehner, M. Y. Kalmykov and O. Veretin, *Nucl. Phys.* **B641** (2002) 285; J. Fleischer *et al*, hep-ph/0202109; A. Onishchenko and O. Veretin, hep-ph/0209010; M. Awramik *et al*, hep-ph/0209084.
3. J. Fleischer, M. Tentyukov, “A Feynman diagram analyser DIANA: Graphic facilities”, in: P. Bhat and M. Kasemann (eds.), *Proc. of the VIIth Int. Workshop ACAT 2000*, Batavia, USA, 16-20 Oct. 2000, AIP Conference Proceedings (Melville, New York, 2001), vol. 583, p. 193, hep-ph/0012189.
4. A. Denner *et al*, *Nucl. Phys.* **B387** (1992) 467; *Phys. Lett.* **B291** (1992) 278.
5. J. Fleischer, F. Jegerlehner, O.V. Tarasov. *Nucl. Phys.* **B566** (2000) 423.