Introduction

Modern physical science has moved a considerable distance from the deterministic materialism of the nineteenth century. Even then, the inclusion of fields (gravitational, magnetic, and electric) complemented the massy, solid atoms in making up the world-picture of physics. But in the twentieth century, science replaced the earlier ontology entirely. Quantum mechanics, the crowning achievement of modern physics, has re-opened ages-old questions about the nature of reality, causation, and the connection between consciousness and the external world. The fundamental ground of modern physics is at the epistemological level – what we can know about physical systems is basic, rather than an ontological account of the world as it ‘really is.’

Materialism itself can no longer be considered the philosophical default position of natural science (Koons and Bealer, eds., 2010). The ‘Principle of Causal Closure,’ the notion that ‘material things are never causally affected by anything non-material (so that, as it is often put, physical science can in principle give a completely adequate explanation of any physical occurrence, without needing to mention anything non-physical)’ is a metaphysical assumption; it is not something that has been or can be established logically or scientifically (BonJour, 2010).¹ For one thing, the mathematical models of natural science are subject to the computability and incompleteness results common to all formal axiomatic systems. More specifically, various impossibility results apply in physics (Barrow, 1998, and the references therein; see also Chaitin, da Costa, and Doria 2012). Even within the deterministic world of Newton and Laplace, sensitivity to initial conditions limits predictability.
Quantum theory itself, despite being the most successful scientific theory yet developed, defies interpretation – that is, while its mathematical apparatus predicts experimental outcomes with remarkable accuracy, the ‘reality’ to which the formalism corresponds is disputed. There are multiple stories purporting to describe what underlies the often counter-intuitive experimental results – wave/particle duality, the role of the observer in bringing about actual outcomes, and the findings that contradict either locality or counterfactual definiteness.\(^2\)

The image of what constitutes science is a matter of some importance for economics. A purely ‘positive’ (to use Milton Friedman’s [1953] terminology) study is only possible if economic behavior – and, hence, also its regularities and laws – can be discovered and examined in a value-free context. However, if the study of human behavior, interactions, and societies must incorporate human freedom of action in an essential way, the game is changed. Exactly what is and is not consistent with modern scientific theories will surely have consequences for what we think about human freedom.

The unresolved quantum ontology

It is remarkable that a century after the discovery of quantum phenomena, and nearly a century after the mathematical formalization of quantum mechanics, there is still no accepted interpretation of the theory. The ontology of the quantum-mechanical world is obscure, and may never be expressible in common-sense terms. Despite being the most successful physical theory in the history of science (in terms of the scope and accuracy of its predictions, and its usefulness in creating technological devices), physicists and philosophers of science still do not agree on what the theory means.

For example, Wikipedia’s (2012a) entry on ‘Interpretations of Quantum Theory’ lists fourteen separate interpretations advanced by distinguished physicists and mathematicians such as Bohr, Born, Heisenberg, de Broglie, Bohm, von Neumann, Everett, Popper, and others whose names are less familiar to the non-specialist world. These interpretations range from the counter-intuitive to the implausible to the downright bizarre; none of them fits easily with our commonplace intuitions about macroscopic objects. The interpretations differ on such fundamental matters as: whether the underlying reality is deterministic or probabilistic (with some interpretations agnostic on this point); whether an observer is required to actualize reality; and whether there is one universe or a ‘multiverse’ that proliferates into new branches every time a quantum