

Preface

This book is intended to be advanced undergraduate–graduate friendly. With a less strict yet formal language, it intends to clarify and structure in a very logical manner concepts that can be confusing in Quantum Field Theory. It does not replace a formal book on the subject. Its main goal is to be a helpful complementary tool for beginners and not-so-beginners in this field. The reader is expected to be at least familiar with basic notions of Quantum Field Theory as well as basics of Special Relativity. However, most of the times being familiar with Special Relativity doesn't mean being familiar with tensor algebra or tensor calculus in general. Many physics books assume that the reader is already familiar with tensors, so they begin directly with advanced topics. On the other hand, many mathematical books are somewhat too formal for a young physicist. Thus, I have introduced at the beginning, a nicely self-contained, student friendly chapter, which introduces the tensor formalism in general, as well as the concept of a manifold. This is done by assuming only that the reader is familiar with the notions of vectors and vector spaces. Key aspects of Special Relativity are also covered.

The kinematics needed for the most common relativistic processes is given. It is a logical schematic list of all the relevant and most important formulae needed for calculating relativistic collisions and decays. It includes one-to-two and one-to-three body decays, and also the two-to-two scattering process both in the center of mass and laboratory frames. It also includes simplified general formulae of one, two, and three-body Lorentz invariant phase space. As a bonus, the three and four-body kinematics in terms of angular observables is also presented.

Noether's theorem is mostly treated in the literature in a somewhat heuristic manner by introducing many ad hoc concepts without too many technical details. I try to fix this problem by stating the most general (Lorentz invariant) form of the theorem and by applying it to a few simple, yet relevant, examples in Quantum Field Theory.

I also try to introduce a simple and robust treatment for dimensional regularization and consistently explain the renormalization procedure step-by-step in a transparent manner at all orders, using the QED Lagrangian, which is in my opinion

the most suitable from an academical point of view. I dedicate thus, one chapter in explaining the Dyson summation algorithm and try to clarify all possible confusions that may arise. Various renormalization schemes are also presented.

Infrared divergences, as well as the ultraviolet ones are also extensively treated. I explicitly calculate a few infrared divergent Green functions and show an explicit example of cancellation of infrared divergences (step by step) using dimensional regularization. Other interesting topics are also discussed.

Possible issues and confusion for tadpole renormalization are commented and some illustrative simple examples are given in Chaps. 7 and 9, where we also treat the renormalization of the W sector of the Standard Model. With the tools given here one should find it straightforward to calculate and renormalize any N -point Green function at one-loop level. A very short example of a two-loop calculation is also given.

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