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NOTE

A Short Program for Dirac Matrix Algebra

Several programming schemes [1]–[6] have been reported in which facilities for the evaluation of traces of products of Dirac matrices are available. For most of these schemes, the programs have incorporated many more operations, such as substitution, differentiation, and recognition of integrals. In efficient programs, it is rather difficult to separate out the code for the evaluation of traces. The general programs [4], [5] written in the language LISP [7] are quite long, and normally an acceptable amount of core storage for computation is available after the entire programs are read in only with computers on which they have been specifically developed. Intending users with access to other machines have therefore found that there may be insufficient storage to complete a relatively undemanding calculation, but that they are faced with problems in making more space available by removing inessential parts of a large program with which they are unfamiliar.

Because most of the users of the program quoted in Reference [5] with simple tasks have asked only for the evaluation of traces, a new short program containing that facility has been written in LISP. The other aim in the construction of the program is that it shall be contained in punched form on a card deck less than 3 cm thick, so that users remote from their computers can send their programs through the mails at the letter rate without undue expense.

In its 3-cm form, the program evaluates traces of products of terms of the type γ_μ or $\gamma \cdot p + m$. The LISP representation of a term like $\gamma \cdot (p - 2q + r) + m$ is

$$(((1 \,.\, \mathrm{P})(-2 \,.\, \mathrm{Q})(1 \,.\, \mathrm{R})) \,.\, \mathrm{M}). \tag{1}$$

The LISP function which initiates the evaluation of a trace has the name MTRACE. It takes one argument, a list of terms of the type (1). For example, the instruction to evaluate the trace of $(\gamma \cdot p + m)\, \gamma \cdot q(\gamma \cdot (r - s) + m)$ is

$$\mathrm{MTRACE}(((((1 \,.\, \mathrm{P})) \,.\, \mathrm{M})(((1 \,.\, \mathrm{Q})) \,.\, 0)(((1 \,.\, \mathrm{R})(-1 \,.\, \mathrm{S})) \,.\, \mathrm{M}))). \tag{2}$$

The outermost pair of brackets in (2) encloses the argument of MTRACE. The next pair delineates the list of terms. Each term has the form of (1).

All four-vectors must be declared in advance of the use of MTRACE. The function

VECTORS, whose argument is a list of these four-vectors, establishes the identification. Before (2), for example, an appropriate declaration is

VECTORS ((P Q R S)).

Any quantity X not so declared, and found in a context "(number . X)", is treated [4] as a label for a Greek subscript index. A representation for γ_μ is therefore (((1 . MU)) . 0).

It has not been possible to take account of factors of γ_5 in the 3-cm form of the program. A 5-cm version to remedy this omission, and to provide some rudimentary facilities for the ordering of the output, will be prepared if there is sufficient demand for it. All who are interested in the present program are cordially invited to write for a copy.

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References

1. H. J. Kaiser, *Nucl. Phys.* **43**, 620 (1963).
2. S. M. Swanson, Institute of Theoretical Physics (Stanford) report No. ITP-120 (1964). Unpublished.
3. M. Veltman, CERN document No. 65/1081/5 p/he (1965). Unpublished.
4. A. C. Hearn, *Commun. A.C.M.* **9**, 573 (1966).
5. J. A. Campbell, *Nucl. Phys.* **B1**, 283 (1967).
6. M. J. Levine, *J. Computational Phys.* **1**, 454 (1967).
7. J. McCarthy *et al.*, "LISP 1.5 Programmer's Manual" (revised ed.). MIT Press, Cambridge Massachusetts (1965).

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