Chapter 23
Quasi-truth and Quantum Mechanics

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23.1 Introduction

Since its early formulation, non-relativistic quantum mechanics (QM) has been
the source of sustained controversy about its foundation. Despite its impressive
empirical success, several foundational issues have not been settled by the theory:
What exactly happens with the observables when a quantum system is not being
measured? And what exactly happens during measurement? What is the nature of
quantum particles? In particular, are they individuals or not? And can identity be
applied to these particles? Not surprisingly, a variety of interpretations of QM have
been developed in the attempt to address these and other foundational questions.
Perhaps also not surprisingly, so far there has been no agreement as to which of
these interpretations (if any) should be preferred.

In this paper, we examine, in outline, some of these interpretations and argue that,
properly understood, they are all quasi-true. That is, they are currently empirically
adequate with regard to the available evidence in their domain (roughly speaking,
the non-relativistic quantum mechanical domain). This explains why, at least at the
moment, there are no empirical grounds to choose between these interpretations. We
then offer a tentative framework to assess such interpretations of QM, and indicate
that, despite their equal empirical support, there are pragmatic factors to prefer some
of them to others.

Due to space constraints, we will need to gloss over several complications
that are inevitable in discussions of QM, and will not be able to offer a comprehen-
sive treatment of the issues. In particular, the selection of interpretations we
will be able to discuss is limited, and our exposition will be fairly informal. Our
goal here is simply to sketch the central ideas, leaving several details for another
occasion.

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23.2 Quantum Mechanics and Some Interpretations

Let us start by discussing a well-known tension that emerges in non-relativistic quantum mechanics, and which is one of the sources for the need for interpreting the theory. Consider a non-relativistic quantum system. In order to describe the system's dynamics, the mathematical formalism of QM offers two distinct kinds of transformations: (a) On the one hand, we have reversible transformations described by unitary operators on the relevant state space, and which are, generally speaking, obtained from the Schrödinger equation. (b) On the other hand, we have non-reversible and random transformations, described by more complex operators, which emerge in the system, in particular, as the result of measurement. The question is: how exactly are (a) and (b) related? What is so special about measurement? The formalism of QM, on its own, does not settle this issue, since it essentially indicates just how to calculate the relevant probabilities in each case. To address the issue, we need an interpretation of the formalism.

On the Copenhagen interpretation—its standard formulation (see Bohr, 1987; Heisenberg, 1955)—there is something special about measurement: it leads to the collapse of the wave function (von Neumann, 1932). Central to this interpretation is the idea that, before measurement, typically it cannot be determined which exact state a non-relativistic quantum system is in. For example, is the spin of an electron up or down? For all we know, the system may be evolving in a superposition (a linear combination) of spin up and spin down. After measurement, however, a definite answer is always obtained. It is determined, for instance, that the spin is up. The measurement process leads to the collapse of the wave function, and the system now has a definite, determined state.

The Copenhagen interpretation is often associated with two principles: (A) Heisenberg's uncertainty principle and (B) Bohr's complementarity principle. Roughly speaking, the uncertainty principle states that it is not possible to measure with full certainty both the position and the momentum of a quantum particle. This principle can be read in two different ways: (A.i) one reading takes the principle as offering an epistemological constraint on measurement, whereas (A.ii) others take it as describing an ontological feature of quantum systems.

(A.i) On the epistemological reading, that Heisenberg seemed to have favored at least initially, the uncertainty emerges as the result of limitations in the measurement process. On this reading, in order to measure the particle's position, we inevitably disturb its momentum, and in order to measure its momentum, we inescapably disrupt its position. The result is the impossibility of measuring both with full certainty.

(A.ii) Bohr seems to have offered, however, an ontological reading of the uncertainty principle. According to this reading, the uncertainty described in the principle is not a mere epistemological limitation of our measuring devices. The uncertainty is an expression of the ultimate nature of quantum reality: the complementary nature of the phenomena involved. Even if we could devise methods of detecting quantum particles with minimum interference, the uncertainty would still be present as an intrinsic component of the quantum phenomena themselves. On this view, the uncertainty is not something that could be, even in principle, overcome.

(B.i) The reason why Bohr may have favored this reading of the uncertainty principle derives from a particular—also ontological—reading of the complementarity principle itself. According to the latter, quantum phenomena have a complementary nature in that their full description requires that one accounts for, e.g., both their wave-like and their particle-like features. However, it is not possible for the phenomena to exhibit both wave-like and particle-like features simultaneously. We have here the wave-particle duality as an intrinsic, ontological aspect of quantum phenomena. And the point can be extended to other complementary properties in the quantum world, such as position and momentum.

(B.ii) But similarly to the uncertainty principle, the complementarity principle can also be read as an epistemological tenet. On this reading, the principle expresses an epistemological limitation, in that the components of the quantum phenomena under study, such as its wave-like and particle-like features, cannot be detected simultaneously. Clearly, the ontological reading is stronger than the epistemological. After all, if it is part of the nature of quantum phenomena that their complementary features cannot be exhibited together, we could not detect these features simultaneously—as long as our measuring devices are reliable.

Typically, however, the Copenhagen interpretation has been presented in a more anti-realist tone, by emphasizing that QM is fundamentally about the results of measurement, and by insisting that what really goes on between measurements is not something that the theory settles. In this way, roughly speaking, anti-realists will tend to support only the epistemological readings of the uncertainty and the complementarity principles. Realists, however, will tend to favor the corresponding ontological readings. But the point stands that on both realist and anti-realist formulations of the Copenhagen interpretation, measurement is crucial—and special.

However, some interpretations of QM deny that there is anything special about measurement; that is, anything that requires special treatment in the formalism of QM. This is, to some extent, the case of the many-worlds interpretation (see Everett, 1957; De Witt, 1970). On this interpretation, the crucial feature of the dynamics would be...

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1 What the Copenhagen interpretation exactly is and who is responsible for its formulation turns out to be complex issues, which unfortunately we cannot discuss here (see Howard, 2004).

2 This is rough since, in principle, realists can adopt both the ontological and the epistemological readings of the two principles. In any case, anti-realists are more likely to deny the corresponding ontological versions.
of a non-relativistic quantum system is given by the Schrödinger equation. What happens in measurement — on De Witt’s version of the many-worlds interpretation — is that the world splits. A non-relativistic quantum system evolves undisturbed, for instance, in a superposition of states of spin up and of spin down, until it is measured. At this point, the world splits: one world ends up with the spin up measured state, and another with the spin down measured state. In this way, each of the alternative components of the quantum system obtains — although in different worlds.

One of the benefits of this interpretation is that it avoids the introduction of the collapse of the wave function, thus bypassing entirely the need to introduce a genuinely random event to explain what goes on in measurement. Ultimately, all there is on this interpretation are the quantum states described in especial by the Schrödinger equation. It just happens that there are many more worlds than we have initially anticipated. And given that all of these worlds exist, strictly speaking there is no collapse of the wave function: each world exhibits one of the relevant definite quantum states. However, this benefit — of avoiding the introduction of the wave function collapse — can be earned only if we do not invoke the suggestion that worlds split as the result of measurements. Otherwise, there is indeed something special about measurement that needs to be taken into account: the splitting of worlds itself (see Barrett, 1999). In other words, Everett’s original formulation of the many-worlds interpretation — free from the splitting worlds assumption — seems better than De Witt’s in this respect (see also Vaidman, 1998).

An objection that has often been raised against the many-worlds interpretation is that it is unclear how to make sense of the concept of probability on this view (see, e.g., Albert and Loewer, 1988; Barrett, 1999). After all, given that each component of the superposition obtains, there is no distinction between what is actual and what is possible, and hence it is unclear how exactly to draw the line between what is actual and what is probable.

Moreover, can the world really split in the way postulated by De Witt’s version of the many-worlds interpretation without anyone noticing? The many-minds interpretation of QM is offered as an ontologically more parsimonious formulation of the many-worlds conception, since it preserves the assumption that there is only one physical world. Our minds, as it were, suffer the split (see Albert and Loewer, 1988; Barrett, 1999). Given that there is no multiplicity of worlds on the many-minds interpretation, but only of minds, the difficulty of making sense of probability does not emerge. After all, on the many-minds interpretation, there is no difficulty to distinguish what is actual from what is possible.

However, even though the many-minds interpretation does not require the existence of more than one world, it is unclear that there are that many minds — one for each possible measurement outcome, or, more generally, for each potential outcome of a quantum interaction in the whole history of the universe. And even if there were so many minds, the commitment to them is not found in the formalism of QM, which does not even quantify over these things. As a result, it is unclear that the commitment to the many-minds hypothesis is ontologically less problematic than the one to the plurality of worlds. Moreover, given that the outcome of a measurement is supposed to be a physical process in the world, rather than a psychological event in the mind, it is unclear that the many-minds interpretation ultimately offers an adequate account of the measurement process. The latter does not seem to be even properly categorized as a physical event.

This small sample of interpretations of QM clearly indicates the difficulty involved in assessing these views. Each interpretation has clear benefits, providing some understanding of the way the quantum world could be (van Fraassen, 1991). Moreover, each interpretation goes beyond the formalism of QM, and offers an account of what may be going on beyond the phenomena. Some interpretations are fairly minimal in what they add to the description offered by the formalism. For example, on the anti-realist reading of the Copenhagen interpretation, the components added to the formalism emphasize the epistemological limitations that restrict our access to some aspects of the phenomena that QM studies. Other interpretations add a significant amount to the formalism, to the point that it may not even be clear whether we are dealing with just an interpretation of QM or, in fact, with a rival theory, which would yield different empirical results than QM does if we had the required technological devices to test these predictions. For example, the many-worlds interpretation can be seen in this way. On the revised Everett formulation articulated by Vaidman, 1998, the many-worlds interpretation entails the existence of a plurality of worlds. However, this is not a prediction made by either the Copenhagen interpretation or by the formalism of non-relativistic QM alone. In fact, the introduction of the collapse of the wave function can be seen as an attempt to block the commitment to the plurality of worlds (Vaidman, 1998). We are, however, currently unable to test the existence of such a plurality, and thus cannot decide empirically on the merits of the contending interpretations.

It becomes clear that the interpretations involved here also have considerable costs. They are inconsistent with each other — at least in the ontological assumptions they make to describe the quantum world. And their attempts to account for what goes on beyond the phenomena introduce, in some cases, inadmissable considerations, such as the number of minds required by the many-minds interpretation. What is needed then is a framework to assess these (and other) interpretations in an objective way. We think that one possible framework is given by the partial structures approach (da Costa and French, 2003).

### 23.3 Quasi-truth and Partial Structures

The partial structures approach has three main concepts: partial relation, partial structure, and quasi-truth (for details, see da Costa and French, 2003). One of the main motivations for introducing this proposal derives from the need for supplying
a formal framework in which the openness and incompleteness of the information that is dealt with in scientific practice can be accommodated. This is accomplished, first, by extending the usual notion of structure, in order to accommodate the partialness of information we have about a certain domain (introducing then the notion of a partial structure). Second, the Tarskian characterization of the concept of truth is generalized for partial contexts, which then leads to the introduction of the corresponding concept of quasi-truth.

The first step, then, to characterize partial structures is to formulate a suitable concept of a partial relation. In order to investigate a certain domain of knowledge $\Delta$ (say, the physics of particles), researchers formulate a conceptual framework that helps them systematize and interpret the information they obtain about $\Delta$. This domain can be represented by a set $D$ of objects (which includes real objects, such as configurations in a Wilson chamber and spectral lines, and ideal objects, such as quarks). $D$ is studied by the examination of the relations that hold among its elements. However, it often happens that, given a relation $R$ defined over $D$, we do not know whether all objects of $D$ (or $n$-tuples thereof) are related by $R$, or we need to ignore some of the relations that are known to hold among objects of $D$, in order to study other relations about that domain in a tractable way. This is part of the incompleteness and partiality of our information about $\Delta$, and is formally accommodated by the concept of a partial relation. The latter can be characterized as follows. Let $D$ be a non-empty set. An $n$-place partial relation $R$ over $D$ is a triple $(R_1, R_2, R_3)$, where $R_1$, $R_2$, and $R_3$ are mutually disjoint sets, with $R_1 \cup R_2 \cup R_3 = D^n$, and such that: $R_1$ is the set of $n$-tuples that (we know that) belong to $R$; $R_2$ is the set of $n$-tuples that (we know that) do not belong to $R$, and $R_3$ is the set of $n$-tuples for which it is not known (or, for reasons of simplification, it is ignored that it is known) whether they belong or not to $R$. (Notice that if $R_3$ is empty, $R$ is a usual $n$-place relation that can be identified with $R_1$.)

But in order to accommodate the information about the domain under study, a concept of structure is needed. The following characterization, spelled out in terms of partial relations and based on the standard concept of structure, offers a concept that is broad enough to accommodate the partiality usually found in scientific practice. A partial structure $A$ is an ordered pair $(D, R_1)_\text{rel}$, where $D$ is a non-empty set, and $(R_1)_\text{rel}$ is a family of partial relations defined over $D$.5

We have now defined two of the three basic concepts of the partial structures approach. In order to spell out the last one (quasi-truth), we will need an auxiliary notion. The idea here is to use the resources supplied by Tarski’s definition of truth. But since the latter is only defined for full structures, we have to introduce an intermediary notion of structure to link partial to full structures. This is the first role of those structures that extend a partial structure $A$ into a full, total structure (which are called $A$-normal structures). Their second role is model-theoretic, namely to put forward an interpretation of a given language and to characterize semantic notions. Let $A = (D, R_1)_\text{rel}$ be a partial structure. We say that the structure $B = (D', R'_1)_\text{rel}$ is an $A$-normal structure if (i) $D = D'$, (ii) every constant of the language in question is interpreted by the same object both in $A$ and in $B$, and (iii) $R_1$ extends the corresponding relation $R_1'$ (in the sense that, each $R'_1$, supposed of arity $n$, is defined for all $n$-tuples of elements of $D'$). Note that, although each $R_1'$ is defined for all $n$-tuples over $D'$, it holds for some of them (the $R_{11}$-component of $R_1'$), and it doesn’t hold for others (the $R_{12}$-component).

As a result, given a partial structure $A$, there are several $A$-normal structures. Suppose that, for a given $n$-place partial relation $R_1$, we don’t know whether $R_{a_1 \ldots a_n}$ holds or not. One of the ways of extending $R_1$ into a full $R'_1$ relation is to look for information to establish that it does hold; another way is to look for contrary information. Both are prima facie possible ways of extending the partiality of $R_1$. But the same indeterminacy may be found with other objects of the domain, distinct from $a_1 \ldots a_n$ (for instance, does $R_{b_1 \ldots b_n}$ hold?), and with other relations distinct from $R_1$ (for example, is $R_{b_1 \ldots b_n}$ the case, with $P \neq ?$). In this sense, there are too many possible extensions of the partial relations that constitute $A$. Therefore, we need to provide constraints to restrict the acceptable extensions of $A$.

In order to do that, we need first to formulate a further auxiliary notion (see Mikenberg et al., 1986). A pragmatic structure is a partial structure to which a third component has been added: a set of accepted sentences $P$, which represents the accepted information about the structure’s domain (depending on the interpretation of science that is adopted, different kinds of sciences are to be introduced in $P$). Realists will typically include laws and theories, whereas empiricists will add mainly certain regularities and observational statements about the domain in question. A pragmatic structure is then a triple $A = (D, R_1, P)_\text{rel}$, where $D$ is a non-empty set, $(R_1)_\text{rel}$ is a family of partial relations defined over $D$, and $P$ is a set of accepted sentences. The idea is that $P$ introduces constraints on the ways that a partial structure can be extended (the sentences of $P$ hold in the $A$-normal extensions of the partial structure $A$).

Our problem is: given a pragmatic structure $A$, what are the necessary and sufficient conditions for the existence of $A$-normal structures? Here is one of these conditions (Mikenberg et al., 1986). Let $A = (D, R_1, P)_\text{rel}$ be a pragmatic structure. For each partial relation $R_1$, we construct a set $M_i$ of atomic sentences and negations of atomic sentences, such that the former correspond to the $n$-tuples that satisfy $R_i$, and the latter to those $n$-tuples that do not satisfy $R_i$. Let $M$ be $\cup_{i \in I} M_i$. Therefore, a pragmatic structure $A$ admits an $A$-normal structure if and only if the set $M \cup P$ is consistent.

Assuming that such conditions are met, we can now formulate the concept of quasi-truth. A sentence $\alpha$ is quasi-true in a pragmatic structure $A = (D, R_1, P)_\text{rel}$ if there is an $A$-normal structure $B = (D', R'_1)_\text{rel}$ such that $\alpha$ is true in $B$ (in the Tarskian sense). If $\alpha$ is not quasi-true in $A$, we say that $\alpha$ is quasi-false in $A$. Moreover, we say that a sentence $\alpha$ is quasi-true if there is a pragmatic structure $A$ and a corresponding $A$-normal structure $B$ such that $\alpha$ is true in $B$ (according to Tarski’s account). Otherwise, $\alpha$ is quasi-false.

5 The partiality of partial relations and structures is due to the incompleteness of our knowledge about the domain under investigation. With additional information, a partial relation can become a full relation. Thus, the partialness examined here is not ontological, but epistemic.
The idea, intuitively speaking, is that a quasi-true sentence ψ does not describe, in a thorough way, the whole domain that it is concerned with, but only an aspect of it: the one that is delimited by the relevant partial structure A. After all, there are several different ways in which A can be extended to a full structure, and in some of these extensions ψ may not be true. Thus, the concept of quasi-truth is strictly weaker than truth: although every true sentence is (trivially) quasi-true, a quasi-true sentence may not be true (since it may well be false in certain extensions of A).

To illustrate the use of quasi-truth, let us consider an example. As is well known, Newtonian mechanics is appropriate to explain the behavior of bodies under certain conditions (say, bodies that, roughly speaking, have a low velocity with respect to the speed of light, that are not subject to strong gravitational fields etc.). But with the formulation of special relativity, we know that if these conditions are not satisfied, Newtonian mechanics is false. In this sense, these conditions specify a family of partial relations, which delimit the context in which Newtonian theory holds. Although Newtonian mechanics is not true (and we know under what conditions it is false), it is quasi-true; that is, it is true in a given context, determined by a pragmatic structure and a corresponding A-normal one (see da Costa and French, 2003).

23.4 A Framework for Interpretations of Quantum Mechanics

The partial structures approach provides a framework in terms of which we can revisit and assess, at least in part, the interpretations of QM discussed above. In this section, we motivate, in outline, this claim.

Despite the significant differences between them, the interpretations discussed above have one common feature: they are all (partially) empirically adequate—in the sense that the empirical evidence currently available does not undermine any of these interpretations. However, the evidence at hand also fails to discriminate between the various interpretations, given that the latter are equally supported by the available evidence. There is the possibility that in the future some new evidence will undermine some of these interpretations without challenging others. But to make sense of this possibility, we need to have a concept of empirical adequacy that is not "absolute"; that is, a theory’s empirical adequacy is not characterized in terms of all past, present, and future evidence (we do not have access to the latter yet in any case). Rather, the empirical adequacy of a theory is better conceptualized as emerging from, and changing with, the evidence as the latter becomes available. Changes in evidence may change a theory’s empirical adequacy as well. For example, van Fraassen (1980, p. 64) offers an account of empirical adequacy that is “absolute” in the relevant sense: a scientific theory is (or is not) empirically adequate with respect to all possible evidence—past, present, and future. It seems to us, however, that it is important to develop an account of empirical adequacy that is more fine-grained and responsive to the way evidence changes in the course of the history of a scientific theory. In particular, the account should be sensitive to the way shifts in evidence bears on the empirical adequacy of the theory under consideration (see also Bueno, 1997).

The partial structures approach allows us to characterize a concept of empirical adequacy that is sensitive to shifts in evidence. Consider a partial structure A that represents the information generated from various kinds of experiments involving non-relativistic quantum systems and the resulting measurement reports. This structure is clearly partial given that, for instance, there is no information available in the structure regarding the outcomes of future experiments. As more and more information becomes available, more partial relations in the partial structure A will shift their R₃-components to either R₁- or R₂-relations. Each of the interpretations of QM discussed above is quasi-true in that partial structure A; that is, the evidence currently available in A does not rule out the possibility that these interpretations turn out to be true. In this way, the interpretations are (partially) empirically adequate—that is, quasi-true with respect to the available evidence in the partial structure A. It is possible, however, that the evidence that becomes available in the future rules out some of the interpretations in question. In this case, there will be a change in the partial structure A that represents the available evidence. And with respect to the new partial structure, some of these interpretations will no longer be (partially) empirically adequate—that is, they will no longer be quasi-true.

Although the interpretations of QM discussed above are (partially) empirically adequate given current evidence, it is still possible to assess them in terms of three pragmatic factors:

(F1) Explanatory power: How well do these interpretations explain puzzling aspects of non-relativistic QM (such as the measurement problem)?
(F2) Novel predictions: Do the interpretations yield novel predictions—even though such predictions cannot be currently tested?
(F3) Coherence: Do the interpretations offer a coherent picture of what is going on beyond the observable phenomena?

These three factors are pragmatic in the sense that even if positive answers are given to the questions above, we cannot conclude that the resulting interpretations are thereby more likely to be true. Why is this the case?

Answering explanatory demands, such as the one in (F1), is certainly a useful aspect of an interpretation of QM. But it is much less clear, and far more controversial to decide, whether a successful answer to (F1) increases the likelihood that the interpretations in question are true. A positive answer to (F1) clearly supports the quasi-truth of the interpretations involved by highlighting the partial structures that can be used in the explanation of the phenomena under investigation. But it is not clear that we are entitled to say anything stronger than that. After all, as classical mechanics beautifully illustrates, a theory can explain several aspects of a given domain without thereby being true.

It might be thought that producing novel predictions, such as those suggested in (F2), amounts to more than a pragmatic feature of an interpretation: it should offer an epistemic appraisal of the proposal. But we are considering here novel predictions that currently cannot be tested. As such, the predictions do not seem to speak to the truth, or even the approximate truth, of the interpretations in question, since the
outcome of the predictions cannot be determined at the moment. Novel, untestable predictions can be counted as having at best a pragmatic role — until the moment in which the predictions can in fact be tested (if we ever reach that point).

Finally, the development of a coherent picture of the quantum world, factor (F3) above, clearly highlights a pragmatic dimension. Having a coherent account of the quantum domain helps us understand such a domain better. But, once again, this understanding underscores a pragmatic, rather than an epistemic, factor. After all, why is it that the fact that a description makes sense to us — by increasing our understanding — should thereby offer us reason to believe that that description is true? Consider, for instance, historical novels. They arguably offer us understanding of nuances, complexities, and significant aspects of life in certain historical periods. But we do not, thereby, take the descriptions provided in these novels to be true. The same point, mutatis mutandis, goes for interpretations of QM.

How does the Copenhagen interpretation fare with respect to (F1)-(F3)? The interpretation does not seem to do particularly well with respect to (F1). If we focus on the measurement problem, the introduction of the collapse postulate rather than offering a well-motivated approach to the issue seems basically to reformulate the problem. If we are supposed to understand why measurement is so special that we need to introduce a truly random event at the core of QM, just stating that the wave function collapses does not quite solve the problem. It essentially restates it.

With regard to (F2), the Copenhagen interpretation does not seem to do much better either. After all, the interpretation does not offer any novel predictions — even those that cannot be currently tested.

However, the Copenhagen interpretation does offer a coherent, very deflationary, account of the quantum domain, particularly in its anti-realist version. In this sense (F3) is properly met. This is probably the main reason why this interpretation seems to be so widely accepted among physicists. Given the capricious nature of the quantum domain, it is a virtue of the Copenhagen interpretation — particularly in its anti-realist form — that it does not force one to be committed to significantly more than is strictly needed to use quantum theory.

How does the many-worlds interpretation fare with regard to (F1)-(F3)? If we consider (F1), and focus on the measurement problem, the many-worlds interpretation does not address the issue very well, particularly in its “splitting worlds” formulation. After all, on this formulation, there is still something special about measurement: worlds split! A better account of measurement is offered by the version of the many-worlds interpretation that does not invoke the splitting worlds assumption. However, this version needs to introduce a measure of existence of worlds (Vaidman, 1998) in order to accommodate probability in the many-worlds interpretation. The worry here is whether we can really make sense of such a measure of worlds, given that we have no empirical access to these concrete objects.

With regard to (F2), the many-worlds interpretation, particularly in the non-splitting worlds formulation, does offer novel, but currently untestable, predictions: the existence of a plurality of worlds. We may never be able to test this prediction, but it is certainly an interesting and quite unexpected prediction to make!

Finally, if we consider (F3), the non-splitting worlds version of the many-worlds interpretation does offer a coherent account of the quantum domain. It just turns out that, if the interpretation is true, there are many more worlds than we initially thought. It is not clear that the suggestion that worlds literally split in measurement is coherent, since it seems to conflict with several physical assumptions (see Albert and Loewer, 1988; Barrett, 1999). So the coherence point does not seem to apply to the splitting worlds version of the many-worlds interpretation.

23.5 Conclusion

In this paper, we sketched how the partial structures approach offers a useful framework to examine interpretations of QM. As we saw, the approach provides an
account of partial empirical adequacy according to which the interpretations of QM that we examined are partially empirically adequate, that is, quasi-true given current evidence. However, it is still possible to assess the interpretations in question in terms of how well they meet significant pragmatic factors. Despite not giving us reason to believe that the interpretations are true, the satisfaction of these factors allows us to accept some of these interpretations for pragmatic reasons, and explore the understanding they offer of the quantum world.

References


Chapter 24

The Qualitative Analysis of Differential Equations and the Development of Dynamical Systems Theory

Tatiana Roque

The first scientific work concerning a qualitative approach to the problem of solving differential equations was published by Henri Poincaré in the end of the nineteenth century (Poincaré, 1881; 1882; 1885; 1886). Before him, the usual methods to treat linear differential equations tried to solve them explicitly, which means to find out a family of functions that satisfy the conditions established by the equation. But a similar procedure is, in general, impossible in the nonlinear case.

Even when the existence theorem affirms there is a solution for any initial condition, in very few cases this solution can be found explicitly. So, in instead of determining the function that actually solves a differential equation, the qualitative approach search a picture of the hole set of possible solutions describing its main geometrical properties. Poincaré justifies the legitimacy and the interest of such a kind of research in two ways:

1. First of all, the qualitative analysis could help the traditional quantitative methods. The theory of analytical functions developed by Cauchy and Weierstrass gave already the conditions under which a series, that expresses a function, can be prolonged from a neighborhood to another. Qualitative methods could help the quantitative research to find how to go from a neighborhood, were the function is expressed by a series, to another one, where the function is expressed by a different series.
2. Besides that, qualitative analysis can be interesting by itself, since it can furnish rich information to the traditional problems of Celestial Mechanics, as the three