Paavo T.I. Pylkkänen

MIND, MATTER AND THE IMPLICATE ORDER

With 8 Figures

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Introduction

1.1 Preamble

In this book we shall be considering some questions that have a long history. These include questions about the fundamental nature of matter and its movement; the nature of mind and its relationship to matter; and the nature of time, both physical and mental. We will also be concerned with how these questions are connected with one another. For example, what relevance might our theories about matter have to our views about the relationship between mind and matter?

Of course, we are in a very different position to tackle these questions today than were those who first formulated them. When it comes to the nature of matter and physical time, we now have advanced theories in physics; when it comes to the nature of mind, there are likewise advanced theories both about the phenomenal (e.g. spatio-temporal) structure of the mind, as well as about how mental processes correlate with the underlying physical processes in the brain and the body.

But regardless of these advances, there are many aspects of these questions that remain unclear. In physics, the basic theories are quantum theory and relativity. It is well-known, however, that the interpretation of quantum theory has been the subject of intense debate ever since the theory was first developed in the 1920s. Quantum theory predicts the results of experiments (e.g. in the atomic domain) with brilliant accuracy. Mathematically, one uses the Schrödinger equation and its solution, the famous wave function, to accomplish the predictions. But how should we interpret the wave function? Is it merely a mathematical *tool*, a part of an algorithm for predicting the probability of finding a particle (e.g. an electron) in a given small region in a measurement (as Bohr thought)? Or is the wave function a complete *description* of the electron, which is thought to be wave-like when it moves but which collapses into a particle in a measurement in which we always observe the electron as a particle (as von Neumann thought)? Or is the wave function a complete description of the electron, which is thought to be wave-like when it moves, while the appearance of a particle in a measurement is explained not by the collapse of the wave but rather by assuming that the universe *branches* into “many worlds”, each with a particle in a different position (as Everett and de Witt suggested)? Or is the wave function a description of just one part of the electron, namely a field aspect that *guides* another part of the electron, namely a particle aspect, so that there is no need to assume a collapse of the wave or the branching of the universe to explain why we observe a particle (as de Broglie and Bohm thought)? These questions are still actively debated, and it is fair to say that the meaning of non-relativistic quantum theory remains unclear and that the jury is still out, perhaps even a bit “far out” at times.

Furthermore, although both relativity and quantum theory work brilliantly in their own domains, their basic concepts seem to be in complete contradiction with each other. Thus, as Bohm has underlined, relativity emphasizes continuity, locality, and determinism, while quantum theory suggests that the exact opposite is fundamental, namely discontinuity, non-locality, and indeterminism. This strongly suggests the need for a yet broader and deeper theory in physics, containing relativity and quantum theory as limiting cases that work in their own domains. There are proposals for such a new theory (e.g. string theory and loop quantum gravity theory), but these remain fairly speculative (see Weinstein (2006)). Thus, although everyone agrees that the classical Newtonian and Maxwellian notion of matter is completely wrong in certain domains, and that quantum theory and relativity are required to deal with many known physical phenomena, there is not yet agreement about what the more fundamental theory of matter is that can unite relativity and quantum theory and describe all known physical phenomena in a coherent and unified way.

Physics, from a philosophical point of view, is also characterized by a great deal of conceptual confusion. For example, it is customary to talk about “elementary particles”, evoking the image of there being some absolute, fundamental building blocks or tiny “billiard balls” that interact mechanically with each other, and out of which the mechanical “clockwork universe”, including bodies and brains as its parts, is constituted. However, it has been known since the 1920s that such “particles”, besides having particle properties (such as mass, charge, and momentum), also exhibit wave-like properties (diffraction and interference) and even properties that strongly violate any mechanistic scheme (non-local correlations and discontinuity of movement). The concept of “elementary particles”, and the images it may evoke, is thus actually very limited in its ability to help us capture what is essential about what we might call the more *fundamental architecture* of the physical world, as revealed in quantum and relativistic phenomena. We need new concepts and images that can better illuminate features such as wave–particle duality, non-locality, and the discontinuity of movement. But there is not yet agreement as to what such concepts should be, and consequently, a great deal of confusion prevails in attempts to discuss the more fundamental structure of the physical world.

This state of affairs also has consequences for other subjects. Thus, for example, in philosophy there has been a strong tendency to look to the natural sciences when trying to resolve traditional philosophical issues, a tendency known as “physicalism” (see, for example, Stoljar (2001)). However, when one examines the work of the leading physicalists, one can see in them little *systematic* effect from, say, quantum and relativity physics, or later developments in physics. To be sure, there is some effect (e.g. emphasis upon the relativistic notion of an event (Davidson 2001)), but on the whole, physicalism remains a relatively empty research programme, instead of relying upon some specific proposal about the nature of physical existence that would do justice to contemporary physics. In a nutshell, physicalism says that our general concept of reality ought to be some sort of a generalization of what the natural sciences, especially physics, tell us (see, for example, Quine (1960) and Koskinen (2004)). But as a matter of fact, most physicalist views currently on offer seem to have a very weak relationship to modern quantum and relativity theory. Physicalism thus does not yet manage to do what it says it ought to do.

This “hollowness of contemporary physicalism” creates a great deal of frustration in philosophy. There are difficulties in the very attempt to formulate problems, let alone in the various attempts to solve them. For when physicalists formulate a philosophical problem, they typically make a reference to the physical world. Questions that are formulated and debated today include: What is the relationship between mental phenomena and the physical processes in the brain and matter more generally? What is the relationship between meaning and the physical items that carry meaning? However, as long as there is no coherent notion of what the physical means, the very problems making a reference to the physical will be out of focus (cf. Montero (1999)). Typically, physicalist philosophers rely upon some common-sense notions about the physical world that more or less resemble the ideas of 19th-century classical physics. But this is, of course, in violation of the stated aim of the physicalist programme, namely that philosophy should rely upon the best natural sciences rather than upon, say, common sense or theories that have shown to be very limited.

Of course, classical physics is a brilliant achievement that still works approximately correctly in a wide range of domains. But it gives *completely wrong* predictions about centrally important domains of the physical world. It typically fails in the domain of very small distances and very small energies, where quantum theory is needed. But there are also macroscopic quantum effects, visible to the unaided eye, such as superconductivity, superfluidity, and Bose–Einstein condensation. Furthermore, classical physics also fails to account for such more familiar macroscopic properties as the stability of matter, the temperature of the Sun, and bulk specific heats. It is thus certainly a mistake to think that quantum theory is irrelevant to explaining the properties of the physical world as we encounter them in everyday experience. On the contrary, one could argue, most of these properties can be explained in terms of the quantum theory. To give yet another example, the wavelengths of the light emitted by atoms can only be understood in terms of quantum theory, thus implicating quantum theory in the physical understanding of colour, a familiar, everyday property of the world.

All this suggests a challenge for modern philosophy. On the one hand, many philosophers are tempted by physicalism, saying, for example, that our general concept of reality (or ontology) ought to be some sort of generalization of what the natural sciences, especially physics, say. On the other hand, it has turned out to be very difficult to take into account what physics, in particular, has to say. What is urgently needed, therefore, is some reasonably general, intelligible account of the results of modern physics, if the Emperor of Physicalism is to ever to put on some clothes.

There are also well-known difficulties in attempts to understand the nature of mind and its relationship to matter. Mind and matter seem very different in their basic qualities and yet they seem intimately related, so much so that many have tried to reduce mind to matter, suggesting that mental processes are *identical with* some neurophysiological processes in the brain. However, such reductive attempts have been questioned. Many philosophers have suggested that *conscious experience* presents a particularly serious problem to mind–body reductionism, because it has many features that seem very different from objective, neurophysiological processes. These include the qualitative character of conscious states (the “raw feels” or “qualia”; for example, the taste of a strawberry milkshake); their subjectivity (e.g. only I seem to have direct access to my inner conscious states, such as my experience of pain); and their meaningfulness or “intentionality” (e.g. my conscious states typically have meaning to me, but how can anything mean anything to anything in a purely physical system?).[1] The greatest puzzle has to do with the simple fact that when I am conscious there seems to be something we might call “experiencing” going on. But what is such “experiencing” and how does it arise? How could objective, physical processes give rise to “experiencing”, which at least *seems* to be something altogether different from objective physical processes?

It seems obvious that whatever else we may be, we definitely are experiencing beings. It seems equally obvious that “experiencing” is not something independent of physical processes, but rather is closely correlated with them. Just think, for example, of the dream–wake cycle. There is a part of our sleep when we are not conscious, but when we are dreaming we are conscious and while we are awake we are conscious. There are neural correlates of the dream–wake cycle, suggesting that the brain is strongly implicated in “experiencing”.

So it seems obvious that “experiencing” is *correlated with* neural processes, but not at all obvious that it is *nothing but* neural processes. In fact, it seems obvious (at least to me) that experiencing cannot be identical with the sorts of mechanical neurophysiological processes that modern neuroscience talks about.

According to modern neuroscience, consciousness, of course, has to do with your brain and nervous system, and the body more generally. So it is typically assumed by neuroscientists that a physical system, made of certain components that interact, is conscious. To put it very simply, there are nerve cells in the brain organized in particular ways to make anatomical regions and connected with each other in complex ways, transmitting information through electrical action potentials, but also in more subtle ways such as chemical pathways.

Most current neural theories of consciousness are expressed in terms of the activities and connections of the neurons. Thus, for example, there is the idea of consciousness having to do with re-entrant connections between brain regions; the idea that consciousness is essentially connected with thalamo-cortical loops; the idea that consciousness has to do with synchronized “40 Hz” oscillations of electrical activity in

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[1] For a very good recent overview of the problems connected with consciousness, see van Gulick (2004). See also Chalmers (1996).

the brain; and the idea that consciousness essentially involves a certain "global workspace" implemented in the brain. (For various neural theories of consciousness see, for example, Baars et al. (2003).) But the question is, why should such mechanical interactions between physical parts make you conscious? I say "mechanical", because most neural theories of consciousness, from the point of view of physics, only appeal to the level of the classical physics of Newton, Maxwell, and the like. And classical physics is mechanical. It has to do with particles moving along trajectories under the influence of forces (gravitational and electromagnetic) and colliding with each other, and with fields (i.e. waves in the electromagnetic field) that influence charged particles and are influenced by them, a bit like the way a water wave can mechanically set a rubber duck in motion, while moving the duck in calm water will produce waves.

It is common in neuroscience to think that when it comes to physics, only neural processes that obey classical physics are required to explain consciousness. A typical idea is that we need a large network of such mechanically behaving neurons to give rise to consciousness (e.g. tens of thousands of neurons). But how could such purely mechanical activity of particles and fields in your brain, not violating the laws of classical physics, give rise to consciousness? Let us construct a simple thought experiment to explore this. Let us say that I am given mechanical components that are structurally equivalent to all the components that the modern neural theories appeal to (e.g. suitable artificial neurons), and I set them up so that the system as a whole is functionally equivalent to the functions that modern neural theories appeal to (e.g. there are re-entrant connections, thalamo-cortical loops, 40 Hz synchronized oscillation, a global workspace, etc. in my system of artificial neurons). This might be difficult in practice but surely conceivable in principle. Will the artificial system be conscious? It seems obvious to me, and to many others, that it will not. It seems that conscious experiencing is something that cannot be derived from mechanical physical processes. But if so, what is it then?

In fact, Leibniz had already realized this difficulty, as has been succinctly described recently by Robert van Gulick:

> In the *Monadology* (1720) [Leibniz]...offered his famous analogy of the mill to express his belief that consciousness could not arise from mere matter. He asked his reader to imagine someone walking through an expanded brain as one would walk through a mill and observing all its mechanical operations, which for Leib-

> niz exhausted its physical nature. Nowhere, he asserts, would such an observer see any conscious thoughts. (van Gulick 2004)

A similar problem is still actively debated in contemporary philosophy of mind, perhaps today best known under the label "the hard problem of consciousness" (Chalmers 1995, 1996). Of course, not everyone agrees that consciousness is such a hard problem. Consider, for example, Daniel Dennett:

> Might it be that somehow the *organization* of all the parts which work one upon another yields consciousness as an emergent product? And if so, why couldn't we hope to understand it, once we had developed the right concepts? This is the avenue that has been enthusiastically and fruitfully explored during the last quarter century under the twin banners of cognitive science and functionalism – the extrapolation of *mechanistic naturalism* from the body to the mind. After all, we have now achieved excellent mechanistic explanations of metabolism, growth, self-repair, and reproduction, which not so long ago also looked too marvellous for words. Consciousness, on this optimistic view, is indeed a wonderful thing, but not *that* wonderful – not too wonderful to be explained using the same concepts and perspectives that have worked elsewhere in biology. Consciousness, from this perspective, is a relatively recent fruit of the evolutionary algorithms that have given the planet such phenomena as immune systems, flight, and sight. (Dennett 1999)

Thus, if Dennett is correct, consciousness might be "an emergent product" in a mechanical system, provided the parts are organized in a suitable way. But as long as we are not given any clue about how "experiencing" could arise from the interactions of parts, the reference to "emergence" is no better than the Cartesian reference to God as the source of consciousness and the mediator of the interaction between matter and consciousness. Reference to "emergence" surely sounds these days scientifically more respectable than reference to God. But is it really any more enlightening? *How* does conscious experience emerge from the mechanical neurophysiological processes in the brain?

One possibility, advocated by Dennett, is that the same mechanical concepts and perspectives that have worked elsewhere in biology will also work for consciousness. Another possibility is that they will not, or not beyond a certain point. In physics, we have seen that concepts and methods that worked well for a given domain of physical phenomena (i.e. the classical domain) fail completely in a wider domain (i.e. the relativistic and quantum domains). Perhaps the same will turn out to be the case in biology. The mechanistic concepts and methods that work well for metabolism, growth, etc. may fail for some important aspects of consciousness. In biology and psychology, just as in physics, we may then need radically new theories. One of the key ideas to be explored in this book is that the new theories in physics may actually help us to develop the sorts of new theories in biology and psychology that may be required to give an adequate explanation of consciousness. This, as such, would be nothing new. The theories of physics have often influenced the theories of mind. Often, however, this has given rise to overly mechanical theories of mind. But perhaps the more holistic theories of contemporary physics will help to inspire theories of mind that can better do justice to the holistic features of the mind.

Of course, one may ask whether it is necessary or even desirable for theories of physics to affect theories of mind at all. One reason why such influence may be inevitable is that physics deals with general categories such as space, time, movement, and causality, which are relevant to almost everything, and certainly to mind. Physics helps us to understand many of our most general concepts better and suggests changes in them; and once you change your general concepts, you will see the world in a new way.

Let us move on to briefly consider some further problems concerning the relationship between mind and matter. One such problem that has been vigorously debated in recent philosophy of mind has to do with the *causal powers* of the mind. Mind seems to be very different from matter (because of some of the features of conscious experience such as subjectivity, inner qualitative feels, meaningfulness, the very fact that experiencing is going on, etc.), but it also seems obvious that our mental states – both conscious and unconscious – influence the behavior of our body. But how are we to make sense of this influence? For example, if minds are not described by the laws of physics, should the laws of physics be modified to allow for the causal influence of minds upon bodily behavior? One of the aims of this book is to provide new ways of thinking about this problem, known as the *problem of mental causation* (see, for example, Robb and Heil (2005)).

There are also problems connected with the spatio-temporal structure of conscious experience. We have already mentioned some features of consciousness that are difficult to relate to matter, such as qualia, subjectivity, and meaningfulness or "intentionality". Yet another important aspect of consciousness is what we might call the *phenomenal structure* of conscious experience. Although the terms "qualia" and "phenomenal properties" are sometimes used interchangeably in the literature, it is useful to distinguish phenomenal structure from the qualitative structure of conscious experience. This has been recently emphasized and succinctly described by van Gulick:

> "Phenomenal organization" covers all the various kinds of order and structure found within the domain of experience, i.e., within the domain of the world as it *appears* to us. There are obviously important links between the phenomenal and the qualitative. Indeed qualia might be best understood as properties of phenomenal or experienced objects, but there is in fact far more to the phenomenal than raw feels. As Kant (1787), Husserl (1913), and generations of phenomenologists have shown, the phenomenal structure of experience is richly intentional and involves not only sensory ideas and qualities but complex representations of time, space, cause, body, self, world and the organized structure of lived reality in all its conceptual and nonconceptual forms. (van Gulick 2004)

There are some paradoxical features associated with phenomenal organization. For example, our experiences typically have a temporal structure, perhaps most evident in situations such as listening to music. However, when listening to music, we are not merely apprehending a process that proceeds step by step, say, paying attention to one note/chord now and another a bit later. No, in a musical experience we also seem to perceive a melody as a whole, a theme that grows, develops, and transforms. Typically, of course, we do hear some notes for the first time "now", but we also seem to directly perceive (rather than, for example, just passively remember) the notes that were first heard some time ago, and also anticipate the perception of future notes. We perceive a *whole structure* that is in some sense "timeless". Yet the usual view of time says that only the present and what is in it exists. But if this is true, how can we then, for example, when listening to music *perceive* (as opposed to just remember) a structure that includes the notes heard a little time ago, which latter, according to the usual view of time, no longer exist? Husserl thought that we perceive the past but admitted that this is like saying there is "wooden iron". This paradox of "time consciousness" is one of the issues that has been debated both in traditional phenomenology and contemporary philosophy of mind and cognitive science (see, for example, Dainton (2000), van Gelder (1999), and Varela (1999)). Another of the aims of this book is to explore a new way of looking at time consciousness.

We have seen in our brief overview that on the one hand, there are difficulties in developing a coherent notion of matter, and on the other hand, there are difficulties in understanding the nature of mind and its relationship with matter. There are also puzzling questions about the relationship between the structure of conscious experience and our usual notion of time. There is something worth noting at this point. When philosophers, psychologists, cognitive scientists, cognitive neuroscientists, etc. consider problems like the mind–matter problem, the problem of mental causation, and the problem of time consciousness, they usually consider some key concepts such as “matter”, “causality”, “movement”, and “time” – implicitly or explicitly – in the spirit of the classical physics of Newton, Maxwell, and others. Of course, we have already referred to this above when we noted that contemporary physicalist philosophers typically ignore quantum and relativity physics, or that neuroscientists typically think that the neural correlates or constituents of consciousness are mechanical. Now, it *could* be the case that those material processes which play a relevant role in the mind–matter relationship and/or our phenomenal experience all lie in the domain of classical physics, that is, in the domain where classical physics provides a good approximation. However, no-one has been able to show *how* the whole of the mind can be reduced to such classically conceived matter. In particular, in the case of conscious experience, we could say that no one has come *anywhere near* to showing this. This is what Leibniz’ analogy of the mill points to, and this, in my view, is what David Chalmers’ well-known work suggests.

In fact, one could argue that a large proportion of the problems concerning mind and matter are problems that arise in relation to the classical notion of matter. If such problems could be solved, then perhaps philosophers discussing the mind–matter problem could safely ignore non-classical physics. But given the fact that no-one has been able to solve the mind–matter problem for the matter of classical physics, one reasonable possibility is to explore whether, in order to understand the relationship between mind and matter better, we need to consider matter in the light of our broader and more accurate theories, such as relativity and quantum theory. For we *know* (in so far as we know anything at all in science) that classical physics gives wrong predictions in some domains of the physical world, and it thus cannot be considered an adequate theory of the whole of matter known to us at present. Could it be that some of the physical processes that enter centrally into the relation of mind and matter could lie outside of the domain of classical physics? I am not claiming that they do so, but given the failure of contemporary mind sciences to relate central aspects of the mind to the classical domain, I suggest that this is an option worth considering.

One might be tempted to see physics in terms of its domains by saying that classical physics describes a certain domain, say A, quantum physics describes another domain B, and relativity theory yet another domain C, etc. One might further be tempted to assume that such domains are separate and independent of each other, and that the physical world is made up of such domains. I think there are good reasons to question such a way of thinking. Firstly, there are various kinds of relationships between the domains – for example, it is the stability of atoms that quantum laws establish which enables, say, the table to exist as a relatively solid macroscopic object. Furthermore, I think it is also interesting to consider the view that a given theory of physics suggests something about the general architecture of the physical world. Thus, Newtonian physics fits well with an atomistic architecture and the idea of a universe as a huge machine. However, quantum theory and relativity theory suggest that although the universe has a mechanistic sub-domain, some other architecture is more fundamental. For example, instead of emphasizing that the universe is made up of its parts, these theories might emphasize the primacy of the whole, and see the parts as derivative.

So I think that physics is concerned not just with separate levels of nature, but also with the general architecture of nature. This gives rise to one important way in which physics can be relevant to the understanding of the mind. For one of the traditional philosophical problems concerning the mind is not only the relationship between mind and matter, but also the broader, more architectural question about the place of mind in nature (see Broad (1925) and Chalmers (2002b)). Quantum theory and relativity theory strongly suggest that we need a new concept of the general architecture of physical reality, and clearly this at least may be relevant when trying to locate the mind and conscious experience in the physical world. I thus think it is not at all clear that quantum theory and relativity can be safely ignored by the "mind sciences" on the basis that they deal with strange and different domains of the physical world, although many researchers seem to think so.

If we agree with the above line of thinking, our challenge is to explore whether the relationship between mind and matter could be understood better if our notion of matter were based on post-classical physics, such as quantum theory or relativity, or some even better theories inspired by them. Here, however, we immediately run into the problems already mentioned above. There is much disagreement about the interpretation of quantum theory, and there are serious problems in trying to relate quantum theory and relativity to each other. There are well-known attempts to develop new, more fundamental theories (e.g. string theory and loop quantum gravity theory), but these attempts are very speculative and still far from being satisfactory. Thus, even if we wanted to try to relate mind to some post-classical notion of matter, this is difficult simply because it is not clear what a coherent post-classical notion of matter is!

To sum up, then, it seems fairly certain that we cannot satisfactorily solve the mind–matter problem, when matter is understood in terms of classical physics. But we also know (insofar as we know anything at all in science) that classical physics, although approximately correct in a certain domain, is completely wrong in other domains. This naturally gives rise to the possibility that perhaps mind and matter connect with each other in the domain that lies outside that of classical physics. In any case, mind could find its place in nature better if our notion of the general architecture of nature was inspired by modern physics. Consequently, the relationship between mind and matter might be understood better if our notion of matter were based on post-classical physics. But there we run into the problem that post-classical physics does not yet provide us with a commonly accepted, coherent new notion of matter.

Now, a very interesting attempt to try to tackle *both* the question about the nature of matter in the light of quantum theory and relativity *and* the question about the nature of mind and its relation to matter was carried out by the physicist-*cum*-philosopher David Bohm (1917–1992). In his work we find, among other things, a new proposal about the more fundamental architecture of matter; a proposal about the nature of the mind and how it relates to matter; and even a proposal about how to make sense of time consciousness (for example, how we might be able to perceive “past” elements of experience, which the usual view of time says do not even exist). Might Bohm’s work help us to go forward in tackling the difficult questions that we have briefly described above? One of the main aims of this book is to explore this question. Let me therefore proceed to give a brief overview of Bohm’s ideas on matter, mind, and their relationship, including his ideas about time and conscious experience. After this, to conclude this introductory chapter, I will briefly explain what the rest of the book tries to do.

1.2 Bohm on Matter, Mind, and Their Relationship

David Bohm was educated as a physicist and made some significant contributions to mainstream physics, working on plasma, metals, and liquid helium. For example, Bohm and Pines' plasma theory of electrons in metals was the first theory to coherently explain the stability of metals (Pines 1987). However, Bohm became more and more interested in philosophical questions in his research. Are electrons waves or particles? Are quantum processes genuinely indeterministic? Are there quantum jumps – that is, is movement discontinuous at the quantum level? Are there instantaneous, "non-local" correlations between spatially separated particles, and does this create problems with the theory of relativity? More generally, is it possible to have a single coherent model of systems at the quantum level, or are we forced to be satisfied with "complementary" but mutually exclusive modes of description (such as wave and particle), as Niels Bohr had famously emphasized? Bohm's research tackles these questions from many different perspectives and suggests different answers, depending on the perspective chosen. Perhaps one of his greatest achievements was precisely to show the possibility of a number of different perspectives in quantum theory. We still do not know which perspective is the correct one; but in the meantime, it is useful to know what the coherent options are, and Bohm certainly made a significant contribution to developing and clarifying the options.[2]

An important influence on Bohm's philosophical development was Einstein, with whom he had many discussions while in Princeton in the late 1940s and early 1950s. Bohm had also early on become interested in Niels Bohr's philosophically sophisticated interpretation of quantum theory. When one looks at his scientific and philosophical contributions as a whole, it would not be completely inaccurate to place him somewhere between Einstein and Bohr. For example, with Einstein, Bohm shared the view that the task of physics is to try tell us something about a reality that exists independently of ourselves. With Bohr, he shared the view that quantum theory emphasizes undivided wholeness,

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[2] Bohm had a dramatic life at times, including political problems in the USA during the McCarthy era in the early 1950s. David Peat's (1996) biography *Infinite Potential: The Life and Times of David Bohm* provides a vivid account of his life. Many researchers have suggested that some of Bohm's ideas about quantum theory were simply suppressed rather than evaluated in the spirit of open, fair, and genuine criticism. For various sociological studies connected with Bohm, see, for example, Beller (1999), Cushing (1994), Freire Jr. (2005), Olwell (1999), and Pinch (1977). See also Forman (1987).

as well as the more philosophical idea that it is important to carefully consider the role of language and communication in physics.

Bohm's first major philosophical contribution was, perhaps surprisingly, his quantum mechanics textbook *Quantum Theory*, published in 1951. This book, which explicates quantum theory from the conventional Copenhagen (i.e. Bohr's) point of view clearly shows the importance Bohm gave to a more philosophical understanding of quantum theory, over and above focusing on mathematical and technical aspects, which was beginning to be the dominant trend in physics. *Quantum Theory* is also important for our theme of mind and matter, for it contains a section in which Bohm discusses striking analogies between quantum processes and the process of thought (see Bohm (1951, pp. 168–172) and Pylkkänen (2004b)). However, this thorough attempt to explicate quantum theory under a Bohrian interpretation left Bohm dissatisfied. Discussions with Einstein – who was a well-known critic of Bohr's interpretation of quantum theory – further prompted him to look for another interpretation of quantum theory. Einstein and Bohm were particularly dissatisfied with the extremely empiricist, "positivistic" feature of the usual quantum theory, which did not allow one to discuss reality beyond the observations. Observations, in turn, were fairly limited (e.g. a spot appearing in a photographic plate), so it seemed that quantum theory was providing a truncated, fragmented view of reality. Einstein himself had been seeking a more realist and causal interpretation of quantum theory as early as the 1920s, but without success.

Bohm came up with two different ideas. One of them introduces the idea of an "incoming wave" to account for a quantum mechanical measurement. In standard quantum theory, a particle such as an electron is mathematically described by a wave function. The wave typically spreads out over a large region, but whenever we measure the electron we always find it as a small particle-like entity in a very small region of space (e.g. making a spot on a photographic plate). There is thus a contradiction between the mathematical wave description (which, when taken as a description of the electron, suggests that the electron is a wave that is typically spread out) and the particle description (which we use to describe what we actually observe in every measurement of an individual electron). Different ways of resolving this contradiction give rise to different interpretations of quantum theory. Some said that the wave function should not be taken as a description of the electron, but instead should be seen as a "probability wave", a mathematical tool that we can use to calculate probabilities of finding the electron, conceived of as a little particle, in a certain small region in a measurement. This "minimal" interpretation is consistent, but it goes strongly against the intuition that physics ought to provide a description of individual systems. Thus others went on to suggest that the wave function does describe the electron. But how then do we deal with the above contradiction? The key new assumption was to say that this wave collapses into a small region in a measurement, thus giving rise to the particle-like manifestation we actually observe. This approach is better than the minimal one because it provides a description of quantum processes even before measurements. However, the notion of the collapse is problematic. It has proved difficult to give it a coherent description, thus making it seem too much like an ad hoc solution to the problem.

This is where Bohm's idea of an "incoming wave" comes in. In a typical experiment, the electron is described in terms of a wave that is spreading out, and yet we always find the electron as a particle. Bohm thought that perhaps the reason we see a particle is not that the outgoing wave suddenly collapses, but that there is another wave closing in to that point – either the original, outgoing wave somehow reflected back, or else a new wave. Symmetry has often played an important role in physics, and there is certainly a quality of symmetry in this proposal by Bohm. If there are outgoing waves, why not incoming ones? What we call a "particle" could then be seen as a certain phase in the movement of these waves, namely that phase when the incoming wave has closed in, giving rise to an intense, particle-like pulse in a small region. Bohm did not, at the time, further pursue this idea of an electron being an aspect of a process of outgoing and incoming waves. However, as we will see later, it plays an important role in his "implicate order" approach, with its notions of "enfoldment" and "unfoldment", which he began to develop in the 1960s.

The second idea Bohm had after his discussions with Einstein soon gave rise to a more concrete proposal and publications (see Bohm (1952)). Remember again that the basic problem of standard quantum theory is that the mathematics we use to describe the electron suggests that the electron is a wave, while every measurement reveals the electron as a tiny particle. So the electron seems to be sometimes a wave and sometimes a particle, making it a very ambiguous entity. But what if the electron is *both* a wave *and* a particle *all the time*? Its having a wave aspect would then explain why it obeys the mathematics of wave behavior; while its particle aspect would explain why we always find a particle when we measure the electron. Note in particular that if we assume that the electron is always both a particle and a wave, there is no need to assume that the wave collapses in order for us to explain why we see a particle. The reason why we observe a particle is simply that the electron always is a particle. And the reason why we observe such particles obeying the mathematics of wave behavior (e.g. in the famous two-slit experiment) is simply that each particle has a wave associated with it and guiding it.

Bohm indeed proposed, independently discovering and further developing an idea de Broglie had already in the 1920s, that we should look at an individual quantum system, such as an electron, as a combination of a particle and a new kind of wave, described by the wave function. He actually arrived at the idea when considering the relationship between quantum theory and classical physics. Strictly speaking, both quantum theory and classical physics apply to the same reality. The usual idea is that quantum theory is the more accurate, general, and fundamental theory. Classical physics can then be seen as a special limiting case that can be derived from quantum theory and that works approximately well in certain domains. However, things were not that simple in standard quantum theory. For as we saw, according to the usual interpretations, the quantum theoretical description of reality is either minimal or ambiguous. Either there is no view of quantum reality beyond measurements at all, or else quantum reality consists of systems that are ambiguously sometimes waves, sometimes particles. If classical physics is supposed to be a special case of quantum theory, then presumably the everyday reality that classical physics describes ought to be somehow derivable from the reality that quantum theory describes. But how could you derive the solid everyday reality from no reality at all or from an ambiguous reality? Bohm's insight was to look at the equations of quantum theory and to see that there actually was a well-defined view of quantum reality implicit in them, a quantum reality from which one could derive the everyday classical reality in a coherent way. To put it very schematically, Bohm saw that quantum reality consists of systems that have a particle aspect and a wave aspect. The wave aspect influences the particle aspect, giving rise to all the strange quantum phenomena we observe in experiments (e.g. electron interference, non-locality). However, whenever the new quantum mechanical wave aspect has a negligibly small effect, we are left with just the particles obeying the laws of classical physics and – bingo! – we have derived classical physics from quantum physics.

This is one of the beautiful aspects of Bohm's "ontological interpretation": it shows us how the classical, familiar everyday world arises from the more exotic quantum world under certain circumstances. Another issue that the ontological interpretation raises is the question of causality at the quantum level. The usual interpretation of quantum theory had suggested that individual quantum processes are indeterministic. On the other hand, in the ontological interpretation, the wave aspect of the electron guides the particle aspect, suggesting that the behavior of individual quantum processes might be deterministic after all. Bohm felt that the situation called for a very careful, more philosophical study of the question of causality and chance, and this resulted in his book *Causality and Chance in Modern Physics*, which was published in 1957. His basic proposal was that both causality and chance are always needed whenever we are dealing with some limited domain of the physical world. Thus, for example, he was not claiming that the quantum level was completely deterministic. Instead, the determinism suggested by the ontological interpretation ought to be seen as a statistical average of chance fluctuations at a deeper level. A closer study of these chance fluctuations might, in turn, reveal some more lawful behavior, which might, however, turn out to be a statistical average of a yet deeper level of chance fluctuations, and so on. Bohm felt that there was no need to assume a fundamental level, and thus the question whether the fundamental level is deterministic or indeterministic would not even arise (see Bohm (1957, 1986)).[3]

The ontological interpretation provides a very useful perspective to quantum phenomena. However, it is also a limited perspective. The challenge for modern physics is to unite quantum theory and the theory of relativity, in particular quantum theory and general relativity. To do this, it is necessary to go deeper than the ontological interpretation by itself can take us. Thus, in the 1960s, Bohm, together with his colleague Basil Hiley, began to develop a more general framework for physics in which one could hope to be able to unite quantum theory and relativity. This more general framework he later called the "implicate

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[3] Bohm's 1952 papers in *Physical Review*, which are the basis of the ontological interpretation of quantum theory (Bohm & Hiley 1993), were originally characterized by him as dealing with "hidden variables" in the quantum theory. The approach has also been called the "causal interpretation of quantum theory" and the "pilot wave theory". However, Bohm felt in the end that the essential point of the interpretation is that it makes a hypothesis about the nature of quantum reality, and not so much its deterministic features or the idea that the variables are hidden. These 1952 papers have given rise to a number of approaches; see, for example, Albert (1992, 1994), Bedard (1999), Bell (1987), Cushing et al. (1994), Goldstein (2002), Holland (1993), and Valentini (2001). In this book I am partly focusing upon Bohm's own further development of the original 1952 approach, developed in particular with Basil Hiley and their research students at Birkbeck College, University of London.

order" framework. He also extended this framework to biological and psychological phenomena, proposing it as a more general metaphysical theory of reality as a whole. Finally, in the late 1980s and early 1990s, we see him trying to bring together his two main schemes – that is, the more specific ontological interpretation of quantum theory and the more general implicate order framework. He thought that the ontological interpretation can help to extend and specify the implicate order framework both as a theory of physics and as a theory of the relationship between mind and matter.

It is clear that Bohm was concerned with providing a description of reality – at the quantum level, and more generally, a unified description of matter, life, and consciousness, all adding up to a general concept of reality or a metaphysical theory. However, it is important to realize that although he was clearly more concerned with describing a mind-independent reality than many other 20th-century physicists or philosophers, this concern did not mean that he ignored the role of the mind (language, perception, etc.) in his attempts to describe reality. In other words, he did not ignore epistemological issues or questions that concern the nature of our knowledge and the problems of justifying it. On the contrary, his broad philosophical work includes extensive studies of various epistemic issues: physics and perception (Bohm 1965a), the notions of truth and understanding (Bohm 1964), a view of science as "perception-communication" (Bohm 1977), experimentation with the structure of language (Bohm 1977), study of knowledge understood as process (Bohm 1974), and discussions of topics such as communication, creativity, art, and so on. To fully appreciate Bohm's views about the nature of reality, they should be understood in the context of his epistemic considerations. Although our focus in this book will be upon ontological questions related to matter and consciousness, this should not be taken as a sign that I consider the epistemic issues unimportant. The reason I am focusing here upon the ontological issues is partly that ontological issues have often been ignored in recent science and philosophy, and partly that a proper consideration of the epistemic issues would make this book too large.

Let us proceed to consider Bohm's general ontological views head on, focusing on his views about the relationship between mind and matter. The strategy will be first to describe the notion of implicate order as it applies to matter; then to consider how it applies to mind; then to note that the implicate order framework needs to be extended in order to provide a better view of the relationship between mind and matter; then to consider Bohm's notion of "soma-significance" as one such extension;

and finally to consider how the ontological interpretation of quantum theory can be used to extend the implicate order framework to provide a better mind–matter theory.

Many people, including myself, have found Bohm's idea of the implicate order difficult to grasp. Indeed, I remember from discussions with Bohm how he was keen to emphasize that the idea was at a fairly early stage of development. Let us therefore begin to unpack it by considering a very succinct description he provided in a 1990 article, "A New Theory of the Relation of Mind and Matter" (Bohm 1990). The basic idea of the implicate order is that

> the whole universe is in some way enfolded in everything and that each thing is enfolded in the whole. This implies that in some way, and to some degree, everything enfolds or implicates everything. However, this takes place in such a manner that under typical conditions of ordinary experience, there is a great deal of relative independence of things. (Bohm 1990, p. 273)

Such an idea of "enfoldment" of the whole universe in each part, which resonates with Leibniz's idea of monads and William Blake's poetry, may seem very counterintuitive, exotic, and strange at first. But as we will see later, enfoldment is taking place in a wide range of domains, and actually right there in front of you. Think of the small region of space where your eye is placed. In this region, there is a movement of electromagnetic waves (light waves) that carries the information you use as the basis for constructing your visual experience. This movement somehow contains or "enfolds" information about the whole room, or if you happen to be watching the night sky, about the whole universe of space and time. This enfolded information is then *unfolded* by the lens of your eye, and later in a very complex process by your brain, resulting, when combined with information supplied by your brain, in your visual experience of a three-dimensional world with objects in it. Of course, as already mentioned above, we do not really understand *how* the objective physiological process becomes a conscious visual experience, but we shall discuss that problem later.

Note further that such enfoldment of information about the whole into each small region typically takes place in *all* wave phenomena, for example in sound waves. Thus, when you go to a concert to listen to a symphony orchestra, information about what each instrument plays is typically enfolded in each region, including the one where your ear is placed. But you have to be quiet, because if you were to speak loudly, information about what you say will likewise be momentarily enfolded in the movement of air molecules in every region, and others might not enjoy your contribution to the enfolded order!

Now, according to quantum field theory, which physicists widely consider the most accurate theory of matter currently on offer, even elementary particles are understood in terms of an underlying activity of fields. Thus, according to this theory an "elementary particle" such as an electron is not just a little billiard ball, although some aspects of its behavior suggest that it has particle-like features (for example, in a measurement, the electron always appears in a very small region of space, and it has measurable particle properties such as mass, charge, and spin). More fundamentally, however, it is thought that the electron is based on the activity of a field, which is in some ways similar to the activity of light waves. The "electron field" gives rise, at least momentarily, to a particle-like manifestation, when there is an intense field in a small region, or a localized pulse. Bohm pointed out that the mathematics of quantum field theory suggests that similar enfoldment and unfoldment that is found with light waves and sound waves also prevails in the movement of quantum fields that underlie all matter. Thus, just as light waves in a small region can enfold information about the whole universe, so the waves that underlie each "elementary particle" can similarly enfold information about the whole universe.

There is thus a sense in which each region or "part" of the universe enfolds information about the whole universe. But we can look at this also from another point of view. With light, we can say that, typically, information about a part can be found in every single region, throughout the whole of space. Consider, for example, the book you are holding. Information about the book is enfolded in each region of the room, in the movement of the light waves. Or imagine that you go outside when there is a full moon. Information about the Moon is enfolded in every region of space where the light reflected from the Moon has travelled. So, more generally, we can say that not only is information about the whole enfolded in each part, but information about each part is also enfolded in every region of the whole.

According to Bohm's interpretation of quantum field theory, this also applies to "elementary particles". Underlying each such particle is a movement of a field. This movement enfolds information about the whole universe into the small region where the field manifests itself as a particle-like entity. But because the field is also spread, in principle, throughout the universe, information about the particle-like entity can be found in every region of the universe. In this sense, the whole universe is enfolded in everything, and everything is enfolded everywhere in the whole universe. The implicate order thus prevails as the most fundamental order of the universe currently known to us.

Of course, this is a very exotic idea. Just think of all the atoms and particles that constitute your body. We are used to thinking about them as tiny little things that just passively sit there. But quantum field theory, as interpreted by Bohm, suggests otherwise. There is a sense in which each particle in your body enfolds information about the whole universe (analogously to the way the activity of light waves in the region where your eye happens to be placed can enfold information about the whole universe). There is also a sense in which information about each particle in your body is enfolded throughout the universe (analogously to the way information about a planet is enfolded in every region of the space in which there are light waves reflected from the planet). The proposal is that, as a part of the universe, each one of us thus enfolds information about the whole universe, not only via our senses, especially vision, but also, and more exotically, via the underlying field nature of the very "particles" that constitute our body. The further suggestion is that through various movements of fields (light and, most fundamentally, quantum fields) information about us is enfolded throughout the whole universe.

Just think how different this proposal is from the traditional mechanistic view of matter and the physical world that was developed by Galileo, Newton, and others! It is common, in this world view, to think of the Earth and human beings as a mere speck of dust in a huge cosmos, externally related to other things, and governed by completely mechanical laws. In contrast, Bohm's interpretation of quantum field theory suggests that there are not just external, but also, and more fundamentally, internal, relationships between the part and the whole and, via the relation to the whole, between the parts themselves. Obviously, this begins to open up a new way of thinking about our place in the universe.

Now, we might agree that there exists such enfoldment (after all, it is just standard physics under a Bohmian interpretation) but add that it is merely something passive and superficial. For example, surely the quantum field theoretical feature that each "particle" allegedly enfolds information about the whole universe applies to all "particles", and thus the fact that "particles" in my body do that is no more special than that the "particles" in, say, the table do that. And surely the effects of any such enfoldment must be negligibly small on the temporal and spatial scales in which we live our lives?

Now, the enfolded information that enters our sensory systems is, of course, more obviously relevant to us; but we might customarily think that even such enfoldment of information of, in principle, the whole universe through the senses is a passive and superficial relationship. Indeed, in traditional cognitive science, there has been a tendency to look at the human body as a machine that receives information through its sensory inputs, processes this information with the help of algorithms stored in the brain, and uses this information to behave in the physical world. In principle, all this has been thought to take place in a mechanical fashion, emphasizing that the environment, the information, and the brain/body have basically an external relationship with each other. Thus, one might think that a human being is basically a machine, and that the enfoldment relationship of this machine to the rest of the world is passive and superficial, not really affecting the inner nature of the machine.

Bohm, however, did not think that the enfoldment relationship between the part and the whole, and between the parts themselves, is merely passive and superficial. On the contrary, he emphasized that the enfoldment relationship is *active and essential to what each thing is*, implying that each thing is *internally related* to the whole, and therefore to everything else (Bohm 1990, p. 273).

What does "internally related" mean? *The Oxford Companion to Philosophy* tells us that the relation, R, between one item, x, and another item, y, is internal if x could not be the same item, or an item of the same kind, without standing in relation R to y (Bogen 1995, p. 756). Thus Bohm is implying that each thing – say, an electron, but also a human being – could not be what it is without standing in the enfoldment relationship to the whole universe. Instead, he proposed that the way the thing enfolds the whole is essential to what the thing is and to how it acts, moves, and behaves quite generally (Bohm 1987a, p. 41).

It is fairly easy to see what this means for human beings. Imagine, for example, losing your understanding that there exists a whole world of a certain kind of which you are a part. This would clearly make you into a very different person, and would probably profoundly change the way you "act, move, and behave" more generally. Of course, we take such understanding for granted and do not perhaps realize how fundamental it is for making us into what we are.

The more exotic suggestion is that even when it comes to an "elementary particle" of physics, such as an electron, the way it enfolds the whole is essential to what it is and how it acts, moves, and behaves.

It is well known that in certain situations at the quantum level of accuracy the electron behaves more like a wave, and in others more like a particle. Thus, according to some interpretations of quantum theory, what the electron is (i.e. whether it is a wave or a particle) is thought to depend on the nature of the environment that it interacts with (see, for example, Bohm's exposition of the "Copenhagen interpretation" of quantum theory (Bohm 1951)). The way the electron relates to the whole is thus thought to be essential to what it is, in a way that is very different from the situation in classical physics, where particles are what they are (i.e. particles), regardless of the kind of environment they happen to be located in. Also, quantum theory implies that tiny changes in the distant environment of the electron (e.g. the opening of a slit in a two-slit experiment) can have a profound effect upon its behavior, further underlining the dependence of the part upon the whole and the other parts. Furthermore, current experiments under so-called EPR conditions indicate that tiny changes in a state of a photon (e.g. those caused by a measurement of its polarization) can have an instantaneous effect on the behavior of another photon 50 km away (or at least there seems to be an influence between the regions that propagates much faster than the speed of light). A certain kind of wholeness is thus strongly implied by the behavior of matter in the light of quantum theory.

On the basis of such evidence coming from physics, Bohm proposes more generally that the whole is in a deep sense internally related to the parts. He adds that, since the whole enfolds all the parts, these latter are also internally related to each other, though in a weaker way than they are related to the whole (Bohm 1987a, p. 41).

Now, common experience tells us that there are also *external relationships* between things. In Bohm's terms, such external relationships are displayed in the *unfolded* or *explicate order*. The relation R between x and y is external if x stands in some relation R to y, but neither its identity nor its nature depends upon this being the case (Bogen 1995, p. 756). Think of a table and the various objects on it – the lamp, the book, the telephone, for instance. They are all related to each other. For example, they are outside one another, occupying different regions of space, at a certain distance from one another, each held to the table by the force of gravity, etc. However, removing one of the objects from the table will not change the identity or nature of the other objects. Another, larger-scale example of an explicate order is provided by the Solar System. And more generally, the physical world has a wide domain in which the explicate order prevails, all the way from the world of molecules to that of galaxies. At each level there are some entities that are relatively separate and extended.

Note that our conscious experience also has a domain in which an explicate order prevails. Think, for example, of your visual experience of the objects upon a table (as opposed to what exists “out there” independently of your experience). In the world of your visual consciousness, the explicate order typically dominates (cf. Honderich (2004)).

In the explicate order, each thing is thus seen as relatively separate and extended, and related only externally to other things. The explicate order dominates typical everyday experience, as well as classical (Newtonian) physics. It appears to stand by itself. However, Bohm proposes that it cannot be understood properly apart from its ground in the primary reality of the implicate order. This is an important point. The mechanistic world picture, based on classical physics, has assumed that the explicate order is all there is to the physical universe. In contrast, Bohm suggests that quantum and relativity theory show that the explicate order is merely a relatively autonomous order that has its ground in the more fundamental implicate order.

The next point Bohm makes is that the implicate order is not static but rather basically dynamic in nature, in a constant process of change and development. This is why he called its most general form the *holomovement.* The idea is that

> [a]ll things found in the unfolded, explicate order emerge from the holomovement in which they are enfolded as *potentialities*, and ultimately they fall back to it. They endure only for some time, and while they last, their existence is sustained in a constant process of unfoldment and re-enfoldment, which gives rise to their relatively stable and independent forms in the explicate order. (Bohm 1990, p. 273)

The above makes it clear that, as was already mentioned above, Bohm’s ontology takes *movement* as fundamental, and here he connects with the tradition of “process philosophers” from Heraclitus to Whitehead (see, for example, Rescher (1996)). What does he mean by “movement”? Does he mean that there is something moving in the holomovement, some little particles or some little substantial fields that constitute *the* fundamental level of reality, and that the movement of these small-scale elements gives rise to the large-scale things (particles and fields) of everyday experience? No. He invites us to consider movement *per se* as fundamental, and things (e.g. particles and fields and whatever can be constructed from these) as derivative.

There are well-known problems with trying to take the notion of particles (whether point-like or extended) as fundamental:

> ... it is not possible in relativity to obtain a consistent definition of an extended rigid body, because this would imply signals faster than light. ... physicists were driven to the notion of a particle that is an extensionless point, but, as is well known, this effort has not led to generally satisfactory results, because of the infinite fields implied by point particles. Actually, relativity implies that neither the point particles nor the quasi-rigid body can be taken as primary concepts. Rather, these have to be expressed in terms of events and processes. (Bohm 1980, pp. 123–4)

(See also, for example, Bohm (1957, pp. 121–123).)

Such difficulties with the notion of particle have given rise to relativistic quantum field theory, and as we have already mentioned, today all matter is analyzed in terms of quantum fields, which are treated as the ground of all existence. However, Bohm and Hiley (1993, pp. 355–7) emphasize that these fields have to be understood not as some substantial entities in their own right that may or may not move, but rather as being *essentially* in movement. They say that, because of relativistic considerations, we can "never have the same field point twice", nor is there a unique form within the field that persists. Something with persistent identity would require a *unique relation* between the field point at one time and at other times. But if we consider the same field point over a period of time in different Lorentz frames, we do not see the same entity but different entities. This is why Bohm and Hiley emphasize that all properties that are attributed to the field have to be understood as *relationships in its movement*. The idea is that *the essential qualities of fields exist only in their movement*. It is not that there is a field with some essential qualities, which then may or may not move. Rather, it is movement that gives rise to the essential qualities of fields. Thus, movement is more fundamental, and the essential qualities (whether those of fields or particles) are derivative.

"Holomovement" then refers to the totality of such movement, which is assumed to be the most fundamental nature of existence known to us at present and which gives rise to the essential qualities of fields and particles. (As we have already mentioned, fields can give rise to particle-like manifestations via certain recurrent unfoldment and enfoldment.) If reality is more fundamentally *movement*, then the notion of a permanently existent entity with a given identity (e.g. a particle or a field with a unique form in it) is at best an approximation that works in a limited context (see Bohm and Hiley (1993, pp. 355–7)).

We have also seen that Bohm says that things *emerge* from the holomovement. But this is not a "something out of nothing" emergence or creation. Instead, Bohm assumes in an Aristotelian fashion that there exist *potentialities* in the holomovement. A potentiality for him is an "enfolded order" that "actualizes" when it unfolds to the explicate order. A thing that has actualized – say, an elementary particle such as an electron – then *endures*, but only for some limited period of time (for example, if the electron meets its antiparticle, the positron, they will both cease to endure as particles and instead transform into radiation). While a thing endures, it does not have a continuous existence as a particle-like entity. Instead, its existence is sustained in a constant process of unfoldment and re-enfoldment. Because such a process typically has *recurrence*, this gives rise to the relatively stable and independent form that we call the "particle" (Bohm 1990, p. 273).

If you like, the "particle" is a recurring *phase* of an underlying process of unfoldment and enfoldment. This, of course, is very similar to the idea of "incoming wave" Bohm had as early as in the late 1940s, in his first attempts to develop a more complete description of quantum reality. To get a better image of what this might mean, think of a spherical wave that closes in to a small region of space and then spreads out again, and think of another spherical wave (either a new wave, or else the original wave that is somehow reflected back) closing in to the same region in the next moment. At the moment when the wave has closed in and all the wave intensity is in the small region, the wave forms a "peak" that is very much like a particle (for example, it can transmit energy almost in a discontinuous, "all at once", fashion like a particle does, give rise to a localized spot on a photographic plate, like a particle would, etc.). And if there are waves closing in one after the other to the same region very rapidly, this approximates a situation in which there would be a particle just sitting there all the time. This is, roughly, the way one thinks of the fundamental mode of existence of a "particle" in the implicate order framework. And of course, as all the objects we find in everyday experience can be thought of as consisting of such "elementary particles" (e.g. electrons, protons, neutrons), then strictly speaking all objects can be seen as recurrent phases of an underlying movement of unfoldment and re-enfoldment.

Bohm's implicate order ontology contrasts with the ontology that has been prevalent in Western philosophy and science. This is the atomistic ontology, which assumes that everything consists of some fundamental elements (i.e. particles and/or fields) that are only externally related to each other. Atomistic ontology dominates much of contemporary science and philosophy (for example, it typically underlies the "mechanistic naturalism" Dennett refers to in the earlier quotation). But Bohm claims that physics strongly suggests that the atomistic ontology does not fit with the experimental facts of relativity and quantum theory. If he is correct, we need a new more fundamental ontology or theory of reality, and this is indeed what he tried to develop. He thought that the implicate order gives a valid and intuitively graspable account of the meaning of the properties of matter, as implied by quantum theory and relativity. He also thought that the implicate order framework can be extended to the domain of biological and psychological phenomena, making it into a proposal about the general architecture of existence as a whole, instead of just about physical existence.

Let us now move on to introduce Bohm's views about the nature of the mind and its relationship with matter, a topic that is the main focus of this book. He suggested that the implicate order applies even more directly and obviously to mind than it does to matter. In the mind, he tells us, there is

> a constant flow of evanescent thoughts, feelings, desires and impulses, which flow into and out of each other, and which in a certain sense, enfold each other (as, for example, we may say that one thought is implicit in another, noting that this word literally means "enfolded"). (Bohm 1990, p. 273)

"Constant flow" in this passage presumably refers to the "stream of consciousness". Bohm is then concerned with the order that prevails in this flow. If one assumes that only the explicate order prevails in the mind, then it would be natural to think that thoughts, feelings, desires, etc., are some sort of separate entities in mechanical interaction. Perhaps to some extent such analysis of the mind in terms of separate elements in mechanical interaction is adequate. However, Bohm suggests that such analysis has a very limited domain of applicability. For example, our thoughts flow into and out of each other. This suggests that a kind of enfoldment and unfoldment are the primary processes taking place in the stream of consciousness.

It thus seems that the implicate order prevails as the primary order of thoughts, feelings, desires, impulses, etc. However, in certain kinds of phenomenal consciousness, such as the visual experience of a static scene, it seems that the explicate order dominates. But there are aspects of even phenomenal consciousness where the implicate order seems to prevail. In particular, consider the structure of conscious experience over a period of time, or what we might call the temporal structure of consciousness or “time consciousness”.

Consider, for example, what takes place when we are listening to music. We hear some notes now for the first time, but we also seem to actively perceive (rather than just passively remember) “past” notes, which the usual view of time says do not even exist. For the usual mechanistic view of time says that only things in the explicate order at the present instant of time exist, and other things (e.g. notes that were first heard some time ago) do not exist anymore. By introducing the notion of enfoldment, Bohm allows for a new kind of existence. Thus, he proposes that when I am listening to music, the past notes can exist as enfoldments, as active transformations of the original notes, and in this way they can be present and perceived in my conscious experience. The implicate order thus typically prevails in conscious experience. In contrast, when contemporary researchers discuss time consciousness, they tend to presuppose the view of time of classical physics (which exclusively emphasizes the explicate order). As a result, they find it very difficult to make any sense of the nature of our actual conscious experience, which seems to go beyond mechanical existence in the explicate order. As I will argue in more detail in later chapters, one of the potential benefits of the theory of the implicate order to contemporary philosophy of mind and consciousness studies is precisely that it provides these disciplines with one scientifically grounded possibility of becoming free from the unnecessary restrictions of classical physics. I suggest that those restrictions cause many of the troubles in philosophy of mind and consciousness studies. Classical physics is no longer the fundamental theory of matter, and thus there may be no valid scientific and philosophical reason to hold onto it as a tacit underlying framework, in the way many of those studying the mind today do.

Let us return to the more general discussion of the relationship between mind and matter. Because the implicate order also seems to prevail as the more fundamental order of the mind, Bohm was led to propose that the *general implicate process of ordering* is common to both mind and matter. This, he suggested, means that mind and matter are ultimately at least closely analogous and not nearly so different as they appear on superficial examination. Given the above analogousness, he thought it was reasonable to go further and indeed suggested in his 1980 book *Wholeness and the Implicate Order* that the implicate order may serve as a means of expressing consistently the actual relationship between mind and matter, without introducing something like Cartesian duality between them. However, he admitted that the implicate order, in the form proposed in his 1980 book, was at a relatively early stage of development. It should be seen as

> *a general framework of thought* within which we may reasonably hope to develop a more detailed content that would make progress toward removing the gulf between mind and matter. (Bohm 1990, pp. 273–4)

Bohm notes that even on the physical side, the theory about the implicate order

> lacks a well-defined set of general principles that would determine how the potentialities enfolded in the implicate order are actualized as relatively stable and independent forms in the explicate order. (Bohm 1990, p. 274)

He further notes that such a set of principles is also absent on the mental side. Even more importantly, he admits that the implicate order theory does not provide a clear idea of *just how* the mental and material sides are to be related. Therefore, if one wants to tackle the mind–matter problem more coherently, it is necessary to *extend* the framework of the implicate order.

Bohm first attempted such an extension by introducing a general theoretical notion he called "soma-significance" (Bohm 1985).[4] This notion tries to relate matter and meaning to each other, and if one assumes that meaning and the mental are overlapping concepts, this should also help to relate mind and matter to each other. The basic idea of soma-significance is that matter and meaning are not separate entities, but rather aspects of one overall reality. Thus, Bohm proposed that each particular significance or meaning is always based on some somatic order, arrangement, connection, and organization of distinguishable elements. For example, the printed marks on this page carry a meaning. When you perceive these marks, the result can be a meaning in your mind. But Bohm assumes, in accordance with contemporary cognitive neuroscience, that even that meaning in your mind is based on some somatic order in the more subtle levels of your brain.

He further suggested that reality, which is strictly speaking an undivided totality (indeed, the "holomovement"), can, for convenience, be thought of as being constituted out of relatively autonomous levels, which are organized into a hierarchy. There are manifest levels and there are more subtle levels, and each level has a somatic side and a

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[4] Actually, Bohm does not explicitly say that the notion of soma-significance is an extension of the implicate order, but in my view it is natural to see it as such.

significant side. We are to think of the relation between the levels in terms of a process that has two directions: *soma-significant* and *signa-somatic.*

Soma-significant refers to the process in which the significance of a particular somatic order is carried over to higher levels, sometimes resulting in an apprehension of meaning in consciousness. Signa-somatic refers to the reverse process in which the significance that is apprehended acts "downwards" and organizes the less subtle levels. This, of course, is fairly similar to the notions of "enfoldment" and "unfoldment" in the implicate order framework. In the soma-significant direction of the process, information is gathered from the world and enfolded, as it were, and such enfolded information is carried over to higher levels where its meaning can be apprehended. When apprehended, the meaning of the information is unfolded, and as it unfolds, it can have an effect upon lower levels, which is the signa-somatic direction of the process.

To use Bohm's favourite example, think of the following situation: you are walking on a dark night and have heard that there is an assailant in the neighbourhood. Suddenly, you see a suspicious-looking shadow and interpret it as the assailant. Typically, this initiates a process that leads to somatic activity in the body in which the adrenalin flows, the heart beats, and one prepares to fight, freeze, or flee. In the example, the manifest level is that of the shadow. This is a somatic order that has a significance. This significance is then carried over, in a soma-significant process, to higher and more subtle levels in the brain, until finally its meaning is apprehended. This apprehension of meaning then typically gives rise to a signa-somatic process, via which the significance acts downwards to organize the somatic processes in less subtle levels.

The notion of soma-significance can clearly help us to think about how mind and matter are related. "Matter" corresponds to the more manifest levels, but it is assumed here that matter is not purely physical but that it always has a significant side, and in this sense a mental side, even though this may be fairly primitive. "Mind", in turn, corresponds to the more subtle levels, but it is likewise assumed that mind is not purely mental but that it always has a physical side, even though this may be very subtle. Because it is assumed that each level always has both somatic and significant aspects, it becomes possible to understand their relationship. Thus, it becomes possible to think that there is a "two-way traffic" between mind and body. The physical processes in the body influence the mind via soma-significant processes (which are enabled and indeed made necessary by the fact that soma is typically significant), while the mental processes in the mind affect the body via the signa-somatic processes (which are likewise enabled and made necessary by the fact that meanings typically "matter", or make a difference to the lower levels, by organizing them). Nowhere is there anything "purely physical" or "purely mental", and thus the traditional problem of how a "purely mental" mind can influence a "purely physical" body does not even arise.

Like the implicate order, the notion of soma-significance is a general scheme rather than a detailed theory. It is very useful for attempts to tackle the mind–matter problem, because meaning is clearly an important aspect of the mental, and soma-significance provides a general suggestion about how to think about the relationship between matter and meaning. It emphasizes that matter and meaning are not separate entities, but rather aspects of one reality, aspects that are present at each level of this reality. It also emphasizes that to understand the relationship between the mental and the physical, it is crucial to understand the relationship between matter and meaning. Matter, in general, has meaning, and thus it affects the mind. But the meanings apprehended in mind, in general, "matter", or make a somatic difference. Meanings are not just passive, abstract, separate entities, as our philosophical and scientific tradition often assumes, but rather they are seen as inseparable from the somatic aspects that underlie and ground them and which they in turn organize.

At the same time, something more specific needs to be said before a more detailed understanding of how mind and matter are related can be achieved. For example, the principle of soma-significance postulates that matter always has a significant side. But is it plausible that this is so, say, at the more fundamental levels of physics, and what could this mean more concretely?

We noted above that on both physical and mental sides, the theory about the implicate order lacks principles that would determine how the potentialities enfolded in the implicate order are actualized as relatively stable and independent forms in the explicate order. The notion of soma-significance as such does not provide us with such principles. Instead, it tries to capture how the implicate order (which can be seen as related to the more subtle levels) affects, via the signa-somatic process, the explicate order (which can be seen as corresponding to the more manifest levels), and how the explicate order (via the soma-significant process) can influence the implicate order. But it does not tell us how the manifest levels (explicate order) arise from the subtle levels (implicate order); it just presupposes that there are manifest and subtle levels.

We saw that a further difficulty with the theory of the implicate order was that although it goes some way toward helping us to understand the nature of and relationship between mind and matter, it does not provide a clear idea of *just how* mental and material sides are to be related. The notion of soma-significance says more about this. The manifest (explicate) levels can affect the subtle (implicate) levels because each level has both a somatic and significant side, and via the soma-significant and signa-somatic processes there can be a two-way traffic between manifest and subtle levels. If we assume that "matter" corresponds to the more manifest levels and "mind" corresponds to the more subtle levels, then we have a more precise way of thinking about how "matter" and "mind" are related and can mutually influence each other. The crucial point is that each level has both a material side and a significant (and in this sense a mental) side. But is it really plausible to claim that, say, matter at the quantum level has a significant side? More has to be said, in particular, about matter before the principle of soma-significance can really help to bridge the gulf between mind and matter.

Now, Bohm suggested that his ontological interpretation of quantum theory goes a long way toward extending the implicate order in the way required above (that is, it can provide a better view of how the potentialities are actualized, and how mind and matter are related). As we will see, it also provides a way of making the notion of soma-significance more specific at the quantum level of matter. Let us thus move on to consider this interpretation in a preliminary way (a more detailed description, involving some simple mathematics, will be provided in Chap. 4).

As we have seen, the ontological interpretation is based on an interpretation of quantum theory that Bohm originally proposed in 1952 and later developed especially in cooperation with his long-time colleague Basil Hiley (Bohm & Hiley 1993). Bohm presented in his 1952 papers both a "particle theory", that is, an ontological model of quantum particles (such as an electron), and, in an appendix, also a "field theory", that is, an ontological model of how the electromagnetic field of classical physics is "quantized" to give rise, at least momentarily, to "bullets of light" (i.e. quanta of energy, or photons), as quantum theory famously says it does.

Remember that Bohm felt that the ontological interpretation can do two things to make the implicate order more specific: firstly, to show

how the explicate order arises out of the implicate order, and secondly, to provide a more specific idea about how mind and matter are related. To see how the explicate order arises out of the implicate order, it is useful to consider the "field theory", that is, the ontological interpretation of the electromagnetic field. Roughly, one thinks of the electromagnetic field being in an implicate order (as we indeed mentioned above when saying that the movement of light waves in, for example, every region of the room enfolds information about the whole room). When one applies the ontological interpretation of quantum theory to this field, one then sees how the explicate order arises. The explicate order here is the famous "quantum", that is, a bullet of light, which in Bohm's theory has to be seen as a momentary, particle-like manifestation, rather than as a continuously existing particle. This, of course, is very much in the spirit of what we have said above about the implicate order. However, we will not discuss the ontological interpretation of the "quantized" electromagnetic field in more detail here but shall proceed to consider why Bohm thought that the ontological interpretation helps to understand more precisely how mind and matter are related. This is most easily seen by considering the "particle theory", that is, the ontological model of quantum particles (such as an electron).

As we have seen, according to Bohm's "particle theory" an individual quantum system (e.g. an electron) is always a combination of a particle and a new type of field described by the wave function ψ (so it is always both a particle and a wave, rather than either a particle or a wave, as one might say in the conventional interpretation of quantum theory).[5] If you like, the electron can be seen as an entity that has two aspects, a particle aspect and a wave aspect.

A useful analogy of Bohm's model of an electron is provided by a ship guided by a radar wave. In this analogy, the ship corresponds to the particle aspect of the electron, while the radar wave corresponds to the field aspect of the electron. Actually, the analogy is fairly good, because just as the radar wave influences the behavior of the ship, with the electron we can say that the field aspect influences the behavior of the

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[5] Tarja Kallio-Tamminen (private communication) pointed out to me that for Niels Bohr, for example, "particle" and "wave" are classical concepts to be applied to classically observable phenomena, and thus he did not say that the electron is literally sometimes a wave and at other times a particle. However, it seems to me that other physicists fairly often think about the electron as a wave before it is observed and as a particle when it is observed (that is, the wave is commonly thought to "collapse" and in that way to give rise to a particle-like manifestation). In Bohm's ontological interpretation, however, there is no such collapse. The electron is always thought to be both a particle and a wave.

particle aspect. Furthermore, the form of the radar wave is determined by the shape of the environment (e.g. rocks in the bottom of the sea), and it is the form of the radar wave that is the key factor determining its influence upon the behavior of the ship. In an analogous way, the form of the quantum field is determined by the environment of the particle (e.g. the presence of various obstacles, slits, etc.) and, as we will see later in more detail, it is the form of the quantum field that is the key factor determining the influence of the field upon the behavior of the particle.

In Bohm's model, the way the field acts on the particle can be described by saying that the field gives rise to a new kind of potential energy, the "quantum potential", which in turn gives rise to a force upon the particle. The particle moves continuously along a trajectory, but now under the influence of the new kind of potential, the quantum potential, that the quantum field gives rise to. In conditions in which the effect of the quantum potential is negligible, quantum mechanics gives rise to Newtonian mechanics as a limiting case, as previously noted. In this way, one obtains an elegant means of resolving the notoriously difficult problem in quantum mechanics, namely the relation between the quantum level and the classical level. It can be argued that this model provides a clear and intelligible account of the movement of quantum particles, while avoiding the notorious paradoxes of quantum theory, such as wave–particle duality and the measurement problem (including the Schrödinger's cat paradox). Because the quantum potential typically gives rise to non-local correlations, it also makes explicit the striking feature of non-locality at the quantum level, a feature that has been demonstrated in a number of experiments since the 1980s (see, for example, Aspect et al. (1982)). On the whole, the ontological interpretation provides a clear and intelligible image of non-relativistic quantum phenomena.

Let us proceed to consider why Bohm thought that the ontological interpretation can be used to extend the implicate order in such a way that we obtain a better understanding of how mind and matter are related. We have seen that, according to this interpretation, an individual quantum system, such as an electron, is always a combination of a particle aspect and a field aspect, and the field influences the particle. The field gives rise to a potential, and from the potential one can calculate a force acting upon the particle. All of this may sound very close to the ideas of classical physics, as there are particles moving continuously and being pushed around by forces. Bohm and Hiley, however, emphasize that the ontological interpretation, although having some mechanistic features, also has new features that go radically beyond classical physics. In fact, this is not so surprising, because one obtains the ontological interpretation directly from the Schrödinger equation. Thus, one might expect that the new features of quantum theory will be carried over to the ontological interpretation. And because we now have an *ontological* interpretation of the mathematics of quantum theory, we might expect that the new, non-classical features of the mathematics stand out more vividly as aspects of the world (instead of being features of the formalism without our knowing their physical significance).

What are these new, non-Newtonian features of the ontological interpretation? When one looks at the mathematics describing the quantum potential, one sees something striking. The effect of the field on the particle *only* depends on the *form* of the field (while the effect of other fields in physics generally depends on the intensity of the field (= "size of the waves")). What does this mean? Bohm suggested that we have to look at the field as containing *information* that literally *informs* or puts form into the energy of the particle – we thus get a new notion of "active information". Active information as a general concept refers to a situation in which a form that carries very little energy enters into and directs a much larger energy. In a number of papers (including the one published in 1990 in the journal *Philosophical Psychology* (Bohm 1990)), Bohm used this idea as a basis for proposing the outline of a "new theory of the relation of mind and matter". The key idea is that there is a strong analogy between the way information in the quantum field acts on elementary particles and the way information in our subjective experience acts on the body. Just think of the above example of the shadow on the dark night. It is clearly the form of the shadow that is crucial for determining whether or not it will interpreted as meaning "assailant", with subsequent signa-somatic activities as a result. Analogously, it is the form (rather than the intensity) of the quantum field that determines its effect upon the particle. We see instances of active information also elsewhere: in the way the form of the DNA molecule is active in shaping the growth of a biological organism, in the way the form of the radio waves informs the energy of the radio receiver so that we hear a sound, in the way the form of the radar waves can guide the movement of the ship, in the way the information in a computer acts with various consequences, etc. Such information is clearly *objective* in the sense that it is primarily *information to the system*, rather than to us (that is, DNA is information to the cell, and the information contained in the wave function is information for the electron) (see Bohm

(1985, 1989, 1990), Bohm and Hiley (1993), Hiley (2003), Hiley and Pylkkänen (2001), and Pylkkänen (1985, 1992)).

Information contained in the quantum wave function has some holistic properties (for example, it "mediates" non-local connections), which makes it interesting to consider whether some of the well-known holistic properties of conscious experience could be connected with quantum active information. As we have already seen, Bohm hypothesized that mental processes are best understood in terms of a hierarchy of levels, each level having both a physical and a mental side, and where the more subtle levels organize the more manifest levels, while the more manifest levels provide content to the more subtle ones. The further proposal is to think that at each level, information is the bridge between the mental and the physical aspects.

Thus, when I consciously decide to move my hand and the hand moves, Bohm suggests that the information content in my conscious thought constitutes a subtle level of information that acts signa-somatically "downwards" in the hierarchy of levels, ultimately reaching the quantum level of information. Quantum-level information, in turn, acts on the elementary particles, atoms, and molecules (e.g. ions in synapses) or the electromagnetic field (for example, associated with the dendrites), and the effects of this can be amplified and result in a more classically describable physiological process, as a result of which the hand raises (see Hiley and Pylkkänen (2005)).[6] In a reverse process (e.g. in visual perception), the idea is that the incoming information is processed by the visual system first (mostly) in a classically describable way (where invariant features are abstracted etc.) up to a point where the information connects to the more subtle hierarchy of levels of information and ultimately the level of information that constitutes the content of conscious experience.

It is important to note here that the ontological interpretation, as proposed by Bohm in 1952 and Bohm and Hiley in 1993, does not take

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[6] Notice that it is already commonly accepted that such amplification of the effects of individual quantum processes takes place in the early phases of vision, where a photon is absorbed by the 11-cis retinal molecule, causing it to change its shape. This effect is amplified and triggers a chain of events that first leads to a signal in the optic nerve, and eventually to a conscious experience of light (see Kandel, Schwartz, and Jessell (1991, pp. 404–5)) – remember, though, that it is not really understood how the physical process gives rise to a conscious experience. This makes it possible, at least in principle, that such amplification of quantum effects could take place elsewhere in the brain (assuming that the retina can be seen as a part of the brain). Note in particular that the retina works at 37 °C. It is thus not, in principle, necessary to have very low temperatures for such amplification of quantum effects in the brain.

into account any effect of the individual particle on its own quantum field (although they briefly sketch some ideas about how this might happen; see, for example, Bohm (1952a, pp. 171, 179); Bohm and Hiley (1993, pp. 345–6)). The idea that particles collectively affect the quantum field of a single particle is, however, contained in the standard notion that the shape of the quantum field of a particle is determined by the shape of the environment of the particle (which environment consists of many particles, and is part of the boundary conditions one puts into the Schrödinger equation before solving it, even in conventional quantum theory). The physicist Jack Sarfatti, in particular, has emphasized the need for an explanation of how the individual particle influences its own field and has proposed mechanisms for such "back-action", also emphasizing, in a very interesting way, its importance in understanding the mind–matter relationship and how consciousness arises (see, for example, Sarfatti (1997)).

Assuming that the notion of such an influence of the particle on its field can be coherently developed, we can then have two-way traffic between the mental and the physical levels without reducing one to the other. The role of Bohm's model of the quantum system then would be that it provides a kind of *prototype* that defines a more general class of systems in which a field of information is connected with a material body by a two-way relationship (a bit analogously to the way the Watt governor provides the prototype for the dynamical systems theory; see van Gelder (1997)).

Of course, what we have said above about active information connects with both the notion of the implicate order and that of soma-significance, when applied to the relationship between mind and matter. One question that was left open by these frameworks was just how mind and matter are connected, and in particular, how it is possible for mental processes to influence the more fundamental physical levels, if these latter are "purely physical". The proposal of active information at the quantum level makes it possible to address this question in a novel way.

We are now in a position to provide a brief summary of Bohm's way of thinking about mind and matter. In general terms, he saw mind and matter as two *aspects* of or *ways of looking* at an underlying reality, which is *movement*. This is a type of viewpoint that has roots in Aristotle and Spinoza and more recently in Russell, and is variously labelled "aspect monism" or "neutral monism" in philosophy. Of course, Bohm's emphasis on the fundamental status of movement connects him with the tradition of "process philosophy", from Heraclitus to

Whitehead. Aristotle's philosophy involves a dual aspect ontology and takes the notion of process as fairly fundamental (see Rescher (1986)). There is thus a particularly interesting similarity between Aristotle's and Bohm's views, also explicitly discussed by Bohm (see, for example, Bohm (1980, p. 12)).

Bohm further proposes that such reality can, for convenience, be analyzed in terms of levels that differ with respect to their subtlety and form a hierarchy. Each level then has both a physical and a mental aspect, and this makes "two-way traffic" between the levels possible. The levels are not separate entities in mechanical interaction. Instead, their relationship could be described as *mutual participation.* Participation has two sides, "to partake of" and "to take part in". A higher level partakes of a lower one, through its gathering of information about the lower one in a soma-significant process. But it also takes part in the lower level, by organizing it on the basis of what the information gathered means. Thus the levels in a sense enfold and unfold each other, and the implicate order prevails.

It has been mentioned many times that each level has both a physical side and a mental side. We have seen that Bohm suggested, radically, that even the quantum level can be thought to have, via active information, a mental side, a *primitive mind-like quality*, although he also thought it obvious that, say, an electron has no consciousness. I think that this is a very important new contribution that he made to mind–matter theory.

The idea that all parts of reality have a mental aspect is known in philosophy as panpsychism (see, for example, Nagel (1978)). To emphasize that the mental aspect associated with inanimate matter is very primitive, and that no full consciousness is attributed to all elements of reality, researchers have coined the term "panprotopsychism". Bohm's suggestion can be seen as an important contribution to panprotopsychism. Quantum theory is currently our most fundamental theory of matter, and Bohm suggests that quantum theory, when ontologically interpreted, reveals a proto-mental aspect of matter. This is the quantum field, described mathematically by the wave function, which is governed by the Schrödinger equation. This suggestion makes panprotopsychism a much more concrete scientific and philosophical proposal than it has hitherto been. Of course, one can always question Bohm's proposal, but he clearly gives some reasons to back up the idea that the wave function contains active information, and that active information in turn should be seen as a primitive mind-like quality (see Chap. 4). Of course, our mechanistic scientific and philosophical tradition goes strongly against attributing proto-mental qualities to the particles of physics. But when one looks at the history of science, one sees many instances where tradition has simply turned out to be mistaken. Thus, instead of just dismissing Bohm's suggestion as "obviously wrong", it might be more reasonable to fully consider the reasons he gives to substantiate his proposal.

What we usually call "mind" can then be seen as a fairly subtle level in the brain, with an internal relationship to the whole universe (through the implicate order). But like all levels, this level too has both a physical aspect and a mental aspect. Bohm assumed that for the "mind" the physical aspect is very subtle, for example more subtle than the quantum field (while in some respects similar to it). But the important point is that the mind is still assumed to have a physical aspect, and it can thus influence other such levels (e.g. the already-known neural levels) and be influenced by them. In this way, he claims to avoid dualism or idealism, without falling into reductive materialism. The whole point of double-aspect theories is, of course, to avoid these extremes.

Finally, we saw that Bohm further assumed that at each level, information is the *link* or *bridge* between the mental and the physical sides. In this way, he tried to answer the traditional objection against double-aspect theories or neutral monism, namely that it is left a mystery what is the nature of the reality of which mind and matter are thought to be aspects. (For a more detailed description, see, for example, Bohm (1990), Bohm and Hiley (1993, pp. 381–390), Pylkkänen (1992), Hiley and Pylkkänen (1997, 2001).)

1.3 An Overview of the Rest of the Book

We have now said enough about Bohm's views to be able to understand what the rest of the book does. His scheme is vast and ambitious, and it needs to be carefully thought about before one can judge whether it can actually provide us with the sort of better understanding of the nature of mind, matter, and their relationship that it tries to do. We need to go slowly and carefully, to explore the ideas, to criticize them, to digest them. Afterwards, we need to consider them in relation to other views, both to bring them into better focus and to see whether they provide any new understanding of the issues. Thus, the rest of the book divides into two parts. The first part (Chaps. 2–4) further explicates Bohm's views, while the second part (Chaps. 5 and 6) considers their relation to other viewpoints and the way they may tackle particular problems concerning the mind and its relation to matter.

I shall discuss Bohm's views in the order that best serves the purpose of understanding his views about mind and matter. The first challenge is to understand the implicate order framework. Chapter 2 examines the way this arises from quantum physics and relativity; the way it accounts for quantum features such as discontinuity of movement, wave–particle duality, and non-locality; the way it can be applied to cosmology; the way it enables one to think about laws of nature in general in a new way; and the way it might be extendable to biological phenomena.

In Chap. 3 we will explore Bohm's proposal that the implicate order is also the basic architecture of conscious experience. My discussion first focuses upon the justification for the suggestion that the implicate order prevails in the mind. This includes consideration of Pribram's holographic theory of memory in the brain; the phenomenal (e.g. spatio-temporal) structure of conscious experience of movement (such as the experience of listening to music or watching a motion picture, and the experience of movement more generally); consideration of the nature of the process of thought; and consideration of Piaget's ideas about the nature of the mind of very young infants. I will then move on to consider Bohm's suggestion about how matter and consciousness are related. The basic idea is that they are not interacting substances but rather correlated projections from a common ground. Their relationship would therefore in some ways be analogous to quantum non-locality, as interpreted by Bohm. I will suggest that this idea is related to Leibniz's famous ideas of "windowless monads" and "pre-established harmony", although there are differences as well. I will conclude the chapter by discussing the nature of time in the implicate order framework as well as the question of how strongly we should take Bohm's suggestions – are they meant as (almost) final truths, or as something more modest?

Chapter 4 then discusses how the ontological interpretation of quantum theory, with its notion of active information, might further enrich the picture, to give rise to a more comprehensive mind–matter theory. The subsequent two chapters will then compare and contrast Bohm's views with those of others in order to better clarify the various questions involved.

In Chap. 5 we fill focus on the paradox of time consciousness. This issue has recently been discussed by many researchers, and particularly extensively by the philosopher Barry Dainton (2000, 2001). I will argue that Bohm's views of the nature of the phenomenal structure of consciousness in terms of the implicate order provide a basis for a more adequate theory of time consciousness than those currently on offer, including Dainton's views.

In Chap. 6, I shall first further clarify Bohm's interesting but perhaps puzzling concept that reality is movement. I shall then consider whether minds have any genuine causal powers in the Bohmian universe. Finally, I shall conclude the book by briefly considering how one might address the so-called hard problem of consciousness in the Bohmian scheme.