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'Mysticism' in quantum mechanics: the forgotten controversy

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Abstract

This paper argues that a European controversy over a 'mystical' hypothesis, one assigning the mind a role to play at the material level of reality, shaped much of the debate over the interpretation of the quantum equations. It traces back the controversy to the past two decades, beginning in the late 1920s—birth of quantum theory—and concluding with Erwin Schrödinger's lectures published as 'Mind and Matter'. Becoming aware of the issues at stake can help us understand the historical, philosophical and cultural background from which today's physics emerged.

1. Introduction

A few years ago in *Science* Charles Seife discussed some variants of the hypothesis that consciousness plays a role in quantum processes. He claims [1]: '[T]he idea attracted a few physicists, some consciousness researchers, and a large number of mystics.' The latter were also the subject of a *New York Times* article [2]:

> Half a century ago Eugene Wigner ventured that consciousness was the key to this mysterious process. Wigner thereby, and inadvertently, launched a thousand New Age dreams. Books like 'The Tao of Physics' and 'The Dancing Wu Li Masters' have sought to connect quantum physics to Eastern mysticism.

It is widely believed that Wigner was the first to introduce the hypothesis in his 1961 paper 'Remarks on the mind–body question' [3]. Some of those who read Wigner agree with his identification of Bohr and his colleagues as the first to introduce consciousness in quantum physics. As we read in a review of Abraham Pais' Bohr biography [4]:

> Pais is to be applauded for his efforts to 'counteract the many cheap attempts at popularizing this subject, such as efforts by the wooly masters at linking quantum physics to mysticism' (p v) and he quite rightly emphasizes that Bohr's philosophy of physics is an attempt to preserve 'objective description' against the common but

> totally groundless view that he embraced the entry of human consciousness into the description of atomic phenomena.

Here I argue that neither the differences represented by these views nor their reference to mysticism is the aftermath of Wigner's paper. Not only was consciousness introduced hypothetically at the birth of quantum physics, but the term 'mystical' was also used by its founders to argue in favour and against such an introduction. In private conversations, at least as early as the 1927 Solvay Congress, the founders discussed ideas about quantum theory, mysticism and consciousness. It was also around this time when Einstein accused Bohr of introducing 'mysticism' into physics. I would argue that it was not Bohr but Pauli who conceived of a 'mystical' hypothesis that found a fertile ground in a 'scientific mysticism' already developed and later made popular by Arthur Eddington. Nevertheless, Einstein accused Bohr of mysticism, igniting a controversy that by the time of the 1936 Copenhagen Congress for the Unity of Science had moved beyond the physics community into the international media. Attitudes towards this proposal of giving mind a role to play at the physical level, a role then labelled as 'mystical' and now defined as such in this paper ad hoc, shaped the way physicists understood quantum mechanics even at the level of fundamental equations. Pais laments in his Bohr biography [5]: '[We may know] what Einstein's objections were but not why he objected. I have often wondered about that but have no good answer.' We can begin to answer Pais' dilemma once we realize that the controversy led to much misunderstanding in the Bohr–Einstein debate. Once Schrödinger joined the fray, his own equation would incite a new battle that would last at least until he published his last work, his lectures on 'Mind and Matter'. Studying this controversy can thus shed light on the historical and cultural legacy that we have inherited from those tumultuous years.

2. Niels Bohr's agnostic attitude towards 'mysticism' and consciousness

The controversy began when Einstein accused Bohr of introducing, through the subjective elements of quantum mechanics, a 'mysticism' incompatible with science. Bohr spent most, perhaps all, of the rest of his life denying this charge and blaming it on misunderstandings. In his defence, Bohr recalls that indeed he

> incidentally pointed out that even the psychophysical parallelism as envisaged by Leibniz and Spinoza has obtained a wider scope through the development of atomic physics, which forces us to an attitude towards the problem of explanation recalling ancient wisdom, that when searching for harmony in life one must never forget that in the drama of existence we are ourselves both actors and spectators.
>
> Utterances of this kind would naturally in many minds evoke the impression of an underlying mysticism foreign to the spirit of science; at the above mentioned [Copenhagen] Congress [for the Unity of Science] in 1936 I therefore tried to clear up such misunderstandings .... I am afraid that I had in this respect little success in convincing my listeners, for whom the dissent among the physicists themselves was naturally a cause of skepticism. [6, p 44]

We will see that much of this dissent among physicists themselves was over the 'mystical' hypothesis that introduced a psychological element into the foundations of physics.

As early as 1927 we find Bohr rejecting the hypothesis which claims that quantum theory requires a conscious observer. At least according to Heisenberg's later written recollections, which Bohr found amusing but not much different from his own [7], Bohr insisted that year: '[I]t still makes no difference whether the observer is a man, an animal, or a piece of apparatus'

[9, p 88]. A few years later, Heisenberg asked him again about the argument in favour of extending quantum theory to accommodate human consciousness. By then Bohr was less emphatic yet he did not change much of his earlier view [9, p 144]:

> This argument, Niels said, looks highly convincing at first sight. We can admittedly find nothing in physics or chemistry that has even a remote bearing on consciousness. Yet all of us know that there is such a thing as consciousness, simply because we have it ourselves. Hence consciousness must be part of nature, or, more generally, of reality, which means that, quite apart from the laws of physics and chemistry, as laid down in quantum theory, we must also consider laws of quite a different kind. But even here I do not really know whether we need greater freedom than we already enjoy thanks to the concept of complementarity.

While Bohr believed at this time that quantum processes evolved without the need of conscious observers, he was certainly sympathetic towards the hypothesis that understanding consciousness might require an extension of quantum theory to accommodate laws other than those of physics. Nevertheless, he seemed to have never been convinced by the argument. Throughout his collected writings [8], he repeatedly distances himself from the consciousness hypothesis, labelling it 'mysticism'. As he writes years later, reiterating his claims above [8, p 367]:

> For a parallel regarding to the lesson regarding the limited applicability of such customary idealizations, we must in fact turn to quite other branches of science, such as psychology, or even to that kind of epistemological problems with which already thinkers like Buddha and Lao Tse have been confronted, when trying to harmonize our position as spectators and actors in the great drama of existence.
>
> Still, the recognition of an analogy in the purely logical character of the problems which present themselves in so widely separated fields of human interest does in no way imply acceptance in atomic physics of any mysticism foreign to the true spirit of science.

Bohr was aware of those suggesting that there was a resemblance between quantum theory and Eastern mysticism. Immediately after this passage, he links it with the consciousness argument that became a popular hypothesis among some physicists: 'There has also been no lack of suggestions to look for a direct correlation between life or free will and those features of atomic phenomena for the comprehension of which the frame of classical physics is obviously too narrow.' Several of these can be related to Bohr's 'psycho–psychophysical parallelism as envisaged by Leibniz and Spinoza' above. For Leibniz, mind and matter were ontologically distinct, and free will a real yet epiphenomenonal element miraculously maintained in parallel with material and deterministic processes [10]. In Spinoza's philosophy, physical matter and immaterial mind are parallel because they are dual and complementary aspects of an ultimate nature [11]. But even more present in the background lays philosopher Arthur Schopenhauer's volitional approach to material reality influenced by Eastern religions. His philosophy influenced two yet unknown students of physics, Wolfgang Pauli and Erwin Schrödinger [12].

3. Wolfgang Pauli's 'lucid Platonic mysticism' and its consciousness hypothesis

In his writings, Heisenberg recalls in detail those conversations that led to the official birth of the Copenhagen interpretation at the Solvay Congress [13, p 35]:

> When in the spring of 1927, opinions on the interpretation of quantum mechanics were taking rational shape and Bohr was forging the concept of complementarity, Pauli was one of the first physicists to decide unreservedly for the new possibility of interpretation.

What was gestating in the spring would become in the congress an official interpretation in physics and the dominant theoretical paradigm for several decades. Still, Heisenberg's topic in the essay above is not the Copenhagen interpretation, but Pauli's role in its development. The context is Heisenberg's 'Wolfgang Pauli's Philosophical Outlook', an outlook he follows Pauli in describing as a 'lucid Platonic mysticism' [13, p 33] involving a 'synthesis embracing both rational understanding and the mystical experience of unity' [13, p 38]. This view was one of those considered from the very beginning of their joint work; Pauli contributing the hypothesis that consciousness was the point where this synthesis was achieved. As Heisenberg notes [13, p 30]:

> Very early in his early career, Pauli had followed the road of skepticism based on rationalism right to the end, to a skepticism about skepticism, and he tried to trace out those elements of the cognitive process that precede a rational understanding in depth.

As mentioned, Pauli was heavily influenced by Schopenhauer's sympathy for Eastern mysticism as presented in the thinker's *The World as Will and Representation* [14]. As Pauli writes later, he appropriates Schopenhauer's idea of a will 'which breaks through space and time', an idea best described by mystics throughout the ages [15, p 163]. He does so in order to hypothesize that the acquisition of knowledge in mathematics or quantum physics 'gives rise, however, to a situation transcending natural science' that can even acquire a 'religious function' in human experience [15, p 261]. In what is probably behind Bohr's later reference to ancient wisdom, Pauli claims [16]: 'I do not believe in the possible future of mysticism in the old form. However, I do believe that the natural sciences will out of themselves bring forth a counter pole in their adherents, which connects to the old mystic elements.' Heisenberg interpreted Pauli as even more rational than Bohr because only he acknowledged that the scientific evidence pointed to something pre-rational or 'mystical'. When Heisenberg asked Bohr above about the argument of including consciousness as an extension of quantum theory he thus recalled Pauli's speculations on the cognitive process. Pauli claimed that this process was presented philosophically by mystics and studied scientifically by psychologists. With the advent of quantum mechanics, physicists would then be able to unify both approaches.

Pauli based the last claim in his own research, the one that would lead to quantum field theory. Finding symmetry between Faraday's unification of the electric and magnetic fields, he speculated that consciousness would be the next field to become part of a unified field theory that would incorporate psychology [15, p 51]:

> The important fact which this 'field' formula commemorates is the indetermination of the margin. Inattentively realized as is the matter which the margin contains, it is nevertheless there, and helps both to guide our behavior and to determine the next movement of our attention. It lies around us like a 'magnetic field', inside of which our center of energy turns like a compass needle, as the present phase of consciousness alters into its successor. [17]

These are not Pauli's actual words, but those that he quoted from philosopher–psychologist William James' *Varieties of Religious Experience*, which concludes with the study of mysticism as a marginal form of consciousness [18]. The latter purportedly best reveals the symmetrical relationship between the mind and physical reality. Pauli extended the quasi-religious quest

for unity he found in Faraday inspired, not by the Sandemanian religion that inspired the latter, but by Schopenhauerian philosophy. Schopenhauer's philosophy could provide in the future a framework for future empirical confirmation of some of James' hypotheses.

Pauli would sway Heisenberg closer to this possibility, but only in later decades. Only then, in his *Across the Frontiers*, would Heisenberg claim that the founders of quantum mechanics reached a consensus by adopting a perspective akin to Pauli's [13, p 227]:

> The physicist Wolfgang Pauli once spoke of two limiting conceptions, both of which have been extraordinary fruitful in the history of human thought, although no genuine reality corresponds to them. At one extreme is the idea of an objective world, pursuing its regular course in space and time, independently of any kind of observing subject; this has been the guiding image of modern science. At the other extreme is the idea of a subject, mystically experiencing the unity of the world and no longer confronted by an object or by any objective world; this has been the guiding image of Asian mysticism. Our thinking moves somewhere in the middle, between these two limiting conceptions; we should maintain the tension resulting from these two opposites.

Heisenberg encapsulates here Pauli's 'lucid mysticism', presenting it as a synthesis between rationality and religion. Bohr may have shared this view at the end of his life, though in his collected writings he oscillates between giving consciousness a role to play in quantum physics and, more often, denying it. The closest Bohr comes to Heisenberg's attitude towards Pauli appears in his last discussion on the topic of consciousness, where he admits [8, p 777]:

> Indeed in renouncing logical analysis to an increasing degree and in turn allowing the play on all strings on emotion, poetry, painting and music, [we discover that the latter] contain possibilities of bridging between extreme modes as those characterized as pragmatic and mystic. Conversely, already ancient Indian thinkers understood the logical difficulties in giving exhaustive expression for such wholeness.

Whether they reached consensus or not, their disagreements in 1927 already had in seminal form all of the elements present in these last decades.

Their debate at the Solvay Congress over the introduction of consciousness in quantum theory was one between what they called 'scientific' and 'mystical' viewpoints, not one between scientific and religious attitudes. Their conversation began with Pauli, Heisenberg and Dirac's discussion on how to approach the religious language of their later scientific rivals, Einstein and Planck. As Heisenberg understands their positions [9, pp 82–84]:

> Planck considers religion and science compatible because, in his views, they refer to quite distinct facets of reality. Science deals with the objective material world .... Religion, on the other hand, deals with the world of values ... [He has] come down squarely on the side of [his] Christian tradition.
>
> I don't believe Einstein is tied to any religious tradition, and I rather think the idea of a personal God is entirely foreign to him. But so far as he is concerned there is no split between science and religion: the central order is part of the subjective as well as the objective realm.

I will discuss later how Planck will not allow subjectivity even in religion: Christianity's ethical values are to be held as objective as scientific truths. Einstein will tolerate subjective differences in religion as long as they do not intrude in science. Both will reject a mysticism that views the objective material world as dependent on the mind. Neither of them will allow mysticism even in religion, its purported irrationality incompatible with the objectivity of those ethical values that Heisenberg presents here as subjective.

What in the conversation is called the 'scientific' view is represented by Dirac. It rejects the introduction of religious vocabulary, such as God and the soul, 'science, like Dirac, objects to such formulations' [9, p 89]'. The reference is to Dirac's earlier contribution to that conversation. 'If we are honest—and scientists have to be—we must admit that religion is a jumble of false assertions with no basis in reality. The very idea of God is a product of the human imagination [9, p 85].' Heisenberg contrasts Dirac's 'atheistic' to Pauli's 'mystical' hypothesis, only the latter introduces a subjective element into the objective realm of science by giving consciousness a role at the foundations of the material world. As Pauli claims in the conversation, he supports reconciling somehow the scientific 'idea of material objects that are completely independent of the manner in which we observe' with 'Asiatic philosophy and Eastern religions [where] we find the complementary idea of a pure subject of knowledge' [9, p 85]'. Had Einstein and Planck not been elsewhere during the Solvay Congress, Pauli's remarks would have met with the strong opposition the two scientists expressed in the following years.

4. Einstein's equations and 'mysticism'

In 1928, Einstein criticized what he called the 'Bohr–Heisenberg tranquilizing philosophy [20, p 31]'. Later when the controversy was at its peak, he would call this interpretation of physics the 'mystic' one, spearheaded by Bohr's purported introduction of mind [20, p 36]:

> There is also the mystic, who forbids, as being unscientific, an inquiry about something that exists independently of whether or not it is observed, i.e. the question as to whether or not the cat is alive at a particular instant before an observation is made (Bohr).

What Einstein means here by 'mystic' is the belief in the existence of what in German is called *Geist*, which can be used for both mind and spirit. We know this from his 1921 warning to what the physics community was slowly becoming aware of. Einstein there criticized the cultural *zeitgeist*:

> The mystical trend of our time, which shows itself particularly in the rampant growth of the so-called Theosophy and Spiritualism, is for me no more than a symptom of weakness and confusion ... the concept of a soul without a body seems to me to be empty and devoid of meaning. [21]

Theosophy refers here to the religious movement introduced some decades earlier by Madame Elena Blavatsky, involving a mélange of European and Asian mystical esotericism. The spiritualist movement was spreading around the same time. Individuals calling themselves mediums claimed to communicate with the dead, purportedly confirming the idea of the after-death survival of a mind that is independent of the material world. At the beginning of the 20th century occultism had made incursions into European science, strengthened in part by Henri Bergson's vitalism linking biology and 'mysticism [or] the establishment of a contact, consequently of a partial coincidence, with the creative effort which life itself manifests' [22]. Bergson challenged not only mechanist thinking in biology, but his philosophy of mind in *Time and Free Will* and *Duration and Simultaneity* also challenged Einstein's theory of relativity. It raised the same problem Max Born posed years later to Einstein: '[H]ow you can combine an entirely mechanistic universe with the freedom of the ethical individual' [23, p 151]. Throughout his life Einstein answered many, many times.

Einstein rejected all of the above mystical ideas as confused and cursed them for infiltrating Bohr's 'mystical religion'. In 1928 he wrote [20, p 31]:

> The Heisenberg–Bohr tranquilizing philosophy—or religion—is so delicately contrived that, for the time being, it provides a gentle pillow for the true believer from which he cannot very easily be aroused. So let him lie there. But this religion has so damned little effect on me that despite everything I say
>
> not: E and ν
>
> but rather: E or ν;
>
> and indeed: not ν, but rather E (it is ultimately real).

Einstein believed that Bohr's 'mysticism' misappropriated the formulae of the light quantum theory, probably reacting to Bohr's claim seven months earlier [8, p 78]:

> Consider Einstein's well known formulae of the light quantum theory $E = h\nu$ [and] $P = h\sigma$, where E and P denote energy and momentum of a quantum, ν and σ frequency and wave number of the corresponding phase wave. According to de Broglie, these formulae are equally valid in the wave representation of material particles and fulfill generally the claims of relativistic invariance. It is now to be remembered, that by limiting the extension of the wave field in space and time, in order to represent individuals, one introduces an uncertainty in the definition of ν and σ, corresponding to the resolution of the field into a group of elementary waves.

The important element from the equations is the interpretation of ν via Heisenberg's uncertainty principle. Einstein misunderstands Bohr and quantum mechanics as giving, via the uncertainty principle, consciousness a role to play at the fundamental level of reality. As we will see, this role would consist in catalyzing the process of resolution or materialization into a localizable particle of what Einstein and others describe as something uncertain, uncanny (*unheimlich*) and 'ghostly'. In their correspondence with Einstein, Max Born and Pauli criticize his 'philosophical prejudice' against the so-called supernatural 'creation' 'outside natural laws' and quantum mechanics' 'spooky [Spuchlich]' method [23]. We cannot separate the language of what we will later find as Einstein's famous criticism of the new theory's 'spooky action at a distance', from his earlier rejection of the indeterminacy introduced in the frequency of the phase wave as not ultimately real. Heisenberg had earlier introduced his famous principle as an *anschaulich* principle involving indeterminacy (*Unbestimmtheit*), with all the connotations of *anschaulich* as involving mystical intuition and the mystical claim of the unreality of world as mere appearance [24]. He appropriated the language, not the content of mysticism, imitating Hermann Weyl who began his very popular textbook on Einstein's relativity (*Space, Time and Matter*) with a thesis he will later connect with European mysticism in the even more popular *The Open World*. His thesis states that

> the real world, all of its constants (Bestandtstucke) and all of their determining factors (Bestimmungen) are given, and can only be given, as intentional objects of conscious acts. What is absolutely given are those conscious experiences (Bewusstseinerlebnisse) that I have—and as I have them. ... The immanent is *absolute*, i.e., 'what it is' is exactly as I have it; I can eventually bring its essence (Wesen) to givenness (Gegebenheit) in reflective acts. On the other hand, transcendent objects [are not absolute, but] appearances, their being only *phenomenal*. [25; italics in the original, translation mine]

As we read in *The Open World*, his mathematical formalism assimilates a new scientific 'mysticism' he first found in European mysticism and in the mystical intuitionism he appropriated from leading mathematician L.E.J Brouwer's *Consciousness, Philosophy and*

Mathematics and *Life, Art, and Mysticism* [26]. Weyl opened his 1934 Yale lectures on 'Mind and Nature' claiming 'the mathematical–physical mode of cognition . . . is decisively determined by the fact that this world does not exist in itself . . . [but] only as that met by an ego' [27]. Nevertheless, years later he would claim that he earlier shared the philosophical premise that postulated consciousness as the foundation of physical reality because 'he was too prone to mix up mathematics with physical and philosophical speculation' [28].

In Britain, Arthur Eddington uses the same language as above for a more explicitly mystical purpose. We read in his best-selling *Space, Time and Gravitation* that 'all through the physical world runs [an] unknown content, which must surely be the stuff of our consciousness' [29]. His assumption that '[b]oth a scientific and mystical outlook are involved in the "problem of experience" ' [30] shapes his understanding of, for example, the Ricci tensor. For Eddington, the human mind purportedly regained the place it lost after the Copernican revolution when Einstein's field equations made matter 'disappear' by exposing it as the observer's construction:

> In the source-free case of 'empty space', these equations (without the cosmological constant) state that the Ricci tensor [introduced as the object of 'world geometrical' construction] vanishes identically,
>
> $$R\mu\nu = 0$$
>
> On the other hand, in the presence of 'matter' (a classical, and purely phenomenological 'matter', that is, a neutral, pressureless 'dust'), the equations run, in one form,
>
> $$G\mu\nu \equiv R\mu\nu - 1/2\ g\mu\nu R = \kappa T\mu\nu,$$
>
> where κ is a coupling constant and $T\mu\nu$ is the so-called stress energy tensor, compactly summarizing the gross mechanical properties of this 'matter' (momentum, stress, pressure, etc). But when the obvious identifications are made, associating physical content with certain purely analytical objects of world geometry, both sets of equations can be regarded *from the perspective of world building* simply as *definitions*. Hence, *within world geometry*, $G\mu\nu \equiv R\mu\nu - 1/2\ g\mu\nu R = \kappa T\mu\nu$ serves to define 'matter' in virtue of the fact that the covariant divergence of $T\mu\nu$ also vanishes, as is required by conservation of energy. Correspondingly, $R\mu\nu = 0$, which implies $R\mu\nu - 1/2\ g\mu\nu R = 0$, defines in perceptible terms a 'vacuum' or 'empty space', the absence of 'matter'. [31, italics in the original]

Since Einstein field equations are now nothing more than definitions, the definer's 'stuff of consciousness' is all that remains. Or as Eddington closes his defence of mysticism in *The Nature of the Physical World*: 'To put the conclusion crudely—the stuff of the world is mind-stuff. matter and fields of force of former physical theory are altogether irrelevant—except in so far as the mind-stuff has itself spun these imaginings' [32, p 276]. Not only does he distort Einstein's theory above, but he also distorts quantum mechanics: '[i]nsofar as supernaturalism is associated with the denial of strict causality, I can only answer that this is what the [new] modern scientific development of the quantum theory brings us to' [32, p 347]. Thus, he would do for scientific mysticism what he did for the theory of relativity; make sure that the physics community and the international media noticed. In this way, he contributed to the controversy that we will find Einstein and Planck publicly addressing for the next decade.

5. Einstein and Planck's reaction

At the peak of his fame, a full decade after he won the Nobel Prize in Physics, Albert Einstein found himself accosted by the international media and its enthusiasm for his theory, 'especially about its mystical aspect'. When a journalist asked about this mystical aspect

> his wife Elsa broke into laughter with the words: 'Mystical! Mystical! My husband mystical!' [She was] echoing [Einstein's] own reply to a Dutch woman, whom he met in the Hague, who said she liked his mysticism: 'Mysticism is in fact the only reproach that people cannot level at my theory.' [33]

Everyone knew Einstein's purported 'mystical' thesis. He had 'already been widely quoted in the British Press as subscribing to the theory that the outer world is a derivative of consciousness' [34, p 213]. Einstein would react and join Planck in their collaboration *Where is Science Going?* and in press conferences:

> No physicist believes that. Otherwise he wouldn't be a physicist. Neither do [Eddington and Jeans]. ... These men are genuine scientists and their literary formulations must not be taken as expressive of their scientific convictions. Why should anybody go to the trouble of gazing at the stars if he did not believe that the stars were really there? Here I am entirely with Planck. [34, p 213]

In Britain Eddington and Jeans did support this theory, understanding physics as confirming the philosophy of German inter-subjective idealism spreading by then among British philosophers [35]. In contrast, Russian physicists opposed this idealism that they associated with Bohr and found it unacceptable to Marxist materialism [36]. Einstein's opposition to Bohr concern did not stand primarily against a philosophical idealism incompatible with his realism, what Pauli called his 'philosophical prejudice' assuming that reality is independent of any mind. In fact, he claimed to understand an idealism based on his theory of space and time, as long as the necessarily subjective choice of conceptual functions in science was not thought to be compelled by the nature of the intellect [31, p 48]. His concern lay in the subjective element of consciousness, which would contaminate all of the other philosophical principles necessary for physics, such as locality or determinism. He put the blame on quantum theorists 'confounding the subjective with the objective world. The indeterminism which belongs to quantum physics is a subjective indeterminism' [34, p 202]. Indeterminism as a philosophical premise would be acceptable had quantum theorists not introduced consciousness with it. When we turn to the violation of locality in the EPR paper, we will see that it constitutes only one facet of the problem. His collaborator Podolsky would by then write to *The Physical Review* reiterating that their article showed in quantum theory a physical system that

> loses the essential property of physical reality—that of existence independent of any mind. This point of view is in direct contradiction with the philosophic point of view explicitly stated in the first paragraph of our article [38, italics in the original].

We will return to the EPR paper and its scientific context, after we see how Einstein's collaboration with Planck illuminates both the cultural and scientific contexts.

In his 1933 collaboration with Einstein, *Where Is Science Going?*, Planck (alarmed) wrote that

> [w]e are living in a very singular moment of history. It is a moment of crisis ..., in the literal sense of that word ... tidings of a downfall to which our civilization is fatally destined. Formerly it was only religion, especially in its doctrinal and moral systems, that was the object of skeptical attack. Then the iconoclast began to shatter

> the ideals and principles that had hitherto been accepted in the province of art. Now he has invaded the temple of science. There is scarcely a scientific axiom that is not nowadays denied by somebody. And at the same time almost any nonsensical theory that may be put forward in the name of science would be almost sure to find believers and disciples somewhere or other. [34, p 65]

In his *Philosophy of Physics*, Planck joins Einstein in decrying the popularization of religions, such as theosophy and spiritualism, which borrowed ideas from Eastern cultures. 'It is surprising to find how many people even of the educated classes allow themselves to be fascinated by these new religions—beliefs which vary from the obscurest mysticism to the crudest superstition' [39]. He is aghast that he has to, against their teaching, devote an entire lengthy section to consider the question 'Is there an external world?' [34, p 65]. Among those answering in the negative would be Eastern thinkers who claim that the world is an illusion and deny an ultimate divinity. Planck separates mysticism and superstition from the 'more highly developed religions', whose role he sees to join in the fray when 'physical science demands that we admit the existence of a real world independent from us'[40]. In order to defend this view, Planck would recruit elements he found in Christian ethics and Kantian philosophy.

Planck redeployed in the 1930s an earlier plan he suggested to a mathematician who wrote against the 'mystical' intuitionism of Brouwer and Weyl [41]:

> [Kant] had the foundations of knowledge right, just as Christ's preaching contained the elements of all true religions. 'Farsighted theologians are now working to mine the eternal metal from the teachings of Jesus and to forge it for all time', correspondingly, 'it would be of incalculable importance for the development of the realistic worldview ... if Kant's philosophy, which once again has shown itself to be a historical force, came completely into its own'.

It can thus be suggested, somewhat simplistically, that Planck would frame the controversy as science, Christianity and Kant against the mysticism of a younger generation who preferred the more popular philosophy of Schopenhauer and his popularization of Buddhism and Hinduism. We will see Schopenhauer's champions to be Pauli, and first the younger then the older Schrödinger. Still, Planck assigns a larger share of the blame to Von Neumann's and his formalism joining the Planck–Einstein equation and Heisenberg's principle of uncertainty.

Today, it is often Von Neumann who is credited with introducing the mind in quantum equations in order to solve the measurement problem [42]. Planck re-presents what Von Neumann calls 'abstract ego' and its 'inner being (Innerleben)', and its parallel above in Weyl's inclusion of the ego, in order to criticize such move as surrendering to decadent popular movements [34, p 160]:

> we might naturally assume that one of the achievements of science would have been to restrict belief in miracle. But it does not seem so. The tendency to believe in the power of mysterious agencies is an outstanding characteristic of our own day. This is shown in the popularity of occultism and spiritualism.

Planck acknowledges the ego to play an important role, but not a miraculous unscientific one. At first, the ego does allow a certain freedom in an individual's 'inner being' that science seems to prohibit [34, p 165]:

> We are at liberty to construct any miraculous background that we like in the mysterious real of our inner being, even though we may be at the same time the strictest scientists. I might put the matter in another way and say that the freedom of the ego here and now,

> and its independence of the causal chain, is a truth that comes from the immediate dictate of the human consciousness.

The ego allows the construction of any scientific 'fancy', but its role is a limiting one. Science 'brings us to the threshold of the ego and there leaves us to ourselves' [34, p 167]. For Planck, Von Neumann's abstract ego is only an abstract point between science and religion. Quantum mechanicists' mistake is not recognizing the ego as introducing ethical religion, not the mysticism of 'those forms of religion which have a nihilist attitude to life out of harmony with the scientific outlook' [34, p 168]. The liberty of the ego has to be rejected by both science and religion because 'mankind has need of fundamental postulates for the conduct of everyday existence . . . [t]he law of causation is the guiding rule of science; but the [Kantian] Categorical Imperative—that is to say, the dictate of duty—is the guiding rule of life' [34, p 167].

Planck wrote the section 'Is there an external world?' to defend those views Einstein shared in conversations with his biographer Pais and which would later take shape in his 1935 paper with Podolsky and Rosen [43]. As Pais tells us [44]: 'We often discussed his notions on objective reality. I recall that during one walk Einstein suddenly stopped, turned to me and asked whether I really believed that the moon exists only when I look at it.' Planck's and Einstein's question lies in the background behind the famous question: 'Can quantum mechanical description of reality be considered complete?' The paper would deploy an original new strategy to defend the argument against mysticism that Einstein had been making for more than a decade.

After presenting their thesis, Einstein, Podolsky and Rosen open their paper with the premise mentioned in Podolsky's letter above insisting on the separation of mind from physical reality:

> Any serious consideration of a physical theory must take into account the distinction between the objective reality, which is independent of any theory, and the physical concepts with which the theory operates. These concepts are intended to correspond with the objective reality, and by means of these concepts we picture this reality to ourselves.

This premise, later rejected by Bohr, reappears when the paper's original argument concludes that, in regard to the non-commuting operators P and Q the argument introduces, accepting quantum mechanics as complete

> makes the reality of P and Q depend upon the measurement carried on the first system, which does not disturb the second system in any way. No reasonable definition of reality could be expected to permit this . . . we have thus shown that the wave function does not provide a complete description of the physical reality.

As we read in Bell's opening to his (also) classic paper [45], the EPR conclusion serves to present 'an argument that quantum mechanics could not be a complete theory but should be supplemented by additional variables. These additional variables were to restore to the theory causality and locality'. In order to fully understand Einstein's conclusion about the need for these additional variables, we have to realize with Pais above that '[we may know] what Einstein's objections were but not why he objected'. As has been noted, all these are part of his realism involving both a separability and a locality principle. We should now add yet another principle, the one inserted into the EPR argument as the philosophical premise 'no reasonable definition of reality could be expected to permit this'. This insertion discloses much of the controversy haunting the physics community at that time.

We often only remember today Einstein's claim that quantum physics introduces a 'spooky [Spuklich]' action at a distance. The moniker appears often, alongside similar others, in his

letters to Max Born [23]. In their original context, all of them show that Einstein was concerned that quantum mechanics implied something even more serious than the violation of causality or locality. The main concern was not only its incompatibility with the theory of relativity, but its introduction of subjective elements related to a spiritual or mental *Geist*. We will see now their discussion to be part not only of the cultural but also the scientific atmosphere they breathed.

6. Schrödinger's response to the situation in the physics community

One important French article on Von Neumann's formalism exemplifies this situation when it concludes [47, italics in the original]: 'It might appear that the scientific community thus created a kind of *spiritualistic society* which studies imaginary phenomena—that the objects of physics are phantoms produced by the observer himself.' This 1932 reference is to the cultural zeitgeist, specifically Spiritualists, and their claims about phantom apparitions and skeptics who use science to show apparitions to be nothing but productions of the observer's imagination. While the article defended the new theory's introduction of mind into the equations, it raised as problematic that the novelty of its language shared many terms in common with mystical language.

We find another example in Von Neumann's collaborator, Pascual Jordan, who also in 1932 interpreted his formalism as confirming that '[o]bservations not only disturb what has to be measured, they produce it . . . . We compel [the electron] to assume a definite position . . . . We ourselves produce the results of measurements' [48]. If we take into account that around this time Jordan was engaged in speculation about parapsychological phenomena [49], we realize that Einstein would have read the original German very differently from how it is read in translation. The verb to produce (hervor rufen) is the same verb used when a spiritualist group gathers to summon or conjure a dead soul, a 'spook', a 'phantom'. Jordan for a time saw some symmetry in both. When hearing Einstein's criticism of quantum mechanics as 'spooky action at a distance', we should not then forget Jordan, who formulated matrix mechanics with Born and Heisenberg, and, with Pauli and Dirac, paved the way for quantum electrodynamics [50]. Jordan will reject his earlier hypothesis in 1949, claiming that 'what in [Von Neumann's formalism] is called ''observation'', must not be interpreted as any mental process, but as a purely physical one [51]'. Yet his earlier claim, reiterated throughout the physics community, certainly would have made Planck and Einstein shiver.

Inspired by Schopenhauer's concept of a will which 'breaks through space and time', Pauli criticizes Einstein's 'philosophical prejudice' against any mental element outside natural laws:

> Now to Einstein's essential question: How are those solutions to the Schrödinger equation which do not belong to class K° (for example, macro-objects) to be interpreted in physical terms? Here Einstein's reasoning is as follows: A. When one 'looks at' a macro-body, it has a quasi-sharply-defined position, and it is not reasonable to invent a causal mechanism to which the 'looking' fixes the position. Comment: . . . I am still in agreement, because in this case I do not consider the appearance of the definite position or, what amounts to the same thing, its appearance as a result of the observation, can be deduced by natural laws. Einstein's reasoning continues: B. Therefore a macro-body must always have a quasi-sharply defined position in the 'objective description of reality'. As those ψ-functions which do not belong to class K° cannot in principle be 'thrown away', and must also be in accordance with nature, the general ψ-function can only be interpreted as an

> ensemble description. If one wants to assert that the description of a physical system by a ψ-function is complete, one has to rely on the fact that in principle the natural laws only refer to the ensemble-description, which Einstein does not believe. What I do not agree is Einstein's reasoning B (please note that the concept of determinism does not occur at all!) . . . [T]he statement 'the particle is there' is [to be] regarded as a 'creation' outside the laws of nature, even though it cannot be influenced by the observer. The natural laws only say something about the statistics of these acts of observation. [23, p 218–21, italics in the original]

Today, most contemporary physicists would balk at such 'supernatural' interpretation. As one physicist criticizes another who sympathizes with Pauli [52]:

> To begin with, an experimental set up to observe in which of two boxes an atom is located does not '*cause*' such a localization. Instead, an observer who examines the output of a recording *finds* the location of the atom in accordance with a probability distribution given by the absolute square of Schrödinger's ψ-function appropriate to the experimental arrangement.

We need to go back then to the original German context and to their philosophical controversies to understand that contemporary assumptions by physicists today do not correlate with those of the founders of the theory. As his biographer tells us, Schrödinger was also strongly influenced by Schopenhauer and Eastern mysticism in his youth, rejecting them in mid-career only to welcome them back [53]. His change of mind occurred when he concluded that

> it is then quite clear that a measurement of x affects not only (as is always said) p [x's momentum], but also x itself. You have not *found* a particle at K' [x's definite position], you have *produced* one there! . . . Before the second measurement, it is ubiquitous in the cloud (it is not a particle at all) [54]

In these notes he focuses on Heisenberg's principle and acknowledges that there is 'a real difficulty in interpreting the uncertainty, [a] difficulty that cannot be explained away by 'positivist philosophy'. Schrödinger would not feel satisfied with any explanation until almost a decade later when he wrote *Mind and Matter*.

By then he would be concerned that 'the world of science has become so horribly objective as to leave no room for the mind' [55, p 120]' and propose not to 'lose the logical precision that our scientific thought has achieved' but to introduce the mind as presented by Schopenhauer and Eastern mysticism.

> [t]o Western thought this doctrine 'has little appeal', it is unpalatable, it is dubbed fantastic, unscientific. Well, so it is because our science—Greek science—is based on objectivation, whereby it has cut itself off from an adequate understanding of the Subject of Cognizance, of the mind. But I do believe that this is precisely the point where our present way of thinking does need to be amended, perhaps by a bit of blood transfusion from Eastern thought. [55, p 130]

He thus proposed to cure Einstein and, by this time, Jordan, both of whom claimed that measuring instruments could take the place of the human mind in Von Neumann's formalism:

> [t]he observer is never entirely replaced by instruments; for if he were, he could obviously obtain no knowledge whatsoever . . . . Many helpful devices can facilitate this work . . . But they must be read! The observer's senses have to step in eventually. The most careful record, when not inspected, tells us nothing. [55, p 162]

Against Jordan here, he claims that the event of registration in a thermometer cannot be considered an act of observation. Against Einstein he claims that uncertainty tells us

something fundamental about physical reality, namely that the acquisition of knowledge is inseparable from it. His premise is that meaning is what makes a random collection become information; the acquisition of knowledge requires that this information be meaningful to someone. Moreover, only quantum physics and consciousness solve the problem that the theory of relativity 'leaves untouched[,] the "unidirectional flow of time; [the mind using] statistical theory constructs it from the events'' ' [55, p 152]. Construction here means that it is not a law discovered but one created by consciousness at the fundamental level of reality. Thus we are not subject to this law, 'a liberation from the tyranny of old Chronos'. His final conclusion to this dialogue climaxes the argument by invoking mystical ideas about the immortality of a fundamental consciousness [55, p 152]:

> But some of you, I am sure, will call this mysticism. So with all due acknowledgement to the fact that physical theory is at all times relative, in that it depends on certain basic assumptions, we may, or so I believe, assert that physical theory in its present stage strongly suggests the indestructibility of Mind by Time.

7. Conclusion

Schrödinger's writings of the 1950s mark the last of a generation that lived with the mysticism controversy. By the time the war was over, research in physics had already moved from its predominantly German context to a new one where English, not German, would be the language of science. The Anglo–American cultural zeitgeist of the second half of the century would be very different from that which permeated war-torn Germany. Yet, while we may perhaps ignore Schrödinger's culturally embedded conclusions, it would only be detrimental to science if we ignore his warning against 'the grave danger of [physics] getting severed from its historical background' [20, pp xiv–xv]:

> History is the most fundamental science, for there is no human knowledge which cannot lose its scientific character when men forget the conditions under which it originated, the questions which it answered, and the functions it was created to serve.

In order to fully understand even the fundamental equations of physics, we must not forget the history of those philosophical and cultural ideas that composed the European soil in which these equations have their roots.

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