

CHAPTER I

THE APPROACH TO THE EXTERNAL WORLD

Twentieth-Century Physics

A century which has run less than a third of its course has already witnessed two great upheavals in physical science. These are associated with the words Relativity and Quanta, and have forced the physicist of to-day to view nature against a background of ideas which is very different from that of his nineteenth-century predecessor.

The latter thought of nature as an assemblage of objects located in space and continually changing with the passage of time. It was something entirely detached from, and external to, himself; something which he could study and explore from a distance as the astronomer studies the surface of the sun through his telescope, or the explorer the desert from his aeroplane. He thought of the apparatus of his laboratory as the astronomer thinks of his telescope, or the explorer of his field-glass; it shewed him things which were there whether he looked at them or not, which had been there before the first man appeared on earth, and would still be there after the last man had been frozen to extinction. Finally he accepted a "common-sense" view of nature, believing that there was no great difference between appearance and reality; the possibility that things were not as they seemed might provide an admirable subject for a debating society of philosophers, but was of as little practical concern to the scientist as to the farm-labourer.

Although he may not have realised it, this complex of beliefs constituted a philosophical creed in itself. No

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[More information](#)

2 THE APPROACH TO THE EXTERNAL WORLD

attempt was made to justify it by abstract argument; so long as it worked satisfactorily none seemed to be needed, the success of the science based upon it providing a sufficient justification. If ever it ceased to work, there would be time enough to probe its foundations and perhaps look for a new philosophy.

That time has now come. The old philosophy ceased to work at the end of the nineteenth century, and the twentieth-century physicist is hammering out a new philosophy for himself. Its essence is that he no longer sees nature as something entirely distinct from himself. Sometimes it is what he himself creates or selects or abstracts; sometimes it is what he destroys.

In certain of its aspects, which are revealed by the new theory of quanta, nature is something which is destroyed by observation. It is no longer a desert which we explore from the detached position of an aeroplane; we can only explore it by tramping over it, and we raise clouds of dust at every step. Trying to observe the inner workings of an atom is like plucking the wings off a butterfly to see how it flies, or like taking poison to discover the consequences. Each observation destroys the bit of the universe observed, and so supplies knowledge only of a universe which has already become past history.

In certain other aspects, especially its spatio-temporal aspects as revealed by the theory of relativity, nature is like a rainbow. The ancient Hebrew—the analogue of the nineteenth-century physicist—saw the rainbow as an objective structure set in the heavens for all men to behold, the token of a covenant between God and man, and as objective as the signature to a cheque. We now know that the

THE APPROACH TO THE EXTERNAL WORLD 3

objective rainbow is an illusion. Raindrops break sunlight up into rays of many colours, and the coloured rays which enter any man's eyes form the rainbow he sees; but as the rays which enter one man's eyes can never enter those of a second man, no two men can ever see the same rainbow. Each man's rainbow is a selection of his own eyes, a subjective selection from an objective reality which is not a rainbow at all. And it is the same with the nature which each man sees.

Again, just as a man's rainbow follows him about as he moves round the country-side, so nature follows us about. At whatever speed we move, we find nature adjusting itself to our motion, so that this motion makes no difference to its laws.

Yet the analogy fails in one respect. A rainbow will disclose our own motion to us by the speed with which it moves against a background of distant forests and hills, but physical science can find no such background for nature. The whole of nature appears to follow us about.

Imperfect though these analogies are, they will shew that the physicist of to-day must needs have some acquaintance with ideas which used to be considered the exclusive preserve of metaphysics.

One of the foremost workers in modern theoretical physics, Professor Heisenberg of Leipzig, has described the present situation in the following words:*

“With the advent of Einstein's relativity theory it was necessary for the first time to recognize that the physical world differed from the ideal world conceived in terms

* *The Physical Principles of the Quantum Theory* (Univ. of Chicago Press, 1930), p. 62.

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[More information](#)

4 THE APPROACH TO THE EXTERNAL WORLD

of everyday experience. . . . The experimental material resulting from modern refinements in experimental technique necessitated the revision of old ideas and the acquirement of new ones, but as the mind is always slow to adjust itself to an extended range of experience and concepts, the relativity theory seemed at first repellantly abstract. None the less, the simplicity of its solution for a vexatious problem has gained it universal acceptance. As is clear from what has been said, the resolution of the paradoxes of atomic physics can be accomplished only by further renunciation of old and cherished ideas. . . .

“To mold our thoughts and language to agree with the observed facts of atomic physics is a very difficult task, as it was in the case of the relativity theory. In the case of the latter, it proved advantageous to return to the older philosophical discussions of the problems of space and time. In the same way it is now profitable to review the fundamental discussions, so important for epistemology, of the difficulty of separating the subjective and objective aspects of the world. Many of the abstractions that are characteristic of modern theoretical physics are to be found discussed in the philosophy of past centuries. At that time these abstractions could be disregarded as mere mental exercises by those scientists whose only concern was with reality, but to-day we are compelled by the refinements of experimental art to consider them seriously”.

This is not meant in any way to suggest that an objective nature does not exist, but merely that it is at present beyond our purview. We can only see nature blurred by the clouds of dust we ourselves make; we can still only see the rainbow, but a sun of some sort must exist to produce the light by which we see it.

Writing in 1899,* F. H. Bradley proposed to define the nature of metaphysics as

* *Appearance and Reality*, p. 261.

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Excerpt

[More information](#)

THE APPROACH TO THE EXTERNAL WORLD 5

‘the bare physical world, that region which forms the object of purely physical science, and appears to fall outside of all mind. Abstract everything psychical, and then the remainder of existence will be Nature’.

A few lines farther on, he brings us to the crux of the present situation in physical science when he writes:

“We sometimes forget that this world [of nature], in the mental history of each of us, once had no existence. There was a time when the separation of the outer world, as a thing real apart from our feeling, had not even been begun. The physical world, whether it exists independently or not, is, for each of us, an abstraction from the entire reality”.

A nineteenth-century physicist, reading this, would have identified the “time when the separation of the outer world had not even been begun” with a few days in his extreme infancy, and would little suspect that he, a scientist of mature years, had not yet effected the separation completely. It was left for twentieth-century physics under the lead of Einstein, Bohr and Heisenberg to discover how large a subjective tinge entered into the nineteenth-century description of nature; recognising this, it tries to discard our human spectacles and study the objective reality that lies beyond. Only in this way has it proved possible to give a consistent description of nature. Thus the history of physical science in the twentieth century is one of a progressive emancipation from the purely human angle of vision.

The physicist who can discard his human spectacles, and can see clearly in the strange new light which then assails his eyes, finds himself living in an unfamiliar world, which

6 THE APPROACH TO THE EXTERNAL WORLD

even his immediate predecessors would probably fail to recognise.

We must now try to explain how this change of thought has come about, examine its implications, and describe, in so far as this is possible, the new world of twentieth-century physics.

The World of Sense-impressions

We may properly approach this world by imagining the entry into life of a child endowed with consciousness, with a mind capable of experiencing sensations and desires, and with a capacity for thought.

At first it has no consciousness except of its own existence; no knowledge of an outer world of nature, as something distinct from and clearly separated from itself, its thoughts and its sensations; no past experiences to form a background to its thoughts or with which to compare its present sensations. Gradually the passage of time provides past experiences, which memory fixes in its mind to form the needed background. It begins to view its sensations against this background, and discovers that they continually change. They fall into the two categories of pleasurable sensations, which it desires to increase, repeat or perpetuate, and painful sensations, which it desires to diminish or avoid. Soon it makes the melancholy discovery that it cannot by its own volition make all its sensations pleasurable; it finds that it has needs, such as for food and warmth; when these are not adequately satisfied, its sensations are less pleasurable than when they were. These needs introduce it to the hard facts of life, for it finds they can only be satisfied from outside itself. Definite acts, such as sucking sugar or running a pin into its hand, produce still more

THE APPROACH TO THE EXTERNAL WORLD 7

acute sensations of pleasure or pain; the materials for these sensations, the sugar or the pin-point, also come to it from outside.

From such experiences the child infers the existence of an environment which is not part of itself—in brief, of an external world. It has every inducement to try to understand the workings of this external world, in which it believes all physical pains and pleasures to originate. It soon learns, when burnt, to dread the fire; once bitten, it is twice shy. Through such experiences, it finds law and order in the external world, and discovers the principle which it will describe in later years as the “uniformity of nature”—like causes produce like effects. Finally, in its efforts to understand the external world, it begins tentatively to endow this world with certain qualities, properties and occupants. The inference that an external world exists obviously stands on a higher level of probability than the conjecture that any special qualities, properties or occupants are associated with it.

For the child has definite knowledge only of the sensations in its own mind. If these originated solely in its own mind, it could choose to make them all pleasurable; since it cannot do this, it is on fairly safe ground in supposing that something external must exist to produce and control these sensations. On the other hand, the nature of this something can never be more than guessed. The child will never be able to test the absolute truth of its conjectures; the most stringent test available is that of their consistency with one another and with the phenomena which they attribute to the external world. Such a test may disprove, but can never prove.

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[More information](#)

8 THE APPROACH TO THE EXTERNAL WORLD

Throughout its whole life, the child will assume that an external world exists, and will make conjectures with a view to understanding its workings. When it does this in a logical and systematic manner, we call it a scientist.

The child's sensations reach its mind through five channels, which we call the five senses—sight, hearing, smell, taste and touch. These all function in similar ways. Something external produces an impression on some part of the body—the retina, the ear-drum, the nostrils, the palate or the skin—and this impression is transmitted along a complicated nervous system to the brain. Up to this stage the impression has been conveyed by atomic changes, but it now crosses what we may describe as the “mind-body” bridge, and when it appears on the other side, it is as a mental sensation, accompanied by such mental attributes as pleasure or pain, satisfaction or irritation, ecstasy or despair.

The nerves may be compared to a number of telephone wires transmitting electric currents into a prison-cell, which suitable instruments subsequently metamorphose into messages of sound, television, etc. The child is a prisoner inside the cell, and is doomed to remain a prisoner all its life. It can have no knowledge of the outer world except through the messages received over the wires. These may give truthful reports of the events occurring outside the prison cell, but its occupant will only be able to interpret them in terms of the contents of its cell, which consist of thoughts and sensations. A mind which is directly acquainted only with thoughts and sensations may be as little able to form a true picture of an outer world as a blind man is able to understand the beauty of a sunset or a

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[More information](#)

THE APPROACH TO THE EXTERNAL WORLD 9

deaf man to grasp the meaning of a symphony. Even a superior being coming direct from the outer world might still be unable to explain its nature to the prisoner, for the simple reason that they would have no common language in which to converse. Nevertheless, from the fragmentary messages which his senses send to him over his nerves, the prisoner may attempt to form a consistent picture of the external world for himself, in terms of the concepts with which his mind is familiar. Science merely attempts to build up such a picture in a systematic, organised way.

The External World

The first messages which the child receives from its senses teach it to regard the external world as a collection of distinct "objects", each possessing a certain degree of persistence or continuity in time. It soon finds that these fall into definite categories. First come other human beings, similar to itself except for differences in age, size and other characteristics. There are also animals, birds, fishes and insects, then plants and trees, and finally objects which consist of inanimate matter.

The child's mind is not only occupied by its sensations but also by its volitions, which are desires to increase or diminish particular sensations according as it finds them pleasurable or the reverse. Having discovered that its sensations come to it from the disposition of the objects of the external world, it would like to alter this disposition, so as to avoid pain and increase pleasure. It finds, or thinks it finds, that it is possessed of a will-power, through which it may at least try to effect the changes it desires.

It soon discovers an essential difference between animate

10 THE APPROACH TO THE EXTERNAL WORLD

and inanimate objects. After a little experience, it can catch a rolling marble without difficulty, because this has no will-power to set in opposition to its own, but as soon as it tries to catch a crawling fly or a crawling wasp, it becomes conscious of an opposing will-power; the fly tries to avoid capture, the wasp resents capture. Finally it finds that other children have a will-power of the same kind as its own. As it believes its will-power to emanate from its mind, it infers that the external world is controlled in part by minds other than its own, but similar to its own; it concludes that it is not the only mind in the universe.

When it establishes contact with these other minds, it learns that they experience sensations and desires similar to its own; not only are they endowed with similar senses but also, most important of all, they perceive objects similar to those which it perceives.

Not only are these objects similar in kind; often they are obviously identical. If I count that there are six chairs in my room, the normal event will be for my companion also to count six chairs. Repeated experiences such as these suggest that the chairs he sees are identical with those which I see. The knowledge that a chair can be perceived by a mind is extended to the knowledge that the same chair can be perceived by two minds, and we conclude that the chairs have what we may call an "objective" existence—an existence outside our individual minds. Something outside both of us, which we loosely describe as a chair, can produce in both of us the sense-impression we describe as seeing a chair. At this stage we naturally begin to inquire—"What is this object which we