The Comprehensibility of the World
By Nicholas Maxwell

Science without philosophy is mindless, but philosophy without science is barren. It is not just philosophers who make this claim. Many of the greatest scientists of this century agreed. But Natural Philosophy has shrunk to natural science. In the hands of philosophers this claim has taken the form of an investigation into the metaphysical presuppositions of science. Science rests on untested assumptions, like strict causality or determinism, absolute time and space, the nature of reality. Without them the scientific enterprise makes no sense. In the hands of scientists, the claim has led to a questioning of the adequacy of such fundamental assumptions for new fields of experience. The theory of relativity abandoned first the classical notions of absolute time and simultaneity and then the notion of absolute space. The orthodox quantum theory abolished the notions of determinism and causality. Yet few philosophers or scientists have ever pursued the symmetry of the claim. Philosophers mostly sinned on the side of concrete science. Scientists mostly sinned on the side of concrete philosophy. Classic analyses of the metaphysical underpinnings of science like Burtt’s The Metaphysical Foundations of Science (1936) neglected the concrete scientific results, which had been established by Copernicus, Kepler, Galilei, Hooke, Descartes and Newton on the basis of the metaphysical principles. Classic studies of the philosophical consequences of great scientific discoveries like Eddington’s The Philosophy of Natural Science (1939) or Jeans’s Physics and Philosophy (1943) were good popularizations of the scientific results but failed to unearth the deeper philosophical insights.

There have always been exceptions. Ernst Cassirer’s insightful monographs on the philosophical foundations of the theory of relativity and quantum mechanics, written between the wars from a neo-Kantian perspective, were exemplary exercises in a modern type of natural philosophy. De Broglie’s Continuité et discontinuité en Physique Moderne (1941) and Born’s Natural Philosophy of Cause and Chance (1949) intelligently combined scientific perspicacity and philosophical insight. The last ten years have witnessed the publication of a number of books exploring to various degrees interconnections between science and philosophy. Moving from science to philosophy, Nathan Spielberg and Bryon Anderson have given us Seven Ideas that Shook the Universe (1995) and James Cushing has published his Philosophical Concepts in Physics (1998). Moving from philosophy to science, John Earman produced A Primer on Determinism (1987) and Michael Redhead wrote From Physics to Metaphysics (1955).

Nicholas Maxwell has struck an excellent balance between science and philosophy. In his work the slogan about mindless science and barren philosophy is fully addressed. Philosophy must operate within the hard
constraints provided by science. But a consideration of concrete science naturally leads back to philosophy. Maxwell pursues an ambitious programme. The study of the interconnections between science and philosophy has launched him on a march from knowledge to wisdom, the title of his last book (1984). There is a certain proximity to the Frankfurt school of sociology, which resides in the mistrust of instrumental reason, the unquestioning acceptance of scientific methods, results and applications. It is the pursuit of knowledge without any consideration for its usefulness to society. Here the proximity stops. The Frankfurt school views science from an external point of view. Science has been turned into the enemy of enlightened reason. This leads to serious misunderstandings and misrepresentations of the role of science in occidental society. Maxwell views science from an internal point of view. Science has the potential to re-enforce the Enlightenment ideals of rationality. His quarrel is with philosophical interpretations of science rather than with science itself.

In his last book, Maxwell pleaded for a fundamental re-orientation of scientific inquiry from the mere accumulation of knowledge to the employment of knowledge in the service of human well being. The use of science for the improvement of human life runs like a thematic thread from the Scientific Revolution to the Enlightenment. Maxwell holds that this theme can be reformulated for the twentieth century. The step from knowledge to wisdom involves a profound criticism of the philosophy of knowledge, which according to Maxwell, limits rational inquiry to the acquisition of objective facts. The philosophy of wisdom looks beyond this aim to incorporate the use of knowledge for human advancement. In order to achieve this aim the implications and consequences of scientific inquiry must be made explicit. Unspoken assumptions must be spelt out. But Standard Empiricism (SE), one of the influential philosophical schools of this century, leaves too many implicit assumptions untouched. A new model of the philosophy of science is needed—Aim-oriented Empiricism (AOE). Maxwell's last book had begun to discuss the advantages, which a replacement of standard empiricism by aim-oriented empiricism would have for the conception of science. These ideas are pursued in his new book The Comprehensibility of the Universe, which has the rather ambitious aim of changing the very nature of science. This is meant in the sense of nudging science closer to a modern conception of natural philosophy. This looks like a forlorn enterprise if judged from many modern science textbooks or even popularized science texts. But the idea of natural philosophy has seen better times. The two great scientific revolutions of this century had the potential to bring philosophy and science together again. Many of the innovative physicists who made contributions to the theory of relativity and the quantum theory showed an acute awareness of the philosophical consequences of these two great scientific developments. The scientific reasoning was not neatly separated from the philosophical argument. A glance at the scientific journals of the first half of this century shows that discussions on causality, determinism, time, space and reality were frequently interwoven with mathematical arguments. They display a superb mix of mathematics, physics and philosophy. One may speculate that the
clipping of the philosophical wings, which the heirs of Bohr, Born, de Broglie, Einstein, Heisenberg, Planck and Sommerfeld have suffered, is a result of the geographical shift of scientific leadership from Europe to the United States. Or perhaps it is simply the price of specialization. Whatever the reason, it makes Maxwell’s plea for a forward-looking ‘return’ to natural philosophy a topical concern. The recent explorations of the scientific landscape are a timely reminder that the philosophical issues lie just beneath the surface.

The new book elaborates on the sustained criticism of various forms of SE, which Maxwell has pursued in many of his publications. It also develops in greater detail the new model of science, Aim-oriented Empiricism (AOE). It is a complex model, which seeks illustration in the finer details of physical knowledge. The basic idea is clear enough. The rationality of scientific discourse is increased if the underlying assumptions, on which it rests, are made explicit. The assumptions must become part and parcel of scientific theories. Scientific theories are not constrained by empirical evidence alone. But the orthodox view, Standard Empiricism (SE), holds that the acceptance of scientific theories is governed solely by empirical evidence. The evidence alone is supposed to decide between rival accounts of the same phenomena. Maxwell formulates a basic objection against this restriction to purely empirical constraints. If two rival accounts, however ad hoc one of them may be, are equally compatible with the evidence, it is impossible to decide which one of the two rivals is the correct representation of the natural world. One obvious rejoinder to the charge that SE must rely on empirical findings to weed out ad hoc accounts, is that apart from testability it allows for an appeal to criteria of simplicity (unification) and empirical success to discredit the ad hoc theories. But SE, Maxwell contends, cannot explain what criteria like simplicity and related concepts (unification, explanatory value and comprehensibility) dignify. It is precisely the strength of AOE that it offers an exploration of these theoretical constraints and solves many of the problems, on which SE founders.

An appeal to both empirical and non-empirical constraints will be needed to separate the chaff from the wheat. There is a problem. According to Maxwell, SE holds a tight grip on the scientific spirit. Maxwell recognizes of course that SE has undergone considerable changes from Popper’s naïve falsificationism, in which a single conjecture faces the court of evidence, to Lakatos’s sophisticated falsificationism, in which rival research programmes compete in progressive problem solving. But once this distinction has been acknowledged in the early part of the book, it is quickly forgotten. The later criticisms are launched against the SE tout court, sometimes leaving the reader in some doubt as to whether a straw man is under attack. More serious is Maxwell’s contention that SE is the official philosophy of the natural sciences. Although SE allegedly leads to sterility, science has made tremendous theoretical and empirical progress. Maxwell has a ready solution to this puzzle. Scientific progress has become possible through the approximate but implicit implementation of AOE in scientific practice. Maxwell can cite a witness for this ad hoc explanation: Einstein was an early practitioner of AOE. However, ‘standard empiricism...
Figure 1. Aim-oriented empiricism

bans serious discussion of the philosophy of science from science itself. In the history of recent physics, the staunchest proponents of standard empiricism were Heisenberg and Bohr. As mentioned before, both physicists also belonged to a very long list of innovative practising scientists in the first part of this century, who were involved in an intense philosophical discussion about the philosophical consequences for quantum mechanics. The philosophical notions, which were at stake, were quite different from the assumptions, which Maxwell considers. The physicists of the 1920s and 1930s were preoccupied with the modifications to the notions of determinism and causality as a direct consequence of new empirical discoveries. If SE had held such sway over scientists as Maxwell claims, these discussions would hardly have been possible. As they openly discussed metaphysical assumptions, they would have as much right to be deemed predecessors of AOE as Einstein. But one may entertain some doubts as to whether even Einstein was an early proponent of AOE. It is true that Einstein destroyed Newton’s notions of absolute time and space. Nevertheless Einstein was very ambivalent in his epistemological attitudes. He pleaded for the rejection of ‘absolute time’ as an inadequate notion in physics. However against all the quantum mechanical evidence, he continued to cling to a strict notion of causality, compatible at best with classical physics, which allowed him to reject quantum mechanics as incomplete.

There lies an irony at the heart of the new model of science. AOE claims to have solved the problem of simplicity. This is achieved at an expense of complexity, which would not pass the test of Occam’s razor. It contends that the representation of scientific knowledge involves a hierarchy of ten metaphysical assumptions concerning the comprehensibility of the universe. And this is only a rough approximation. But already with the ten assumptions it is sometimes difficult to distinguish clearly between them. Perhaps this is hardly surprising as Maxwell takes his assumptions to become increasingly ‘imprecise’ and vague. These increasingly ‘contentless’ cosmological assumptions concerning the ‘comprehensibility of the universe’ are needed to solve the problems of simplicity and induction as well as paradoxes in the interpretation of quantum mechanics. As AOE renders these assumptions explicit, scientific progress gains in rationality. This becomes possible because AOE envisages a positive feedback between the improvement of knowledge and the improvement of the cosmological assumptions. This cross-fertilization between cosmological assumptions and scientific knowledge gives this position its name: Aim-oriented Empiricism. Maxwell retains the term ‘empiricism’ because the cosmological assumptions are employed in the service of a better understanding of the natural world. Maxwell’s graphical presentation of AOE is reproduced in Figure I.

Throughout the book Maxwell vacillates considerably about how far the empirical evidence reaches up into the realm of the cosmological assumptions. On the one hand he holds that the lower-level ones are subject to falsification and revision in the light of scientific discoveries. It is true that the fundamental assumptions, which were revised in the light of new discoveries, concerned views on nature, time, space, causality and determin-
ism. These actual metaphysical presuppositions from the history of science are, however, not discussed in this book. On the other hand, Maxwell also calls these assumptions 'untestable' but this conflicts with some of his own examples and scientific practice. The mechanistic worldview of the seventeenth century arose from the scientific discoveries of the founding fathers of modern science. In the twentieth century both quantum mechanics and relativity theory led to fundamental conceptual revisions of the basic epistemological tools, which had lain at the root of the mechanistic worldview.

Maxwell could counter that he is addressing deeper-lying issues. Whatever the ultimate nature of the metaphysical assumptions, which science needs to progress, Maxwell clearly hangs a huge load on them. A look at the philosophical debates, in which some of the leading physicists of this century were actually engaged, helps to dampen the optimistic expectations. Maxwell expects that the espousal of AOE by the scientific community will encourage a rational and objective discussion of the metaphysical assumptions, which accompany scientific theories. The fact is, however, that when scientists turn philosophers they cease to agree on the metaphysical assumptions. Bohr and Heisenberg felt that quantum mechanics had spelt the end of causality. Einstein held that the lack of a causal explanation in the study of spontaneous emissions demonstrated the incompleteness of quantum mechanical explanations. De Broglie and Born argued that a revised notion of causality could be retained for quantum mechanics. The theory of relativity led Gödel to an idealistic notion of time and Einstein to the conception of the block universe. Others reject the interpretation of Minkowski space-time as a block universe. The general consensus on scientific results does not spill over to a consensus on philosophical positions. This is not to deny that rational discussion is possible. But philosophy operates with a limited number of conceptual models and scientists tend to use their scientific knowledge to lend support to one or the other of the philosophical models.

There is a reading of the Maxwell model, which could be seen as encouraging the expected scientific progress from the positive feedback between metaphysical theses and scientific theories. Going up the pyramid of assumptions means that the air gets thinner and thinner at the top. The assumptions grow more and more abstract, even vague. But vagueness as to what assumptions like 'physicalism' and 'comprehensibility' mean typically results in diversity of opinions. Little conceptual progress is to be expected from vagueness. But Maxwell needs the increasing vagueness of the assumptions for another job. There is a sense of the comprehensibility of the universe, which is more compatible with scientific progress than some rival sense. Maxwell shows that the adoption of these increasingly 'emptier' metaphysical assumptions is more conducive to a rational pursuit of science than either the neglect of assumptions or the adoptions of less neat ones. As Maxwell argues, quite convincingly, a physicalistic sense of comprehensibility does a better epistemological job than say Aristotle's Unmoved Mover. If imprecision is allowed to mean, not just winnowing of contents, but adherence to one of the conceptual models of philosophy,
then the possibility of progress can be gleaned from, say again, the notions of causality. Einstein was a believer in strict causality and locality. The inability of quantum mechanics to determine the direction of the spontaneous emission of photons and later, the apparent existence of ‘spooky’ action-at-a-distance in EPR-type experiments, led him to a rejection of quantum mechanics as a fundamental theory. Here the prior commitment to a deterministic type of causality inspired Einstein to call for a more fundamental theory of atomic processes. David Bohm’s hidden variable theory of quantum mechanics and the work of his disciples is similarly based on prior commitments to stringent notions of causality. As Bohm pointed out, the conceptual progress results from the development of alternative models, based on different metaphysical conditions. However, a deterministic type of causality is hardly an imprecise or vague assumption.

By Maxwell’s own admission new theories in physics did not emerge according to the prescribed way of AOE. According to the proper manner, previously articulated metaphysical blueprints should inspire new theories in physics. However, the metaphysical assumptions tend to emerge from the new theories. Certainly, new notions of causality tended to arise as a consequence of the development of quantum mechanics. The block universe was also consequent upon the development of the theories of relativity. The reason seems not too hard to guess. Given the apparent vagueness of at least the higher assumptions, their lack of concrete contents, and remoteness from the empirical evidence, it is hard to see how they could deliver the necessary basis for the formulation of new scientific theories. Einstein’s special theory of relativity sprang from a very slender notion of time (clock time) and raised the empirically known value for the constant velocity of light to the level of a theoretical postulate. It is unrealistic to assume that metaphysical models should be the driving forces behind scientific theorising. But if Maxwell means that metaphysical convictions concerning the nature of reality could act as constraints, then indeed his view is warranted. For instance, the dissatisfaction with the wave-particle duality of orthodox quantum mechanics encourages Maxwell to offer his own propensity interpretation of quantum mechanics in chapter 7 of the book. This is inspired by a sense of unity, inherited from prior physics. Other alternative interpretations of quantum mechanics take their cue from the notion of strict causality. The fundamental metaphysical assumptions of a theory are best regarded as constraints on a theory, which is based on hard empirical evidence. This could be modelled on Max Jammer’s feedback thesis: fundamental presuppositions lie at the root of scientific theories; but scientific theories are subject to observational and experimental testing; these assumptions may become questionable in the light of evidence which the theories produce; this may lead to a revision of the conceptual foundations of the physical theories. But note that this process is not automatic. All parties involved in the development of quantum mechanics agreed that radioactive decay, spontaneous emissions and blackbody radiation posed a threat to the classical notion of causality. Disagreement entered when the philosophical responses were spelt out.

These philosophical presuppositions do not necessarily lie hidden at the
heart of the theory. Newton’s notions of absolute space and time were explicitly defined in the *Principia*. Leibniz rejected them and proposed a relational view of space and time. The concept of the aether was explicitly introduced in many classical theories of mechanics and electricity. Boyle, the English chemist, delivered a brilliant nominalist critique of scholastic notions of Nature. He introduced a new mechanical view of the natural world. All this happened, presumably, under the iron grip of SE. Maybe—but it did not prevent many episodes in the history of occidental science, in which metaphysical assumptions were explicitly discussed and used as constraints, amongst more technical ones, in the conceptions of new theories.

What additional advantages, then, would accrue from an official espousal of AOE? It solves the problems of simplicity and induction, renders the context of discovery rational and suggests a solution to the wave-particle duality in quantum mechanics. Contrary to the announced vagueness or imprecision of the higher-order metaphysical assumptions, the notions of physicalism and comprehensibility are actually made more precise. The hierarchy of assumptions is not simply stated but made to do some work. The rationality of scientific reasoning will benefit. A solution to the problem of simplicity (this comprises notions like unification and explanatory value) would point the way towards the rational selection of the best explanatory theories. A solution to the problem of induction would lend support to the inference from the evidence to the best universal theories.

Consider how Maxwell proposes to solve the problem of simplicity. Maxwell rejects various attempts to make simplicity language-dependent or define it in terms of the unification of theories. What matters in the assessment of the simplicity of theories is not their form but their content. Theories are ‘simple’ if they conform as closely as possible to the metaphysical assumption of ‘physicalism’—the idea that underlying all change, \( V \), in the universe, there is an underlying ‘unified unchanging something, \( U \),’ which determines all physical change. Maxwell does not formally specify what \( U \) is, hoping that a Theory of Everything will eventually provide the details. \( U \) constitutes the content by which the simplicity of theories is to be assessed. Although Maxwell grants in a footnote that the distinction between form and content cannot be clearly drawn in practice, they are distinct in principle.

The content of a physical theory is the possible physical states of affairs that the theory specifies and asserts to exist; the form applies to what we write down on paper.

Maxwell relies heavily on the form/content distinction in his discussion of simplicity. It is curious to observe then that in his historical illustrations of unification in physics he falls back on the ‘unification-as derivability-idea’, which he had earlier criticized. The detailed discussions of theoretical unification in physics—from Newton, Maxwell and Einstein to Feynman, Weinberg and Salem—form some of the best material in the book. Maxwell is good at explaining physics. Nevertheless the discussion
depends essentially on a close scrutiny of the equations and various limiting conditions to be imposed on them. Although there are hints at the underlying U, form and content are not separated in this discussion. It is the form of the equations, which reveals the process of unification.

Maxwell’s commitment to unification as a progressive approximation to physicalism (U) leads to interesting results for the realist. One wonders whether the overemphasis on the continuity of growth, at the expense of bizarre constructions, is necessary. Against Kuhn’s incommensurability idea he affirms that all new ideas in science always emerge as a modification of pre-existing ideas. All scientific revolutions, in the Kuhnian sense, must then be reconstructed as progressive approximations of a series of theories, T_0 to T_n, towards some ultimate true theory T. T comprises the true characterization of the nature of the unchanging something U, which is responsible for all changes. As T is not (yet) known, it is a puzzle how the series T_0 to T_n can be understood as an approximation to it. Even if this point is ignored, the insistence on strict continuity leads to a distorted interpretation of the history of science. For one thing, the introduction of discreteness, symbolized in Planck’s constant h, into quantum mechanics represented one of the most radical departures from established physical worldviews. Planck’s constant was a revolutionary move, not a modification of previous ideas. Even with the amount of hand waving, which Maxwell performs, continuity can not always be established. Let M_0 be Thomson’s plum pudding model of the atom. According to this model, atoms consist of a positive sphere of electrification with electrons arranged in concentric rings around the centre, in which there is no nucleus. Let M_1 be the Bohr-Rutherford model of the atom, whose central features are the stipulation of a heavy nucleus, around which the electrons orbit, and the postulate of discrete energy levels. Then Maxwell would have us believe that the behaviour of atoms in M_1 can be made analogous to states, which look as if atoms were in fact M_0 systems. But this is simply not so. Even in the simplest case, where helium nuclei were made to scatter on impact with gold atoms, the helium nuclei displayed behaviour, which was compatible with M_1 but incompatible with M_0. In other words, even on a strictly realist, continuous model of the growth of scientific knowledge, the incompatibility between certain solutions (M_1 and M_2) and the elimination of a number of rival accounts must be incorporated to be compatible with the history of science.

Has Maxwell solved the problem of simplicity? If there were a U, captured by a true T, then theories, which evolve towards T, would be ‘simple’ by virtue of their increasing exemplification of physicalism. If U can only be approximated, as for instance in Maxwell’s theory of electromagnetism, it still serves to drive home the basic point. It is not the structure of theories (the form), which solves the problem of simplicity but the structure of the natural world (the content). The realist, however, makes the assumption that the structure of the natural world is captured approximately in the structure of our physical theories. The form is constrained by the content. That is why Maxwell finds it so difficult to separate the two. This realist assumption is basically the assumption of comprehensibility.
The solution of the problem of simplicity depends on the assumption of comprehensibility. The message of the book is that the assumptions get ‘vaguer’ but that the higher-ranking assumptions are less harmful to adopt than more complicated rivals. In reality, Maxwell’s assumptions do not get ‘simpler’ and this is just what is required if they are to act as constraints in the construction of new theories.

Again there are exaggerations. Just as the idea of smooth continuous growth stretches credulity, Maxwell’s reflections on essentialistic physics produce many question marks on the margins. Here the reader will have to deal with the idea that the laws of science are analytic—of course under suitable essentialistic modifications elsewhere. Conjectural essentialism may explain the distinction between genuine laws and accidental regularities and even why there are lawful regularities at all but it does so at a heavy price. The Necessitarianism of the Australian school is an approach to the question of laws of nature, which has been criticized for its reliance on modalities. All these approaches lack what John Earman once described as ‘the texture and feel of real-life laws.’ Maxwell’s discussion of laws of nature moves far away from the constraints set by the physical sciences. The obvious complaint is that ‘the texture and feel’ for real-life science, which the book illustrates so beautifully throughout, gets lost. The old metaphysical barrenness beckons.

The appeal to increasingly ‘thinner’ assumptions is also the backbone of the solution to the problem of induction. Maxwell identifies several problems of induction and conducts a long series of plausibility proofs. Essentially he follows Popper’s reformulation of the problem of induction: it is the question of inferring universal theories from the basis of particular evidence. Instead of appealing to the old idea of the uniformity of nature, Maxwell employs eight distinct uniformity principles at eight different levels. The essential point is that the old reliance on one principle—the uniformity of nature—is to be replaced by a number of increasingly ‘thinner’ metaphysical assumptions. It may be difficult to accept the ‘uniformity of nature’. There are fewer objections, Maxwell holds, to such notions as comprehensibility. Through the interplay of metaphysical assumptions, at varying distances from the empirical evidence Maxwell shows, rather convincingly, that in the pursuit of rational science the inference from the evidence to a small number of acceptable theories, out of the pool of rival ones, is justifiable if the acceptable theories are compatible with the metaphysical assumptions, which can be defended independently. This is not the type of proof one encounters in physics textbooks. But the argument shows that, from the point of view of a rational growth of knowledge, it is better to adopt the metaphysical assumptions espoused by AOE than alternative ones. Maxwell discusses a number of such alternative assumptions. Whilst they could all serve as a foundation to the scientific enterprise, some are in much better agreement with the type of comprehensibility thesis on which occidental science has always relied.

The plausibility arguments of these chapters are very detailed and involved but they do establish rather convincingly that not all metaphysical assumptions will do. The chapters on progress and discovery, always with
the enemy, SE, in sight, proceed in a similar fashion. Physicalism and the assumption that a Theory of Everything will be ‘precisely true of everything’ feature prominently in these discussions. The ideas of theoretical and empirical progress and unity are again cashed in by appeal to the notion of ‘derivability’.

Essential for the success of AOE is the case of quantum mechanics. In his career Maxwell has had a lot to say about quantum mechanics and many of these insights find their way into chapter 7 of the new book. (Some of his more technical papers were published in the American Journal of Physics, Nature and Foundations of Physics.) From the point of view of AOE orthodox quantum mechanics (OQT) is unacceptable, despite its tremendous empirical success. But as is well known, the mathematical formalism of quantum mechanics has produced a variety of different interpretations. Quantum mechanics is good at calculating the behaviour of quantum systems but an understanding of the quantum world has eluded quantum physicists. Unsurprisingly, philosophers have stepped into the breach with conceptual models, aimed at providing a physical-philosophical interpretation of the quantum world.

Maxwell’s model takes its start from the failure of OQT to solve the wave-particle duality. This chapter introduces some technical terms (like ‘pure and mixed states’, ‘observables’ and ‘measurement theory’) for the explanation of which the reader will have to refer to the Appendix. (In this excellently written Appendix some of the basic mathematical technicalities, including the principles of quantum mechanics, are very well explained.) The Copenhagen interpretation of quantum mechanics (OQT) claimed that both the wave and the particle pictures of quantum systems were necessary to give a satisfactory account of the observable phenomena. Bohr and Heisenberg regarded them as complementary in that both pictures could only give partial information about the quantum systems. But both pictures were necessary since quantum systems display wave- or particle characteristics, depending on the experiments performed. When electrons or photons are fired at a barrier with two slits they will, under suitable conditions, exhibit either particle or wave properties. Because of the Heisenberg indeterminacy relations neither picture gives a complete account of the behaviour of quantum systems. Furthermore both Heisenberg and Bohr insisted that nothing could be known about the actual behaviour of a quantum system in between acts of measurement. It is only when the quantum system is made to interact with some measurements device that it jumps from potentiality into actuality.

It is this lack of micro-realism, which Maxwell wants to remedy. Micro-realism would give quantum theory a consistent ontology, which it lacks in its orthodox interpretation. AOE promises to provide a good metaphysical blueprint. The key to a consistent interpretation of quantum mechanics is probabilism. Quantum objects are discrete propensitons. They have a probabilistic nature at the ontological level. They evolve deterministically into virtual states, which under suitable conditions collapse into one actual state. Unlike other approaches to an interpretation of quantum mechanics, Maxwell is not preoccupied with explaining the strange spin correlations
revealed in EPR-type experiments. The Bell inequalities are not even mentioned in the book. Some passages suggest, however, that discrete probabilism allows for some form of non-local realism. Talk of potentialities was also a feature of Heisenberg's attempts at interpreting quantum mechanics. But the Copenhagen interpretation relied on measurement for the actualization of quantum states whilst Maxwell moves the probabilistic features of quantum states one level down to the nature of the quantum states themselves (about which the Copenhagen interpretation made no pronouncements). Maxwell sees it as a virtue of his interpretation that the measurement problem—the sudden collapse of the wave function—is avoided. Probabilistic collapse occurs under the specific physical condition of inelastic collisions and not when physicists decide to make some measurement.

One of the virtues of the wave-particle talk, routinely exploited in physics textbooks, is that it can explain rather well the famous experiments, which have established the validity of quantum mechanics. At first there were the particle experiments. The scattering experiments by Geiger and Marsden (1909–10) and the Frank-Hertz experiment (1914) display the particle nature of atomic systems. Some experiments require the wave- and the particle aspects, i.e., the Compton experiment (1923) and the double-slit experiment, which at first only existed as a Gedankenexperiment, but was realized in the laboratory for the first time in 1961. The Davisson-Germer experiment (1926–7) shows the wave nature of atomic systems. It remains an important task, if Maxwell's proposal is to be viable, that it must give a consistent interpretation of these experiments. The propensiton model gives the reader only an interpretation of the double slit experiment as a thought experiment. This gives rise to the characteristic interference patterns under a suitable arrangement of the slits. But the electrons or photons are emitted from the source as particles with specific physical properties: spin, mass, kinetic energy. It is these particle-like properties which provide an explanation of the characteristic results produced in the Frank-Hertz experiment of the scattering experiments. From the point of view of AOE the Copenhagen interpretation may be unsatisfactory because of its lack of ontological unity. Discrete probabilism will restore ontological unity only if the particle-like properties, so often observed in quantum mechanical experiments, can be incorporated in this view. It will not do for Maxwell to declare that 'as a special case it is possible to envisage a kind of discrete propensiton, which is such that the values of its propensities remain fixed during deterministic evolution'. The physicist who is to be tempted by this interpretation will want to know under which conditions the 'natural quantum-mechanical-type spatial smearing out, or non-locality' fails to arise. Thus it is not obvious that this interpretation really has avoided a wave-particle duality. The propensiton idea, with its emphasis on the probabilistic collapse from non-local virtual states to local actual states, favours the wave-like characteristics of the quantum systems. If propensitons are probabilistic 'entities', deterministically developing into virtual smeared-out states, there needs to be an explanation how the particle-like features, characteristic of many quantum mechanical experiments, arise.
The propensiton interpretation is inspired by a sense of unity, which for Maxwell is one of the great achievements of the history of science. It is an example of the inspirations, which theoretical constraints can give to the development of alternative interpretations of quantum mechanics. As it promises to deliver a realist interpretation of the quantum world, it deserves a fair hearing. But Maxwell must practice the virtues, which he preaches. The propensiton model must itself satisfy the unity postulate, on which so much emphasis is put throughout the book. The propensiton model may give rise to new predictions but it must also give an account of the already established results in quantum mechanics, which in the physics textbooks are conveniently 'explained' by appeal to the wave-particle duality. As the propensiton model seems to retain much of the mathematical apparatus of quantum mechanics, the unification it proposes must state more explicitly what role, if any, is to be assigned to the classic ingredients of quantum mechanics. In the book, the propensiton interpretation assigns no role to the Heisenberg indeterminacy relations. But surely a fundamental question which any coherent ontological interpretation of quantum mechanics must address is whether the Heisenberg indeterminacy relations are epistemological limits to knowledge, as Bohn affirms, or ontological building blocks of the natural world. Recent experiments even suggest that it is the notion of entanglement, not Heisenberg indeterminacy, which is fundamental to the explanation of the double-slit experiments. The Maxwell interpretation does leave room for the Schrödinger equation. But its scope reduces to the evolution of the virtual states and ceases to apply in the probabilistic actualization to one state. This part of the interpretation is worked out in some detail. Maxwell gives a more precise formulation of the postulate for probabilistic quantum jumps and predicts that the difference between the propensiton model and OQT is open to empirical testing.

The main idea is the quantum jumps only occur in inelastic collisions, which can be detected as the creation of a new particle state. (Are these perfectly inelastic collisions?) Maxwell is keen to avoid the measurement problem but his proposal is less than specific on the question of what constitutes physical conditions as opposed to measurements in quantum mechanics. For instance in his discussion of the double slit experiment the screen plays a prominent part as a physical condition, which has an effect on the spread of the electron beam. But it is not clear why the two slits and the photographic screen should not constitute a measurement apparatus. Maxwell claims that 'all measurements that actually detect quantum systems (...) must involve some (...) inelastic particle-creating process'. However in the Stern-Gerlach experiments (1920-1), in which a beam of particles is sent through a non-uniform magnetic field, specific properties of the particles are detected (their quantized angular momentum) but no collisions (elastic or inelastic) are involved. In the Frank-Hertz experiment, the detection of discrete energy levels of the mercury atoms is explained by a combination of perfectly elastic and imperfectly inelastic collisions.

In sum, this is a complex book. It contains many interesting proposals. As it moves along its circles of ever increasing complexity some of its
theses become questionable. Its greatest virtue is the detailed programme for a modern version of natural philosophy. Along the way, Maxwell homes in on the notion of comprehensibility by the exclusion of less attractive alternatives. In an age of excessive specialization the book offers a timely reminder of the close link between science and philosophy. There is a beautiful balance between concrete science and abstract philosophy. Einstein may not exactly fit the role of clear-sighted predecessor of AOE. But Einstein definitely held that ‘epistemology without science becomes an empty scheme’ while ‘science without epistemology is primitive and muddled’. Maxwell’s new book is a long-running commentary on this aphorism.

Friedel Weinert

Fichte’s Transcendental Philosophy. The Original Duplicity of Intelligence and Will
By Günter Zöller

Life as a ‘Continental philosopher’ in the English-speaking world is not easy at the best of times. While analytical colleagues engage in established (if not always very fruitful) debates in the ‘Philosophy of Mind/Science/Language’, etc., those working on European philosophy are often left with an unsatisfactory choice between either enjoining debates that mainly take place in Germany, France or Italy—which therefore have little effect on their own philosophical milieu—or spending their time trying to convince their colleagues of the importance of thinkers they have never troubled to read. Anyone undertaking a book on one of these ignored figures is therefore left with the unenviable task of mediating between camps whose expectations are radically divergent. In the case of Johann Gottlieb Fichte this task becomes even more intractable, given both the formidable difficulty of Fichte’s texts and his reputation, recently given a boost by the publication of Isaiah Berlin’s entertaining, but sloppy and inaccurate Romanticism lectures, as a deranged idealist who takes no account of the necessary constraints on what thinking can make of the world. Such problems are often further compounded by the fact that most of the texts by the author in question are not available in English. Here Günter Zöller at least has the advantage that there are recent translations of some of the texts by Fichte upon which he concentrates in his presentation of Fichte’s thought between the years 1794 and 1800. Why, then, should Cambridge University Press publish its second book on Fichte in recent years?

Anyone working on the history of modern European philosophy would have no trouble in demonstrating that Fichte’s influence on the direction of modern thought has been quite spectacular. As Zöller remarks in a footnote, Fichte’s conception of the will in the later part of the period dealt with in this book very often closely resembles that of Schopenhauer, who was familiar with it (though he actually got more of his conception from Schelling’s less obviously Idealist philosophy of the period from 1809 onwards). In the light of the effect of Schopenhauer’s conception on
Wagner, Nietzsche and others, Fichte's inheritance is clearly substantial, if rarely detailed as such in English-language accounts of European thought. However, the fact that Zöller points out this link in a footnote gives an indication of the way he conceives of his project. This is not an attempt to situate Fichte historically as part of a major intellectual tradition which has had huge effects beyond the confines of academic philosophy, but rather an immanent reconstruction of Fichte's major arguments from a fairly small number of texts. Zöller acknowledges the problems such a reconstruction involves in his remark that ‘As any reader of Fichte knows, criticizing him comes easy; the hard part is making him intelligible’ (p. 6). Any book on Fichte depends heavily on the strategies adopted for making him intelligible, and the existing attempts have not always been wholly successful. In Cambridge's other book on Fichte, for example, Frederick Neuhouser largely opts to extract from Fichte the arguments that can contribute to the agenda of the contemporary philosophy of mind. This results in a useful demonstration that many of the topics which now concern philosophers of mind, such as the difference between self-knowledge and knowledge of world objects, were the bread and butter of Fichte's own conception. However, Neuhouser does not really engage with the much more ambitious metaphysical programme that Fichte attempted to complete. Zöller makes this his task, considering Fichte's programme in the light of the problems of Kant's critical philosophy that Fichte aimed to overcome, but this approach, as we shall see, has its own problems.

For those reasonably familiar with Kantian and post-Kantian issues Zöller's approach is informative, and he succeeds in making some of Fichte's ideas clearer than they are made in most existing accounts. He begins with Fichte's 'precarious balance between loyalty and patricide in his relationship to Kant' (p. 11), which leads him to the attempt to turn the critique of pure reason into the 'system of pure reason'. Zöller illuminatingly shows how Kant's restriction of the idea of transcendental idealism to the a priori forms of intuition, space and time, in the Transcendental Aesthetic prevents him from assuming that transcendental idealism could form a complete philosophical system of the kind Fichte and others of Kant's successors would try to establish. The problem Fichte sees in Kant's restriction—namely the relationship between passive, receptive sensibility and active, spontaneous understanding, which seems to entail that Kant's forms of intuition are both active and passive—leads to the heart of his own philosophy. Fichte seeks to transform the apparently passive aspects of thinking into products of the I’s own activity, basing the whole of his system on 'the notion of the self as spontaneous intelligent activity ... that is originally independent from anything other than itself' (p. 19). It is, of course, here that the suspicion arises that Fichte thinks the I produces the world, in a conception which seems like a version of Berkeley that replaces God with the I. Zöller insists, though, that Fichte wishes to 'dispel' such ideas, and contrasts his "critical or transcendental idealism," which presupposes the original determination of the intelligence through its own laws' (ibid.) with the idea (assumed, among many others, by Berlin) of 'an absolutely lawless intelligent activity' (ibid.).
Zöller's views seem evidently to be what Fichte intended, but it does not dispel questions either about the extent of Fichte's Idealism or about whether his version of the notion of a self-determining intelligence can really be made convincing.

The obvious question here is how Fichte accounts for the undoubted fact that we are compelled by the necessities of the natural world. As we saw, Fichte wishes to establish an Idealist emphasis on the activity of the I in all operations of thought, including receptive operations, so that the Kantian divisions between active and passive are avoided. If we feel limited by the object world, the 'not-I', the prior aspect must in some sense be that which can apprehend limitation as limitation, and this is what leads Fichte to lay such emphasis, even in his theory of knowledge, on the freedom in thought. At the same time, though, Zöller is very good at showing that Fichte also insists that the laws of the object world which the mind apprehends 'are not of the mind's own, absolutely free making but reflect the irreducible contingency of a being that has reason without being its own ground or reason' (p. 27). This means that Fichte, rather than leading in Berkeley's direction, in fact already begins to open the path leading to the later Schelling, Schopenhauer, Nietzsche and Heidegger, for reasons that in Fichte's own later philosophy (which could usefully have been characterized in the later parts of the book) will lead him, under the influence of Jacobi, away from the I as ultimate ground to a theological position.

The question that defines so much of the philosophy in this tradition is how thought can come to terms with this ground. Fichte terms the ground the 'Absolute' and his philosophy dealt with in this book is a—failed—attempt to give an account of it. The decisive term in Fichte's attempt is 'intellectual intuition', which Zöller characterizes as 'the philosopher's ability to raise to consciousness the very processes through which the I comes about' (p. 34). The I of intellectual intuition, which is not your or my reflective empirical I, but rather the ground which makes empirical knowledge possible, is 'an inferred condition, grasped in philosophical thought by means of abstraction from what is empirical in consciousness and reflection on what remains after such abstraction' (p. 36). It is, therefore, what makes my thoughts my own, which cannot, on pain of a regress, be apprehended as an object by my own thinking. As the work of Dieter Henrich has shown, Fichte thereby addresses the problem, which still troubles the philosophy of mind, of the pre-reflexive consciousness that seems to be required for self-ascription and thus for the coherence of our experience. However, Zöller does not engage with the issue at this level, and the book increasingly concentrates upon detailed reconstruction of a few texts, with little sustained reference to their significance for wider philosophical debate.

This approach is rather questionable because of the uneasy relationship between its hermeneutic and its philosophical aspect, which is a frequently encountered form of the dilemma for the European philosopher described above. On the one hand Zöller justifiably wishes to present as convincing an account of Fichte's ideas as possible; on the other, he seems unsure what to do when he reaches the points where they cease to convince. Fichte is,
for example, forced into the position of admitting that there is no reason a philosopher of freedom can give to a hard-line materialist for accepting his essential Idealist tenets: he basically implies that if one does not understand freedom one cannot be a philosopher at all. This does not necessarily invalidate what Fichte is trying to do. The very attempt to argue for the objective existence of freedom can be seen as self-refuting, and this fact has played a role in various areas of subsequent philosophy, such as the work of Sartre. However, Zöller does not extend his perspective to take in such issues, and, having pointed out the problems, merely moves on to more of Fichte's—admittedly often very intriguing—attempts to legitimate his version of Idealism. This leads Zöller to some acute formulations of key Fichteian ideas and some major corrections to the still too-often encountered received image of Fichte, but it also leads to a feeling that much of what we are told could be gleaned directly from the texts to which the author refers. The text on which much of the later part of the book focuses, the *Wissenschaftslehre nova methodo*, for example, though dense and convoluted, is not wholly impenetrable. What one really needs in relation to Fichte is a developed and consistent attempt to make sense of his more bizarre ideas by moving outside his own terms. How, for example, are we to understand the 'Anstoß', the 'check', which is the effect of the not-I that determines the 'I in a most general, unspecific way to bring about its own determinations' (p. 51)? Zöller here largely just repeats Fichte's own terminology instead of seeking to find new ways of making this vital idea accessible. The initial way to clarify such ideas is, surely, to relate Fichte's arguments to those of other philosophers, including contemporary ones. The ways in which he was understood in his own period are also crucial in this respect: Hegel, Jacobi, Novalis, Schelling, Friedrich Schlegel, and a host of others offer revealing criticisms and elucidations of Fichte's positions, but they are not addressed in Zöller's account. In consequence the book seems just to tail off at the end, leaving one with too little sense of why, if his central ideas were ultimately indefensible, Fichte was such a major figure in modern European thought. It would be wrong to diminish this book's achievement: understanding Fichte is undoubtedly rendered much easier by reading it, and the sense of Fichte's quite remarkable conceptual ability is well conveyed in Zöller's detailed analyses, but the author seems caught in the dilemma of many contemporary philosophers working in the European tradition even where there are strategies available for minimising the effects of that dilemma. A little more attention to Fichte's demand to think for oneself would have made this a more valuable book.

Andrew Bowie