



SYMBOLIC MANIPULATIONS IN HIGH-ENERGY THEORY

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Abstract

This document demonstrates the use of computer-aided symbolic manipulations in high-energy theory. It includes two Mathematica notebooks that can be safely extracted and viewed. The first notebook shows the manipulations used in a theory dealing with an 18-dimensional unification model, the construction of the associated algebra, and its tensorial and spinorial multiplets, decomposing with respect to 4 dimensions and an internal SU_7 . The second notebook shows the manipulations used in a theory dealing with E_8 unification, the construction of the associated algebra, and its fundamental multiplet, in a decomposition with respect to SU_9 . We describe the various other comprehensive capabilities of the underlying programming code for symbolic computations in quantum field theory and related manipulations.

1 Introduction

Symbolic manipulations with the aid of programming code have become an increasingly important manipulative tool for the high-energy mathematical theorist. Our purpose in this document is to illustrate our use of such tools with reference to two articles^{[1], [2]} that were dependent on very extensive algebraic manipulations with tensorial and operator objects.

Over many years, we have been developing a programming package under the renowned *Mathematica* program, and have been applying it very extensively to our advanced theoretical manipulations. This package, with associated file **qft.m**, can handle all the symbolic manipulations, and other useful computations, in quantum field theory and related high-energy theory.

We have embedded in the present document two notebook files (extension **.nb**) showing our pertinent manipulations. These files can be read by a *Mathematica* program. The following two sections will describe the embedded notebooks and how to extract them.

On the other hand, more on the capabilities of the underlying package code will be described in a subsequent section.



2 The Symbolic Manipulations of an 18-Dimensional Model

The embedded notebook file, **qft18DimO4U7.nb**, illustrates symbolic computations pertaining to the 18-dimensional unification model^[1]. Right-clicking on the icon below, you can either open this file under *Mathematica*, if available on your computer, or you can save it for use elsewhere. We do recommend the use of the older versions of *Mathematica* (like versions 3 and 4), being most suitable for reading such files, much less demanding from your computer, and much more efficient.



If you manage to open the file for reading, please inspect its various sections, and learn how it is possible to use the underlying programming code. Notice that the essential code is loaded at the beginning of the notebook, with the command: `<<qft.m`. However, *be careful not to execute any code*, because the notebook file is only for reading. You need the file **qft.m** for executing the exhibited commands. If you have any questions, feel free to ask by [email](#).

3 The Symbolic Manipulations of the E_8 Model

The following notebook file, **qftE8SU9.nb**, illustrates symbolic computations that pertain to the E_8 unification model^[2]. Right-clicking on the icon below, you can either open this file under *Mathematica*, if available on your computer, or you can save it for use elsewhere. We do recommend the use of the older versions of *Mathematica* (like versions 3 and 4), being most suitable for reading such files, much less demanding from your computer, and much more efficient.



If you manage to open the file for reading, please inspect its various sections, and learn how it is possible to use the underlying programming code. Notice that the essential code is loaded at the beginning of the notebook, with the command: `<<qft.m`. However, *be careful not to execute any code*, because the notebook file is only for reading. You need the file **qft.m** for executing the exhibited commands. If you have any questions, feel free to ask by [email](#).

4 About the QFT Computing Package

As you may have noticed, reading the embedded notebooks, our *Mathematica* package, **qft.m**, embodies very powerful technology for the automatic manipulation of advanced mathematical and symbolic expressions in high-energy theoretical physics and quantum field theory.



The significant manipulations handled by this program pertain to symbolic tensorial objects with all kinds of internal space indices, as well as spacetime indices. Tensors with any kind of symmetry, and expressions involving them, would be handled and simplified most consistently.

For instance, the package knows about deltas (δ_i^j), etas ($\eta_{\mu\nu}$), and epsilons ($\epsilon^{abc\dots}$), and handles them in spaces of any number of dimensions.

The significant manipulations also concern all kinds of operators whether bosonic or fermionic, and all kinds of Lie algebraic or superalgebraic systems. Objects such as the Dirac algebraic elements (gamma operators like γ_μ , $\gamma_{\mu\nu}$, etc.) can be handled with ease. Symbolic generators and representations of all classical algebras and superalgebras can be introduced most conveniently.

On the other hand, the package can handle Feynman integrals in arbitrary number of dimensions, and *almost every tedious kind of symbolic computation that the high energy theorist would need to perform again and again.*

The package has an open source code that is *accessible for inspection and modification.* In fact, for many years, I have been in the process of extending its capabilities.

Readers who are able to view the *Mathematica* notebooks, embedded in the preceding sections, would also be able to use our underlying programming package, **qft.m**. The author would be willing to release all programming *source code*, contained in a file **qft.nb**, together with *detailed guiding instructions*, for the benefit of any interested researcher.

References

- [1] N.S. Baaklini, “The SU_7 Structure of 18-Dimensional Unification”, *N.S.B. Letters*, **NSBL-EP-018**, <http://www.vixra.org/abs/1401.0205>
- [2] N.S. Baaklini, “The SU_9 Structure of E_8 and Boson-Fermion Couplings”, *N.S.B. Letters*, **NSBL-EP-015**, <http://www.vixra.org/abs/1401.0099>

