The Knowable and the Unknowable

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Modern Science, Nonclassical Thought, and the "Two Cultures"

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Und darum: Hoch die Physik! Und höher noch das, was uns zu ihr *zwingt,*—unsre Redlichkeit!

—NIETZSCHE

The significance of physical science for philosophy does not merely lie in the steady increase of our experience of inanimate matter, but above all in the opportunity of testing the foundation and scope of some of our most elementary concepts.

—BOHR

Contents

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Preface

This study offers an exploration of the relationships between modern mathematics and science—in particular quantum mechanics, arguably the most controversial scientific theory of the twentieth century—and what I here call nonclassical thinking and the theories, nonclassical theories, to which this thinking gives rise. This thinking and these theories radically redefine the nature of knowledge by making the unknowable an irreducible part of knowledge, insofar as the ultimate objects under investigation by nonclassical theories are seen as being beyond any knowledge or even conception, while, at the same time, affecting what is knowable. Thus, according to Niels Bohr's nonclassical understanding of quantum mechanics, as expressed in the statement to which I continue to return throughout this study, "we are not dealing with an arbitrary renunciation of a more detailed analysis of atomic phenomena, but with a recognition that such an analysis is *in principle* excluded" (Bohr's emphasis). It is this impossibility, *in principle,* of any analysis of the phenomena considered by nonclassical theories beyond certain limits (which nonclassical theories establish as well) that defines these theories. By the same token, this impossibility also defines "the unknowable" of my title as that which is placed by such theories beyond the limit of any analysis, knowledge, or conception, while, again, having shaping effects upon what can be known. Indeed, as will be seen, in these circumstances, the very concept of "phenomenon," as relating to these objects, or the concept of "object," requires a special reconsideration and redefinition, which Bohr was compelled to undertake in the case of quantum mechanics.

By contrast, classical theories, as understood here, consider their primary objects of investigation as, at least in principle (it may not be possible in practice), available to conceptualization and, often, to direct or, at least sufficiently approximate, representation by means of such theories—in short, as knowable. This is "the knowable" of my title. Classical thinking does not deny that there are things that are, in practice or even in principle, beyond theory or any knowledge. In contrast to nonclassical theories, however, classical theories are not concerned with the irreducibly unknowable or its effects upon the knowable. The irreducibly unknowable, if allowed, is placed strictly outside their limits, rather than is seen, as it would be in nonclassical theories, as a constitutive part of knowledge. Thus, most of classical physics, such as classical, Newtonian, mechanics, can be and customarily is seen as classical theory in this sense, in contrast to quantum mechanics in Bohr's or other nonclassical interpretations. It is a separate question whether quantum mechanics could be interpreted classically, or, conversely, classical mechanics nonclassically. As will be seen, the cases of classical and quantum physics are not symmetrical as concerns their respective resistance to classical interpretation. This resistance is much greater and is perhaps even impossible to overcome in the case of quantum mechanics. In any event, on the view adopted by the present study, the knowable and the classical are one and the same. By the same token, classical theories become a pathway to establishing the existence of and the link to the unknowable, and they have also contributed and often led to the emergence of nonclassical thinking historically. Indeed classical theories provide not only a pathway to the unknowable but, by definition, the only such pathway. For how could we otherwise *know* about the unknowable, or, more crucially, how could we rigorously establish or conjecture the existence of the unknowable in this radical sense, rather than only imagine it, did the unknowable not have manifest effects upon what we can know? These manifestations, however, or these effects of the unknowable, cannot be properly understood by classical means and instead require nonclassical theories. Accordingly, nonclassical theories theorize both the knowable *and* the unknowable, found in nonclassical situations, and their (nonclassical) relationships. This different (from that of classical theories) relationship between the knowable and the unknowable is just as crucial to understanding nonclassical theories and their place in intellectual history or culture as the radical nature of the nonclassical unknowable itself. Indeed both, this relationship and the nonclassical unknowable, define each other.

The nonclassical theories and ways of thinking specifically discussed in this study are those exemplified, in various ways and to various degrees, in the works of Niels Bohr, Werner Heisenberg, Jacques Lacan, and Jacques Derrida. This study devotes a chapter to each of them (a little less in the case of Heisenberg, whose work, however, is prominent throughout the book). Bohr's interpretation of quantum mechanics, known as complementarity, serves as the primary paradigm of nonclassical theory for this study. The ideas of a number of other figures—such as Karl Friedrich Gauss and Bernhard Riemann, on the side of mathematics and science, and Friedrich Nietzsche, Georges Bataille, Maurice Blanchot, Emmanuel Levinas, and

Gilles Deleuze, on the philosophical side—will be addressed as well. While extraordinary in their own right, these ideas indicate the broad historical and conceptual range of nonclassical thinking and of the interactions between nonclassical thinking and mathematics and science. The argument of this study is that these interactions proceed in both directions. Modern mathematics and science, from at least the early nineteenth century to quantum physics and beyond, contain elements of nonclassical thinking and sometimes borrow these elements from other areas of human inquiry. Reciprocally, nonclassical thought elsewhere often depends on modern mathematics and science and their philosophically nonclassical aspects.

Although some among the mathematical and scientific subjects to be considered here are complex, no disciplinary knowledge of mathematics and physics is required for understanding my argument. I have tried to introduce these subjects for nonscientific readers and to be as clear and accurate as possible in my exposition of them; and I have tried to do the same for the nonscientific subjects discussed here. While the book is not a primer on the nonscientific subjects anymore than it is on the mathematical and scientific subjects in question, my aim is to make the nonscientific material sufficiently available to the reader, including possible scientific readers, just as it is to make the mathematical and scientific parts of the book available to nonspecialists. However, the character of *our* "two cultures," as C. P. Snow famously called them, the humanities and the sciences (mathematics included), makes the situation to which this project belongs (and that it indeed addresses), and, accordingly, this task itself asymmetrical. This asymmetry persists, even though there may be more symmetry than is often thought and even though there are, and have always been, arguably, beginning at least with Plato, more than two cultures involved, or perhaps both more than two and less than one. Partly real and partly imaginary, the "Snow divide" persistently and perhaps unavoidably reenters this multiplicity and this less than unity. The Greeks might have introduced this split when they invented mathematics, arguably the first science in the full sense of Snow's argument, since mathematics appears to have managed to place itself apart from philosophy, poetry and the arts, politics, and to some degree even language, although it could not be born or exist without them. But then, neither this type of invention nor this type of divide could have a single origin, a point or even a culture of unique emergence, or have occurred one single time, even leaving aside large-scale cultural entities (that is, cultural multiplicities), for example, Babylonian, or, later, Arab mathematics and astronomy, or the always partly evolutionary nature of such events. All of these—emergences of new sciences, the many (more than two and less than one) cultures that give them birth, the two cultures and divides to which they give rise, and so forth—occur all the time, sometimes without involving mathematics and science. The complexity, the irreducible nonsimplicity, of these dynamics makes it difficult and ultimately impossible to establish once and for all (in many cases, even provisionally) what defines each culture and what divides them. In the case of Snow's two cultures, however, the divide persists. It is equally difficult to say whether the Snow divide will ever allow a "dream of great interconnections," of which Bohr speaks and which requires greater cultural multiplicity, to become much more than a dream. One of the persistent effects of the Snow divide is the asymmetry, just invoked, of the ways in which we discuss the two cultures. The nature of this asymmetry, or of the Snow divide itself, is outside the scope of this study, although, thematically and in practice, it could not be avoided either. In any event, in view of this asymmetry, while nonclassical theories in other fields of inquiry in turn require as rigorous and careful treatment as possible, the presentation of mathematical and scientific ideas places greater demands on a project like the one undertaken here and, accordingly, at certain points on the book's readers.

I stand by my argument and claims concerning mathematics and physics. As far as quantum mechanics qua physics is concerned, most of my claims will be supported by arguments offered in Bohr's works (with some of Heisenberg's ideas added on), obviously, in turn given a particular interpretation, and, hence, also entailing a particular interpretation of Bohr's interpretation of quantum mechanics. This role of interpretation or reading is unavoidable, even by classical, let alone nonclassical, standards of interpretation, however careful and rigorous one tries to be. Most of my arguments, moreover, would apply whether or not one agrees with Bohr's interpretation of quantum physics, although I argue this interpretation to be at the very least viable and effective, even if not inevitable, however troubling or even epistemologically unacceptable it may be for some. The latter was actually the view of Albert Einstein, who ultimately found quantum mechanics itself consistent and effective but epistemologically unpalatable in view of its nonclassical implications (his view of Bohr's complementarity is more complex and ambivalent).

While, in accordance with the outline just given, conceived more broadly, the argument of this book is also a response to both long-standing and more recent debates concerning the two cultures. The most recent stage of these debates also involves what has become known as the "Science Wars," following the appearance of Paul R. Gross and Norman Levitt's book, *Higher Superstition: The Academic Left and Its Quarrels with Science* (1994) and

Alan Sokal's hoax article published in the journal *Social Text* (1996). A more recent book, *Impostures intellectueles* (1997), coauthored by Sokal and another theoretical physicist, Jean Bricmont, first published in France and later in England and the United States under the title *Fashionable Nonsense: Postmodern Intellectuals' Abuse of Science* (1998), and hosts of related publications have expanded these debates still further, both intellectually and politically, and indeed geographically, in particular to the French intellectual scene. One of the aims of this study is to contribute to more productive approaches to understanding the relationships among the various disciplines involved in these debates and to a better understanding of the debates themselves. A more sustained understanding of the nature and significance of nonclassical thought in mathematics and science, on the one hand, and in the humanities and social sciences, on the other, is, I would argue, crucial to this task.

Outline of the Chapters

The following outline is designed to help the reader navigate through this study and perhaps choose an alternative trajectory or sequence for following its argument(s). For example, one might, after reading chapter 1 (which serves as a general introduction to the book) and portions of chapter 2 (which contains a comprehensive introduction to its epistemological argument in the first section, while the details of quantum mechanics and complementarity are given in subsequent sections), follow a two cultures and Science Wars trajectory extending to chapters 3, 4, and 5 (especially the first section of the latter). Conversely, one may proceed to chapters 2, 3, and 5 (especially the second section of the latter) for the conceptual discussion of the relationships between nonclassical thinking and quantum mechanics, complex numbers, and other areas of modern mathematics and science. On the other hand, the actual sequence of the chapters is designed to make the overall argument as comprehensive as possible.

Chapter 1: An Introduction to Nonclassical Thought

This chapter explains the key terms of the book and sketches the broad lineaments of nonclassical thinking in mathematics and science and elsewhere.

Chapter 2: Quantum Mechanics, Complementarity, and Nonclassical Thought

This chapter offers an extended discussion of quantum mechanics and Bohr's complementarity as a nonclassical theory. It considers both Bohr's own key concepts and some of the key aspects of the century-long debate concerning the epistemology of quantum theory, especially those involved in Einstein's criticism of it, and eventually leading to and, as Bell's theorem, extending the famous argument of Einstein, Podolsky, and Rosen (hereafter referred to as EPR, following a long-standing convention) concerning the possible incompleteness and nonlocality of quantum theory. (Nonlocality has to do with a possible instantaneous physical action at a distance, incompatible with Einstein's relativity theory.) The EPR argument played a crucial role in Bohr's thinking and indeed forced, but also enabled, him to refine his earlier argument concerning complementarity. The chapter also comments on some of Heisenberg's work (a subject that takes center stage in chapter 5). Finally, using Bohr's epistemology of quantum physics as a paradigmatic example, the chapter argues that, in certain circumstances, the nonclassical epistemology becomes a necessary condition of disciplinarity, scientific or philosophical, rather than inhibiting it, as many opponents of nonclassical thought believe.

My discussion of Bohr is somewhat more technical than the rest of the book. Or rather (since following it does not require a technical knowledge of physics), this discussion is especially detailed as regards specific features of quantum physics. Beyond the more general asymmetry indicated in the Preface, there are several reasons for pursuing this approach.

First, my aim is to bring out the philosophical content of Bohr's interpretation and its radical nature to the maximal degree possible. The most radical aspects of his interpretation have rarely been given their due even in scientific and philosophical literature. One of the main reasons for this neglect is that the more subtle and sometimes minute nuances of Bohr's argument are often missed or misunderstood. His argument, however, crucially depends on and explores these nuances, as do other key philosophical arguments in question in this study. Accordingly, some of the features of quantum mechanics considered here may be unfamiliar to the general reader, while the presentation of others departs from their renditions in literature on the subject.

Second, specific details and nuances of Bohr's interpretation are fundamental to the general argument of this study concerning the nature and viability of nonclassical theory wherever it emerges.

Third, a careful consideration of these details and nuances is necessary in order to argue (this is my disciplinarity argument) that nonclassical theory can be fully rigorous, scientifically and philosophically, and fully consistent with the disciplinary practice of science as currently constituted.

Chapter 3: Versions of the Irrational: The Epistemology of Complex Numbers and Jacques Lacan's Quasi-Mathematics

This chapter considers Lacan's work in the context of modern mathematics, which extends from imaginary and complex numbers, such as the square root of –1, usually designated as "*i*," and related developments in late-eighteenth- and early-nineteenth-century mathematics to our own time, including that used in quantum mechanics (which, in fact, crucially depends on the role of complex numbers). This mathematics will be considered under the broad heading of non-Euclidean mathematics, of which (the more familiar) non-Euclidean geometry is a part as well. This chapter will delineate this concept and explain its relationships to nonclassical thought well beyond, and sometimes against the grain of, Lacan's work.

The context itself just invoked is, as is well known, explicit in Lacan's work, which deliberately and rather liberally (sometimes too liberally) deploys ideas borrowed from these and related areas of mathematics. While conceived much more broadly (as is this study as a whole), chapter 3 is a response to some of the questions and debates concerning Lacan's use of mathematics posed during the Science Wars. Lacan's work has occupied a special place in academic and intellectual debates for quite a while now, whether one speaks of psychoanalysis, philosophy, literary studies, or, most recently, the Science Wars. In *Fashionable Nonsense,* Lacan's is arguably presented as the most notorious case of the postmodern abuse of science.

The argument of the chapter is applicable to Lacan's deployment of mathematical ideas borrowed from a variety of fields, such as mathematical logic and topology (the latter will be considered in some detail here in the general context of non-Euclidean mathematics rather than in the context of Lacan's work). This chapter, however, deals directly only with imaginary and complex numbers and Lacan's argument linked to them. My analysis primarily concerns, first, the *way* mathematics is used in Lacan and why it is so used, not the mathematical accuracy of his mathematical references. This accuracy may, admittedly, be sometimes improved upon, although, all things considered, Lacan is not as bad as some of his recent scientific critics think. Indeed, sometimes he even displays a better sense, if not knowledge, of mathematics or, at least, of something in mathematics than do these critics. Second, it concerns the philosophical (rather than more specifically psychoanalytical) dimensions of Lacan's work. I argue that the structure of philosophical concepts (in Deleuze and Guattari's sense) is where Lacan's usage of mathematics most fundamentally belongs and is the best perspective from which this usage can be meaningfully considered. I would like to emphasize that my argument is not a defense or endorsement of Lacan's use of mathematics or of his psychoanalytical, philosophical, or other ideas (personally, I am inclined to be critical of Lacan), but instead a kind of epistemological case study. Ultimately the discussion of complex numbers and non-Euclidean mathematics is the conceptual center of this chapter.

Chapter 4: "But It Is Above All Not True": Derrida, Relativity, and the "Science Wars"

This chapter examines the Science Wars and related debates concerning the two cultures, in part by specifically considering the role and treatment of Derrida's work in these discussions. Similarly to the preceding chapters, it also offers a discussion of the substantive connections between Derrida's ideas and modern mathematics and science, including relativity, which was the primary subject of the Science Wars exchanges on Derrida. More broadly it addresses the question of reading nonscientific texts, such as Derrida's, when these texts engage or relate to mathematics and science and philosophically reflect, and reflect on, fundamental conceptual conjunctions of scientific and nonscientific fields. This argument is extended in the next chapter in conjunction with some of Heisenberg's conceptual arguments concerning quantum mechanics, which may, with due qualification and caution, be seen as deconstructive. The chapter, thus, brings together the questions of the ethics of intellectual discussion and of the philosophical content of modern mathematics and science and their relationships with nonclassical philosophy.

Chapter 5: Deconstructions

The first section of this chapter discusses the representation of mathematics and science, most especially quantum physics, in some of the Science Wars criticism, specifically in Gross and Levitt's and Sokal and Bricmont's books. In part as a contrast, the second section considers the positive significance of nonclassical thought, in particular Derrida's work, for mathematics and science, here specifically in conjunction with Heisenberg's discussion of quantum mechanics in his 1929 lectures at the University of Chicago.

The scholarly and intellectually unacceptable treatment of the humanities and the social sciences in the Science Wars books just mentioned is by now recognized by commentators. It is a less realized and still less, if at all, commented upon fact that these books contain significant problems in their representation of mathematics and science themselves. The first section of this chapter is concerned primarily with these latter problems, some of which are discussed in earlier chapters as well, especially in chapter 3 in the context of Lacan and complex numbers. As I argue there, Sokal and Bricmont are almost worse on complex numbers than they are on Lacan, and, at points, worse than Lacan is. I would further contend that an adequate treatment, positive or critical, of the radical philosophical work considered in this study requires a rigorous and nuanced treatment *both* of this work itself and of mathematics and science. The Science Wars books in question not only, by and large, uniformly fail in the first task but often also, and, given that the authors are scientists, less forgivably, fail in the second as well.

By way of a contrast and extending the argument of the preceding chapter, the second section, closing this study, brings together Heisenberg's 1929 lectures and Derrida's work as both instances of deconstruction in Derrida's sense. Heisenberg's argument is seen as establishing a kind of Kant-Derrida axis in the epistemology and, to some degree, even physics of quantum theory and as posing significant questions concerning the relationships between deconstruction and nonclassical epistemology in quantum mechanics and, by implication, in Derrida's own work.

Conclusion

Taking as its point of departure Bohr's final thoughts (expressed literally on the last day of his life), the conclusion offers a brief, codalike commentary on the two cultures and on the ethics of intellectual discussion, an ethics defined by the necessity of communicating those ideas that bring the cultures involved—say, mathematics and science, on one side, and the humanities, on the other—to the limits of both what is known and unknown, or unknowable, to them. In the case of nonclassical theory, found, I argue here, in both cultures, the unknowable reaches arguably the farthest known limits. This, however, may enable us to open more effective channels of communication and even ethical relationships between our two cultures, or, again, always more than two and less than one.

Abbreviations

BCW	Niels Bohr. *Niels Bohr: Collected Works.* 10 vols. Amsterdam: Elsevier, 1972–96.
PWNB	Niels Bohr. *The Philosophical Writings of Niels Bohr.* 3 vols. Woodbridge, CT: Ox Bow Press, 1987.
QTM	John Archibald Wheeler and Wojciech Hubert Zurek, eds. *Quantum Theory and Measurement.* Princeton, NJ: Princeton University Press, 1983.