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Relativistic Quantum Particles and Fields
Some Theoretical Basics

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Abstract

Outline:

- Relativistic Kinematics and Special Relativity
- Quantum Dynamics
- Relativistic Quantum Particles and Fields
- Scattering and Perturbation Theory
- Feynman Rules and Cross Sections
- Lie Groups and Symmetries

A first part of the lectures consists of reminders about Special Relativity and its particle kinematics. This is built up starting from some well known facts, in order to quickly reach towards some of the important issues in the context of particle physics.

In a similar spirit, the basics of quantum dynamics are recalled, starting from the well known harmonic oscillator, which in the perturbative context is the "mother of all quantum field theories". The discussion is pursued solely within the operator quantisation approach, leaving the functional/path integral approach aside. The main features of the canonical formalism, the specifics of quantum dynamics, and so on, are recalled starting from the example of the harmonic oscillator, emphasizing what is required to lay the ground for what comes next in the lectures. A first discussion of symmetries and Noether's (first) theorem is also provided.

Putting all the above to good use, a construction of quantum fields starting from free relativistic particles is performed, by dressing up step by step the quanta of the harmonic oscillator with more and more conserved quantities. The main features of relativistic quantum fields as theories for relativistic quantum point particles are thereby recalled, without all the benefits, however, of a full fledged discussion.

Once the dynamics of free particles are understood, interactions may be built in again by analogy with the harmonic oscillator. In the perturbative framework, the S matrix is constructed. By way of an example, the relevance and meaning of Feynman rules are discussed, leading to the evaluation of cross sections and decay rates.

Finally, as a prelude to gauge theories and their interactions which are to be discussed in other Lectures at the ASP2010 School, the lectures conclude with some basic facts of Lie symmetries in quantum physics, once again working from specific cases towards a general description.

By the character of the lectures which have to address a whole series of important topics in only that many hours available, rather than try develop a complete discussion, they offer a "red thread" through all that material as it may be found in many sources, hoping that participants may find it useful to start navigating through it all and benefit from the entire three weeks ASP2010 School.