From a Lost History to a New Future: Is a Phenomenological Approach to Quantum Physics Viable?[*]

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Introduction

In 1939 London and Bauer published a short pamphlet on the measurement problem in quantum mechanics (London and Bauer 1939). For many years, physicists and philosophers took this to be merely a re-statement of von Neumann's view that it is the intervention of consciousness that somehow leads to the wave function collapsing into some definite state. This view was robustly criticised by Putnam and Shimony in the early 1960s and has been generally abandoned ever since. However, before he became a physicist, London studied phenomenology and his work with Bauer is infused with a phenomenological sensibility. In (French 2002) I tried to excavate this 'lost history' and articulate the details of London's approach. Here I want to further consider the extent to which this history might be said to have been 'effaced', to use Ryckman's term (Ryckman 2005) but also indicate how this phenomenological approach might be further articulated in the broader context of recent interpretations of quantum theory and thereby be regarded as a viable alternative.

Recovering 'Effaced' History

As is well-known, the history of philosophical reflections on physics in the twentieth century has been overshadowed by certain prominent views.

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Consider, for example, space-time physics and in particular the development of the General Theory of Relativity as appropriated by and presented within the framework of logical empiricism. Alternative and sometimes intertwined strands of thought have been obscured in this history, or, to use Ryckman's term, have been 'effaced'. Thus he charts the role of neo-Kantian and phenomenological thought in philosophical reflections on Einstein's theory, thereby helping to recover this 'effaced' history (Ryckman 2005). In particular, he focuses on Weyl's adoption of an explicitly phenomenological stance with respect to both the relevant physics and its philosophical interpretation, where this shift 'reflect[s] the theory's ambiguous character as lying in the intersection of physics and philosophy' (ibid., p. 159). I shall consider whether a similar ambiguity of character can be ascertained in the case of London and Bauer's analysis of the measurement problem in quantum mechanics.

Here too, when it comes to quantum physics more generally, we have seen the recovery of a history that has effectively been smothered by positivistic construals of the infamous 'Copenhagen Interpretation' for example. Recently, a neo-Kantian perspective has been recovered in the work of Cassirer (1936; see Ryckman 2018), which has been appropriated by more recent (and broadly realist) philosophical stances (see French 2014). The natural question arises whether there are also phenomenological strands to this history that can be brought into the light and in (French 2002) I argued that there are, as manifested most clearly in London and Bauer's pamphlet (1939)[1]. In the next section I will sketch the 'usual story' of this problem and the purported role of consciousness in resolving it.

The Measurement Problem: Usual Story

The usual story that we tell about the measurement problem is often illustrated by Schrödinger's famous 'cat in a box' thought experiment[2]: a cat is placed in a box, together with a portion of radioactive material and a Geiger counter

[1] Originally published in French and subsequently republished in English translation in Wheeler and Zurek 1983.

[2] This amounts to a kind of appropriation of the thought experiment as Schrödinger's original intention was to undermine Bohr's insistence on the distinction between macroscopic and microscopic systems, with classical physics applying to the former and quantum theory to the latter.

connected to a device that will release poison if triggered. If the material decays, the Geiger counter is fired, the poison is released and the cat dies; if not, the cat continues to live. According to quantum mechanics, the state of the system of radioactive atoms must be described in terms of a superposition of possible states, whose evolution will be governed by Schrödinger's equation. But then, noted Schrödinger, the radioactive material + Geiger counter can also be considered as a system and its state must be described in terms of a superposition, and likewise for the radioactive material + Geiger counter + poison-releasing-device and so on, to include, of course, the unfortunate cat. Thus, Schrödinger remarks, '… an indeterminacy originally restricted to the atomic domain becomes transformed into macroscopic indeterminacy' (Trimmer 1980, p. 328). But of course, he continues, when we open the box the indeterminacy is resolved – we observe either a live or a dead cat.

von Neumann, equally famously, enshrined this transformation in terms of his distinction between Processes of the First Kind, which apply to measurement, as represented in Schrödinger's thought experiment by opening the box, and which are indeterministic, discontinuous and thermodynamically irreversible and Processes of the Second Kind, as represented by the evolution of the wave function representing the state of the system, which are deterministic, continuous in time and reversible (1932). However, to formally represent the distinction this way does little, if anything, to resolve the problem, expressed, pithily as ever, by Albert in the following terms: 'The dynamics and the postulate of collapse are flatly in contradiction with one another ... the postulate of collapse seems to be right about what happens when we make measurements, and the dynamics seems to be bizarrely wrong about what happens when we make measurements, and yet the dynamics seems to be right about what happens whenever we aren't making measurements.' (Albert 1994, p. 79)

von Neumann, of course, would most likely respond that it is not *so* bizarre that the dynamics, as represented by Schrödinger's equation, gets things so wrong when it comes to measurement because measurement culminates in an observation and observation involves a kind of interaction that cannot be captured in quantum mechanical terms, namely one involving a conscious observer.[3] Indeed, he presented an argument – his famous 'Chain Argument' – to that effect: if we assume that quantum mechanics applies to all physical systems[4], then it will apply to, for example, the radioactive material and the radioactive material + Geiger counter and the radioactive material + Geiger counter + poison-releasing-device and so on up the chain, to include the physical body of the observer opening the box, encompassing her visual system and brain. All the links in this chain will be embraced by the superposition and thus can be taken as subject to Processes of the Second Kind. What then could generate a definite result when the box is opened? Something non-physical, namely the consciousness of the observer, which is not subject to quantum mechanics, cannot be included in the superposition and, in effect, leads to the 'collapse' of the relevant wave function (describing the entire system from radioactive material to the cat and the brain of the observer).

Continuing to follow 'the usual story', this postulation of the role of consciousness, about which von Neumann did not actually say anything (see Bueno forthcoming), was (so the story goes) summarised and presented in a little pamphlet by London and Bauer (London and Bauer 1939/1983)[5] and generated considerable discussion, not all of it either philosophically or physically sophisticated, about the observer-dependence of quantum physics. More significantly it was brought to the attention of philosophers of physics through the advocacy of Wigner (I'll come back to this below) who invoked it in his own, also famous, argument for the role of consciousness, based on the 'Wigner's Friend' thought experiment: portrayed as an extension of the 'Schrödinger's Cat' case sketched above, we are invited to imagine someone – Wigner's friend – about to open the box containing the cat, the Geiger counter, the radioactive material etc., but in a room that is sealed with a further observer outside the room. The observer outside the room asks her friend whether she saw the cat alive, say, knowing that quantum mechanics predicts a 50% probability of observing such an outcome. The observer now asks her friend

[3] Albert of course was writing at a time when measurement had come to be regarded as just another interaction.
[4] An assumption that Bohr would reject of course; for a useful account see Freire 2015, p. 147.
[5] This characterisation of the London and Bauer manuscript can be found scattered throughout the relevant literature; see Atmanspacher 2015.

what she observed before she was asked that question, and we would expect her to reply, "I already told you, I saw the cat alive", since the question whether she did or did not see the cat alive was already decided in her mind before she was asked (Wigner 1961). And here Wigner cites in support a specific line from London and Bauer's pamphlet, one that I shall return to later: 'He [the observe in the room] possesses a characteristic and quite familiar faculty which we can call the "faculty of introspection." He can keep track from moment to moment of his own state.' (London and Bauer 19383, p. 252) Since the issue as to what she saw was already decided in the friend's mind before the question was asked, the state immediately after the interaction between the friend and the whole cat-in-a-box system cannot be a superposition. Thus, Wigner concludes, 'It follows that the being with a consciousness must have a different role in quantum mechanics than the inanimate measuring device ...' (Wigner op. cit.)

It was primarily by means of Wigner's work that this 'solution' to the measurement problem, and the piece by London and Bauer in particular, was brought to the attention of the likes of Shimony and Putnam (Shimony 1963; Putnam 1964) who subjected it to severe criticism, raising the kinds of questions that many of us like to invite our students to consider, such as how, precisely, does consciousness, being non-physical, cause a physical change in the state of the system? And how can the universe as a whole be treated as a quantum system? Wigner, together with Margenau, attempted to respond to these, and other, concerns but Putnam's and Shimony's critiques became entrenched and with its apparent adherence to a philosophically naive form of mind-body dualism, this solution to the measurement problem was subsequently dropped, in favour of the now well-known alternatives. End of story.

However, as I argued in (French 2002) the 'usual story' is wrong in at least one crucial respect: London and Bauer's pamphlet is not a mere summary of von Neumann's position and interpreted correctly, it offers a much more sophisticated account of measurement which, being grounded in the tradition of Husserlian phenomenology, is capable of responding to Putnam's and Shimony's criticisms. Let me now outline this alternative narrative.

London and Bauer's Pamphlet: the 'True' Story

Fritz London's scientific biography has been presented in admirable detail by Gavroglu (1995) and can be briefly summarised as follows[6]: he studied with Sommerfeld at Munich and might be characterised as one of the first post-revolutionary quantum physicists, applying the theory to chemical bonding with Heitler and developing quantum models of superconductivity and superfluidity. The development of such models has a direct bearing on the issue of how to approach the measurement problem since they were taken by some as undermining Bohr's approach, grounded in the distinction between the macroscopic and the microscopic, with classical theory applicable to the former and quantum mechanics to the latter. London's work helped to suggest to many that such a hard and fast distinction was simply not viable. Furthermore, the 'Sommerfeld School' was quite distinctive from the Copenhagen group, famously centred around Bohr, not least because of the former's emphasis on puzzle solving rather than broader, foundational issues (Seth 2010). Indeed, the above characterisation of London as a post-revolutionary is in a sense wide of the mark, since, as Seth nicely sets out, there was no sense of 'crisis' within the Sommerfeld School and hence, he argues[7], the very attribution of a quantum 'revolution' is inappropriate in this particular academic context.

Significantly, London brought to his work in physics an acute and well-formed philosophical sensitivity that he had begun to develop prior to his scientific studies (for further details see again Gavroglu 1995). His early essays, written over a period covering his final year of school and the first year of university, reveal Kantian and phenomenological themes (Gavroglu, *ibid.* esp. pp. 8-23). While at Munich London met Pfänder, the leader of the Munich group of phenomenologists and second only to Husserl within the phenomenological movement (*ibid.*, pp. 11-12). Pfänder was so impressed with an essay that London showed him that he urged him to write it up and submit it as a

[6] As in (French 2002) I shall not say much about Bauer, although I will add that in 1933 he published an introduction to group theory and its application to quantum mechanics (Meijer and Bauer 1962) which is significant, of course, because of London's involvement with group theory in the late 1920s (Gavroglu *op. cit.*, pp. 53-57).

[7] In a sense this is a warning to those, like Kuhn, who are seduced by what Seth calls 'the romance of revolution' and fail to note or acknowledge the differences in approach and attitude of different 'schools' of physics at the time and, indeed, different physicists.

dissertation in philosophy.[8] London's thesis was then published in 1923 in the *Jarbuch für Philosophie und phaenomenlogische Forschung*, which was co-edited by Pfänder with Husserl as editor-in-chief and according to Gavroglu, '[t]he dominant features of Fritz London's thesis place it within the phenomenological movement ...' (*ibid*., p. 15).[9]

It is this philosophical sensitivity that London brings to bear on the measurement problem in the pamphlet with Bauer. Before getting into the details, it is worth bearing in mind two points regarding the relationship between his scientific and philosophical work. One might question whether a philosophical view developed in the context of classical physics can offer an appropriate framework for the revolutionary new theory that replaced that context. However, as just noted, the Munich 'ethos' was to treat the development of the new quantum mechanics as another problem solving exercise, using tools adapted from those applicable to classical physics. There was no sense of 'crisis' or even of a revolution taking place[10] and I suggest that just as in his physics, so in his philosophy, London would have felt it entirely appropriate to apply the same philosophical devices as he had used before.[11]

One might also worry that following the publication of Husserl's *Crisis of European Sciences and Transcendental Phenomenology* (1936/1970)[12], London might have had further reason to feel that it may have been inappropriate to apply a phenomenological perspective to this new highly mathematised theory. After all, it is in the *Crisis* that Husserl famously emphasizes the importance of the 'lifeworld', conceived in terms of a 'natural', pre-theoretical understanding that has been overlaid with the 'mathematisation' initiated during the Scientific

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[8] Shimony suggests that it was London's brother, Heinz, who encouraged him to then go into physics (Shimony in *AIP Oral History Interviews*, 2002).

[9] According to Gavroglu, 'What London was thinking programmatically in 1921 was very close to Husserl's thoughts. In this sense London's problematique was not marginal at all.' (*op. cit*. pp. 13-14).

[10] Seth suggests that in his interviews with those quantum physicists still alive at the time, one gets a sense of Kuhn posing leading questions in his efforts to elicit a sense that a revolution took place!

[11] Gavroglu (1995) has also emphasised the similarities between London's philosophical and physical concerns, particularly with regard to the treatment of theories as 'wholes'. He cites Mormann's claim that London's 1923 thesis '[...I can be considered as a set-theoretic concretization of Husserl's largely programmatic account of a macrological philosophy of science' (Mormann, 1991, p. 70; his emphasis).

[12] Some have argued that this represents a major break with his earlier work; others that it offers a fresh perspective on it motivated by the socio-political context of the time.

Revolution. It is ultimately due to the introduction of the infinite manifold via this mathematisation that modern science has been plunged into 'crisis', in the sense of a 'loss of its meaning for life'.[13] Here the suggestion that just as London, following Sommerfeld and his school, saw no crisis in physics, so he would have seen none from a phenomenological perspective, might justifiably be viewed as somewhat facile. What Husserl was concerned with went much deeper and further back in history than the latest developments in quantum physics, back indeed to the arithmetization of geometry which thereby emptied the latter of its meaning. Indeed, Husserl might well have viewed the use of group theory that was so favoured by London as exemplifying this tendency and contributing to the 'crisis'! Of course we could always effectively exclude *The Crisis of the European Sciences* … from consideration in reconstructing the phenomenological basis of London and Bauer's approach, perhaps on the grounds that it appeared long after London's education in phenomenology and at a time when he was fully committed to the quantum project. But perhaps that would be too quick. At the very least we would expect London to be sympathetic to Husserl's insistence on an examination of the 'original meaning-giving achievement' of mathematics as applied to physics. Perhaps, then, we can understand London and Bauer's re-insertion of consciousness into quantum theory as a response to Husserl's call to restore the subjective-relative to physics. Indeed, it is the relative aspect that is absolutely crucial as we shall now see.[14]

Let me begin by noting their reconceptualisation of quantum mechanics as implying a *theory of knowledge*: they write,

'Without intending to set up a theory of knowledge, although they were guided by a rather questionable philosophy, physicists were so to speak trapped in spite of themselves into discovering that the formalism of quantum mechanics already implies a well-defined theory of the relationship between the object and the observer, a relation quite different from that implicit in naïve realism, which had

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[13] Egg draws an interesting parallel between Husserl's concerns and those motivating certain current forms of the 'metaphysics of science' (Egg this volume).

[14] Føllesdal argues that science and the lifeworld should not be seen as being in opposition, since the latter mediates the reference to reality of concepts of the former and acts as the relevant touchstone through scientific revolutions, say (Follesdal 1990); see also Bilban (forthcoming) and Egg (this volume).

seemed, until then, one of the indispensable foundation stones of every science.' (1983, p. 220). Note the reference to 'a rather questionable philosophy' at the beginning of this passage – it may be that London and Bauer are referring here to the positivistically inclined approach of Heisenberg in his work on matrix mechanics, or the curious admixture of different philosophical strands in Bohr's thought[15] or, more likely perhaps, to a general stance within science of supposing that objectivity meant excising the subjective. Despite such a stance, they write, the formalism itself implies a specific relationship between subject and object. Note also their insistence that this relationship is not that which is supposed by 'naïve realism', underpinned as it is by the firm distinction between the inner (subjective) and outer (objective). And note, in sum and significantly, their core point that quantum mechanics is not to be thought of as merely another theory that can be straightforwardly evaluated in terms of various epistemological approaches; rather, *it itself embodies a particular such approach*.

The nature of that approach is then revealed by consideration of the measurement situation. Here, London and Bauer note 'the essential role played by the consciousness of the observer' in the transition from the superposition, ascribed by the theory to the cat + Geiger counter + etc etc., to the pure state, in terms of which we characterise a definite result, such as 'cat alive'. Looking at that situation from 'outside', as it were, they write: 'Objectively - that is, *for us* who consider as "object" the combined system [object, apparatus, observer] - the situation seems little changed to what we just met when we were considering only apparatus and object.' (ibid., p. 251). However, they continue,

'The observer has a completely different impression. For him it is only the object x and the apparatus y that belong to the external world, to what he calls "objectivity." By contrast he has with himself relations of a very special character. He possesses a characteristic and quite familiar faculty which we can call the "faculty of introspection." He can keep track from moment to moment of his own state. By virtue of this "immanent knowledge" he attributes to himself

[15] Although see Bilban (forthcoming) for an interesting and useful analysis of Bohr's thought from a phenomenological perspective.

the right to create his own objectivity - that is, to cut the chain of statistical correlations … ' (ibid., p. 252)

Note here the distinction between the observer's relations with the system and with himself, the latter having a 'very special character'. This is embodied in the 'characteristic and quite familiar' faculty of introspection in terms of which he has immanent knowledge of his own state; that is, knowledge that is indubitable. Here we see London and Bauer's adherence to the phenomenological norm:

'… to avail ourselves of nothing but what in consciousness we can make essentially evident *in its pure immanence*' (Husserl1913/83, p. 59).

Attention should also be drawn to the emphasis on the free creation of objectivity in this account. In a note added by London we find the following: 'Accordingly, we will label this creative action as "making objective." By it the observer establishes his own framework of objectivity and acquires a new piece of information about the object in question.' (London, added note; *ibid*.) This bears obvious comparison with Husserl's statement that '... we persistently *create for ourselves* new configurations of objects ... which have for us lasting reality. If we engage in radical self-examination - that is, return to our ego ... - then all these forms are seen to be creations of spontaneous "I"-activity ... There we also find all the sciences, which, through my own thinking and perceiving, I bring to reality within myself' (Husserl 1929/1964, p. 30; my emphasis). Again, I shall come back to this aspect of London and Bauer's account.

It should now be obvious that what is involved in the 'cutting' of the 'chain' of statistical correlations is not as typically characterised on the 'usual story' sketched above, namely consciousness intervening and mysteriously causing the collapse of the wave function. Indeed, London and Bauer themselves are quite explicit on this point:

'... it is not a mysterious interaction between the apparatus and the object that produces a new y for the system during the measurement. It is only the consciousness of an "I" who can separate himself from the former function $\Psi(x, y, z)$ and, by virtue of his observation, *set up* [*'constituer'*] *a new objectivity* in attributing to the object henceforward a new function $y(x) = u_k(x)$.'(1983, p. 252)

In French (2002) I suggested that in the light of this, the transition from a superposition to a definite state might be more suitably characterised in terms of a mutual separation of both the 'ego-pole' and the 'object-pole' through this familiar act of introspection. As a characteristic act of reflection on the observation, this yields a relational act, in which the ego appears as itself related to the object of the act through this act itself. It is of the essence of such an act and of the immanent knowledge that it yields that the ego should appear as one pole but this should not be taken as implying that the ego is to be conceived of as something substantial, over and above or existing prior to this act. Rather it should be thought of as a non-autonomous centre of identity or subject-pole that stands at one end of the relational act, the other relatum of which is the object. The latter is then 'made objective', in the sense of having a definite state attributed to it, by this objectifying act of reflection, thereby cutting the 'chain of statistical correlations'.

Given this, we can now return to the situation of Wigner's 'friend'. Here we need to recall a crucial Husserlian point, namely that between 'living in' the observation, as an experience, and describing it, an essential descriptive change occurs. In making such a description we are no longer 'living in' the observation, but instead we attend to it and pass judgment on it and in doing so we cannot avoid reference to an ego or 'I'. Thus, in such a description, performed after an 'objectifying act of reflection', the ego is 'inescapable' since it *necessarily* appears as related to the object of the act of observation. What the friend set-up illuminates, from this perspective, is precisely that descriptive shift: normally we do not explicitly 'keep track' of our mental states, e.g. in the sense of making a note of them, but what Wigner's argument illustrates is that we do possess this 'characteristic faculty' and can say what our state is, if needs be. Of course, in observing his 'friend', Wigner's consciousness will also separate from the relevant superposition and he will then set up a new objectivity.

We can also see how Putnam's and Shimony's objections are wide of the mark. First of all, the observer *is* included within the remit of the theory – she is not something beyond or outside of it, that mysteriously intervenes to somehow 'cause' the wave function to collapse. Of course there is more to say (see French forthcoming) but it is also not the case that the separation of the ego places the observer beyond the theory prior to the observation. At the point of observation, there is a separation but only in the above sense that the object and subject poles of the relationship between the knower and the world emerge. It is certainly not the case that the ego or consciousness lies outwith the situation before and after, acting in some way to bring about a definite result. Thus consciousness does not 'affect' nature in a peculiar way and there is no 'mysterious interaction'; rather as sketched above, there is a separation of system and observer. Furthermore, there can be no superposition of mental states of the 'I' since the 'I' can only be said to appear post-separation and relatedly, there can be no (internal) mental process of reduction.

The criticisms are hence side-stepped and Shimony, at least, appears to have acknowledged this, eventually, writing that, 'In view of London's philosophical training as a student of Husserl, however, we now are inclined to believe that the attribution [of the usual story of wave function reduction via consciousness) is incorrect and that the passage quoted [the one above beginning '… it is not a mysterious interaction …'] should be given a phenomenological interpretation.' (Shimony 1977, pp. 760-761, fn 7).[16] Likewise, in his interview for the American Institute of Physics Oral History Archives, he says, 'As a student of Husserl, there were some residues of phenomenology in the little booklet of London and Bauer. ' (Shimony in *AIP Oral History Interviews*, 2002; the interview was conducted by Joan Bromberg who unfortunately does not follow up on this remark of Shimony's).[17]

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[16] It is perhaps worth mentioning that this is a bit of an odd paper, especially from today's perspective, concerned as it is with the possibility of using quantum entanglement to demonstrate telepathy. A useful context is Kaiser 2011.

[17] The use of the word 'residue' is interesting here, particularly given Shimony's earlier acknowledgement. He also says that the '…booklet was more explicit about the intervention of mentality in the measurement process than von Neumann is …' (Shimony in *AIP Oral History Interviews*, 2002) because of London's interest in phenomenology. Shimony goes on to describe how he translated London and Bauer's pamphlet from the original French and used it in his class at MIT in the late 1950s. He also states that Wigner was keen to see the English translation published with an introduction by himself and that Bauer liked the translation (London of course had sadly died by then) but that the original publishers declined, because, Shimony speculates, they wanted to publish it themselves. As he notes, they thereby lost the opportunity to have it published with commentary by Wigner (it was subsequently published in the Wheeler and Zurek collection of course). As Shimiony goes on to admit, it was the London and Bauer pamphlet that led him into the measurement problem and his paper 'On the Role of the Observer in Quantum

The 'Effacement'/Co-Option of Phenomenology

Given my claim (again, expanded in French 2002), and the brief discussion above, the question arises: why was the phenomenological underpinning of London's approach to the measurement problem so comprehensively ignored, noted only (so far as I know) by a critical commentator (namely, Shimony) much later?[18] Here I cannot hope to give anything close to a complete answer but can only suggest some relevant strands of thought, of a rather speculative nature.

One feature of the relevant historical period has to do with what might be seen as a move from foundations to pragmatics: with the combination of von Neumann's reconciliation of matrix and wave mechanics and Bohr's apparent victory in his debate with Einstein, attention shifted to the more 'practical' applications of the theory, a shift also powered by the move in centre of gravity of quantum physics from Germany to the USA. With that shift various philosophical nuances may have been lost. There's also the further point that, as Gooday and Mitchell (2013) argue, the distinction between classical and quantum physics itself only emerged over a long period of time, extending into the 1930s, and was dependent on the geographical location considered, a point that meshes with Seth's claim noted above. Thus, although many physics textbooks tend to emphasise the classical/modern distinction as representing a distinctive conceptual break, or revolutionary moment, others, and sometimes the same books, note the continuities in theoretical practice. Indeed, the distinction gets applied in different ways to emphasise either continuity or change, depending on the pedagogical or more broadly cultural aims and interests involved, yielding different versions of what was characterised as 'classical' and 'modern' physics.

The conclusion Gooday and Mitchell draw is that classical physics can only be understood to have existed in the limited sense that the label was developed and attributed by theoreticians in the early twentieth century '…who

Theory' was initially presented at a conference on the foundations of quantum mechanics organised by Podolsky in Cincinnati in 1963, with the likes of Wigner, Dirac and Bohm present.

[18] Bueno (forthcoming) suggests that there was no such underpinning in the first place, offering a 'minimalist' interpretation of the London and Bauer text, stripped of any phenomenological reading. I think such a claim not only goes against London's own stance towards his work in physics but renders problematic Shimony's acknowledgement of such a reading.

sought to preserve a restricted role for established theory and techniques whilst setting forth a future research programme based on new forms of theorizing. ' (ibid., p. 751). And of course, this throws further doubt on the reciprocal sense in which 'quantum physics' can be said to have been brought into being by contrast. Thus, rather than the rendering invisible of revolutions by the followers of the new paradigm, as Kuhn would have it, what we observe is physicists constructing a 'classical' identity for their forebears in order to serve their own interests (ibid., p. 722).

Interwoven with this post-hoc establishment of such a contrast are two further strands: first, the construction of the Copenhagen Interpretation itself, as it has come to be understood, via a 'dialogical' process in which different principles and theoretical features were woven together in a manner that was driven by the contingent forces powering the debates at the time (Beller 1999). Indeed, Beller argues that these principles and features themselves became established as such – that is, as features of the emerging theory – via a process of dialogue between the scientists concerned. Likewise, Camilleri has insisted that the Copenhagen Interpretation understood as a more-or-less unified interpretation 'of' quantum mechanics only came into focus via the opposition of Soviet scientists (Camilleri 2009; see also Freire Jr 2015, pp. 79-83). Secondly, the characterization of the measurement problem as a problem, is something that appears quite late in the day as well. de Ronde (personal communication) notes that the phrase 'measurement problem' only begins to appear after the mid-1940s and 'quantum measurement problem' only in the late 1960s. Freire Jr notes that Wigner was of the first to use the phrase (ibid., p. 142 and records that '[in] the second half of the 1950s there was a rise of studies on the measurement problem …' (ibid., p. 86).

This provides some of the background to what might appear to have been an effacement of London's phenomenological approach – instead of the rise of logical positivism, as in the case of Weyl, we have the rise of orthodoxy in the form of the Copenhagen interpretation as quantum theory itself distinguishes itself from its predecessor. However I want to suggest that there was a further factor in play that renders this less of an effacement in the sense that holds for Weyl's case and more like a *co-option* of London's approach, minus its phenomenological core, by no less a person than Wigner.[19] As Freire Jr nicely sets out (ibid., pp.149-161) through the 1950s and '60s, Wigner attempted to re-shape the conception of the orthodox view with von Neumann at its heart and Bohr displaced (just as Kuhn and others were setting up the *Archives for the History of Quantum Physics* which can be viewed as a manifestation of historians' interest in the theory; ibid., p. 153).[20] Thus, in his famous paper with Margenau (who had previously criticised the phenomenological approach to physics; see Margenau 1978), he wrote 'According to von Neumann and London and Bauer, who gave the most compact and the most explicit formulations of the conceptual structure of quantum mechanics, every measurement is an interaction between an object and an observer.' (Margenau and Wigner 1962, p. 292). And the following year, he noted 'There is a very nice little book, by London and Bauer, which summarizes quite completely what I shall call the orthodox view' (Wigner 1963, p. 7).

Here we see quite explicitly the co-option of London and Bauer's approach but in order to 'fit' that conception into the orthodox view the phenomenological element must be quietly shoved off centre stage![21] Subsequently, of course, it is Wigner's 'friend' argument that becomes the focus of attention and also the subject of criticism and debate[22] and over time Wigner came to recant his view of the role of the mind in this context (Freire Jr. 2015, p. 168).[23] My suggestion then is that it was not the case that the London and Bauer pamphlet was itself effaced, as Weyl's work was, but rather that its central point was obscured by Wigner's co-option of it as merely a summary of von

[19] Wigner knew London from their time in Berlin (when Wigner was working on group theory) and described him as 'a very thoughtful, very industrious, thorough, imaginative person.' (Interview with Kuhn, Session II, AIP Oral Histories Archive).
[20] Wigner's antipathy to Bohr's philosophy of complementarity is apparent in his own interview with Kuhn from these archives where he notes that, possibly under the sway of von Neumann, the duality inherent in complementarity is not reflected in the formalism where one can easily find three operators that do not commute, such as in the case of spin (Wigner Interview Session III, AIP Oral History Archives). Given what Bilban suggests in (forthcoming), this displacement may be construed as a further effacement of the phenomenological 'strand' of thought.
[21] Here Bueno and I agree on the role of Wigner in this history.
[22] For a recent revival of the argument, that I also think can be handled phenomenologically, see Frauchiger, D. and Renner, R. (2016).
[23] Further evidence of the effect of this co-option can be found in Freire Jr's commentary on the London and Bauer pamphlet, in his chapter on Wigner, which makes no mention of London's phenomenological background.

Neumann's view as part of his campaign to re-orient the discipline's understanding of its foundations.[24]

A New Hope?

There is, as there always is, more to say about the history. However, let me now turn to the question: Can we recover, via the London and Bauer manuscript, a phenomenological interpretation of quantum mechanics? I will not pretend to be able to offer a complete answer here but I hope I can at least sketch some possible fruitful directions in this regard (see French forthcoming).[25]

Let me begin by noting that, first, such an interpretation will not fit neatly into the space defined by the axes of the realism-antirealism debate and, secondly, neither will it compare straightforwardly with the most well-known of the current interpretations of quantum mechanics.

With regard to that first point, there have been attempts to render phenomenology (more or less) compatible with realism (see for example Hardy 2013). It has also been compared to anti-realist lines of thought, such as constructive empiricism (see Wiltsche 2012). Although there are interesting points of comparison made here, I shall adopt the more widely accepted stance that phenomenology sits askew both (traditional) idealism and current forms of realism and anti-realism, not least insofar as it denies the 'philosophical absolutizing' of the world inherent to metaphysical realism (see Zahavi 2017). Here I shall take that as amounting to the denial of the 'absolutizing' of the state of the system with the concomitant explication of the constitution of the system as an object of knowledge via the correlative relationship in which consciousness and the system stand (ibid.); that is, in terms of the *mutually dependent context of being* (Beck 1928).

Regarding the second point, it is commonplace to remark that there is an extensive underdetermination of interpretation when it comes to quantum mechanics (French and Saatsi forthcoming). Skipping over a lot of nuances, we

[24] And as Freire Jr also notes (2015 p. 150) as part of that re-orientation, Wigner maintained that the measurement problem should not be dismissed as philosophy of physics but should be regarded as a fundamental part of physics itself.

[25] Of course, such considerations should not ignore the prior work of Heelan, for example and in this context see his 2004.

can in effect draw another set of axes: along one, we have various forms of 'primitive ontology', based on a consideration of material entities in space-time. For the Bohmian, in her current guise, these will be particles with position as a privileged observable (corresponding to a not-so-hidden variable).[26] For the advocate of the GRW view, these will be rendered either in terms of the matter-field or flashes plus a new physical constant that, in effect, 'clumps' the field and 'sparks' (in a sense) the flashes (at the same space-time points). For the phenomenologist, all such interpretations get off on the wrong foot, of course, not least by assuming an unproblematic reification of the notion of a 'material entity'.

Along another axis we might situate those interpretations that take the theory 'literally' or 'as is', the most prominent being the Everettian or 'many worlds' interpretation. This, perhaps, bears closer comparison with a phenomenological approach than the above interpretations, not least because Everett's core relativisation of the quantum state brings it closer to the correlative framework of a phenomenological view. One might also dwell a little on the fact that in its current revival, the interpretation depends on a decision-theoretic device in order to recover the crucial 'Born rule' of quantum mechanics (which specifies, in its simplest form, that the probability density for finding a particle at a certain position is given by the modulus squared of the wave-function at that position). Here one could speculate that a subjective element creeps into the interpretation, or, at least, a certain view, albeit widely held, of what it is to be rational that underpins this device. I shall come back to this, briefly.

It is also interesting that Everett, in his 'long' thesis of 1956, introduced an 'amusing, but *extremely hypothetical* drama' (Barrett and Byrne 2012 p. 74)

[26] Again in his interview with Kuhn, Wigner asks (AIP session III): 'Why is it that we always see positions macroscopically? Position operator is just an operator like every other operator. What is it that makes our minds principally think in terms of position operators? Why are there macroscopic bodies? Why do they have definite positions rather than having another, arbitrary, wave function, or another, arbitrary, operator measured? I may be completely wrong, but I do feel that there is some mystery here not completely cleared up. Several times I've had ideas on this but nothing really convincing.'

which is, in fact, a version of Wigner's 'friend' argument.[27] However, the upshot of the argument is different: for Wigner it demonstrated the role of consciousness in 'solving' the measurement problem, whereas for Everett it showed what was wrong with the 'orthodox' view as simply stated (and here he followed Wigner in taking von Neumann as representative of that view), thereby clearing the way for his 'relative state' interpretation. There is, again, more to say (not least about the many *minds* variant of this interpretation) but from a phenomenological perspective, the initial move of taking the theory literally also gets off on the wrong foot, albeit a different one!

More fruitful comparisons might perhaps be drawn by focussing on the *correlative* relationship in the context of Dieks' perspectivalism or Rovelli's relationalism. Running throughout such accounts one finds a concern with including consciousness, or not. Thus Dieks writes:

'The appeal to consciousness … appears to invoke a *deus ex machina*, devised for the express purpose of reconciling unitary evolution with definite measurement results. More generally, the hypothesis that the definiteness of the physical world only arises as the result of the intervention of (human?) consciousness does not sit well with the method of physics.' (Dieks, 2018, p. 4)

However, from a phenomenological perspective, of course, consciousness is invoked not as a *deus ex machina* but as that which provides the 'ultimate court of appeal of all knowledge' (Ryckman 2005, p. 142). If we then take as central the *correlative* relationship by which mind and world are bound constitutively together (Zahavi 2017, p. 117), understood in the quantum context, we can perhaps retain the advantages of relationist-type interpretations without having to invoke a multiplicity of worlds or of minds. In this regard, as I said, I can only offer a sketch here but the fully-fledged interpretation (if it could be achieved) should at least incorporate the following considerations.

First of all, it goes without saying that the nature of the 'state' in quantum mechanics is problematic (an issue that can perhaps be traced back to Bohr's

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[27] As Barrett and Byrne note (op. cit., p. 29, fn 2), Everett took a class with Wigner on Methods of Mathematical Physics at Princeton in 1954 and presented this version of the 'Wigner's Friend' argument some years before Wigner's appeared in print.

introduction of the 'stationary' state). From a phenomenological perspective, the mutually dependent context of being implies that the traditional notion of state (as non-relational or intrinsic or more broadly, mind independent) must be abandoned. From this standpoint, 'systems' do not possess states in and of themselves independently of observers and in this regard, again, there is an obvious point of comparison with perspectival/relational/relative state approaches. However, this should not be understood in terms of some form of 'splitting' of reality; on the contrary, there is but one 'world' in the sense of a reality, comprised of the relevant systems, that is transcendent but there are many contexts of being, in the sense that the states of these systems are dependent on consciousness.

The obvious question, then, is why are certain states preferred? (this is, in effect, the so-called basis problem). One can take a leaf out of the Everettian's book here and appeal to decoherence, whereby the interaction between a system and the environment (where the latter has many more degrees of freedom than the former) leads to the suppression of interference between certain states that are robust in the sense that information about them is stored redundantly in the environment. The observer can then recover that information without further disturbing the system (see Bacciagaluppi 2016). We can then answer why position is privileged in the way it is (answering Wigner's concern above in fn 20): the interaction potentials are functions of position and thus the states effectively picked out by decoherence tend to be localised in position. Hence, subsequent to the 'separation' of observer and system, position states come to be preferred.

But of course, as is now widely recognised, decoherence in and of itself does not 'solve' the measurement problem, because the combination of system + apparatus + environment will still be in a superposition. It is only through the action of the conscious observer, by engaging in the crucial act of reflection and distinguishing herself as the 'ego-pole', that the relevant separation between system and observer can be achieved.

There remains the further worry, prevalent throughout the discussions of both the von Neumann and London and Bauer approaches, that allowing a role for consciousness in this regard introduces a fatal element of subjectivity and undermines the objectivity of not just quantum mechanics but physics as a whole. Let us return to London and Bauer, who write that understanding this concept of objectivity involves '... the determination of the necessary and sufficient conditions for an object of thought to possess "objectivity" and to be an object of science' (1983, p. 259). They continue, '... Husserl ... has systematically studied such questions and has thus created a new method of investigation called "Phenomenology"' (*ibid*.; here they refer to both the *Logical Investigations* and *Ideas*). The classical concept of objectivity is dismissed as 'useless and even incorrect, [generating] actual obstacles to progress' (*ibid.*). It is the phenomenological concept which is now sufficient for physics' needs, in the sense that '[t]he transcendency belonging to the physical thing as determined by the physics is the transcendency belonging to a being which becomes constituted in, and tied to, consciousness.' (Husserl 1983, p. 123). Taking objectivity to be cashed out in terms of a transcendency that is independent of or separated from a knowing consciousness is what has generated many of the problems associated with quantum physics (and also, Weyl might say, relativity theory) in the first place. To overcome these problems the phenomenologist insists on objectivity itself being constituted by consciousness.

How, then, is *inter-subjective agreement* to be established? Here we can take a leaf out of the book of relational quantum mechanics (see Rovelli 1996 and Laudisa and Rovelli 2013) and note that establishing such agreement itself involved a physical interaction. So, consider a simple arrangement of a system that can be in spin up or down and a measurement device that can indicate 'up' or 'down' (this is adapted from Laudisa and Rovelli 2013). Assume the interaction between the two is such that when the system is in state 'spin up/down' the measurement device records 'up/down' and observer$_1$ observes a reading of 'up' or 'down' accordingly. The system starts in a superposition of spin up and spin down, interacts with the measurement device, and the observer takes the reading, yielding a particular mental 'state' upon reflection, which of course would be either 'I see a reading of 'up'' or 'I see a reading of 'down''. But we can consider the system + measurement device + observer$_1$ as itself as system, observed by observer$_2$. From this perspective, prior to observer$_2$ taking a reading, the whole composite must be regarded as in a superposition (here we recall the flexibility in the von Neumann 'cut' between measured system and measuring system). Observer$_2$ can then take a reading, there is a reflective act and she too will say either 'I see a reading of 'up'' or 'I see a reading of 'down''. When observer$_1$ and observer$_2$ then compare their results there will be no contradiction because that comparison must itself be considered as a physical interaction describable by quantum mechanics.

As Laudisa and Rovelli remark, 'This internal self-consistency of the quantum formalism is general, and it is perhaps its most remarkable aspect. This self consistency is taken in relational quantum mechanics as a strong indication of the relational nature of the world.' (ibid.) Note that this can be adapted to the phenomenological case precisely because on the London and Bauer picture, consciousness is not set outwith the wave function but, rather, the observer is taken to be embraced by the theory too, so that the latter's internal self-consistency applies in this case also. Of course, for Rovelli the relations that make up the 'nature of the world' are physical relations, understood from a broadly naturalistic viewpoint, but there doesn't seem to be any obstacle in principle to situating them within a correlationist framework.

There remains the issue of accommodating and, more generally, making sense of probabilities within such an interpretation. Here we might recall London and Bauer's emphasis on the *free* creation of objectivity, reminiscent as it is of Husserl's remark that, '... we persistently *create for ourselves* new configurations of objects ... which have for us lasting reality. If we engage in radical self-examination - that is, return to our ego ... - then all these forms are seen to be creations of spontaneous "I"-activity ... There we also find all the sciences, which, through my own thinking and perceiving, I bring to reality within myself' (Husserl 1964 p. 30; my emphasis). Insofar as we freely create a new objectivity through this regard that separates the ego-pole from the superposition, one can speculate that it is the spontaneous 'I'-activity that generates the relevant quantum probabilities.[28] Note, first of all, that this is not to subscribe to some form of the 'epistemic' approach to probability in quantum mechanics, given, of course, that the distinction indicated by this label is

[28] The notion of freedom being employed here plays a major role with regard to the phenomenological epoché in general.

inapplicable in this context. Note, furthermore, that the above freedom does not imply that such creation and the separation (or 'collapse' on a non-phenomenological reading) are somehow subject to our will!

That's all well and good but the question remains how can the probabilities in this interpretation agree with those of textbook quantum mechanics (cf. Greaves 2007)? Here again we can steal a page from someone else's book, literally. In Wallace's exposition of the Everettian interpretation (Wallace 2012), as touched on above, the Born rule is recovered via considerations based on decision theory, itself understood as embodying the core features of rational behaviour. It is via our understanding of such behaviour, it is claimed, that probability makes contact with the world. The phenomenologist can appropriate that approach, and the relevant formal proofs, but, of course, would give the underlying understanding of rationality her own interpretation. As Zahavi states, reflection is a pre-condition for the kind of self-critical deliberation involved in such behaviour and, as he says, 'If we are to subject our different beliefs and desires to a critical, normative evaluation, it is not sufficient simply to have immediate first-personal access to the states in question. Rather, we need to deprive our ongoing mental activities from their automatic normative force by stepping back from them.' (2017, p. 23). In other words, we need to effect the core phenomenological move by engaging in a reflective self-distancing through which we enter into a critical relationship with our mental states. Zahavi continues, 'To live in the phenomenological attitude is for Husserl not simply a neutral impersonal occupation, but a praxis of decisive personal and existential significance …' (ibid., p. 23).

There are also alternatives of course, In their review of Wallace's book, Bacciagaluppi and Ismael note that 'Although the proof of the Born Rule is formulated within the decision-theoretic framework, the mathematical core of the proof does not depend on it: as Wallace remarks, it '… establishes that if probability basically makes sense, and has the usual qualitative features, in unitary quantum mechanics, then quantitatively it is given by the Born rule' …' (Baccigaluppi and Ismael 2015, p. 141). As they go on to note, one could take the Born rule to be merely a phenomenological (not in our sense!) add-on to the theoretical structure of quantum mechanics, but then the worry is that one loses any theoretical underpinning for it. However, '… Gleason's theorem provides another natural way of justifying the Born Rule (perfectly acceptable as part of a pragmatic justification). And to do justice to Everett, he presents such a theoretical argument himself.' (ibid., p. 142; as they note, Everett understands the Born rule in terms of a typicality measure, rather than a credence measure as Wallace does).[29] It seems to me that again, there is nothing in principle that prevents the phenomenologist from adapting any of these justifications and indeed, some of the earlier discussions of this issue in the context of the many-minds variant of the Everettian interpretation appear to sail within reach of a phenomenological understanding (see French forthcoming).

Finally, and briefly, there is the well-known claim that the Everettian or many worlds view is the only interpretation that is relativistically kosher as all other interpretations assume a privileged reference frame (this is a criticism that has been levelled at the Bohmian interpretation in particular given the central role played by the notion of a configuration, in terms of the simultaneous position of all the particles). Here we might bring Weyl back into the picture: the separation of the 'I' from the mutual dependency to yield a definite result should not be understood in terms of establishing such a privileged frame; rather, if we understand any such frame of reference as 'the necessary residue of the ego-extinction', to use Weyl's phrase, we can de-privilege it, as it were, by emphasising its subjective character.

Conclusion

I noted in the introduction Ryckman's point that Weyl's theory has an 'ambiguous character' in that it lay 'in the intersection of physics and philosophy' (2005 p. 159). The question can be asked, where, then, does the measurement problem lie? Or, relatedly, is the L&B account *physics* or *philosophy*? The answer may seem both contestable and historically contingent. According to many physicists, for many years, the measurement problem was dismissed as a

[29] Gleason's theorem essentially states that the Born rule follows from the lattice structure of events in Hilbert space. One would of course have to give a phenomenological reading of this structure. Alternatively, one might adopt Everett's argument that that an observer's relative measurement records in a typical branch would be randomly distributed according to the standard quantum probabilities and establish a phenomenologically appropriate 'typicality measure' (for a useful discussion of such measures see Barrett 2017.

philosophical concern. As indicated above, Wigner disagreed and so, I hazard, would London and Bauer, insofar as they saw physics as implying a theory of the relationship between the object and the observer. In this respect, their approach does not suffer from any ambiguity, since from their perspective, to 'do' physics is to 'do' philosophy!

Sadly, whether it is regarded as effaced or co-opted, London and Bauer's approach to the measurement problem has been lost to the majority of philosophers of physics. As a result, the phenomenological perspective that it embodies has not been properly explored and evaluated. Here I've merely indicated possible avenues down which such an exploration might proceed but even if one is not phenomenologically inclined, as it were, such explorations should be interesting, for the possible alternative understanding of quantum mechanics that they may reveal and for the contrast they thereby offer to current interpretations that have been worn thin through repeated examination.

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