Chapter 2
The Causal Interpretation and Causality and Chance

In spite of the book's acclaim, as the letters show, Bohm was not satisfied that he had dealt adequately with the philosophical issues from the standpoint of Marxism. In a relatively short period at Princeton, in the year before leaving for Brazil, he developed his alternative "hidden variable", or "causal", as it was later called, approach to quantum mechanics. It is also known as the Bohm-de Broglie approach, since Bohm unwittingly repeated Louis de Broglie's so-called "pilot wave" theory of the 1920s. After criticism from other physicists, particularly Wolfgang Pauli, de Broglie had dropped this approach in 1927. Bohm had a thorough grasp of the standard theory and its weaknesses after writing his book and was therefore able to deal in detail with Pauli's criticisms.[1] He eventually published the two papers setting out the "causal" interpretation at the beginning of 1952, after he had arrived in Brazil.[2] Pauli, who was now the reviewer of Bohm's papers, had to admit they gave a consistent approach to quantum mechanics, despite his intense hostility to Bohm's philosophy. To this day, Bohm's version of quantum mechanics is just as valid as the standard theory. No experimental test that gives a result confirming the standard theory has yet been devised that does not also confirm Bohm's theory.

As we shall see from these letters, in Brazil, notwithstanding illness and depression, Bohm intensively developed scientific, philosophical and political views from his distinctive Marxist standpoint. In science, he not only worked on developing the "causal" approach so as to include spin and relativity, he also carried out concentrated work on probability theory and statistical mechanics. He had hoped to interest other physicists in the "causal" interpretation but as the letters show, he became increasingly discouraged at the possibility of achieving this. Physicists, even Communist Party members, wanted to see "results". Unless new physical phenomena, explicable only by Bohm's interpretation, were discovered, or developments were

[1] See Freire Jr. (2015), pp. 31–32 for more on this.

[2] Bohm (1952a,b).

C. Talbot (ed.), *David Bohm: Causality and Chance, Letters to Three Women*,
DOI 10.1007/978-3-319-55492-1_2

made by Bohm in new areas, such as particle physics, the physics community remained sceptical.[3]

It must be stressed that Bohm's ideas in this early period formed a closely integrated whole, with philosophy and politics being given as much, if not more, attention than science in the letters.[4] The politics was definitely Stalinist but was not intended for public discussion, and in any case, went through a drastic shake-up after Bohm's moving to Israel, with all the revelations about the USSR that became available. However, from 1952 onwards, Bohm clearly intended to put together a book on science and philosophy from a Marxist standpoint.[5] This was eventually published as *Causality and Chance in Modern Physics* in 1957.[6] As with *Quantum Theory*, there are no explicit references to Marxism in the book, but the letters help to shed much light on how the dialectical materialist ideas that went into it were developed, making it one of the few serious attempts to bring together the Marxist philosophical tradition and physics in the 20th century.[7]

It is worth recalling here how the "causal interpretation" is referred to in *Causality and Chance*. The new interpretation of quantum mechanics was not to be regarded as a finished or final theory. That would go entirely against the dialectical materialist conception, namely that scientific theories are not free from error but rather an "unending process in which the degree of truth in our knowledge is continually increasing".[8] In *Causality and Chance* Bohm explains that he had intended to show that "alternative interpretations of the quantum theory were in fact possible".[9] He even argued that his theory had "many aspects which seemed quite artificial and

[3]It was probably mainly this pragmatism and inherent conservatism that prevented Bohm from making a greater impact, though widespread anti-communism certainly also played a part. See Freire (2005) for a discussion on this issue.

[4]References to letters throughout this introduction are given in the form (X,**Y**, p. Z) where X is the chapter in Part 2, **Y** the letter number, and Z the page number.

[5]There are several references in the letters to Miriam Yevick in 1952 to the difficulties in writing a proposed book on philosophy. Then, in February 1953 (26, **96**, p. 317), he tells Miriam he is experimenting with a number of ideas, which he may publish first as articles. A little later, he writes to Melba Phillips about a book gradually taking shape (18, **42**, p. 163) and thanks her for efforts in trying to get a "paper" on causality published (18, **45**, p. 169). In April 1954, he tells Miriam that his book has been accepted by Routledge and Kegan Paul (30, **116**, p. 395), and in August (31, **120**, p. 414), he has a six-page summary of his ideas on probability (not found in the archives). Finally, in October 1955 (19, **52**, p. 180), he writes to Melba that the publishers have asked him to shorten the book, cutting out some technical material, and he also decides to cut out material on positivism. The revised version, with five chapters remaining, is probably the book in its present form.

[6]Bohm (1957).

[7]This is not to dismiss the work of Soviet physicists such as V.A. Fock (see Graham (1971), especially Chap. III), but they were working under even more disadvantageous circumstances than Bohm, as we will attempt to show in Chap. 12 on Soviet Physics and Philosophy.

[8]Bohm (1957), Chap. 5, especially Sect. 12.

[9]Bohm (1957), Chap. 4, Sect. 3.

unsatisfactory", and listed the criticisms of his new approach.[10] In particular, he made the remarkable point that:

> . . . our model in which wave and particle are regarded as basically different entities, which interact in a way that is not essential to their modes of being, does not seem very plausible. The fact that wave and particle are never found separately suggests instead that they are both different aspects of some fundamentally new kind of entity which is likely to be different from a simple wave or a simple particle, but which leads to these two limiting manifestations as approximations that are valid under appropriate conditions.[11]

This was written long before the seminal work of John Stewart Bell appeared, and the recognition of the phenomenon of quantum "entanglement", including the fact that at the quantum level, in either the standard or Bohm's interpretation, matter cannot be isolated in a localised, particle-like form. Bell would later use the term "beable". Bohm himself seems already to have intuited the existence of some such entity.

Whatever the limitations of Bohm's theory, it was and still remains a challenge to standard quantum mechanics. Even if one accepts that the standard interpretation does not necessarily imply that the observer's consciousness affects the outcome of quantum processes,[12] the idea that there is an ultimate purely random level in nature is at odds both with Bohm's version of quantum mechanics and the philosophy he put forward in *Causality and Chance*.

References

Bohm, D. (1952a). A suggested interpretation of the quantum theory in terms of hidden variables i. *Physical Review*, *85*(2), 166–179.

Bohm, D. (1952b). A suggested interpretation of the quantum theory in terms of hidden variables ii. *Physical Review*, *85*(2), 180–193.

Bohm, D. (1957). *Causality and chance in modern physics* (first ed., p. 1984). London: Routledge and Kegan Paul (Second edition with new preface by Bohm).

Freire, O., Jr. (2005). Science and exile: David Bohm, the hot times of the Cold war, and his struggle for a new interpretation of quantum mechanics. *Historical Studies on the Physical and Biological Sciences*, *36*(1). Also at http://arxiv.org/abs/physics/0508184.

Freire, O., Jr. (2015). *The quantum dissidents: Rebuilding the foundations of quantum mechanics (1950–1990)*. Berlin, Heidelberg: Springer.

Graham, L. R. (1971). *Science and philosophy in the Soviet Union*. London: Allen Lane.

Rosenblum, B., & Kuttner, F. (2011). *Quantum enigma: Physics encounters consciousness*. USA: Oxford University Press.

[10] As Bohm wrote in his second 1952 paper: "We should never expect to obtain a complete theory of this structure [the objectively real world of unlimited complexity]" (Bohm 1952b), and in 1953: "It is true that this model is somewhat crude, and that a deeper synthesis should be sought" (18, **43**, p. 165).

[11] Bohm (1957), Chap. 4, Sect. 5.

[12] Though many writers appear to think it does. See Rosenblum and Kuttner (2011) for a recent example.

http://www.springer.com/978-3-319-55491-4

David Bohm: Causality and Chance, Letters to Three Women

Talbot, C.
2017, X, 446 p. 25 illus., Hardcover
ISBN: 978-3-319-55491-4