Demystifying the multiverse "The Emergent Multiverse: Quantum Theory according to the Everett Interpretation"

Wilson, Alastair

DOI:
10.1007/s11016-013-9759-5

The Emergent Multiverse: Quantum Theory according to the Everett Interpretation. David Wallace, Oxford University Press, 2012. 530p.

Alastair Wilson[1]

November 16th 2012

Superpositions are the characteristic feature of quantum mechanics. Schrödinger's cat, to take a familiar example, is supposed to be in a superposition of states: one corresponding to being alive, the other corresponding to being dead. This presents a conceptual difficulty: how can a cat be both alive and dead? And it presents an empirical difficulty: when we observe cats, they always appear to be in definite states. The Everettian solution to these problems (introduced by Hugh Everett III in his Princeton doctoral thesis of 1957) is intriguingly simple: macroscopic superpositions are interpreted not as indeterminacy but as multiplicity. Rather than a single cat in an indeterminate state, Everettians recognize multiple cats, each in a determinate state, and multiple observers, each of which observes a cat in a determinate state.

Given the prominence (some would say notoriety) of the Everett interpretation of quantum mechanics in physics, and its enthusiastic reception in popular culture, it is perhaps surprising that there have been no full-length defences of the view in the philosophy of physics literature[2]. David Wallace's hugely impressive new book fills that gap. It's a descendant of his Oxford B.Phil and D.Phil theses, and there is overlap with several of his articles from the last ten years, but

[1] Philosophy, University of Birmingham, Birmingham B15 2TT, UK; Philosophy, Monash University, Victoria 3800, Australia.

[2] *Many Worlds? Everett, Quantum Theory, & Reality*, eds. Simon Saunders, Jonathan Barrett, Adrian Kent, and David Wallace (OUP, 2010) comes closest; but that is an anthology, and it includes a number of critical responses.

even those who have followed Wallace's published work closely will find much here that is new.

There have been several different elaborations of Everettian quantum mechanics; most of them have, for one reason or another, included additional theoretical structure. The notable group of Oxford-based advocates – David Deutsch, Hilary Greaves, Simon Saunders, and Wallace himself – favour a minimalist version of the interpretation, which neither adds to nor tinkers with the basic quantum formalism. While Wallace embraces talk of 'many worlds' and of 'parallel universes', there is no clumsy (and relativistically non-invariant) auxiliary dynamics associated with splitting of worlds to be found here. Nor is there any supernatural ontology, such as the disembodied minds of 'many-minds' approaches to quantum mechanics. Wallace's book provides a canonical formulation and a capable defence of this minimalist Everettianism.

In the first chapter, Wallace's main contention is that Everettian quantum mechanics is just quantum mechanics taken literally; accordingly, all of the (undisputed) predictive and explanatory success of quantum mechanics counts directly as evidence for Everettian quantum mechanics. Wallace argues persuasively that our general reasons for preferring realism to instrumentalism in the philosophy of science carry straight over to quantum mechanics, and that the intuitive weirdness of the Everettian picture provides no good reason for resisting it.

While Everett's is the interpretation most favoured amongst theoretical physicists and cosmologists, philosophers of physics have proven reluctant to embrace it. Aside from objections which turn on its supposed conflict with intuition or on the sheer size of its ontology, resistance to Everettian quantum mechanics has typically focused either on determinacy or on probability. Critics argue that Everettians can give no determinate identity criteria for their many universes (this is sometimes called the 'preferred basis problem'), or they argue that even if a many-worlds ontology were granted, no sense could be made of probability in an Everettian multiverse. Wallace makes a sustained and resourceful attempt to answer these challenges.

Working in the tradition of Saunders and Dieter Zeh, Wallace co-opts the theory of decoherence to solve the determinacy problem. Here his distinctive philosophy of science - ontic structural realism - does much of the interpretive work. Influenced by Dennett, by Saunders and by Ladyman and Ross, Wallace argues that – quite generally – what science discovers is the mathematical structure of reality. Against a background of ontic structural realism, all that Everettians need to show is that a pattern corresponding to multiple distinct worlds can be found that is embedded within (or as Wallace puts it, *instantiated by*) the structure of the universal quantum state. Wallace argues that we can't, in general, see classical mechanics as a limiting case of quantum mechanics. Instead, quantum systems instantiate approximately classical systems within particular domains.

That leaves the probability problem. When faced with this objection, Everettians often protest that a double standard is being applied, that critics of Everettian quantum mechanics are demanding a positive theory of objective probability of a kind which we do not possess in the classical context. Wallace expresses plenty of sympathy with this response. But, developing ideas originally due to Deutsch, Wallace has over the past decade attempted to go further and to derive a positive theory of Everettian probability from decision-theoretic principles. Chapters 4-6 summarize and extend this project, culminating in a unified decision-theoretic treatment of the 'unknown theory problem' involving an agent uncertain of whether Everettian quantum mechanics is correct.

The decision-theoretic approach to Everettian probability has not yet had the impact on the debate that it deserves. Perhaps the sheer complexity of the issues involved has hindered thorough evaluation; philosophers of physics are typically not experts in formal epistemology. Absent a full understanding of the program, there has been a tendency to fall back on more general considerations of the 'no-ought-from-is' form; it is doubted whether such an ambitious program could possibly succeed. Wallace certainly claims dramatic results: no less than a demonstration that any rational agent in an Everettian universe, exposed to the sort of evidence we have for quantum theory, will come to believe in the Everett interpretation and will adopt credences in line with the quantum mod-squared amplitudes (the Born rule).

One central theme of *The Emergent Multiverse* is that many objections to EQM are in fact traditional problems that EQM throws into sharp relief, and which it can even help to resolve. Here the proof of the pudding is in the eating, and Wallace's contributions will be judged by their fruitfulness. But the omens are good. The introduction to the physics of decoherence is the clearest available, and will be invaluable to students and to non-specialists; Wallace develops an interesting variant of decision theory, applicable even to the classical context; and he offers an exciting new approach to the foundations of thermal physics.

A second theme is that, if Everettian quantum mechanics is in fact true, then we don't need to be able to make sense of phenomena like objective probability and the time-asymmetry of thermal physics in the non-quantum context. This suggestion is likely to encounter plenty of resistance. In particular, metaphysicians who think that – even if true – Everettian quantum mechanics is contingent will insist on accounts of probability and of time-asymmetry which do not rely essentially on the details of quantum mechanics. My own sympathies here are with Wallace: if Everettians are right about the physics, then the only acquaintance we have with probability, time-asymmetry, etc. is acquaintance with quantum probability, quantum time-asymmetry, etc. Our apparent ability to make sense of objective probability in classical contexts may be of a piece with our apparent ability to make sense of water which is not H_2O.

The presentation is excellent, with a good index and helpful diagrams of various different types. Particularly nice are the spacetime diagrams illustrating the propagation of decoherence, and the set of flow-charts illustrating the complex relationships between approaches to Everettian probability. Guidance is given to the impatient or non-technical reader regarding which parts can be usefully skipped; there are 60 pages of appendices, containing some more technical material as well as a discussion of classical decision theory. Several entertaining dialogues between the Author and the Critic are also included; readers who struggle with the full technical detail will find these particularly welcome.

Does the book have any weak points? I felt that the treatment of metaphysical issues was often unsatisfying. Wallace is no friend of metaphysics, and

is often sanguine about the meaningfulness of metaphysical questions. He is happy, for example, to endorse indeterminacy in where decoherence breaks down, with corresponding indeterminacy in the distinction between macroscopic and microscopic reality and in the number of worlds: '*there is no such thing as the number of branches*' (p.120: emphasis in original). Here Wallace follows Saunders; but many will hesitate at this point. It is one thing to endorse a huge multiplicity of cats, it is another to endorse with Wallace the existence of indefinitely many cats. Wallace does not engage with metaphysical debates over 'vague identity' and 'ontic vagueness', which might have clarified this aspect of his view.

I have related concerns about Wallace's treatment of the metaphysics of objective probability, and its conceptual relations to uncertainty and determinism. Wallace effectively treats all metaphysical puzzles in the vicinity as problems in the philosophy of language. As he notes, this constitutes a change of heart from the subjective-uncertainty approach he advocated in earlier work. (Oddly, Wallace's discussion of these issues in the context of the 'quantum suicide' problem is hedged and inconclusive, and sits uneasily with the confidence of chapter 6.) In a similar vein, Wallace doesn't take the debate over supersubstantivalism seriously, and he doesn't distinguish carefully between different varieties of reduction and emergence. However, even if metaphysical questions are sometimes neglected in Wallace's physics-oriented treatment, this book will be indispensable to metaphysicians trying to fill in the gaps.

Well-written, wide-ranging, and authoritative, *The Emergent Multiverse* presents a formidable challenge to non-Everettian approaches to quantum mechanics. It is essential reading for anyone interested in philosophy of physics, in formal epistemology or in the metaphysics of modality.