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The Influence of Quantum Physics on Philosophy

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Abstract
We ponder the question whether quantum physics has had any influence on philosophy, and if not, whether it ought to have had any. Answers to these questions are provided, and they turn out to depend on *which* branch of the tree of philosophy we sweep, sway and swing, and even *which* twig of the branch we touch when we sweep, sway and swing.

1 Preamble

Quantum mechanics matured in the 1920s, barging into adulthood with the books of Weyl (1931), Dirac (1931) and Neumann (1932); see Jammer (1966, 1989). That quantum mechanics was more than just another physical theory, became clear comparatively quickly. Bohr's ruminations about 'the epistemological lessons that quantum theory has taught us' have become legendary. Most of the founding fathers of quantum mechanics were sensitive to philosophical consequences of quantum mechanics. They thought about it, talked about it, and wrote about it in letters and papers (see Jammer 1974). A little earlier, Einstein's theories of relativity had also proved to have philosophical consequences. The Relativity Revolution and the Quantum Revolution changed physics fundamentally: modern physics was born. Classical physics had to step aside.

Did these philosophical consequences actually reach philosophy? Has the Quantum Revolution had any influence on philosophy? If it had not had any influence, *should* it have had any influence? These questions are the topic of this paper.

A terminological remark. The term *quantum physics* designates that part of physics where quantum theories and models are used. This includes quantum mechanics, quantum field theories, the standard model of elementary particles and their interactions, quantum solid state physics, quantum cosmology, quantum optics, quantum chemistry, quantum information theory, quantum gravity, and the new kid on the block: quantum biology.

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Since I started in Academia as philosopher of physics about 30 years ago, philosophy of physics is the first thing that comes to my mind when considering the influence of quantum physics on philosophy.

2 Influence of Philosophy of Physics

Philosophy of physics is a young branch of the tree of philosophy. The grandfathers were philosophers of science who fully engaged with modern physics:

> Hans Reichenbach, Adolf Grünbaum (Germany), Hilary Putnam, Howard Stein, Abner Shimony (USA), Mario Bunge (Argentina), Paul Feyerabend (Austria), ⋯

We are talking about the 1950s–1970s. Availing myself to loose generation talk, the next generation of philosophers of physics were philosophers, some of them physicists who became philosophers (1970s onwards):

> Clifford Hooker (Australia), Diederik Aerts (Belgium), Roberto Torretti (Chile), Carl Friedrich von Weizsäcker, Peter Mittelstaedt (Germany), Bernard d'Espagnat, Jean-Marc Lévy-Leblond (France), Franco Selleri, Gino Tarozzi, Enrico Beltrametti, Maria Dalla Chiara, Gian Carlo Ghirardi (Italy), Max Jammer (Israel), Jan Hilgevoord, Dennis Dieks (The Netherlands), Michael Redhead (UK), John Earman, Arthur Fine, John Norton, Lawrence Sklar, David Malament, Jeffrey Bub, James Cushing, Bas van Fraassen, Paul Teller, Gordon Fleming (USA), ⋯

Most of them retired, some of them have passed away. The third generation (1980s onwards) includes:

> Michel Ghins (Belgium), Steve Savitt (Canada), Michel Bitbol (France), Brigitte Falkenburg, Paul Busch (Germany), Miklós Redei, Lásló Szabó (Hungary), Jos Uffink (The Netherlands), Julian Barbour, Simon Saunders, Steven French Jeremy Butterfield, Harvey Brown (UK), Jon Dorling (UK-The Netherlands) Richard Healey (UK-USA), Rob Clifton (Canada-USA), David Albert, Don Howard, Tim Maudlin, Robert Rynasiewicz, Robert Weingard (USA) ⋯

Most of them have supervisors from the previous generation and have now retired or are approaching retirement. Today philosophers of physics have populated the Earth (some of them have left the branch, between fresh post-docs and approaching retirement, 1990s onwards):

> Pablo Acuña, Emily Adlam, Alexander Afriat, Valia Allori, Frank Arntzenius, Aristidis Arageorgis, David Atkinson, Guido Bacciagaluppi, Jonathan Bain, David Baker, Yuri Balashov, Jeffrey Barrett, Thomas Barrett, Robert Batterman, Gordon Belot, Jossi Berkovitz, Thomas Bigaj, Soazig Le Bihan, Robert Bishop, Alisa Bokulich, Katherine Brading, Tim Budden, Craig Callender, Claudio Calosi, Elena Castellani, Adam Caulton, Karen Crowther, Michael Cuffaro, Erik Curiel, Radin Dardashti, Richard Dawid, Talal Debs, Neil Dewar, Michael Dickson, Julius Doboszewski, Mauro Dorato, Armond Duwell, Mathias Egg, Michael Esfeld, Vincenzo Fano, Sam Fletcher, Doreen Fraser, Simon Friedrich, Roman Frigg, Matthias Frisch, Chris Fuchs, Roberto Giuntini, Alexei Grinbaum, Alexandre Guay, Hans Halvorson, Amit Hagar, Sebastian de Haro, Stefan Hartmann, Meir Hemmo, Leah Henderson, Ronnie Hermens, Guy Hetzroni, Carl Hoefer, Mark Hogarth,

Nick Huggett, Alexander Hütteman, Jenann Ismael, Vassilios Karakostas, Ruth Kastner, Eleanor Knox, Fred Kronz, James Ladyman, Vincent Lam, Marc Lange, Federico Laudisa, Dennis Lehmkuhl, Matt Leifer, Peter Lewis, Olimpia Lombardi, Janneke van Lith, Holger Lyre, John Manchak, Michela Massimi, James Mattingly, Owen Maroney, Casey McCoy, Gordon McCabe, Kerry McKenzie, Matteo Morganti, Margaret Morrison, Wayne Myrvold, Thomas Müller, Jill North, Antigone Nounou, Thomas Pashby, Kent Peacock, Slobodan Perovic, Itamar Pitowsky, Brian Pitts, Tomasz Placek, Oliver Pooley, Huw Price, James Read, Henk de Regt, Katinka Ridderbos, Dean Rickles, Bryan Roberts, Katie Robertson, Joshua Rosaler, Thomas Ryckman, Laura Ruetsche, Juha Saatsi, Chris Smeenk, Michael Stölzner, Ward Struyve, Mauricio Suárez, Michiel Seevinck, Orly Shenker, Sheldon Smith, Adán Sus, Nicolas Teh, Karim Thébault, Chris Timpson, Giovanni Valente, Antony Valentini, Pieter Vermaas, Peter Vickers, David Wallace, Jim Weatherall, Steven Weinstein, Charlotte Werndl, Chris Wüthrich, Nino Zanghí, Henrik Zinkernagel, Lena Zuchowski, ⋯

I have not strifed for completeness in listing these philosophers of physics: I am just bowing my head sideways and all these names pour out, surprisingly in alphabetical order (I have seen or talked to nearly every single one of them; I have not included PhDs; I should have included myself but I didn't; and embarrassing omisions will exist). The global community of philosophers of physics I estimate between 100 and 250 people—this is in the order of magnitude of one millionth % of the world's population: how many philosophers of physics does the world need?

Then there are physicists and mathematical physicists who publish, occasionally or frequently, in the field of philosophy of physics, such as Sean Carroll, Lucien Hardy, Adrian Kent, Klaas Landsman, Tony Leggett, Roger Penrose, Carlo Rovelli, Henry Stapp, Tony Sudberry, Yogi Aharonov and Lev Vaidman.

The grandfathers published their papers mostly in philosophy of science journals, e.g. *Philosophy of Science*, *The British Journal for the Philosophy of Science*, *Studies in the History and Philosophy of Science*, in general philosophy journals, such as *Synthese*, *Journal of Philosophy*, and *Erkenntnis*, and in conference volumes, e.g. the marvellous Minnesota series in philosophy of science. *Foundations of Physics* and the short-lived *Physics Essays* published philosophy of physics papers. In 1995, *Studies in the History and Philosophy of Modern Physics* was born, as an off-spring of *Studies in the History and Philosophy of Science*. Conferences, workshops and PhD theses devoted to philosophy of physics became routine. During the past decades, summer schools devoted to philosophy of physics have been organised. Philosophy of physics seems here to stay.

As happens with a burgeoning branch in academia, branching has set in. We can discern roughly four sub-branches of philosophy of physics:

- Quantum Physics (quantum mechanics, quantum field theory).
- Spacetime and Cosmology (classical mechanics, two theories of relativity).
- Statistical Physics and Thermodynamics.
- Quantum Gravity and String Theory.

The grandfathers as well as the next generation were mainly interested in the first two sub-branches. The last two arose later, in the order mentioned above. The attention to speculative physics, e.g. quantum gravity and string theory, is the most recently grown sub-branch. Yet still today, as a glance at the Pittsburgh Archive for the Philosophy of Science suggests, quantum physics attracts by far the most philosophical attention. On 18 July 2020, the Pittsburgh Archive held 2882 philosophy of physics items, categorised as follows:

1. Quantum Theories: 1673 = 1301 (Quantum Mechanics) + 372 (Quantum Field Theory).
2. Relativity Theory: 756.
3. Statistical Mechanics and Thermodynamics: 303.
4. Fields and Particles: 289.
5. Classical Physics: 359.
6. Symmetry and Invariance: 358.
7. Cosmology: 257.
8. Quantum Gravity: 159.
9. Condensed Matter: 50.
10. Astrophysics: 11.

Admittedly, various papers are counted more than once: 4215 is the sum of the numbers above, not 2882. But many if not most papers classified under ‘Particles and Fields’, ‘Symmetry and Invariance’ and ‘Condensed Matter Physics’ concern quantum theories. So when correcting for these two considerations, we arguably shall still reach the conclusion that quantum theories form the biggest sub-branch of philosophy of physics (at least 60%). To assert that quantum physics has influenced philosophy of physics is a platitude, quantum physics has been and still is constitutive of philosophy of physics.

To conclude: being constitutive of a growing and blossoming new branch at the tree of philosophy, how much more influential on the tree of philosophy can you get?

3 Influence on Philosophy

The most obvious way to take the question whether quantum physics (quantum mechanics, quantum field theory) has had any influence on philosophy generally is whether it has had any influence on discussions about prominent questions addressed in philosophy of the Twentieth century. We can safely shove Continental Philosophy aside: the influence of quantum physics on the writings of Merleau-Ponty, Heidegger, Sartre, Baudrillard, Derrida, Foucault, Sloterdijk, Deleuze, Zizek, Badiou, Lacan, Lyotard, Laruelle, Kristeva, etc. is epsilonically small if not zero—exceptions I am aware of is some of the work of Bitbol (2020), who trades between Analytic and Continental Philosophy, and the same holds for Cassirer (1937). Concerning Analytic Philosophy, we can take heed of the results of the Philosophical Papers Survey, conducted by David Chalmers and David Bourget (2014; an update and extension is in the making). They asked opinons about 30 controversial issues in philosophy and obtained 3226 responses:

1. A priori knowledge: yes or no?
2. Abstract objects: Platonism or nominalism?
3. Aesthetic value: objective or subjective?
4. Analytic–synthetic distinction: yes or no?
5. Epistemic justification: internalism or externalism?
6. External world: idealism, skepticism, or non-skeptical realism?
7. Free will: compatibilism, libertarianism, or no free will?

8. God: theism or atheism?
9. Knowledge: empiricism or rationalism?
10. Knowledge claims: contextualism, relativism, or invariantism?
11. Laws of nature: Humean or non-Humean?
12. Logic: classical or non-classical?
13. Mental content: internalism or externalism?
14. Meta-ethics: moral realism or moral anti-realism?
15. Metaphilosophy: naturalism or non-naturalism?
16. Mind: physicalism or non-physicalism?
17. Moral judgment: cognitivism or non-cognitivism?
18. Moral motivation: internalism or externalism?
19. Newcomb's problem: one box or two boxes?
20. Normative ethics: deontology, consequentialism, or virtue ethics?
21. Perceptual experience: disjunctivism, qualia theory, representationalism, or sense-datum theory?
22. Personal identity: biological view, psychological view, or further-fact view?
23. Politics: communitarianism, egalitarianism, or libertarianism?
24. Proper names: Fregean or Millian?
25. Science: scientific realism or scientific anti-realism?
26. Teletransporter (new matter): survival or death?
27. Time: A- or B-theory?
28. Trolley problem (five straight ahead, one on side track, turn requires switching, what ought one do?): switch or don't switch?
29. Truth: correspondence, deflationary, or epistemic?
30. Zombies: inconceivable, conceivable but not metaphysically possible, or metaphysically possible?

Quantum physics had no discernible influence on any of these debates, full stop. Should it have influenced these debates? For most issues, I don't see what it could have contributed or how it should contribute. There are *possible* exceptions. In the next Sections, we shall next take a look at specific branches at the tree of philosophy, where some of the issues of the Chalmers-Bourget list will return.

4 Influence on Philosophy of Mind

The widely adumbrated and conceptually almost vacuous supervenience thesis (see below) suggests that quantum physics should connect with philosophy of mind. After all, quantum mechanics and quantum field theories are our best scientific theories of matter, and the supervience thesis is about the relation between matter and mind: it claims that the correlations between brain states and mental states imply that *different* mental states are correlated to *different* brain states. None other than David Chalmers had a Chapter on the many-worlds interpretation of quantum mechanics, in his landmark treatise *The Conscious Mind* (1996). Yet a glance at any companion and anthology in the philosophy of mind testifies to the absence of any influence of quantum physics.

Should it have any influence? The brain is a macroscopic physical system, according to physics. The only part of quantum physics relevant for it might be condensed matter quantum mechanics. But the brain is no neatly arrayed lattice of atoms of a single type (which is the starting point in nearly every quantum-mechanical model of matter in the solid state), but an extremely complicated and composite physical system with many types of atoms and molecules, forming neurons having dendrites and axons, chemically and electrically interacting all the time, overall in a solid state but having trillions of parts in a liquid state, which makes the brain far too complex for any feasible quantum-mechanical model. Roger Penrose (1989, p. 400) is one of the very few who has not closed down the road to quantum physics when it comes to understanding of the brain: "One might speculate, however, that somewhere deep in the brain, cells are to be found of single quantum sensitivity. If this proves to be the case, then quantum mechanics will be significantly involved in brain activity." Might speculate. Yet the idea has now been touched by the magic Nobel wand, and in *Star Trek Picard*, I saw someone having a PhD in quantumconsciousness: who knows what the future has in store for us?

So quantum mechanics has had nothing to say about the brain, despite first appearances and some speculations otherwise notwithstanding. This is why quantum mechanics justifiably is absent from philosophy of mind. Please don't be alarmed that a Google-search the www for 'quantum consciousness' yields almost 21 million hits—a search for 'little green men' yields 300 million hits (on 23 October 2020).

The idea of Von Neumann and Wigner to invoke consciousness to solve the reality problem of quantum mechanics, a.k.a. the measurement problem, which according to Wigner put an end to 'materialism' (reduction of mind to matter, in a nutshell), has had no influence on developments of, and debates in, the philosophy of mind. The Berkeley physicist Henry Stapp (2009) belongs to the very few still pursuing this line. It shouldn't have had either; for sympathetic reviews of these issues, see Butterfield (1998) and the Lemma 'Quantum Approaches Consciousness' of the Stanford Encyclopedia of Philosophy.

5 Influence on Logic

Since 1936, when Birkhoff & Von Neumann (1936) published their seminal paper on quantum logic, suggesting that quantum mechanics fitted a logic different from standard classical logic better, quantum propositional logic has often been referred to as opening up the possibility of the synthetic and *a posteriori* character of logic, rather than analytic and *a priori* (Putnam 1971). During the 1960s and 1970s, Hilary Putnam used quantum propositional logic explicitly to defend the *empirical* character of logic, i.e. as being synthetic and a posteriori; and Putnam intrepidly trotted further by claiming that adopting quantum logic would dissolve various, if not all, interpretation problems of quantum mechanics, in such a way that *realism* about quantum mechanics could be upheld after all, *contra* Copenhagen. This has not ended well for Putnam, who had to face a collection of stamping critics, among which McGrath (1971), Stairs (1983), Bacciagaluppi (1993), Redhead (1994), and a caustic Maudlin (2005). Putnam (2005, p. 625) has admitted this frankly. Charitably speaking, the best quantum logic can achieve is to block the deductive road to *some* paradoxical answers to questions evoked by quantum mechanics. The central problems of interpretation of quantum mechanics (reality problem, locality problem, completeness problem) can however not be solved or dissolved by replacing classical logic with quantum logic. Consequently, philosophers have lost interest in quantum logic.

The interest of Birkhoff & Von Neumann resided in the structure of the lattice of projectors on Hilbert-space, which projectors were connected to so-called *experimental propositions*, used to report measurement-outcomes—as Von Neumann had already obeserved in his *Grundlagen* (1932). The quantum propositional logic that seemed to emerge, however, lacked both a conditional and a consequence relation; and a natural extension to predicate logic was not in sight. These last-mentioned features were *au fond* the reason why quantum logic has not been taken seriously by logicians (the central business of Logic being: what follows from what, and how). Only algebraists interested in lattice theory payed attention to it—small wonder that Birkhoff (1940) inaugurated lattice theory officially with the very first monograph on the subject, with a title that leaves no room for misinterpretation what the monograph is about: *Lattice Theory*. Thus via quantum logic, quantum mechanics has had little if any influence on (the development of) logic in the Twentieth century.

Nonetheless serious attempts have been made to extend Birkhoff & Von Neumann's work to a full-blown deductive system, with a conditional and a consequence relation. The classic two-volume anthology Hooker (1975) bears testimony to the interest in quantum logic. More recent, Nishimura (1994) proposed proof theory for quantum logic, and Elgy and Tompits (1999) Gentzen-like methods (see further Giuntini et al. 2004; Engesser et al. 2009). We also would like to mention Baltag and Smets (2005) on 'quantum actions'. Finally worth to mention is Landsman's employment of topos theory to provide a new mathematical characterisation of quantum mechanics with Copenhagen overtones ('Bohrification'), which mathematical structure generates nothing less than an *intuitionistic quantum logic* (see Landsman's (2017a) tome of nearly 900 pages, Chapter 12).

Quantum logic has never died, its philosophical interest has died, almost.

6 Influence on Metaphysics

The notorious interpretation problems of quantum mechanics are philosophical problems: more specifically, metaphysical problems (see Muller 2015). The reality problem of quantum mechanics resides in metaphysical territory. The growing interest in Analytic Philosophy in metaphysics since the 1960s , a.k.a. analytic metaphysics, had nothing to do with quantum mechanics and its philosophical problems—but more with the decline of logical positivism and the rise of realism in phlosophy of science. In *Every Thing Must Go* (2011), Ladyman and Ross ferociously criticised the lack of influence of scientific achievements generally on analytic metaphysics:

> The result has been the rise to dominance of projects in analytic metaphysics that have almost nothing to do with (actual) science. Hence there are now, once again, esoteric debates about substance, universals, identity, time, properties, and so on, which make little or no reference to science, and worse, which seem to presuppose that science must be irrelevant to their resolution. They are based on prioritizing armchair intuitions about the nature of the universe over scientific discoveries.

Ladyman and Ross proclaim naturalising metaphysics, just as Quine had proclaimed naturalising epistemology, which boiled down to replacing it with cognitive psychology, clouded in vapor mumbling that philosophy 'is continuous' with science. Resounding echoes of logical positivism to be sure. "Philosophy of science is philosophy enough", Quine quipped. On behalf of Ladyman and Ross, one could say: philosophy of physics is metaphysics enough. In recent decades, various philosophers, analytic metaphysicists and philosophers of science, have engaged in naturalised metaphysics. The annual conferences of the Society for the Metaphysics of Science in the USA (since 2016) are tokens of it; for literature, see for example Schrenk (2017). Ironically, because the endeavour to interpret quantum mechanics has lived in metaphysical territory since its inception, it has been a piece of very naturalised metaphysics, and therefore the call to naturalise metaphysics is partly an invitation to analytic metaphysicists *to acknowledge* this very fact.

Some exceptions include Wilson (2020), who relates the nature of contingency to Everett's interpretation of quantum mechanics, Pashby (2013, 2016) on persistence and temporal parts, Maudlin (1998) on mereology and quantum mechanics; see also Maudlin (2010) and Morganti (2020) for serious interaction between metaphysics and philosophy of physics.

There remain issues in analytic metaphysics that seem beyond naturalising, such as whether abstract objects exist, 'absolute generality' is a coherent concept, and all logically possible worlds exist (*pace* DeWittified Everett). Ladyman and Ross proposed that we should stop thinking about these issues, where no progress has been made and can be made: a hopeless waste of brain power, which could be employed for so many better things in life.

All in all, on the one hand, the endeavour to interpret quantum mechanics has been metaphysical in nature from its inception, and therefore quantum mechanics did have an influence on metaphysics, but its influence was restricted to feeding philosophy of physics. On the other hand, analytic metaphysics has proceeded without any influence by quantum mechanics until recently, with the advent of naturalised metaphysics and 'the metaphysics of science' movement. Whether quantum mechanics *ought* to have more influence in metaphysics: *that* depends on the metaphysical issue at hand. Even if you cherish a modest ambition for metaphysics, such as Lowe's (1998) ambition of erecting and analysing a framework of general concepts that are used and presupposed by *all* scientific disciplines, from physics to history and from biology to sociology, and therefore needs to be *independent of* the specific contents of the achievements in all those disciplines, then an occasional serious look at science, in particular at quantum physics, is needed to ensure that the erected and analysed framework of general concepts will cover the achievements of quantum physics too.

7 Influence on Ethics

When we subsume the issue of free will in Ethics, then some might think that quantum mechanics bears on this very issue in the light of 'The Free Will Theorem', by Conway and Kochen (2006), which claims that quantum mechanics ensures that we have free will. An enduring debate since Augustine of Hippo (Fifth Century) scratched his head about Predestination and the Lord's imperative to lead a moral life in order to go to Heaven, has been finally decided, after Fifteenth centuries, by quantum mechanics?

The theorem of Conway and Kochen, which is just another version of Bell's celebrated theorem, essentially proves that, for the entangled two-particle system in the usual Bell set-up, a local deterministic model plus the assumption that Alice an Bob are free to set their spin-measurement apparatus in any direction they want to is incompatible with quantum mechanics. Landsman (2017b) has argued that the notion of free will surreptitiously employed by Conway and Kochen is Lewis' 'local miracle compatibilism', so that in Landsman's view, the 'Free Will Theorem' "challenges compatibilist free will à la Lewis (albeit in a contrived way via bipartite EPR-type experiments), falling short of supporting libertarian free will." If and when this claim remains standing, we can expect some influence of quantum mechanics on the free will issue in Ethics. But for now, we must conclude that quantum physics has had no influence on the free will debate. Again, consult any recent companion or anthology on free will: quantum mechanics is absent.

Another intrusion of Ethics in the philosophical discourse about quantum mechanics worth mentioning is Lewis' (2004) rejection of the many-world interpretation of quantum mechanics on ethical grounds. For this interpretation makes one accept the existence of an infinity of worlds with each world having numerous counterparts of some or several human beings on counterpart Earth suffering intensely (due to low but non-zero probabilities of terrible events happening). Such an infinite increase in suffering no one ought to accept. So Ethics has had *some* influence on the philosophical discourse on quantum physics. In recent years, ethical considerations have become more vocal in discussions about the Everett interpretation of quantum mechanics.

Finally, worthy of mention is Ismael's book *How physics makes us free* (2016), a panegyric on compatibilism which mostly concerns classical physics.

8 Influence on Philosophy of Science

After the great debates in general philosophy of science about the scientific method and the rationality of science in mid-twentieth century (Kuhn, Popper, Feyerabend, Lakatos, Laudan), philosophy of science grew new sub-branches, notably philosophy of physics, of biology, and of economics. Quantum mechanics did have some influence on the realism debate. As an illustration of the under-determination thesis, quantum mechanics is second to none: it has empirically equivalent rivals in the De Broglie-Bohm theory and the theory of Ghirardi, Rimini and Weber. On top of this, the many interpretations of quantum mechanics are a thorn in the realist's flesh: if the aim of science is to provide, by means of its theories and models, a literally true description of reality, then the part of reality that quantum mechanics is about seems out of the reach of science. Rather than conclude that quantum mechanics makes science fail, perhaps it would be better to have a view of science that sets aims for science that can be reached and have been reached, also by quantum mechanics. So quantum mechanics has been invoked in the realism debate in philosophy of science, and rarely has it been to strenghten the realist's case, as Van Fraassen's book on quantum mechanics bears witness (1991).

Van Fraassen's (1970, 1972) state-space version of the semantic view on scientific theories was inspired by Beth's application of logical semantics to quantum theory and by quantum logic, which shows an indirect influence of quantum physics on philosophy of science.

Last but not least, I want write down some snarky sentences about Healey's recent book *The Quantum Revolution in Philosophy* (2017). The title suggests that nothing less than a revolution has taken place in philosophy, due to quantum mechanics. Say *what*?! Most of the topics Healey treats belong to philosophy of science (theories, models, representation, probability, explanation, objectivity), and some of them belong to metaphysics (causation, fundamentality). Healey claims that quantum mechanics has changed 'our' view of the topics mentioned above between brackets. On closer inspection, and careful reading, what the claim boils down to is that not quantum mechanics, but that quantum mechanics *plus Healey's pragmatist interpretation* has motivated *Healey* to adopt new views on the mentioned philosophical issues. Well, as soon as a substantial majority of philosophers subscribes to Healey's pragmatist views, we can welcome Healey as the prophet of a revolution in philosophy. *Hail Healey!* Which presumably will not happen. That quantum mechanics has influenced the philosophical views of Healey shows that quantum physics *stricto sensu* has influenced philosophy, because Healey is a philosopher. Presumably there will be others like him, in this regard, in particular philosophers of physics when they engage with general philosophy of science. But that's about it.

9 Recapitulation

Although quantum physics has influenced philosophy in the sense that it has grown a new flourishing and blossoming branch of the tree of philosophy, apart from some recent contact between philosophy of physics and metaphysics, quantum physics has had hardly any influence on philosophy at all, and at best *some* influence on metaphysics, mostly in recent times. With regard to prominent issues intensely thought about by philosophers, such as those on the Chalmers–Bouget list, we dare conclude that it is difficult to see how quantum physics could bear on those issues. If it cannot, it ought not, for ought implies can.

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