World without World: Observer-Dependent Physics

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> We have found a strange footprint on the shores of the unknown. We have devised profound theories, one after another, to account for its origins. At last, we have succeeded in reconstructing the creature that made the footprint. And lo! It is our own.
> Arthur Eddington, 1921.
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> Physics is to be regarded not so much as the study of something a priori given, but as the development of methods for ordering and surveying human experience.
> Niels Bohr, 1961.
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> The brain is small. The universe is large. In what way, if any, is it, the observed, affected by man, the observer? Is the universe deprived of all meaningful existence in the absence of mind? Is it governed in its structure by the requirement that it gives birth to life and consciousness? Or is man merely an unimportant speck of dust in a remote corner of space? In brief, are life and mind irrelevant to the structure of the universe - or are they central to it?
> John Wheeler, 1975.

How can mindless mathematical laws give rise to aims and intention? How can purpose in the universe emerge when there is no purpose at a fundamental level: what do quarks know about it? How is it that the (free) mind can exist in a purely material universe governed by rigid laws of nature? The mind and its goals and purposes are surely subjective while the world is objective. The inanimate world surely has no such thing as goals...

Our question contains two very obvious assumptions: (1) the idea that mathematical laws are indeed mindless; (2) the idea that there are indeed such things in the world as 'aims' and 'intentions'. This essay focuses on assumption (1). There is a long and venerable history, going back at least to Kant, of the view that the regularities and structure we find in the world of physics (laws) correspond to what the mind has itself imposed: we are engaged (to some extent: the degree leading to varying strengths of idealism) in a form of self-study when we study the laws of nature. There have been several subsequent versions of this idea with their roots in physics. What each involves is the view that the laws of physics (and possibly many other features of our scientific representations of the world) are heavily laden with materials from the humans devising such representations and laws. The structure of the universe, on such views, is intimately connected with our own existence.

Our answer to the question, then, is to deny assumption (1): mathematical laws are *not* mindless but are instead infused with features of our cognitive framework.[1] This seems initially shocking. But on closer inspection the shock should be done away with: unless we suppose some kind of mind/matter dualism, we should fully expect the mind to be bound up with worldly things, just as much as worldly things find themselves bound up with the mind. As Schrödinger puts it, to suppose that there is a division between mind and world such that there exists an interaction between them smells of something "magical" or "ghostly" ([5], p. 63). The initial question puts the explanatory cart before the horse. We should be asking how can the mind generate and/or be implicated in laws that appear on the surface to be so mindless.

One can readily speculate about evolutionary accounts involving pattern-finding and the abstraction of invariances from a jumble of data so as to minimize energy and stay alive: it is a very useful thing to be able to predict events that have yet to take place, but we only need to keep track and predict some features of the environment. Indeed, we don't need to be scientists to engage in this kind of behaviour. Even rats do it quite naturally: by training, a rat can *predict* that some stimulus will lead to a reward and so will have discovered a primitive 'law of nature' in its own limited universe. Of course, the question remains: how is it that this is possible in the first place? Ernst Cassirer suggests a way:

[1] As regards assumption (2), I think Sean Carroll ([1], pp. 294-5) rather effectively shows that the notion of 'wants' and 'intention' is really just as *façon de parler*: there are simply situations in which it is more useful than not to describe things in terms of something wanting another thing.

> The fleeting, unique observation is more and more forced to the back-ground; only the "typical" experiences are to be retained, such as recur in a permanent manner, and under conditions that can be universally formulated and established. When science undertakes to shape the given and deduce it from definite principles, it must set aside the original relation of *coordination* of all the data of experience, and substitute a relation of superordination and subordination. ([2], p. 272)

And later: "We finally call objective those elements of experience, which persist through all change in the here and now, and on which rests the unchangeable character of experience" (ibid., p. 273). Hence, the division into 'objective' and 'subjective' is central to why the question of 'mindless mathematical laws giving rise to mindful behaviour' feels so natural. This division basically bundles a whole bunch of properties thought to be on the side of science (permanence, reality, concrete, physical, etc.) with 'the objective', and a whole bunch thought to be anti-scientific (spiritual, mental, varying, abstract, etc) with 'the subjective'.

The problem is, with every scientific experiment there is always a pair of poles, the observer and the observed; the experiencer and the experienced. To cut out one or the other, by saying that laws are only ever 'objective,' leaves an incomplete world. Moreover, the bundling up of the previous properties into objectivity pushes us almost by necessity to feel as if we must eradicate subjects (agents, observers, experiencers) from science and laws. Schrödinger again:

> The scientist subconsciously, almost inadvertently, simplifies his problem of understanding Nature by disregarding or cutting out of the picture to be considered, himself, his own personality, the subject of cognizance. Inadvertently the thinker steps back into the role of an external observer. This facilitates the task [of science] very much. But it leaves gaps, enormous lacunae, leads to paradoxes and antinomies whenever, unaware of this initial renunciation, one tries to find oneself in the picture or to put oneself, one's own thinking and sensing mind, back into the picture. This momentous step—cutting out oneself, stepping back into the position of an observer who has nothing to do with the whole performance—has received other names, making it appear

> quite harmless, natural, inevitable. It might be called objectivation, looking upon the world as an object. The moment you do that, you have virtually ruled yourself out. ([4], pp. 92–93)

Hence, physical reality is deemed tantamount to independence from some arbitrary observer. Inasmuch as one can relate these arbitrary observers to the objective realm, one must 'average over' them in some sense, or take the equivalence class of their perspectives (as one does to get the notion of a 'geometry' from metrics related by diffeomorphisms in general relativity). However, the presence of the observer makes its presence felt at some level since it is still the frames of reference that are being bundled into the equivalence class.

Arthur Eddington famously developed a quasi-idealist worldview in which much of what we might naturally think of as 'the stuff of the world' is 'spiritual' (what we would now call 'mental'). The *physical universe*, as described by the physical sciences and running according to physical laws, is not equivalent to *objective reality*. Instead, Eddington argued for what he called 'subjective realism,' a position that enabled him (in his mind) to deduce the laws of nature and the values of the fundamental constants they involve purely from his armchair (through the study of the basic principles of observation and measurement). In other words, the laws that we often suppose to be entirely mindless and free from any kind of human influence (e.g. subjectivity), are in fact products of the mind:

> An intelligence, unacquainted with our universe, but acquainted with the system of thought by which the human mind interprets to itself the content of its sensory experience, should be able to attain all the knowledge of physics that we have attained by experiment. [2, p. 3]

At this simplistic level, the position sounds rather absurd, and it certainly received its share (often justified) of criticism.[2] To modern ears any denial of the primacy of empirical methods for learning about the construction of the world is met with an incredulous stare—it precisely contravenes the objectivity mentioned earlier. However, it is important to note that this is not

[2]The main thrust of the criticisms were directed at Eddington's claims to have deduced the fundamental constants (the fine structure constant in particular) by examining the methods of observation rather than the world being observed.

idealism in the orthodox sense of, e.g., Bishop Berkeley: there are *particular facts* about the world too, and these must be derived from experience.[3] More importantly, the subjectivism is not taken too far: there are overlapping aspects of the world in multiple subject's consciousness that are grounded in an external world that itself is not part of the content of any observer's mind. Facts about the distance to Mars cannot be deduced from pure reason. But claims about possibility and necessity (e.g. of what processes can and cannot occur) are the stuff of minds.

Eddington had his own criticism of current science which he thought was far more 'mystical' than his own ideas. For example, unlike in earlier times where clockwork and engineering with the dominant paradigms for scientific credibility ('the tyranny of the engineer'), modern physics is beholden to more abstract ideals ('the tyranny of the mathematician'). It is possible that this use of mathematics imposes 'blinkers' on the view of the world more so than those earlier physicalistic models. The success of the mathematical approach according to Eddington stems primarily from the fact that this approach gets to set the terms of its own success: a numerical test.[4] There's objectivity in numbers for sure, but the kinds of mathematics we choose to use is still a reflection of features of observers.

If this stretches incredulity too far, let us consider a modern version of what is in many respects a similar position: Wheeler's 'It From Bit' and the related notion of existence as a 'self-excited circuit'. Whereas Eddington was inspired to his more subjectivist physics by general relativity, Wheeler was pushed there by quantum mechanics, especially his own delayed-choice experiment which shows that experimenters (agents) can decide, after the event, whether a photon was in two places or one in the context of a double-slit type experiment.[5]

[3]The position he espoused is known as 'Selective subjectivism'. As he puts it, this "the modern scientific philosophy, has little affinity with Berkeleian subjectivism, which, if I understand it correctly, denies all objectivity to the external world. In our view the physical universe is neither wholly subjective nor wholly objective—nor a simple mixture of subjective and objective entities or attributes" (*The Philosophy of Physical Science*, 1938, Cambridge University Press, p. 27).

[4]Eddington was pushed to this viewpoint by the changes brought about by general relativity. His final work, *Fundamental Theory*, explicitly distinguished between observables and unobservables, with the former being those quantities that can be ascertained by a measurement procedure, and the latter not thus capable because they contain mathematical baggage (they include an auxiliary mathematical component that cannot be observed).

[5]Wheeler called himself a "radical conservative'. It's no surpirse that Eddington's

> 'It from bit' symbolizes the idea that every item of the physical world has at bottom—at a very deep bottom, in most instances—an immaterial source and explanation; that what we call reality arises in the last analysis from the posing of yes-no questions and the registering of equipment-evoked responses; in short, that all things physical are information-theoretic in origin and this is a participatory universe. [[6], p. 5]

The observer participates in the defining of reality (see fig. 1). In many ways this inclusion of the observer as an active player in the development of the universe is somewhat like the inclusion of spacetime geometry. It extends background independence.

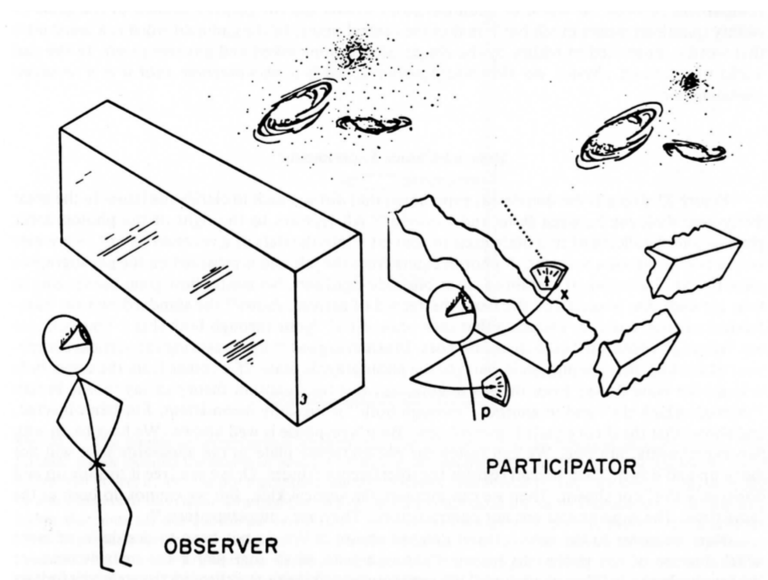

Figure 1: A Wheelerian participant: active in the universe, unlike a classical observer. [Source: J. Wheeler, "Beyond the Black Hole", in H. Wolf. (ed.), *Some Strangeness in Proportion*, 1980, Reading, MA: Addison-Wesley, p. 355].

Wheeler takes this observer involvement to extremes as can be seen in another neat little picture (a 'self-excited circuit', fig. 2). This picture refers to the

longterm student and friend Peter Putnam was obsessively interested in Eddington's philosophical scheme. I don't doubt that Putnam influenced Wheeler's it from bit through his discussions of Eddington.

fact that, in quantum theory at least, our observations determine the very reality we are studying (by choosing which experimental questions to put to nature), so that we are in effect studying aspects ourselves when we examine the quantum world. This can even be extended to observations way into our own past (before there were observers: *very* delayed choice experiments). In this case, we bring about our universe, lifting it into existence by its bootstraps. Not only are laws not mindless, minds (or observers) are at the root of their very existence and the arena in which they operate.

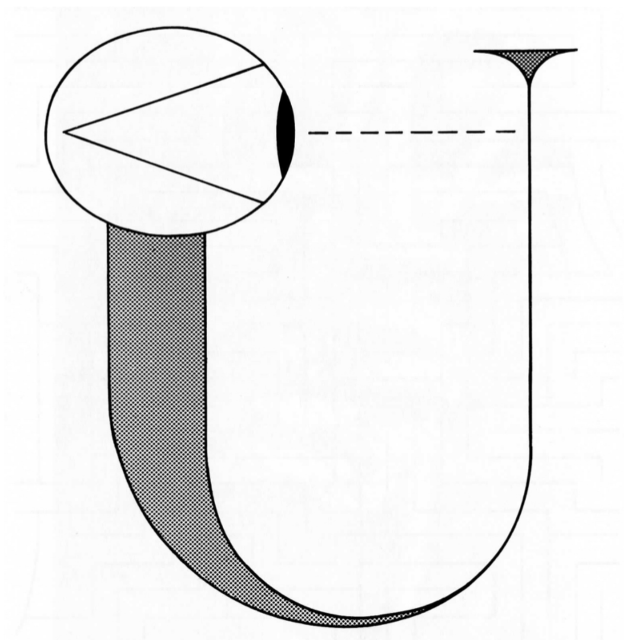

Figure 2: The self-excited circuit of John Wheeler, representing the idea that the universe 'bootstraps' itself into existence by observing itself, thus creating 'phenomena'. [Source: J. Wheeler, "Beyond the Black Hole", in H. Wolf. (ed.), *Some Strangeness in Proportion*, 1980, Reading, MA: Addison-Wesley, p. 362].

Like Eddington's selective subjectivism, this is an epistemological theory that explicitly incorporates 'observer-selection effects' (the idea that in some sense our presence as observers influences *what* we observe). It is thus deeply anthropic. But it is also intended to be ontological: what there is (the world itself) is built up from the specific yes/no questions observers put to Nature.

What *is* is what *happened*. And what happened is guided to a certain extent by the experimenter.[6] This general participatory scheme has been fleshed out in the form of a novel interpretation of quantum mechanics: QBism.

> QBism says that when an agent reaches out and touches a quantum system—when he performs a quantum measurement—that process gives rise to birth in a nearly literal sense. With the action of the agent upon the system, something new comes into the world that wasn't there previously: It is the "outcome," the unpredictable consequence for the very agent who took the action. ([3], p. 8)

As the architects of QBism make clear, Wheelerian participatory principles are at the root of this approach. It introduces subjectivist elements by simply treating probability via a Bayesian framework rather than some objectivist framework.

The orthodoxy amongst scientists (especially physicists) is that the universe is a purposeless block. It just *is*. The goal of the scientist is to uncover its invariant features, its laws. But where does the scientist's goal come from if the very universe they are studying, in which they are also embedded, is supposed to possess nothing of the sort? The scientist will quickly respond that it (their very own goal) is merely illusory: their aims and dreams are simply the stuff of physics too, and as such are determined by the very same laws they study. Any choice the scientist might appear to make was in

[6] Wheeler envisages a scaled-up version involving photons having travelled a billion light years from a quasar, separated by a grating of two galaxies (to act as lenses offering two possible paths for the light), to be detected at the Earth using a half-silvered mirror at which the twin beams can be made to interfere. For Wheeler, this means that the act of measurement (our free choice) determines the history of that entire system: actions by us NOW determine past history THEN (even billions of years ago, back to the earliest detectable phenomena, so long as we can have them exhibit quantum interference). It is from this kind of generalization of the delayed-choice experiment that his notion of the Universe as a self-excited circuit comes: the Universes very existence as a concrete process with well-defined properties is determined by measurement. Measurement here is understood as the elicitation of answers to 'Yes/No' questions (e.g. did the photons travel along path A or B?): bit-generation (gathering answers to the yes/no questions) determines it-generation (the universe and everything in it). However, Wheelers notion does not privilege human observers, but rather simply refers to an irreversible process taking uncertainty to certainty.

accord with the laws of nature and was determined by them. These observer-dependent (or, less strongly: observer-inclusive) approaches do not involve a 'ready-made world.' In a letter to Gödel from 1974 Wheeler wrote, in apparent consternation, that he had just learned at a party that Gödel "believes in the existence of what is sometimes called 'an objective universe out there'. Whether through general relativity or quantum theory, our best theories allow interpretations that put observation center stage.

Let us end with a few selections from Wheeler's final blackboard:

- 8. Physics has to give up its impossible ideal of a proud unbending immutability and adopt the more modest mutability of its sister sciences, biology and geology.
- 9. If the kingdom of life and the highest mountain ranges are brought into being by the accumulation of multitudes of small individual processes, it is difficult to see what else can give rise to the universe itself.
- 10. What other possibility is there for "law without law" except the statistics of large numbers of lawless events?
- 11. No elementary process is as attractive for this statistics as the elementary act of observer-participatorship.
- 15. No working picture that can be offered today is so attractive as this: the universe brought into being by acts of observer- participatorship; the observerparticipator brought into being by the universe ("self-excited circuit").

And so we spiral full-circle to the idea that the world is in some sense mind-stuff (world without world), or at least infused with some kind of mind stuff, through observations and so on. The viewpoint expressed in this essay is that a pressing problem of physics is to recognize that our role as observers is more deeply embedded in our theories and laws than is often realised. Whether we wish to go to the extremes of Eddington and Wheeler is another matter...

References

[1] Carroll, S. (2016) *The Big Picture*. Dutton.

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[3] Fuchs, C. (2010) QBism, the Perimeter of Quantum Bayesianism. https://arxiv.org/pdf/1003.5209.pdf

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[6] Wheeler, J. (1990) Information, Physics, Quantum: The Search for Links. In W. Zurek (ed.), *Complexity, Entropy and the Physics of Information*. Westview Press.