

Chapter 1

Introduction

The method for physics put forward in this book is *constructive*. One may alternatively say that it is a *process* theory. In it one does not imagine the space and time continua as existing outside the theory and giving us a universe of objects already distributed in these continua to start from. All this has to be constructed.

Any construction of this kind must necessarily start from discrete quantities — numbers in fact. However remote that may seem from the classical basis of physics, we argue in this book that it is the place at which the physicists concerned with the high energy physics of the particles in fact have to start. The book constitutes a discussion from the process point of view of the evolution of the concept of *particle*. In high energy physics, new knowledge about particles has to be expressed in terms of properties like those familiar from classical physics even though they are not classical particles.

To make this clearer we begin by specifying what is meant by a classical particle. That concept has changed over time but by, say, the mid-eighteenth century a particle had one *primary* property, its mass, and two *secondary* properties, its position and its momentum. Change in position as time elapsed then produced a path. The other primary properties quoted by Newton (*Opticks*) of roundness and hardness were no longer necessary. As electromagnetism developed a second primary property, charge, was added. It would have been possible to introduce another secondary property, intrinsic spin, which could have been useful in the analysis of ball games, for example billiards, but as a matter of history, the notion of a rigid sphere was used instead to carry spin. The advent of relativity pro-

duced no great conceptual change by itself. It is true that relativity allowed a convenient description of the spinning particle but the stimulus for this came from quantum mechanics.

Quantum mechanics called for major changes in the concept of particle. The two secondary properties, position and momentum, were restricted by the uncertainty principle. In practice, the momentum became more important and the position increasingly disregarded so that the path became uncertain. The two primary properties, charge and mass, and the secondary one, spin, were taken over though only with important modification. The charge could have only three possible values including zero, a fundamental unit or its negative. A given particle has always the same charge. The mass could have a range of values, but again all particles of one kind had always the same mass. Finally, the spin became a third primary property whose value was some multiple of a fundamental unit.

The new knowledge that was coming in about particles in high energy physics has to be expressed by new primary properties. These are represented by descriptors which are called 'quantum numbers'. Descriptors are things that either exist or do not exist in any particular case. (For example some particles have charge though the neutron does not.) Conventionally they are given the values 0, 1 or digits reducible to 0, 1. The rules for assigning these quantum numbers capture their conservation laws in particle interactions. The first step from these descriptors toward the notion of a particle is the interaction strength. This is no longer an all-or-none property but has one definite value which characterizes a given particle process. An important investigation is always necessary to relate this value with the value of the mass, since mass will have a range of values even though it is not continuously variable.

The interaction strength is moreover a *number* that comes from counting of processes and only at a further remove should it be thought of as a field strength. The classical notion of a field is, in any case, inappropriate when the position of the particle is uncertain. Underlying the interaction strengths is a set of coupling constants that are dimensionless.

In our theory we find the origins of the coupling constants in a study of the building up of structures from interactions with an unknown background rather similar to the vacuum of high-energy particle physics. Construction does not go on into ever-increasing complexity but can be reversed or started all over again, so that there is a dynamic process at work.

This book is therefore an essay in the conceptual foundations of physics. Its purpose is to introduce what we shall call a *combinatorial* approach.

A process approach is necessarily combinatorial but the opposite is not the case. To clarify this consider a combinatorial approach in quite a different sphere, that of plane geometry. The fundamental entity there is the *point*. A pair of points is *defined* as a line. Two such pairs then define a fifth point. In normal parlance this would be the intersection of the two lines. Appropriate rules governing the derived entities then lead to the construction of projective geometry. (Euclidean geometry would be another matter.) In contrast the usual view would be of a continuum containing all the points of the plane and all their joins. These would all be on an equal footing so that it can only be an accident in what order they appear.

In physics our method will be to view physical theory under the aspect of a particular point of view which is combinatorial in character. In the course of the book questions will be asked and discussed which may have a long history, but which are not seen as live issues at the present because of the special philosophical stance of present-day physicists. However for combinatorial physics they are very much alive.

The idea which underlies combinatorial physics is that of *process*. The most fundamental knowledge that we can have is of step-by-step unfolding of things; so in a sequence. This is the kind of knowledge we have of quantum processes, and that fact becomes specially evident in the experimental techniques of high-energy physics. Such a process is necessarily combinatorial but not conversely. The example of plane geometry above exhibits a combinatorial theory which is not a process one.

The contrasting view, which has been the main guide of physics in the past, is of a background of physical things whose spatial relationships are on an equal footing in the sense that it can only be an accident in what order we happen across them. To put it another way, when the sequence or process is fundamental then we have to specify the steps by which we get to a particular point, whereas in the conventional picture we imagine we are free to move about in the space in which phenomena occur, without its being necessary to be explicit about it.

Suggestions for fundamental revision of the conceptual framework of physics are unlikely to engage the attention of physicists unless they bring about major improvements in the technical understanding of physics — particularly in new explanations and calculations of experimental results. The strong position of the combinatorial theory is that it has been used to deduce some experimental quantities that have not been deduced from more conventional theory. The closeness to the experimental values of these deductions makes it very unlikely that their success is fortuitous. Moreover

it would be agreed on all sides that the experimental quantities in question play a sufficiently important part in physics to warrant attention being paid to any theory that claims to calculate them.