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PROLOGUE: THE CORRESPONDENCE PRINCIPLE

It used to be argued by many scholars that physics develops or it should develop so as to make valid what they call the Correspondence Principle. It was also said that in order for a scientific change in a more general sense to be continuous or cumulative (in some intuitive meanings of the words) the principle should apply to it. As we shall see later, we can even consider this principle from a more universal point of view and insist that something similar is needed in order to make conceptual and cultural changes understandable inspite of meaning variance.

In the present chapter, I shall mainly investigate Thomas S. Kuhn's earlier criticism of the view that scientific progress is cumulative and his proposal that if those intertheoretic relations which were claimed to exemplify the Correspondence Principle are to be more than mere formal relations, some terms occurring in the supplanted theories must be reinterpreted in the framework of their successors to take account of the fact that their meanings change. I point out that this proposal, rather than his later account of translation, can be construed as having something important in common with what I have in mind when reconstructing intertheoretic and intercultural relations by using a notion of translation that might be relevant if the principle is generalized.

1.1. A HEURISTIC PRINCIPLE

A heuristic rule, which Bohr (1920) calls *Korrespondenzprinzip*, was extensively used in the early developments of quantum mechanics. It says that a future theory is to be a generalization of a classical theory in that the former yields the latter as a special, or limiting, case in an appropriate sense.[1] In his description of how quantum mechanics was created, van der Waerden (1967) remarks that the principle had guided physicists during the transition period from 1918 to 1925 and that a number of important results had been obtained by systematic guessing which was based on the Correspondence Principle.

Bohr was mainly interested in the role that the principle played in quantum mechanics, and it was originally mentioned in that context, but it has been considered crucial for developments in other branches of modern physics. Thus, for instance, Einstein used it as a guide in his search for relativity theory. Heisenberg (1958) and Born (1969) generalized it for the whole of physics. Heisenberg argues for the principle by saying that it plays an important role as a methodological principle, and Born maintains that the older theories have always been included in the new theories as limiting cases.

According to Heisenberg, modern physics can be grouped into four sets of concepts: (1) Newtonian mechanics, (2) phenomenological thermodynamics, (3) special relativity, electrodynamics, optics, and the like, and (4) quantum mechanics.[2] Now (1) is contained in (3) and (4) as the limiting cases where the velocity of light is considered infinite and Planck's constant infinitely small, respectively, and (2) is connected with the other sets. Heisenberg then goes on to argue that the independent existence of (3) and (4) suggests that there will be a fifth set in physics such that (3) and (4) are its limiting cases, and it is likely that it will be found in connection with the theory of elementary particles. Heisenberg in fact suggests that in the future correspondence relations could even obtain more generally, for in order to understand organic life it might be necessary to go beyond quantum theory and construct a new coherent set of concepts to which physics and chemistry would belong as limiting cases.

Similar views on the role of the Correspondence Principle in physics and in science more generally have been presented by several philosophers of science.[3] Post (1971), for instance, thinks of it as the most important heuristic restriction for developments in science, since to be acceptable a new theory should account for the success of its predecessor by being transformed into that theory under those conditions on which it has been well confirmed. The new theory should explain the well-confirmed part of its predecessor.[4] Post even argues that the principle is not only heuristic and normative but it is a historical fact that the successors have always carried out that task. There is one exception, however, according to Post. The principle fails in the case of quantum mechanics, for, contrary to what is said in some textbooks, quantum mechanics is not transformable into classical mechanics except locally, that is, with respect to certain subtheories. This is to be considered, says Post, a shortcoming of quantum mechanics rather than a breakdown of the principle itself, and therefore indicates that a better theory is needed.

1.2. REDUCTION AND THE CONTINUITY OF SCIENTIFIC CHANGE

The Correspondence Principle in the sense discussed by Bohr and other physicists was, as we saw, emphasized as a heuristic device. It has also been considered in the context of justification: as soon as a theory has a successor, the latter can be tested by checking whether the former is its special or limiting case. If it is, it is one indication that the respective scientific change is progressive.

According to some authors, the Correspondence Principle refers to a kind of intertheoretic relations, namely the correspondence relation, which can be regarded – perhaps subject to some reservations, however – as a kind of a general reduction relation. There are several reasons why reduction has been extensively discussed in the philosophy of science and in science itself. For example, it is often assumed that behind an observed, or otherwise given, phenomenon there exists a more fundamental reality to which the phenomenon can be reduced and which can be employed to explain and understand it. Furthermore, it is usually thought that scientific research is not feasible if it cannot be reduced to methods that in some sense are objective and reliable. Philosophy and science abound in historical examples and consequences of these ontological and methodological forms of reductionism. Such are radical empiricism and rationalism, the idea that the axiomatic method is reliable (these examples represent methodological reductionism deriving from the struggle for epistemic certainty), reductive materialism and idealism, the discussion concerning the reduction of biology to physics (which, in turn, represent ontological reductionism), and discoveries of elementary particles (which are a consequence of a kind of ontological reductionism). We may see that reduction has been discussed at various levels, at the levels of theories, knowledge, methods, and ontology. An important tacit idea has been, however, that if there is an ontological reduction, it should be mirrored at the theoretical level, and *vice versa*. In what follows, I shall mainly be concerned with the theoretical level.

The notion has also been important in debates concerning scientific change since it is often held – or, rather, it used to be a common view in the philosophy of science before Kuhn and other critics – that one indication of scientific progress is that theories are reducible, in some accurate, approximate, or limiting sense, to their successors, so that the latter theories are more comprehensive and more advanced than the former. A reduction, in turn, was thought to imply an explanation: If a theory is reducible to its successor, or to another more comprehensive theory, it follows that the latter explains the former in (something like) the sense of deductive-nomological explanation. Because the explanation is something that increases understanding, we should, after the reduction, be in a better position to see the nature of the reduced theory, and the nature of the change in question.

To place this discussion about reduction in its proper context, let us next make a quick survey of some earlier views concerning the question of what scientific progress might mean and whether it has been progressive. By progress I shall mean here progress within a given science, that is, I shall consider theories belonging to the same branch of science.

An important characteristic of progress mentioned in the literature is that scientific knowledge grows *cumulatively*, which means that old theories and the knowledge they represent survive, to some extent at least, when new and better ones appear, so that the latter extend the domain of scientific knowledge. Another characteristic is that a theory is *reducible* to its successor, which means that the old theory is not supplanted by the new one but can be thought of as being included in the new one as a special case. A third feature is described by suggesting that a new theory *explains* its predecessor, so that at least the most important principles, or laws, of the old theory can be deduced from those of its successor together with some auxiliary hypotheses. These characteristics go hand in hand, whereas the following two criteria are based on somewhat different ideas (but how far they are from the first three depends on how they are interpreted). One of the criteria is that a science is progressive if new theories *solve* the *problems* their predecessors do plus some further ones, or, rather, if they solve more or better problems,[5] and the other that progress means that scientific knowledge *approaches the truth*, that is, new theories are better than their predecessors if they are closer to the truth and hence describe and explain the world more accurately.[6]

These are, perhaps, the main characteristics of scientific progress that one can find in the literature, where it is maintained, moreover, that they apply to developments in 'mature' sciences, such as modern physics. Different authors defend different characteristics. For example, many empiricist philosophers, such as philosophers close to logical empiricism or its heir, the so-called Received View, held the view that the first three features are typical of modern science,[7] whereas some of their critics emphasize the fourth or fifth feature.[8] It seems that a crucial presupposition for the validity of the first three features would be that theories are well confirmed in some sense, so that they are relatively immune to rejection. That they are well confirmed implies, for instance, that they yield good predictions concerning phenomena to which they are applicable. That a new theory is adopted means then that the domain of application is extended.

In this book, I shall only consider the former view. One of its most outstanding representatives is Nagel (1961) whose classical concept of reduction has usually been assumed when the view has been advocated. In short, that a theory T is reducible to another theory T' means in a logical sense that the laws of T are deducible from the laws of T' together with appropriate auxiliary assumptions, some of which may link the languages of the two theories to each other. It follows that the reducing theory T' then explains the reduced theory T in the sense of deductive-nomological explanation, provided, of course, that the auxiliary assumptions satisfy appropriate theoretical and pragmatic conditions of adequacy.

According to Nagel, it is an undeniable feature of modern science that theories have been reduced to more inclusive theories, and he assumes that reduction will play an important role in the future. Among standard examples of reduction in the Nagelian sense that are usually mentioned are the reduction of rigid body mechanics to classical particle mechanics, of Kepler's laws of planetary motion to Newton's gravitational theory, and of classical particle mechanics to relativistic particle mechanics.

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