NIELS BOHR’S COMPLEMENTARITY
Niels Bohr, his words and his ideas, have occupied a considerable part of my mind ever since the early 1980s, when I began studying the history and philosophy of science. Bohr’s discourse first sounded just puzzling and enigmatic, but I gradually became aware of its significance for the issues I was vitally concerned with – particularly a problematic that came up during the preceding years of my studies in physical science.

Up until my mid-twenties, as a student of geophysics, specifically meteorology, I was both intrigued and troubled by what seemed to be a large gap between nature as the object of scientific research and nature as experienced in other contexts of our life. This gap even appeared to render the use of the same word ‘nature’ questionable. The movement of air as described by the hydrodynamic equation of motion, for example, scarcely resembled the gentle rustling breeze I felt while walking in the woods or the raging storm whose overwhelming power inspired me with awe. The more I advanced in my research in meteorology, the more severely I felt this gap between the two notions of nature, or between our two different modes of relating to nature. In those days, I still naively held the belief that nature as described or explained scientifically is nature as it truly is, while most other aspects of nature disclosed in our life are merely subjective appearances thereof. At the same time, however, I could no longer suppress my acute feeling of losing contact with nature as I tried to approach the natural world along the lines of physical science. It was in order to engage squarely with this problem, to make it a theme of my own investigation, that I switched to the field of the history and philosophy of science.

At this juncture, I was struck by Bohr’s idea of “complementarity,” especially as expressed by the dictum that ‘we are both spectators and actors in the great drama of existence.’ Bohr discussed the relation of complementarity in quantum theory as well as other fields of knowledge and experience – the relation between space-time coordination and the claim of causality (corresponding, respectively, to the roles of the ‘actor’ and the ‘spectator’), between psychical experience and its reflective analysis, and so on. It was crucial that, in his view, neither of the two complementary relata, neither of the roles of ‘spectator’ and ‘actor,’ has priority over the other. As I saw it, the implications of Bohr’s complementarity extend so
far as to bear essentially on the above problem I was wrestling with. Specifically, there appeared to be a sense in which the ‘spectator’ is the one who treats nature as the object of physical-scientific analysis, whereas the ‘actor’ experiences nature in a non-objectifying manner. At the same time, however, as emphasized by Bohr, the scientific, objectifying approach to nature also acts upon natural processes in its irreducible effect of observational intervention. Further, even the conceptual and discursive dimension of science might, in a sense, be regarded as being an ‘actor,’ if we can no longer simply separate nature in itself and our conception of nature. This suggested that the relation between the objectifying and the non-objectifying approaches to nature – or, more generally, the relation between the roles of ‘spectators’ and ‘actors’ – may be much more complex than they first appeared.

It was along this line of thought that I set out to study Bohr’s work with a focus on complementarity, and, in due course, made it one of the main themes of my research. My approach slowly took shape as a combination of the following two lines of inquiry: On the one hand, I took pains with an intensive reading of Bohr’s texts and a conceptual analysis thereof, especially of those elements of his thought which first seemed too subtle and elusive to grasp. On the other, I strove to extend my scope to a broader philosophical context in which to situate his idea of complementarity. Specifically, I gradually became convinced that his thought may be meaningfully compared and connected, not so much with approaches belonging to the analytic tradition of philosophy, but rather with such (so-called Continental) currents of thought as hermeneutic philosophy and Derridean deconstruction. I confess, however, that, during the early stages of my research, I often felt as if I alone had been walking a narrow and obscure path, with no one else understanding, let alone endorsing, my unconventional approach to Bohr. Yet, under these circumstances, it was all the more encouraging that, in the mid-nineties, I came across Arkady Plotnitsky’s analysis of complementarity in its intersections with deconstruction, and later Karen Barad’s and other authors’ no less unorthodox approaches. I was again greatly encouraged when, at the 2003 Conference of the International Society for Hermeneutics and Science held in Tihany, Hungary, I met a number of researchers who took interest in my approach to complementarity – notably Hans Radder, who would soon kindly assume the role of my doctoral supervisor.

As it turned out, however, it took much more time and greater effort than initially expected to carry through my research project. While writing some separate articles on the subject, I spent a large part of my endeavor to weave together the different threads of my analysis of Bohr’s thought into a more or less coherent texture. It was not until 2005 that I largely achieved this goal, when I completed my doctoral project at the Vrije Universiteit, the Netherlands, with a dissertation entitled “Niels Bohr’s Complementarity: Its Structure, History, and Intersections with Hermeneutics and Deconstruction.” The present book is based on this thesis, although it has been revised and expanded at a number of points.

Some ideas and arguments in the book have already appeared in preliminary forms elsewhere. In addition to the basic exposition of Bohr’s complementarity in Chapter 2, the first half of Chapter 4 has, with substantial changes, grown out of my article “Bohr’s Early Complementarity Argument,” Historia Scientiarum, 8,

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Introduction

In the second half of his academic career, the Danish physicist Niels Bohr (1885–1962) developed philosophical thought revolving around the concept of “complementarity.” Bohr’s idea of complementarity is primarily concerned with quantum theory, his major field of research, but extended to other fields of knowledge and experience as well. Since the rise of quantum theory itself was closely intertwined with philosophical questions concerning such basic notions as subject and object, space-time and causality, chance and necessity, and so on, it is no wonder that Bohr’s complementarity has philosophical implications reaching far beyond the field of atomic physics.¹ The question may be posed, however, whether these implications have so far been adequately understood.

Bohr often characterized his idea of complementarity by the metaphorical dictum that ‘we are both onlookers (or spectators) and actors in the great drama of existence.’ In his view, while modern physical science has hitherto sought to see nature from the standpoint of a pure ‘spectator,’ the development of quantum theory has suggested that there can be no such purely detached standpoint, and that scientists themselves, as it were, unavoidably get involved in the drama of nature. More specifically, the observation of an atomic object carries with it an unavoidable and uncontrollable interaction with the measuring instrument – a circumstance which puts in question the conventional notion of independent objective reality. This led Bohr to develop the idea that space-time coordination and the claim of causality (or the use of the momentum-energy conservation laws) stand – as an ‘actor’ and a ‘spectator,’ respectively – in a “complementary,” that is, mutually exclusive and yet jointly completing relationship. Further, he extended this idea of complementarity to fields outside quantum theory, pointing to the complementary relation between access to the typical aspects of life and its physical analysis, between psychical experience and its reflective analysis, and so forth. In this way, he presented the idea of complementarity as a basic conceptual framework not only for quantum theory, but covering wide-ranging fields of knowledge and experience.

¹ Throughout this study, I follow Bohr himself in using the term ‘complementarity’ to refer not only to his concept of complementarity, but also, in certain contexts such as the present one, to his overall philosophical thought revolving around this concept.
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On closer inspection, however, Bohr’s complementarity will prove to be neither structurally homogeneous nor historically unchanged. It appears to me that, in the ‘early’ period starting in 1927, his complementarity argument with regard to quantum theory centers on the notion, which I call static, that we are ‘spectators’ and ‘actors’ only in different and separate situations. On the other hand, his account of complementarity in psychology and epistemology during the same period contains the dynamic notion that we are ‘actors’ precisely in being ‘spectators.’ It will further turn out that subsequently, in and through his 1935 debate with Einstein and his collaborators, Bohr carried over this dynamic conception of complementarity into his very interpretation of quantum theory, thus tacitly but significantly reorganizing his conceptual framework. That is, the use of the momentum-energy conservation laws, initially associated only with a ‘spectator’s’ detachment, was reinterpreted as having the character of an ‘actor’s’ involvement as well, so that the dynamic relation between the roles of ‘spectators’ and ‘actors’ became all-embracing.

Regrettably, in my view, neither the structural complexity nor the historical development of Bohr’s complementarity as just briefly suggested has been fully or appropriately treated by many commentators. As regards the structural complexity, von Weizsäcker’s early (in part valid) distinction between “parallel” and “circular” complementarity (1976, 284, 294), in particular, has not been taken seriously enough or further elaborated by others. In the historical dimension, although recent studies on Bohr’s thought have increasingly addressed its development over time, their arguments are limited by their mostly unquestioned premise that his philosophical position and its possible diachronic changes are to be found along the conventional axis of realism and anti-realism. Generally speaking, many prior studies have sought to situate Bohr’s complementarity within contexts formed by the analytic or ‘mainstream’ philosophy of science. In these contexts, his thought has often been interpreted under tacit presuppositions – specifically the “unambiguous meaning” of concepts or words, and definite philosophical positions such as realism and anti-realism – which are precisely of the kind targeted by his epistemological critique. This problem seems also to be connected with the widespread underestimation, or even the sheer disregard, of his complementarity argument outside quantum physics – a part of his work which would strongly suggest the need to broaden or transform the common interpretive schemes. In this way, many commentators’ insufficient recognition of the different, and in part conflicting, layers of Bohr’s thought as well as the different phases of its development appears to be correlative with what I see as the narrow or inadequate conceptual frames of their overall interpretive approaches.

Designed to exceed these limitations, the present work is characterized by the following set of interrelated methodological features. First, as suggested above, I

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2 By the ‘early’ period I mean not the early phase of Bohr’s whole career, but that of the development of his idea of complementarity starting in 1927. The designations ‘middle’ and ‘late’ are also used in a parallel way.
focus on the complex conceptual structure of Bohr’s complementarity as comprising different modes of the ‘spectator–actor’ relationship. Specifically, I not only distinguish between the static and the dynamic conceptions of complementarity, but further subdivide the former into what I call static-contrastive and static-symmetrical conceptions. By doing so, I seek to elucidate the heterogeneous roles played by these distinct layers of his thought in questioning and transforming traditional scientific-philosophical notions. Second, this analysis is closely coupled with an investigation into the historical process through which Bohr’s complementarity underwent significant conceptual changes. Dividing the whole period in question into three consecutive phases, I will argue, in particular, that the transition from the ‘early’ to the ‘middle’ period is characterized by an extension of his dynamic conception of complementarity from non-physical fields to quantum theory, while this dynamic conception later paradoxically helped produce the static-symmetrical conception. It will further be shown that, in the ‘late’ period, this static-symmetrical conception became predominant, serving as a basis for his eventual attempt to restore the standpoint of a pure ‘spectator.’ The third aspect of my study concerns situating Bohr’s thought in a broader recent and contemporary philosophical context. In particular, I explore the possible conceptual links between Bohr’s complementarity and hermeneutic philosophy, specifically between the ‘spectator–actor’ relation in the former and what Gadamer and Ricoeur characterize as the relation between “belonging” and “alienation” or “distanciation.” Further, I examine the conceptual intersections of complementarity with Derridean deconstruction as well, proceeding through a critical appraisal of Plotnitsky’s prior analysis of the subject. This series of inquiries will hopefully not only contribute to a better understanding of Bohr’s complementarity, but also help bridge the gulf between the ‘main-stream’ philosophy of science and important branches of contemporary philosophy hitherto little associated with physical science. In other words, this work is designed not simply as a new approach to Bohr’s thought, but, by extension, as a step toward overcoming the still persisting conceptual barriers between different orientations of contemporary philosophy.

The present work consists of six chapters, preceded by this Introduction and followed by Concluding Remarks. After briefly tracing in Chapter 1 the historical rise of quantum theory and Bohr’s contribution to it, I proceed in Chapter 2 to survey the development of his idea of complementarity during the above three periods from 1927 until the end of his life. In Chapter 3, I review a number of prior interpretations of complementarity – some of which have important bearing on later discussions – by physicists as well as historical and philosophical commentators. Starting from and with reference to the findings in these earlier chapters, Chapter 4, arguably the most pivotal of the whole work, is devoted to a philosophical-historical analysis of Bohr’s complementarity from my own interpretive point of view as sketched above. Based on the outcome of this analysis, in Chapters 5 and 6 I further discuss the relation of complementarity to hermeneutic philosophy and Derridean deconstruction, respectively, pointing out both conceptual similarities and divergences. Readers already familiar with, or not particularly interested in, the historical development of quantum theory can skip Chapter 1 without having essential difficulty
in understanding the philosophical import of the following chapters. Chapter 3 may also be skipped in the first reading, although my accounts of prior studies should serve to elucidate my own interpretive standpoint on Bohr’s thought. Further, readers who are already well versed in Bohr’s texts and want to enter quickly into the core arguments of this work could even start with Chapter 4 and, when occasion demands, move back to earlier chapters.