On the Received Realist View of Quantum Mechanics

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Abstract

In this article I defend that an underlying framework exists among those interpretations of quantum mechanics which crucially consider the measurement problem as a central obstacle. I characterise that framework as the Received View on the realist interpretation of quantum mechanics. In particular, I analyse the extent to which two of the most relevant attempts at quantum mechanics, namely, many worlds interpretations and Bohmian mechanics, belong within the Received View. However, I claim that scientific realism in itself does not entail commitment to such a view, and I propose to consider a form of realism that dissolves the measurement problem. It is simply a stripped down version of realism. I derive the methodological questions in this form of realism, speculating that within it a novel realist interpretation of quantum mechanics could be conceived.

Key-words: scientific realism, quantum mechanics, methodology, intertheory relations.

1 Introduction: realism and quantum mechanics

In this article I intend to spell out motivations for reconsidering a debate on how scientific realism could approach the interpretations of quantum mechanics (QM) in a novel way. The plethora of realist approaches to QM in the literature evidences the lack of consensus over how to describe in simple words what QM *really* talks about. The different interpretations present dramatic differences between each other. Moreover, none of the strategies for articulating a suitable quantum metaphysics seem to be able to respond what a quantum system really is or what the formalism is telling us about the structure of the world. Of course, regardless of the impasse in philosophy over the meaning and scope of QM, scientists have been producing astonishing technological developments like the ones the C20th has seen, which are more or less based on QM. However, a central task of the realist view ought to be to address the interpretative question 'what is a quantum system really?' in a way that both philosophers and scientists from other fields, and the laymen, could grasp.

This article explores the idea that the well-known realist interpretations of QM might have overlooked issues that are of a broader philosophical nature. In particular, I will argue that current realist attempts to interpret QM have not paid enough attention to methodological considerations, which in significant ways frame and constrain the type of problems the candidate interpretation encounters. By identifying what the different approaches have in common and claiming that that thought presents an obstacle to the development of the realist interpretation of QM, I motivate considering a novel view.

In Section 2 I will present what I call the Received View as a framework which underlies the standard formulation of the measurement problem. I will continue in Section 3, by arguing that the Received View configures the philosophical domain for two of the most advocated realist interpretations of QM, Everettian Interpretation and Bohmian Mechanics. Section 4 will present a bare form of realism which enables an approach to QM that dissolves the measurement problem. In Section 5 I will emphasise the methodological differences between the Received View and the Core Realism I consider. The article ends without having provided a novel solution to the realist question about QM. That question will be left for future works. What I intend to do here is not to provide an interpretation of QM, but to explore the possibility of a philosophical framework within which a novel interpretation could ever be conceived.

2 The Received View and the measurement problem

Despite the plethora of realist interpretations of QM, I claim that it is possible, and useful, to question whether there is an underlying framework common to most of them. The obvious candidate is the measurement problem (to be explained below), which invariably appears at the centre of the scene. Indeed, the interpretations of QM have been seen traditionally as a reaction to the measurement problem. In addition, I claim that it is plausible to consider that the measurement problem is partly what it is in virtue of a philosophical framework in which it is formulated. I will call that framework the Received View[1]. In subsequent Sections I will analyse the extent to which relevant interpretations can be seen within it. I think the Received View can be characterised as including the following two conceptions particularly conceived as intertheory relations:

A) At the *metaphysical or ontological level*, it holds the hypothesis that certain type of metaphysical relation connects the everyday (classical) objects, like tables and chairs, with more fundamental quantum objects like molecules, atoms, and elementary particles. This metaphysical relation is hierarchical, it imposes an order across the objects of the different theories. Some of these relations in the literature are: reduction, emergence, composition, dependence and grounding.

B) At the *epistemic level*, it claims that a certain relation holds between scientific theories. This is expressed in various forms, such as cumulationist or retentionist hypothesis, cf. (Laudan, 1981), epistemic reduction, cf. (Nickles, 1973), principle of correspondence, cf. (Post, 1971), emergence, cf. (Batterman, 2002), etc. They all refer to an aspect of heuristics and justification, and consider that more fundamental theories are successors over less fundamental predecessors, whereby the former has to include some of the terms or structures of the latter.

Hence the framework of the Received View embraces the belief that the realist must give an account of the 'every-day' metaphysics of macroscopic objects as somehow the consequence of the quantum (via some suitable relation), the belief that she must explain why there are tables and chairs as stably localised and continuos objects.

Let us identify these components in the understanding of the measurement problem and the challenges brought by QM. The literature assumes that it is necessary that any realist interpretation of QM explains[2] the appearance of the 'classical world', Landsman (2007, 417). To some extent this comes from the intuition that, somehow, the less fundamental classical 'everyday' objects, such as tables and chairs, are made of elementary particles, which are more

[1] de Ronde (2016) presents a similar analysis in terms of what he calls the Bohrian approach to QM. I will not contrast his analysis with mine here.

[2] The conception of explanation involved here is a broad one. Fully articulating the complex relationship between metaphysics and explanation is still a matter of debate, e.g. Saatsi (forthcoming). Either case, metaphysical consequences or not, the demand to explain the classical appearances as a priority matches well with my account of the Received View.

fundamental. And one way to justify this is by looking historical development of QM: Classical physics describes the motion and properties of such tables and chairs, but it fails – among other things – to account for the structure and stability of matter. Partly because QM was created over the failure of classical physics to account for certain experiments, the new theory stimulated scientists to approach novel questions on the structure of matter, which resulted in an unexpected success. Hence a motivation for the realist to expect that QM explains the appearance of the classical world.

In addition, there is the problem of the quantum-classical limit. This problem includes considering the question of how to recover classicalities from within the quantum. Methods like the mathematical limits ($\hbar \to 0$, $N \to \infty$, etc.), Ehrenfest theorem, and perhaps more importantly, decoherence, attempt to address this problem. However, as it is well known: "quantum theory may give rise to classical behaviour in certain states and with respect to certain observables. [...] If, instead, one uses superpositions of such states, or observables with the wrong limiting behaviour, no classical physics emerges. Thus the question remains why the world at large should happen to be in such states, and why we turn out to study this world with respect to the observables in question. This question found its original incarnation in the measurement problem (cf. Subsection 2.5), but this problem is really a figure-head for a much wider difficulty", Landsman (2007, 492).

Therefore, it is fair to say that the measurement problem significantly captures the motivation to both explain the relationship between classical and quantum and the appearance of classicalities. The measurement problem is presented the reaction to the need to "justify the appearance of the classical world", Bacciagaluppi (2014).

Let us recall this problem: A measurement is seen as an interaction between the object-system and the measuring apparatus, both described by QM. At the outset, system S and apparatus M are assumed to be uncorrelated and in pure states. The 'ready-to-measure' state $|M_0\rangle$ is the initial state of the apparatus and the state of the system is an unknown pure state $|\phi\rangle = \sum c_n |\alpha_n\rangle$, expanded in terms of $\{|\alpha_i\rangle\}$ an orthonormal basis of eigenvectors of the observable A (for simplicity with non-degenerate eigenvalues). The unitarian time evolution of the system+apparatus given by the Schrödinger equation results:

$$\sum_n c_n |\alpha_n\rangle \otimes |M_0\rangle \longrightarrow \sum_n c_n(t) |\alpha_n\rangle \otimes |\beta_n\rangle \,. \tag{1}$$

Where $c_n = \langle \alpha_n | \phi\rangle$ and it is assumed that the measuring apparatus contains a discreet indicator with values $\{b_1, b_2, \ldots\}$, which are the eigenvalues of the observable B pertaining to the apparatus, with eigenvectors $\{|\beta_j\rangle\}$.

The difficulty arises in that the final state (right hand side of Eq. (1) cannot be interpreted to mean that the apparatus indicator is actually in one of its possible states, because the final state is an entangled quantum superposition of $|\alpha_n\rangle \otimes |\beta_n\rangle$. Hence, it is not straightforward to interpret whether the apparatus, considered as a subsystem, has its property with a definite value. This is in contrast with experience, for after an actual measurement has taken place, the apparatus does indicate a definite value. In other words, the problem is that the formalism does not clearly indicate what is going on. That is one basic interpretative problem of QM.

Two notes to make on this. First, that the intense debate in the literature focuses on determining which interpretation correctly explains the appearance of classicalities, and thereby deciding what type of metaphysical relation – in the likes of those mentioned in A) – is to be derived as a consequence of, or fundament for, that 'explanation' of the classical from the quantum. Now, whilst there is disagreement over precisely which type of relationship holds, it seems to be a commonality that there should be one in the first place. Hence I characterised the Received View as embracing the idea that for every event there is a relationship between the objects of the classical and those of the quantum realms, even in the face of the fact of the lack of answer to the metaphysical question of QM: how to spell out the physical nature of the electron in a language that the laymen understands?[3]

Second, there is also not much debate over how to understand the measurement problem nor what it amounts to. The current measurement problem is essentially the same problem that Von Neumann (1996) discussed in 1932, and what it amounts to is standardly characterised by Maudlin (1995). In fact, the different interpretations of QM have traditionally been understood as different ways to approach its solution, cf. Putnam (2005).

Therefore, I indicated the Received View as a general framework underpinned by two broad conceptions of metaphysical and epistemic character. And I defended that the central problem of QM, the measurement problem, can be seen as meaningful within that Received View. In the next section I will analyse the extent to which the Received View underlies two of the most well-known interpretations, namely, Everettian interpretations and Bohmian Mechanics.

3 Interpretations of QM and the Received View

The interpretations of QM that I am interested in discussing are framed within scientific realism. However, they are not as explicit on the form of realism they are committed with as one would wish[4]. The aim of the this section is to briefly recall the main points of two well-known realist interpretations, picking out their explicit or implicit conceptions which highlight the extent to which their research programmes fit within the Received View. Needless to say, for each interpretation there is a whole literature and the topics branch out becoming a complex field that I do not intend to cover entirely. It is not my intention to discuss in detail each one of these libraries, but merely to mention their core aspects, so I will eventually overlook nuances in their account.

A traditional approach to classify the different interpretations – see for example (Putnam, 2005) – is in terms of how they attempt to solve the measurement problem, then the two broad routes are collapse and non-collapse kind of interpretations. The interpretations which provoke most research and are most widely adhered in the literature are the non-collapse interpretations named Everettian mechanics (or Many Worlds interpretations, MWI hereafter) and Bohmian mechanics. Both were brought up as alternatives to the collapse approach by Von Neumann and Dirac. Whilst the actual relevance of the collapse in the practise of physicists has been recently challenged – see Cordero (2001), Wallace (2016a) –, for some time the collapse approach as developed in (Von Neumann, 1996) was seen as the orthodox QM.

Alternatively to the traditional collapse/non-collapse distinction, one could consider a novel way of classifying the different interpretations of QM. Namely, one can classify the realist interpretations by asking what intertheory relations approach they adopt. Questioning this, as I will argue, highlights the dominance of the broadly construed framework of the Received View – discussed above –, whereby a central aim is to 'explain the appearance of the classical world'. I claim that this results in philosophical constraints for the realist at the time of elaborating a metaphysics for QM. In fact, another contribution to the literature is to explore conceiving a philosophical framework away from such Received View mandate.

[3] I acknowledge that some reject the demand that physics should be able to be described in simple words, and I do not deny that it may be impossible. However, as I do not know any firm argument that proves its impossibility, I claim that the best attempt ought to be undertaken to achieve that.

[4] Indeed, this observation is getting more and more recognised as an important question in the community. And the ongoing AHRC Scientific Realism and the Quantum project at the University of Leeds has this research question at its core.

Cordero (1990) and Wallace (2016a) have challenged the traditional conception of the measurement problem and the associated hypothesis of collapse, indicating that they do not actually play a significant role in the practise of QM. Yet, the idea that QM should provide an "account for the 'classical' world of ordinary experience in appropriately scientific terms", (Cordero, 2001, S301), is still an accepted view. However, as I have argued, this expectation is not a strictly necessary requirement from a realist point of view, but a conception within the Received View. Whilst I do not claim realists should abandon the task of relating QM with the classical world, I argue that methodologically speaking this relationship should be secondary to addressing the realist question of 'what a quantum system really is' or 'how the world could possibly be the way QM says'. I will propose a form of realism which suggest this.

But first let us now briefly go over some of the realist attempts to QM, aiming to emphasise the extent to which they match with the Received View.

3.1 Everettian Interpretations

Everettian interpretations (MWI) were initiated with the 'relative state interpretation' put forward by Everett III in his 1957 PhD thesis. MWI reject the postulate of the collapse of the wavefunction, and are presented as a straightforward reading of the standard formalism. There are many versions of the Everettian approach to QM. The most popular one is articulated by the Oxford School, namely, Wallace, Deutsch, Saunders and Greaves. In the words of Wallace, all there is to MWI is the following: "it consists of two very different parts: a contingent physical postulate, that the state of the Universe is faithfully represented by a unitary evolving quantum state; and an a priori claim about that quantum state, that if it is interpreted realistically it must be understood as describing a multiplicity of approximately classical, approximately non-interacting regions that look very much like the 'classical world' ", (Wallace, 2013, 465)[5].

In MWI, the object-system, the apparatus and the observer are regarded as one closed system described by QM. In the process of measurement (and in general, regardless of an actual experiment being made), all possible outcomes are realised in approximately separate but real, actual, worlds. The interaction between the different branches is in practise negligible, thus them being effectively unaware of each other. For an occurrence of an experimental result, all the other branches are necessary even though one is realised in the branch where 'you are at'. The splitting of the world into many as a consequence of the measurement interaction avoids any postulate of the non-causal evolution (the collapse of the wavefunction) and whilst it is logically consistent, it implies the literal existence of an immense – perhaps denumerably infinite – plurality of worlds, approximately independently of each other.

The typical criticism to MWI arises from the problem of the preferred basis, and the problem of the probabilities or the derivation of the Born rule. The former stems from the basic properties of a Hilbert space-based formalism: a vector in the Hilbert space can be expressed as a linear combination of infinitely many different orthogonal bases. So the branches which compose the original state depend over the selection of a preferred basis. But the interpretation does not say which basis should be preferred. Decoherence is used in order to help MWI to resolve this problem. The observables super-selected by decoherence are the ones to be preferred. In fact, part of the great boost in interest on MWI is due to Wallace and Saunders who incorporated decoherence as a main element in the theory for that purpose, cf. (Wallace, 2010) and (Saunders, 2010, 5). Briefly, decoherence allows for the splitting of the worlds into approximately independent, approximately classical ones. However, the power of decoherence to achieve this has been criticised, see for instance (Bacciagaluppi, 2014), where it is claimed that decoherence far from

[5]The conceptual possibility of describing the state of the universe with a pure state evolving unitarily on time is not an uncontroversial idea, and has been criticised by the likes of (Barandes and Kagan, 2014, 18).

solving the measurement problem, exacerbates it, and (Kastner, 2014) where it is argued that the use of decoherence is invalid as it involves a circular argument.

The problem of probabilities relates to articulating how QM is meant to be a probabilistic theory (generally thought that the probability determines in some way which outcome will be realised), given that MWI proposes that all possible outcomes actually occur – in different worlds. Deutsche, Wallace and Greaves defend that incorporating decision-theory into the interpretation resolves this, cf. (Wallace, 2003). However, critics claim that the framework requires decoherence which in turn utilises Born rule in the first place, undermining the strategy, cf. (Baker, 2007).

3.2 Everettian interpretation and the Received View

That MWI aim at 'explaining the appearance of classicalities' is an explicit one. In fact, the advocate of current versions of MWI is not particularly concerned with providing a metaphysical account of, for example, the quantum state during the time when coherence is retained, or the metaphysical status of the quantum state at a pre-measurement stage. At that point, MWI presents a mathematical description of the quantum system – which can arguably be metaphysically construed in realist terms, for example via adopting a structural realist approach, but whether that is a satisfactory account is not a central issue for MWI. By contrast, this interpretation should be seen, essentially, as operating at the level of the macro-world, Wallace (2016b).

Therefore, it is fair to conceive MWI as essentially concerned with the question alined with the Received View: Given that QM is more fundamental than CM, given that there is significant physics from which no classicalities 'emerge', then how to explain that we observe the classical world? This question matches with the framework presented by the Received View.

The philosophical cost to pay for a justification of the appearance of the classicalities is to put forward a conception of an infinity of worlds interacting with each other but for-all-practical-purposes independent from each other. This seems to be a high price to pay, but insofar as the motivation is described by the Received View, the advocate of MWI is willing to accept such controversial conclusions.

Regardless of assessing the power of MWI as an interpretation, what we have found is that, from a methodological point of view it appears clear that MWI operate within the Received View.

3.3 Bohmian mechanics

Avoiding known historical considerations, de Broglie-Bohm theory is empirically identical to standard QM, although conceptually presents some differences. It started as a non-collapse hidden variables research programme, and it has many ramifications. The independent works of de Broglie and Bohm, modify the standard formalism, considering not only the wavefunction but also the configuration of the particles. Currently widely known version is Bohmian mechanics (BM), the proposal initiated by Bell and followed by Dürr, Goldstein and Zanghi (DGZ). Dürr et al. (1996, 21-22) present that the complete description – i.e. without the need for the collapse postulate or further axioms – of an N-particle system is provided by its wavefunction $\psi(q,t)$ where $q = (\vec{q}_1, \vec{q}_2, ..., \vec{q}_N) \in \mathbb{R}^{3N}$, and also its configuration $Q = (\vec{Q}_1, \vec{Q}_2, ..., \vec{Q}_N) \in \mathbb{R}^{3N}$, where the $\vec{Q}_k$ are the positions of the particles (assuming that neither electromagnetic force nor spinorial part are present). Now, the wavefunction evolves always according to Schrödinger's equation – no collapse hypothesis –,

$$i\hbar\frac{\partial\psi}{\partial t} = H\psi. \tag{2}$$

Further, the actual motion of the point-mass particles of masses $m_1, m_2, ..., m_N$, evolve according to the guidance equation

$$\frac{d\vec{Q}_k}{dt} = \frac{\hbar}{m_k} \frac{Im(\psi^* \nabla_k \psi)}{\psi^* \psi} (\vec{Q}_1, \vec{Q}_2, ..., \vec{Q}_N), \tag{3}$$

where $\nabla_k = \partial / \partial q_k$.

Dürr et al. (2013) view it that the wavefunction is not as 'real' as an element as the particles. They consider that there is a primitive ontology constituted by particles with position in the ordinary (classical) space (for non-relativistic QM). The wavefunction is not part of the primitive ontology, and instead is a 'nomological entity' which governs the motion of particles, (Goldstein and Zanghì, 2013, 92). The nomological role of the wavefunction is analogous to the role of the Hamiltonian in classical mechanics: to implement the law of motion for the primitive ontology, (Allori, 2015, 111). See Dorato and Laudisa (2015) for criticism.

As noted by Barrett (2003), BM is grounded of a number of (metaphysical) assumptions of what QM – as a physical theory – is expected to represent or describe. BM justifies the modification to the standard quantum formalism on the grounds that the local beables or the primitive ontology, point-like masses, are the real content of the world. These particles do follow trajectories, although their nature is different to that of classical particles. One qualitative difference between classical physics and BM is the non-local character of the latter. For in classical physics the velocity and positions of the particles are related by being conjugate variables, but are essentially independent from one another, whilst in BM they all particles are related by the guiding equation $\vec{v}_k = d\vec{Q}_k/dt$. This means that the motion of every particle and the positions of all the other particles are associated, at the same time. How to conceptualise this is still a matter of debate.

Lastly, it is worthwhile to note that within the BM research programme, a central challenge is to account for the problematic relationship between BM and relativity theory. DGZ recognise as an urgent challenge to reconcile the non-local character of the theory and the fact that the equations (2) and (3) are not Lorentz-invariant. That is, to account for a smooth intertheory relationship between BM and relativity theory, cf. Dürr et al. (2013).

3.4 Bohmian mechanics and the Received View

The presentation of BM suggests that the Received View operates by the central commitment to conserving a classically inspired metaphysics of local beables, and the central concern of providing a unifying account of BM in a Lorentz-invariant framework. However, these come at the price of a controversial non-local realism.

However, there is a seemingly unorthodoxy character in BM, in considering the wavefunction as a scientific law. Spelling out this is still a source of disagreement, for what does it mean that Ψ is a law? Then, one might find this as placing BM away from a Received View. On the contrary, I argue that the inclusion of BM within the Received View is actually suggested by the specific reason why they do not allow an interpretation of the wavefunction as representing something real. The reason the wavefunction is not as real for the bohmians is that it is not suitable to represent *matter*, which is what has to be recovered. Indeed, particles are considered as real and that which cannot represent matter cannot be accepted as real, (cf. Allori, 2015). Hence, the requirement that the realist content of the ought to be that which can be made to represent matter, matches well with the Received View. For the Received View takes the 'everyday' as what is really real. They assert a priori that only the classical metaphysical elements – massive objects – are a guide of what should be considered real. Methodologically that is similar to saying that whatever QM tells us about the world it must justify the appearance of classicalities.

4 Core Scientific Realism

So far I have argued that most well-known realist interpretations of QM, namely many worlds interpretations and Bohmian mechanics, operate under a framework which I called the Received View. I will leave this for future works the question whether this analysis could be extended over to other interpretations, such as GRW and wavefunction realism. Now I will outlining a form of realism which does not precisely go against the Received View, but contains it. I defend that scientific realism does not entail commitment to the pillars of the Received View, e.g. commitment to the two statements mentioned above A) and B).

Indeed, the debate over scientific realism is a central topic in philosophy of science, and as such, it can be approached from a number of angles. I will consider a distinction in the debates based on two possible types of questions:

1. What is Realism? This relates to the debate over the sort of commitments that realism entails, the worldview it holds, what it takes the aims of science to be, etc.

2. How can realism be justified? This debate aims at convincing the philosopher to prefer realism over anti-realism. Here the discussion is framed in terms of argument vs. counter-argument, criticism vs. reply, and so on.

At some point the debates influence each other, and surely the debate of realism/anti-realism (within 2.) has provoked further development in each side (within 1.). However, for the purposes of this article, it will be worthwhile to emphasise specific aspects of question 1., setting aside however interesting discussions related to question 2, see Psillos (1999) for a standard textbook on these issues.

Hence, I will present a 'minimal form of realism' which picks out common and basic features to any particular form of realism. Possibly denying any of the intuitions alluded in the following statements would entail commitment with an anti-realist view. What I defend is essentially that realism claims that the world is real but we do not know what it is prior to our scientific theories being interpreted. That intuition is the same one involves in de Ronde (2016)'s representational realism. Whilst de Ronde's proposal is focused on QM, the following can be applied also to other sciences.

Core Scientific Realism:

i) The world exists independently of us humans, our consciousness and perceptive apparatus.

ii) Our theories capture truths of the world, or are approximately true of the world, or represent real features of the world, etc.

iii) The realist is concerned with the interpretative questions: how is the world according to the theory? What is the theory telling us about how the world is?

Indeed, i) and ii) are quite similar to Papineau (1996, 2)'s presentation, or the metaphysical and semantic theses advocated by Psillos (1999, xvii)[6]. The distinction made before over the questions 1. and 2. exempts me from having to thoroughly discuss the meaning and compatibility of (i) and (ii). The philosophical work required to spell out how theories capture true features of the world, or what notion of truth is involved, would take us into a philosophical debate that I do not intend to engage here, the reason being that it would distract the discussion away from the realist interpretation of QM.

[6]The discussion of how they are compatible or defensible against other frameworks relates to question 2. and so it will not be discussed here. There are entire debates on that, which I do not engage with in order to limit the scope of the analysis.

Now, in addition to (i) and (ii), I emphasise the methodology concerned in a realist approach to scientific theories. Which is why I add (iii): It is just the way Van Fraassen defines an interpretation of a theory, divorced from typically realist commitments. He says that an interpretation responds to the questions of "what would it be like for this theory to be true, and how could the world possibly be the way this theory says it is? [...] However we may answer these questions, believing in the theory being true or false is something of a different level", (Van Fraassen, 1991, 242)[7].

In relation to the problem of QM, to follow the methodological guidance of Core Realism means that the realist ought to be primarily concerned with giving an account of the 'quantum' aspect of the world in appropriately realist terms – i.e. as representing something of a real character. Hence, the Core Realist account of QM ought to be able to give an account of what a quantum state represents in the world independently of a measurement result. Therefore, the measurement problem seen as the reaction to the need to justify the appearance of classicalities is dissolved. Of course, this line of work is just one option that I think would be worthwhile, but so far has not been explored to the extent it deserves.

Two other lines of research that have a similar strategy in their analysis are worth mentioning. One is the idea explored in the context of the modal interpretations of QM by de Ronde (2011), who considers those variants of modal interpretation which depart from the standard formalism, by contrast with those who start from metaphysical presuppositions. The second is Friederich (2014)'s 'therapeutic approach[8], who draws on Healey's pragmatic approach to QM. Healey and Friederich consider basic problems encountered in the literature as based on misconceived assumptions which, if changed, dissolve, rather than solve the problems of the interpretation of QM. Their view is a pragmatic/anti-realist one, whereby QM does not represent the world.

5 Core Realism and the Received View

It is not uncontroversial to claim that there is no clear solution to the problem of measurement, hence to the interpretation of QM. In this article I attempted to provide a different approach. Rather than focusing on devising a novel solution to the measurement problem, I explored a framework where the problem could be dissolved instead, where it does not appear, or at least appears in a different, reconceptualised, manner. However, this analysis should not be seen as a flat rejection of such research project. Insofar as the measurement problem involves a consideration of intertheory relations, I do believe that it would be necessary, at some point, to relate the goings on at the quantum level with those at the classical level. However, I claim that methodologically speaking the Received View has inverted the proper realist priorities.

Current forms of realism involve more theses than Core Realism. By adding more commitments and claims to Core Realism one can obtain different forms of realism. However, whilst the above three statements define a general form of realism, there are, in principle, neither implications of what type of relation should be taken to exist between different regions of knowledge (different scientific disciplines, or different theories within one discipline), nor whether there should be a fixed and particular one at all. That ought to be decided once the metaphysical content for each theory is appropriately developed. However, that means that I do not deny the possibility of a realism which includes commitments to intertheory relations. Indeed, one can be

[7] Of course, Van Fraassen is a well-known anti-realist. His conception of what an interpretation is, however, the same as the realist one. The difference is that Van Fraassen just does not commit that "acceptance of a scientific theory involves the belief that is it true", but only that is empirically adequate – without commitment to truth (Van Fraassen, 1998, 1066).

[8] See Friederich (2014) for a discussion of the term 'therapeutic', it does not have the psychological meaning, that is why the quotation marks.

realist and hold either pluralist or reductionist views; emergentists and/or reductionists, and so on. This means that the Received View is a more specific case of realism than merely holding a Core Realist view. The Received View includes the commitments of Core Realism, and adds those A) and B) which pertain to intertheory relations.

By contrast with the Received View, which primarily focuses on explaining the appearance of classicalities, Core Realism invites the philosopher to be concerned with an interpretation of QM that articulates a quantum ontology without demanding a specific relationship with classicalities. Only at a second phase, the realist shall try to address the relationship between that realist account of QM and that of classical physics, in the context of intertheory relationships.

Insofar as the priority is to explain the appearance of the classical world, little room is left within the Received View for developing an appropriate quantum ontology which is not significantly constrained by classical metaphysics of particles and waves, tables and chairs. Hence, the claim being made is at a 'meta-philosophical level', a strategical move introduced by Core Realism relegates the relevance of the account on intertheory relations, with the aim of helping the realist have a better vantage point towards approaching QM.

Conceiving the measurement problem as the predominant concern of an interpretation, entails – I argue – unnecessary constrains to the scope of the interpretation, to merely being able to refer to the already known classical reality, also defended by de Ronde (2016).

A visual way to synthesise this discussion is by considering Table 1.

	Core Realism	Received View
General Methodology	1. Realist account of the theory. 2. Address intertheory relations which accommodate 1.	1. Assume metaphysical and epistemic relations. 2. Provide a realist account of the theory which accommodates 1.
The problem of QM:	to provide a realist account of Ψ.	to provide explanation of classicalities from QM.

Table 1: Summary of the discussion of Core Realism vs Received View.

6 Conclusions

In this article I have characterised the standard conception of the most crucial problem within a realist interpretation of QM, the measurement problem, as the problem of explaining the appearance of the classical world from quantum mechanics. I have argued that this problem is not self-evident, but meaningful within certain philosophical framework, which I have called the Received View. I have characterised the Received View as crucially including two central claims. At the metaphysical level, that a relation holds between the objects of one theory and the objects of the other: 'tables and chairs reduce to, are grounded on, are composed by, supervene on, elementary particles', etc. And a statement at the epistemic level, whereby more fundamental theories retain some aspects of less fundamental ones (this capable of being expressed in various ways, such as theory reduction, retentionism, epistemic emergence, etc.).

After having presented this Received View, I discussed in general terms Many Worlds interpretations and Bohmian mechanics and concluded that they operate within the Received View. However, I argued that in itself scientific realism does not entail commitment to the Received View. In fact, I presented Core Realism, which picks out weaker – and more general – claims of any realist view. Within Core Realism, I discussed the dissolution of the measurement problem of QM in its accepted understanding. Therefore, I presented a framework which could allow the realist to conceive the articulation of the metaphysics of QM without necessarily that being wedded to explaining the appearance of classicalities, as the standard approach to the measurement problem commands.

Now the question is, if the measurement problem is dissolved, how do we approach the realistic interpretation of QM? Following the methodology derived from Core Realism, one ought to attempt to answer 'what is QM telling us about the world?' without having preconceptions of what the answer should amount to.

I speculate that one alternative worthwhile to pursue is to follow the line of research suggested by de Ronde (2016), which includes utilising a novel metaphysical scheme within the metaphysics of powers. More work in this direction might be a positive contribution to a realist interpretation of QM.

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