On the Philosophical Views of Werner Heisenberg and His Notion of a Closed Theory from the Later Wittgenstein's Perspective

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Abstract :

I interpret the philosophical views of Werner Heisenberg as a pragmatism and non-metaphysical realism of a Wittgensteinian kind. The "closed theory" is a Wittgensteinian rule/concept.

ملخّص

أقرأ تصوّرات ف. هايزنبارق الفلسفية على أنها تمثّل نزعة براجماتية و ليست ضربا من الواقعية اللاميتافيزيقية مثل تلك التي يؤسّس لها فيتجنشتاين. النظرية المغلقة هي قاعد / مفهوم فيتجنشتاني.

Résumé

J'interprète les vues philosophiques de Werner Heisenberg comme un pragmatisme et un réalisme non-métaphysiques de type wittgensteinien. La « théorie close » est une règle (concept) wittgensteinienne.

1. In this paper, I suggest a possible interpretation of Heisenberg's notion of a closed theory in the context of the comparison of the philosophical views of Heisenberg, Paul Dirac and Niels Bohr on the nature of the connections between scientific theories (in particular, between classical and quantum mechanics). The understanding of the nature of a closed theory is tightly connected with that of the nature of the inter-theoretical connections.

In particular, I give my answers to the questions posed by Erhard Scheibe (2001) about (1) the precise meaning of the notion of a closed theory, (2) the nature of the connections between the laws and concepts within a closed theory, (3) the connection between two closed theories.

Scheibe himself thought that we are far from understanding the notion. It seems to me, however, that we are not much further from its understanding than from the understanding of Wittgenstein's philosophy (alas, pseudo-Wittgenstein is still popular) and its synthesis with analytic philosophy.

2. Although it is considered that among the founding fathers of quantum physics Niels Bohr was more philosophically oriented than other theoretical physicists, it seems to me, that the contribution of Heisenberg to the philosophy of physics was not less important than that of Bohr.

Of course, Heisenberg was thinking about Niels Bohr's "correspondence principle" between classical and quantum mechanics (and even generalized its initial version and used the generalization to construct his variant of quantum mechanics), the "principle of complementarity" of classical and quantum concepts (to which Heisenberg maintained an ambivalent attitude), and the idea of particle/wave dualism of quantum objects (which Heisenberg considered as an imaginary representation of properties of quantum objects in the language of classical physics. From Heisenberg's point of view, quantum properties can be precisely formulated only in the language of mathematics). His major contribution, however, consisted in introducing and using the notion of a closed theory.

3. Let me start with Heisenberg's examples of a closed theory. Heisenberg considered as being "closed" the following theories: Newtonian mechanics, electrodynamics (including special theory of relativity), thermodynamics (including statistical physics) and quantum mechanics in a broad sense (that is, including quantum field theory). He had every reason for doubt as to the status of general relativity. Still today the empirical data and the established inter-theoretical connections are not enough to consider it as a closed theory. For example, gravity waves have not yet been discovered. Until now there has been no satisfactory synthesis of gravity and quantum theory.

According to Heisenberg, closed theories are absolutely true, perfect and final (true for all times).

Such a characterization may resemble a dogmatic metaphysics and, in particular, metaphysical Platonism (and Heisenberg himself characterized his philosophical position as Platonism).[1] However, this first impression is false. As we will see, Heisenberg is a realist, but not a metaphysical realist (though there is some place within Heisenberg's system for a metaphysical realism of "things-in-themselves" (see below)); he is a non-metaphysical Wittgensteinian pragmatic realist in the broad pragmatic and realistic spirit of language games and forms of life of the later Wittgenstein. As for Platonism, it takes in Heisenberg's philosophy a non-metaphysical naturalistic form in the sense that scientific ideas turn out to be anchored in experience and reality which aliment them.

Heisenberg himself talks not only about his "Platonism", but also about his "practical realism" which he contrasts with "dogmatic realism". By way of correcting (or generalizing) Kant he also introduces the notion of a *practical a priori*. The practical *a priori* is not a necessity, or it is a necessity only in a restricted domain (that is, at the same time it is a *relative a priori*). For instance, the classical principles of causation and determinism are relative (practical) *a priori*. They are valid only in the domain of applicability of classical physics, and, ultimately, are the result of a long preliminary experience.

[1] In particular, for Heisenberg, an elementary particle is "nicht Stoff, sondern mathematische Form" (not substance, but mathematical form. *Translation mine*) of a very complicated and abstract kind (Heisenberg 1984b, p. 407).

However, Heisenberg is not an empiricist in the classical sense. He thinks that the rationality contributes to the experience. For instance, Heisenberg claims that his conception of space and time is situated between two extremes: apriorism and empiricism.

Nor is Heisenberg a positivist. He himself criticizes positivism. Although his method consists in describing only what is observable (for him, only the observables are real), this is not at all positivism, because the *description* by Heisenberg is not phenomenological. Heisenberg criticizes the phenomenological theories, including (from his point of view) the Ptolemy system. Such theories are not closed, because they are not *flexible* (that is, they depend on the variable concrete experience).

4. What is important is that for Heisenberg the closed theories as being true, perfect and eternal, are such only in a restricted domain of their applicability. And in this domain they do correspond to reality (describe reality). Heisenberg is a realist.

Different closed theories have different domains of applicability. In this sense, as, for example, Alisa Bokulich (2008) claims, Heisenberg is a pluralist, or a pluralistic realist. However, there are good reasons to think that his philosophy is deeper than pluralism. For Heisenberg, physics is one, although not in a dogmatic, but in a moderate sense, namely in the sense of the existing connections (respectively, gaps) and also some hierarchical order between different theories. For example, Heisenberg says that the conceptual structure of special theory of relativity contains in itself the conceptual structure of classical mechanics as a limit case. Heisenberg also makes use of the correspondence principle.[1] That is why Heisenberg is not an absolute pluralistic realist (notice that Wittgensteinian pluralism of language games and forms of life is not an absolute metaphysical pluralism either).

5. For instance, classical mechanics and quantum mechanics are two closed theories which are true, perfect and unchangeable in their domains of applicability. One cannot say that quantum mechanics is true and classical mechanics is false, or that quantum mechanics is exact and classical mechanics is approximate. Both theories are true and exact, but they are true and exact in their domains of applicability. And there are some connections between them.

For Heisenberg, as for Bohr, Newton's mechanics is a kind of *a priori* for quantum mechanics. Quantum mechanics, its concepts *presuppose* classical mechanics and its concepts (despite the fact that classical concepts are not applicable in the quantum domain). On the other hand, classical laws and concepts are applicable only in the classical domain; they are relative (non-Kantian) *a priori*. Heisenberg sees this as "the fundamental paradox in quantum mechanics" (Heisenberg 1958, p. 82). I notice that there is no paradox. Quantum theory is a generalization of classical theory (Heisenberg, Bohr and Dirac, all physicists talk about it, though slightly differently); and quantum concepts are simply generalizations of classical concepts. It is a confused (but very

[1] The correspondence principle has a slightly different meaning for Heisenberg, Bohr and Dirac (see § 7 below).

suggestive!) way to talk about the latter as invalid and at the same time indispensable or *a priori*.

Both theories had arisen in a close connection with experience. Later, however, they became detached from concrete experience, relatively independent from it. They became *established*, *rigid* theories (in German: *harte Theorie*. Both physicists, Einstein and Heisenberg use this term[1]). Closed theories are established theories.

In a sense, closed established theories are in a one-to-one correspondence with "things-in-themselves" of a metaphysical reality, which Heisenberg identifies with mathematical structures derived directly or indirectly from experience (in opposition to Kant).

Classical and quantum mechanics as mathematical structures do correspond to "things-in-themselves". The mathematical structure of classical mechanics is most appropriate to describe one domain of reality (roughly, at ordinary scales). The mathematical structure of quantum mechanics is most appropriate to describe another domain of reality (roughly, at atomic scales).[2]

Thus, a positive answer to the following question posed by Erhard Scheibe (2001, p. 163) is possible:

"Can we then point to a kind of mathematical structure and claim that this kind of structure is characteristic for the given theory in the sense that another physical theory would have another kind of structure non-equivalent to the first as being characteristic for it (…)."

The *ultimate ontology*, however, is not that of metaphysical realism in the classical sense where reality is considered as consisting of objects and facts (or "states of affair") which are situated "in front of" the subject (that is, metaphysical realism supposes a de-contextualized view from outside) and *absolutely* independent of it (conceptually completely predetermined).

Heisenberg's ontology can be understood within a Wittgensteinian contextualism as a *sensitive ontology* in the sense introduced by Jocelyn Benoist (2012): "The question of what

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1 I notice also that Heisenberg accepted Einstein's thesis that theory determines what is observable. Within my Wittgensteinian interpretation of Heisenberg's philosophy (see below) this means that a concept/rule determines the domain of its applicability (and is itself determined by this domain). And, of course, a concept/rule determines its concrete application not purely *a priori*, but in a context. Einstein and Heisenberg's position is not idealistic.

2 Such a correspondence between domains of reality and mathematical structures is not obvious, because in principle any mathematical structure may have different physical interpretations. (And *vice versa*: a physical phenomenon may have different mathematical descriptions/interpretations. For instance, an interpretation of the quantum entanglement in terms of the analytic continuation in complex analysis has recently been proposed (Feiler 2013).)
For instance, the AdS/CFT correspondence in String Theory has been used in explanation of high temperature superconductivity. That is, there is a mathematical connection between black holes and superconductivity. (Cubrovic 2009). Some artificially created „meta-materials", and some vortices recently discovered in the South Atlantic are also mathematical analogues of black holes (http://arxiv.org/abs/1308.2352).
Thus, the mathematical apparatus of general relativity is applicable not only to space and time (gravity). Nevertheless, one can suppose that the latter application is the *central* one.

it is to be an F comes out as inseparable from the fact that *we already take some* a *or* b *to be* F's *in some definite way*" (Benoist 2012, p. 424). An object x of the kind F exists if and only if the concept F is adequately applicable to x. An "adequate concept" - a technical term introduced by Benoist – is intimately connected with reality (the "epistemic gap" is closed) and, hence, reflects reality in all its richness (and *vice versa*, reality "aliments" the adequate concept) (see Benoist 2010/2011, 2011, 2012).

The nature of quantum concepts is different from that of classical ones. The quantum ontology is, respectively, different from the classical one. Heisenberg himself explicitly criticizes the extrapolation of classical "materialistic ontology" to the quantum domain.

6. Because there are good reasons to think that Heisenberg's philosophy can be understood within a pragmatic realism and contextualism of a Wittgensteinian kind, I suggest looking at a physical theory and experience/experiment from the point of view of a language game as a normative practice governed by the concepts of the theory and the corresponding "laws of nature".

A pure theory, that is, a theory as an abstract theoretical schema, can be identified with a Wittgensteinian rule/concept.[1] In a sense, a theory makes explicit an experience by means of which it enters into contact with reality. The so-called *principle of the best explanation* is the principle of the correct *explicitation* of the corresponding Wittgensteinian rule.

Wittgenstein's notion of a rule is not separable from his notion of a form of life. The rules are determined by the forms of life, and, in turn, determine them. The rules are the *hinge propositions* of the forms of life.

Thus, a theory as a rule/concept corresponds to a "form of life" which is a set of correct applications of the theory (a form of life is a "language game" of the second order; applications of the theory are language games of the first order). If a theory (concept) corresponds to a given form of life, the theory is appropriate. If, in addition, it is correctly applied, it is adequate.

My interpretation of Heisenberg's notion of a closed theory says that the closed theory is a Wittgensteinian rule. Heisenberg's practical realism is, respectively, a non-metaphysical Wittgensteinian realism. If this is true, the philosophical intuitions of Heisenberg were in advance of the philosophy of science of his time.

7. Heisenberg's view on classical and quantum mechanics and also on other scientific theories as being "closed", is opposed to Paul Dirac's view according to which all theories are "open" and "approximate" (Dirac himself does not use the expression "open theory", but he rejects Heisenberg's idea that a theory can be closed, and, in particular, that classical and quantum mechanics are closed theories).

[1] For Wittgenstein, as well as for Kant, concepts are rules. The difference between the two philosophers is that Wittgenstein's notion of a concept/rule is naturalized (in particular, this means that a rule/concept is determined by means of its exemplifications).

In other words, Heisenberg's position concerning inter-theoretical relations is that they are discontinuous. Dirac claims that there are continuous relations between theories. As for Niels Bohr, he considers quantum mechanics as a universal theory (that is why he needs the principle of complementarity).

The differences between Heisenberg, Dirac and Bohr also manifest themselves in slightly different understandings of the correspondence principle. For Heisenberg, it is the principle of analogy (as well as generalization). For Dirac, it is the principle of structural similarity (a more mathematical approach). For Bohr, it is the principle of natural/rational generalization.

For Heisenberg, quantum mechanics is a revolutionary "jump into the void", which became possible due to the use of the principle of analogy. Unlike Kuhn, Heisenberg sees this jump – a paradigm change – as a rational (though intuitive) act. And, for Heisenberg, there are connections between the paradigms. For him, the progress in physics consists in extending the domain of experience and, respectively, theoretical description.

Dirac's approach is mathematical. For him, quantum mechanics is a non-commutative generalization of classical mechanics (Dirac considers the move between the two theories as continuous, though he agrees that the similarity between Newton's mechanics and special theory of relativity is stronger)

Bohr focuses on conceptual connection between the two mechanics. The correspondence principle establishes such a connection. Here is one of Bohr's formulations of the principle (Bohr 1925):

"The correspondence principle expresses the tendency to utilize in the systematic development of the quantum theory every feature of the classical theories in a rational transcription appropriate to the fundamental contrast between the postulates and the classical theories." [1]

One can explain these differences in terms of a theory as a concept/rule.

8. Any concept (rule) can be determined by means of a set of its paradigmatic applications, or exemplifications.[2]

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[1] In (Pris 2013) I argued that the correspondence principle can be understood as the principle of natural/rational generalization. My formulation of the principle is very close to some formulations of it proposed by Bohr and Heisenberg.

[2] A definition of the concept can be made more explicit in the spirit of the pragmatic maxim of Charles Peirce. We "understand" a concept, if we understand its "nominal definition", know its instantiations (it would be better perhaps to say "exemplifications"), and also know what to expect from beliefs which the concept contains. The last condition – his own contribution – Peirce calls the "third degree" of clear understanding of a concept (see, for example, Misak 2012). It seems to me that in Wittgensteinian terms it corresponds to the condition of the existence of a family resemblance between exemplifications of a concept (this kind of similarity, which is both natural and normative (that is, justifiable in a context) allows one to extend the applications of a concept). If this is so, Peirce's notion of a concept is close to Wittgenstein's notion of a rule/concept.

For Heisenberg, all concepts are anchored in experience. The experience itself, however, has a rational dimension (this brings Heisenberg's notion of experience closer to Wittgenstein's notion of a language game – normative practice).

A new application of a concept is not pre-determined (there is no rule for a correct new application of a rule), but *post factum* it must have a justification.

When one deals not simply with a new application of a concept, but with its generalization, the indeterminacy is even more important. Not only one cannot know in advance whether a concept is applicable or not, but one cannot know the sense in which one should know it (that is, one cannot know in advance how the concept should be generalized). This sense can be established only in practice.

In this sense, quantum mechanics (as well as relativistic mechanics and Newton's mechanics before it) was not "discovered", but "created". (The question can be posed whether the development of science could have been different.) Classical mechanics as a Wittgensteinian rule was generalized; the domain of applicability of Mechanics was radically extended.[1]

Already the creation of special relativity was a radical enough extension of Mechanics (though it was less radical than the creation of quantum mechanics). Until that moment, Mechanics had been extending the domain of its applicability within the same theory – Newton's mechanics (although Maxwell's electrodynamics already put some restrictions on the extension).

The process of extension of the domain of applicability of a rule/concept or the process of generalization of a rule/concept must satisfy three conditions.

First of all, a new use of a given rule (or a new rule, that is, a new use of a super-rule) must not contradict a set of its established applications (the given rule). For instance, the so-called "old quantum mechanics" did not satisfy this condition. Second, the contradictions must be excluded at the inferential level of consequences of the new use (the new rule). Finally, the new use (the new rule) must have *a post factum* justification. For example, each application of classical mechanics has a theoretical justification within its framework. Analogously, a justification of quantum mechanics consists in the fact that it can be understood as a generalization of classical mechanics.

For instance, one can establish various connections between classical mechanics and quantum mechanics within different mathematical schemes of the move from one to

[1] One can say that in quantum mechanics the equations of Mechanics are the same as in classical mechanics, but their use is different (the move from one theory to the other is a change of aspect). For Dirac (in quantum mechanics) "it is not the equations of classical mechanics that are in any way at fault, but (...) the mathematical operations by which the physical results are deduced from them require modification" (Dirac 1925).

the other ("methods of quantization"). The latter, for example, can be considered as a non-commutative generalization of the former.[1]

9. There is a close connection between the notions of a concept, judgement and knowledge.

A judgement is a use of a rule/concept and *vice versa*. A correct use of a rule/concept, that is, a correct judgement, is knowledge; and *vice versa*: any knowledge can be represented in the form of a judgement.

According to Robert Brandom's (2011b) analytic interpretation of Kant's normative concept of judgment, judging is integrating a new commitment into a constellation of prior commitments, so as to maintain the rational normative unity of apperception.

In Brandom terms, synthesizing a Kantian unity of apperception is accomplishing three normative task-responsibilities: critical (rejecting commitments that are materially incompatible with other commitments one has acknowledged), ampliative (acknowledging commitments that are material consequences of other commitments), and justificatory (providing reasons for the commitments one has acknowledged, by citing other commitments one acknowledges of which they are material consequences). (Brandom 2011b)

The natural/normative process of extension of the domain of applicability of a concept, described in § 8, is, explicitly, a naturalized version of Brandom's account of the evolving Kantian synthetic unity of apperception, which plays the role of a Wittgensteinian form of life.

Heisenberg himself distinguishes three steps in the development of science: (1) expansion of the domain of applicability of a theory, (2) new laws occur, although concepts are left untouched (new laws contradict the old ones, says Heisenberg. Notice that the "old quantum mechanics", in particular, Bohr's theory of atom, corresponds to this step), (3) the whole conceptual structure of the theory changes. (See, for example, Scheibe 2001, p. 138)

Roughly, Heisenberg's step (3) in the development of science corresponds to the task of justification of the commitments (because without an appropriate conceptual apparatus such a justification is not possible). Though Heisenberg's quantum mechanics (as well as classical mechanics) can be treated as a unity of apperception (Heisenberg has

[1] The non-commutativity of physical quantities in quantum mechanics was discovered by Heisenberg. In the beginning, however, Heisenberg himself was embarrassed by his discovery. Later he realized the importance of it and even characterized the move from classical mechanics to quantum mechanics as that from «classical visualised geometry» to «symbolic quantum geometry». (Born, Heisenberg & Jordan 1925) (A general theory of non-commutative geometry has been developed only at the end of the 20th and the beginning of the 21st century.) Alain Connes – the founder of a variant of noncommutative geometry and its application in physics – was inspired by the ideas of Heisenberg's matrix mechanics. At present, however, Connes' noncommutative geometry in physics is an example of a theory which is not closed.) On the contrary, Dirac understood immediately the essential role of non-commutativity. He used it when constructing his own variant of quantum mechanics. According to him, the only difference between classical and quantum mechanics consists in the fact that the latter is non-commutative.

accomplished all three tasks in construing it), from the point of view of a more general, super-unity of apperception, involving both classical and quantum mechanics, Heisenberg's generalization of classical mechanics should be treated as accomplishing only the first – critical – task in integrating the new quantum mechanics into Mechanics as a super-unity of apperception. The move from classical mechanics to quantum mechanics is just a more radical "judgment", made within a certain super-unity of apperception – called "Mechanics" - involving (in its final form) classical mechanics as well as quantum mechanics. I suggest that Dirac is rather situated on the level of the ampliative task, and Bohr – on the level of justificatory task (justification of the new (quantum) paradigm as such).

So the approaches of all three physicists are compatible with and complement each other. In particular, Heisenberg's view that theories are "closed" and "perfect" is compatible with Dirac's view that theories are "open" and "approximate".

For Dirac, neither classical nor quantum mechanics are definitely established. Classical mechanics governs the development of quantum mechanics (and *vice versa*, according to the *inverse correspondence principle*, quantum mechanics governs the development of classical mechanics).

Dirac writes:

"It appears that all the important things in the classical (...) treatment can be taken over, perhaps in a rather disguised form, into the quantum theory" (Dirac 1932b).

For instance, Dirac (1932) proposed the idea of constructing a Lagrangian quantum mechanics (in addition to the Hamiltonian one). This led to Feynman's path integral which uses the classical notion of a path.

10. Nevertheless, in my view, Heisenberg's idea of a closed theory is primary and it is philosophically deeper than Dirac's view. The view that theories are open and approximate is secondary.

On the contrary, Bokulich (2008) prefers Dirac's position, because she thinks that Heisenberg's pluralism is incompatible with the unity of physics.

She calls her own position "inter-structuralism". In substance, according to the latter position, the unity of physics is secured because of the continuity of connections between structures of physical theories. Such a view is rather superficial (and it is not clear what one should understand by the "continuous" connections between the structures). I interpret the "continuity" as the Wittgensteinian family resemblance, that is, as the existence of a common (in general) implicit (super)-rule. This means that the meaning of the unity of physics is that physics is a process (respectively, the result of the process) of the generalization of our knowledge about the world, which, in the end, manifests itself in establishing connections (respectively, gaps) between different domains of physics (unity within a physical theory is, of course, stronger, but it has the same meaning).

For Heisenberg, physics is one in this moderate sense (which does not exclude the existence of gaps between theories and domains of one and the same theory). For Heisenberg, there are no pre-established rules of unity of physics, in accordance with which one could move from one domain of physics to any another. (A new theory of (moderate) reduction of physical systems and, respectively, a new (moderate) view on unity of physics, recently proposed by Erhard Scheibe (2007, 2009), are compatible with the views of Heisenberg.)

One can agree with Scheibe that Heisenberg's position is a compromise between two extremes: unity (in the strong sense) and pluralism.

11. Semi-classical mechanics extends and blends borders of classical and quantum worlds. It shows clearly the sense in which one can speak of a continuous move between theories, their openness and approximate character. In a sense, it is a rediscovery of the "old quantum mechanics", in particular, Bohr's theory of atom, which has found its own domain of applicability.

For instance, in some cases the notion of a classical orbit turns out to be appropriate and useful, and yet not only in the mathematical but also in the ontological sense. In a semi-classical domain, it may turn out that "one and the same" phenomenon has different adequate descriptions – classical, semi-classical and quantum. Which description is more "real"? The answer is that the question is incorrect. There is no privileged description. Different descriptions (in different contexts) might correspond to different aspects of the phenomenon or, strictly speaking, even different phenomena. Ontology is sensible to context.

For instance, it may turn out that in a (classical) context the electronic orbits do really exist, while in another (quantum) context they are only useful mathematical fictions (or real only potentially). In such a case, strictly speaking, in the classical and the quantum contexts, we will deal with two different (but similar) phenomena.

12. The idea I try to justify in this paper is that Heisenberg's philosophical views, in particular his notion of a closed theory (and also Erhard Scheibe's interpretation of this notion), can be understood within a naturalistic normative pragmatism of a Wittgensteinian kind.[1]

Indeed, in his paper (Heisenberg 1948) Heisenberg characterizes a closed theory by means of the following four criteria which can be interpreted in broadly Wittgensteinian terms.

(1) A closed theory is an established system of axioms and definitions (Hilbert's axiomatic method is implicit in the Heisenberg notion) which, in the end, arise from

[1] The view that later Wittgenstein can be understood as a naturalistic normative pragmatist and a realist is not common. Some followers of Wittgenstein simply refuse to consider his later philosophy as an "ism", emphasizing the Wittgensteinian "therapeutic method" (see, for example, Horwich 2012).

experience. (Let me just add here that according to Heisenberg a closed theory is true at all times.)

I interpret the first criterion in the sense that a closed theory is a Wittgensteinian rule (concept, conceptual structure) which is implicit in a certain experiential/experimental scientific "language game" or "form of life". The axioms and "laws of nature" are the corresponding philosophical grammar of the form of life. Thus, within a closed theory concepts/rules and "laws of nature" are on a par.

For example, Heisenberg (1970) says that the Archimedes law of the lever, which was formulated more than 2000 years ago, will be always correct. Using his own terminology, one can say that the Archimedes "theory" of the lever is closed. This theory consists of only one law/rule of the lever.

(2) According to Heisenberg, a closed theory "represents" experience, refers to something in the world. However, the connection between theory and experience is not immediate. Otherwise, the concepts of a closed theory would depend on changing experience; theory would be phenomenological. A phenomenological theory is less flexible, although it may be more precise.

As a consequence, the concepts of a closed theory do not refer to experiences in a "secured" way; their correct application is a matter of *success*.

In my terms, Heisenberg raises the problem of a correct application of a concept/rule. This is also Wittgenstein's rule-following problem. A correct application of a concept/rule, if it is a new application - not an already established one, - is not certain; the error is easily possible.

Moreover, a new application is not pre-determined. It is neither "true" nor "false", but "successful" or not (Heisenberg criticized "pragmatism" in the pejorative sense of a successful phenomenological description (see, for example, Heisenberg 1929). At the same time, he explicitly used the pragmatic slogan: "Success (not the "goal") justifies the means" (*Der Erfolg heiligt die Mittel*) to pass from classical mechanics to quantum mechanics (Heisenberg 1921)). The "successfulness" is understood in the sense of a normative pragmatism: a successful application of a rule is *post factum* justifiable.

The pragmatic criterion of a correct application of a rule is more fundamental than that of truth as correspondence (the latter, however, is valid in the domain of already established applications of a theory).

The holistic rigidity of a rule (a closed theory) is, at the same time, the condition of the flexibility of its pragmatic applications (the applications of a rule are multiple because the rule itself is unchangeable). The flexibility of applications is the reverse side of the rigidity of a rule. The phenomenological theories are not flexible.

(3) The borders of applicability of a closed theory are not known *a priori*. But they can be established in practice.

Within my interpretation, the third criterion talks about the extension of the domain of applicability of a rule/concept. The borders of this extension cannot be known *a priori* and are *not pre-determined*. They can be established only in practice.

(4) A new system of concepts describing new experiences could appear when one crosses the borders of a closed theory. The old theory remains a part of scientific language. It is presupposed by a new theory. So, it plays the role of an *a priori* for the new theory. Heisenberg suggests that there are degrees of *a priori*.[1] Heisenberg's position is situated between rationalism and empiricism.

In my terms, Heisenberg talks about the extension/generalization of a rule/concept (closed theory). A rule/concept can be generalized. A new more general rule/concept can be formed. In this process of extension/generalization the old rule/concept plays the role of an *a priori*.

For Heisenberg, such a move means a move to another closed theory.

13. Now we can answer the questions posed by Erhard Scheibe (see § 1).

(1) A closed theory is a rule/concept in the sense of the philosophy of later Wittgenstein.[2] (2) Within a closed theory concepts are on a par with laws. (3) The closed theories are connected in accordance with the law of natural/rational generalization. For instance, quantum mechanics is a generalization of classical mechanics. (That being said, for a theory (concept/rule) there is no pre-determined rule of generalization. Such a rule can be established only *post factum*. For instance, as it turned out quantum mechanics is a non-commutative generalization of classical mechanics.)

These answers are not trivial because the notions of a concept and an application of a concept are not trivial. Scheibe himself says (Scheibe 2001, p. 141):

"Are we that stupid that we don't even know what it means for concepts to be applicable? To this I say: This is stupidity of philosophers, and we owe it to the physicist Heisenberg that he was not afraid to share it with us".

Concerning a closed theory, Heisenberg says: "wherever the concepts can be used for the description of natural processes, the laws are exactly correct" (quoted by Scheibe 2001, p. 137). He also says: "the laws are valid with the same degree of accuracy with which the appearances are describable using the concepts" (quoted by Scheibe 2001, p. 136). (For Scheibe, who emphasizes the difference between the classical view of the scientific theory and Heisenberg's view of it, in the notion of a closed theory the applicability of concepts and validity of laws reverse their roles: the former become the premise and the latter the conclusion.) From my point of view of a closed theory as a rule/concept, both characterizations of a closed theory are tautologies.

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[1] The consequence is that a theory can be more or less closed.

[2] Scheibe himself mentions that the understanding of the notion of a closed theory requires the understanding of what we mean when we say that concepts are applicable.

For Weizsäcker, a closed theory cannot be corrected by means of a small change (see Scheibe 2001, p. 137). Heisenberg says that in a closed theory

"die Verbindung zwischen den verschiedenen Begriffen des Systems ist so eng, daß man im allgemeinen nicht irgendeinen dieser Begriffe ändern könnte, ohne gleichzeitig das ganze System zu zerstören" (the connection between the different concepts of the system is so close that in general one cannot change any of these concepts without at the same time destroying the whole system. *Translation mine*) (Heisenberg 1984, p. 81).

Both claims are obvious, if a closed theory is viewed as a (Wittgensteinian) rule.

For Scheibe the familiar dichotomy of the logical and the empirical is inadequate to describe the situation (Scheibe 2001, p. 141) with a closed theory. "The path of physics (…) passes in between rationalism and empiricism – somewhat like the path between Scylla and Charybdis" (Scheibe 2001, p. 71).

Heisenberg's philosophy paves this path. In modern terms, this is the way of rationalist pragmatism – a synthesis of rationalism, pragmatism and empiricism. (Brandom 2009, 2011)

14. Unlike a phenomenological theory, a closed theory is *not falsifiable*. It can be either applicable or not, but cannot be false. So my position is quite the opposite of Popper's: the non-falsifiability is a criterion of a genuine scientific (closed) theory.

Is there any sense at all in which one could say that a closed theory is false?

Jocelyn Benoist introduces two conditions for concepts: *appropriateness* and *adequacy*. The last condition is stronger. An appropriate concept corresponds to a domain of reality that it describes (represents). An adequate concept is an appropriate one which is anchored in reality, is alimented by it, and reflects it in all its richness (of course, the problem is how to understand this intimate connection between concepts and reality). The *epistemic gap* between concepts and reality is absent. (Benoist 2010/2011, 2011, 2012) What has just been said is directly transferred to closed theories.

A closed theory may be "false" in the following cases.

(1) A theory is inappropriate, or bad. This amounts to a bad choice of a theory/rule (or a method of acquiring knowledge) for a given domain of reality or *vice versa*. That is, in this case there is no correspondence between a theory and a domain of reality.

An inappropriate theory is false, but it is not "closed" (though it could be closed mathematically, that is as a mathematical, not physical theory). That is, it is not an established scientific theory, but a formal schema which does not fit the domain of its presumed applications.

(2) A theory is appropriate but the condition of its adequacy is violated. This amounts to a wrong application of an appropriate (good) theory. In this case, there is an epistemic

gap between a theory and its application - a concrete physical phenomenon. In principle, it can be closed by a correct application of a theory.

In this case, the theory is not wrong. What is wrong is its application.

(3) One tries to apply a good theory in a domain where it is not applicable (by consequence, the theory becomes inappropriate). Here the problem of the applicability of a concept arises: what is a concept and what is a (correct) application of a concept? What are the limits of the applicability of a concept? (The problem of the application of a concept is related to Wittgenstein's rule-following problem).

To apply a theory outside the domain of its application, strictly speaking, does not make any sense. By consequence, it does not work well or does not work at all. However, the problem is not with the theory. The problem is dissolved when one notices that some applications of the theory are meaningless.

On the contrary, there is a natural sense in which a closed theory is *absolutely true*. It is absolutely true in the sense of the truthfulness of a normative practice. This is the sense in which the language games and forms of life are "true".

15. A closed theory is *perfect*, absolutely exact

Conventionally, one can speak of a closed theory as being "approximate" in a domain outside the domain of its applicability.[1] Obviously, it can be "approximate" only to the same degree to which the concepts of the theory are applicable. One of Heisenberg's formulations of the notion of a closed theory - "The laws are valid with the same degree of accuracy with which the appearances are describable using the concepts" (quoted by Scheibe 2001, p. 136) – is a tautology.

One can also understand "approximate" in another sense - as something that forms part of an "approximate" language game. For Wittgenstein an "approximate" phenomenological description is not inferior in comparison with a more exact description; it is a genuine (governed by its own rules) phenomenological language game. (To give an example, a good impressionistic picture is not less "perfect" than a good realistic picture.) In the same sense one can understand the approximate character of a closed theory. For example, the "approximate" character of Newtonian mechanics (for example, in comparison with relativistic mechanics) as a form of life (or a language game – when it is said about a concrete use of Newtonian mechanics) is consistent with its "perfectness" (rules/concepts are "perfect", and a genuine form of life (or a genuine language game) is "perfect", too).

16. So, I claim that the closed physical theory has the status of a Wittgensteinian rule, concept (or, equivalently, a form of life). Its truthfulness is logical in the sense of the

[1] In this sense of "approximate" one can understand the following Dirac (1934) words: "As we know, no physical theory should be regarded as absolutely correct; rather, it must have definite limits of validity, within which it can be regarded as a sufficiently good approximation to reality. In particular, quantum theory itself possesses such limits of applicability (...)."

Wittgensteinian "philosophical grammar". It can be either applicable or not, but cannot be false.

At the same time, a closed theory does "reflect" reality (even a "metaphysical reality", that is, "things-in-themselves", when the theory is detached from experience and becomes established, "rigid" (*harte Theorie*)). And it does it in a non-metaphysical way, by means of its Wittgensteinian uses/applications in concrete situations - "language games". A closed theory is both appropriate and adequate in the sense used by Jocelyn Benoist (2010/2011). It is a well established true theory.

My interpretation agrees with Heisenberg's methodological approach - to abandon « rules » (concepts) of classical mechanics and to find new « rules » (concepts) allowing one to describe quantum phenomena (Heisenberg 1924, 1925), - and Scheibe's view of "a physical theory as being a concept of physical systems" (Scheibe 2001, p. 354).

References

Benoist, J. 2010/2011. *Concepts*. Paris: Les éditions CERF.

Benoist, J. 2011. *Eléments de philosophie réaliste*. Paris: Vrin.

Benoist, J. 2012. "Making Ontology Sensitive". Cont. Philos. Rev. (Published online. 04 August 2012)

Bohr, N. 1925. "Atomic Theory and Mechanics", *Supplement to Nature*, No. 2927, December 1925, p. 849 In Stolzenburg, K. (ed.) Niels Bohr, Collected Works. Vol, 5 The Emergence of quantum mechanics, (mainly 1924 - 1926) 1984. north Holland physics publishing p. 277)

Bokulich, Alisa, 2008. *Re-Examining the Quantum-Classical Relation: Beyond Reductionism and Pluralism*. Cambridge UP.

Born, M., Heisenberg, W. and Jordan, P. 1925. Zur Quantenmechanik II, Zeitschrift für Physik, **35**, 557-615, 1925

Brandom, R. 2009. *Reason in Philosophy. Animating Ideas*. Harvard UP

Brandom, R. 2011. *Perspectives on Pragmatism*. Harvard UP

Brandom, R. 2011b. *Brandom's München Lectures* (May 2011)

Cubrovic, M. 2009. "String Theory, Quantum Phase Transitions and the Emergent Fermi-Liquid." *Hep-th*.

Dirac, P.A.M. 1925. "The Fundamental Equations of Quantum Mechanics." In The Collected Works of P.A.M. Dirac., p. 67)

Dirac, P.A.M. 1932. "The Lagrangian in Quantum Mechanics". In (Dirac, P.A.M. 1995. Collected Works. 1924-1948. Edited by R.H. Dalitz, p. 661)

Dirac, P.A.M. 1932b. *Letter from Dirac to Fock*, 11 November 1932

Dirac, P.A.M. 1934. "Theory of the positron", in (Dirac, P.A.M. 1995. Collected Works. 1924- 1948. Edited by R.H. Dalitz, p. 725)

Feiler, C. 2013. „Entanglement and analytical continuation: an intimate relation told by the Riemann zeta function." *New J. Phys.* 15, June 2013. http://www.njp.org/ doi:10.1088/1367-2630/15/6/063009

Heisenberg, W. 1921. Letter to Pauli. November 19, 1921.

Heisenberg, W. 1924. "Über eine Abänderung der formalin Regeln der Quantentheorie beim Problem der anomalen Zeeman-Effekte". Z. Phys. 26: 291–307.

Heisenberg, W. 1925. "Über quantentheoretische Umdeutung kinematischer und 64 mechanischer Beziehungen". Zeitschrift für Physik 33: 879–893.

Heisenberg, W. 1929. Atomic Physics and Pragmatism

Heisenberg, W. 1948. „Der Begriff ‚Abgeschlossene Theorie' in der Modernen Naturwissenschaft". *Dialectica*, 2, 331-336

Heisenberg, W. 1958. *Physics and philosophy: The revolution in modern science*. London: George Allen & Unwin.

Heisenberg, W. 1970. "Abschluß der Physik?" In *Collected Works*, C, III, 1985, p. 386.

Heisenberg, W. 1984. Collected Works, C, II.

Heisenberg, W. 1984b. In Gesammelte Werke. Collected Works. Vol. II. Physik und Erkenntnis. 1984.

Horwich, P. 2012. *Wittgenstein's Metaphilosophy*. Clarendon Press.

Misak, C. 2012. "The Origins of Cambridge Pragmatism". A talk given at the research workshop „Cambridge Pragmatism". Cambridge. 31 May – 1 June, 2012

Pris, François-Igor. 2013. "О смысле принципа соответствия и единства физики." ANALYTICA.

Scheibe, E. 1997. *Die Reduktion physikalischer Theorien. Ein Beitrag zur Einheit der Physik. Teil I: Grundlagen und elementare Theorie*. Berlin: Springer

Scheibe, E. 1999. *Die Reduktion physikalischer Theorien. Ein Beitrag zur Einheit der Physik. Teil II: Inkommensurabilität und Grenzfallreduktion*. Berlin: Springer

Scheibe, Erhard. 2001. (Ed. by Falkenburg, B.) *Between Rationalism and Empiricism. Selected Papers in the Philosophy of Physics*. Springer