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ИСТОРИЧЕСКАЯ ЭПИСТЕМОЛОГИЯ НАУКИ И ТЕХНИКИ

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Trying to Fancy What the Flame of a Candle Is Like After the Candle Is Blown Out: Some Notes About the Ontological Structure of the Copenhagen Interpretation of Quantum Mechanics

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In the present article the author will deal with an inquiry of the ontological structure of quantum mechanics, and he will analyze the evolution of the heno-ontological equation (the identity of being one and of being) in the shape of the new arrangement prepared by the orthodox interpretation of the theory. Hence the article will particularly focus on the Copenhagen interpretation and the lack of intuition [*Anschaulichkeit*] in the representation of physical external objects; as far as the latter topic is concerned, the author will also consider the classic representation of Heisenberg's philosophy given by Heelan. The author will then show the impossibility of holding the old physical body-representation which worked for classical mechanics as well, because quantum mechanics denies an absolute localizability of physical entities. A non-defective determination of localizability was in fact the very postulate which lays at the basis of the heno-ontological equation as Aristotle had envisaged it: what is not localizable, is not one being. It also has to be considered a specific lack as regards the chronological permanence of the identity of the quantum object, which appears to be constantly modified by its interaction with the devices and with other particles. Accordingly, the author will explain the peculiar definition of physical entity in the Copenhagen interpretation of quantum mechanics as a non-substantial entity, as a non-body, considering the argument that henceforth the actual substance, in physics, will be only the whole totality. Arguing about the latter point, the author will develop a definition of individuality which could not be extraneous to the most recent interpretations of quantum mechanics. He will indeed aim for a non strictly ontological definition of individuality, if one has to figure out the *individuum* as a body of daily experience. Rather than a body, the quantum *individuum* is almost *a* being whose ontological content is only relative to the transformations of a primitive context: this implies that his ontological charge cannot be considered permanent. From this point of view, one can argue that quantum mechanics is very close to the old representation of nature as being by the ancient Greek physicists, which tended to distinguish between the ontological definition of individual entities and the unity of being as a whole. Hence the article will show, through Cassirer's review, how it is possible to depict a new setting for the relationship between one and being, as well as trying to shed some light on the basic assumptions of the ontology of Copenhagen interpretation and of modern quantum mechanics.

Keywords: Aristotle, E. Cassirer, Copenhagen interpretation, henology, Quantum mechanics, question of being, W. Heisenberg, ontology

1. The first philosophical definition of the concept of being was coined by the Greeks. Indeed, the word "being" was firstly born as the name of the whole nature, and it later became the name of the single being that a thing actually is.

However, the English word "being" is a bit compromising, for it just erases the difference between a supposed general acceptation of being and its particular content, viz. it puts aside the ontological difference. Besides, there is a further mistake in the formulation of the ontological difference, which could lead hiding the basic motion animating the concept of being. Let us start our inquiry from a simple scheme, which can show in an immediate way the distinctions we are referring to:

	Physiology (Heraclitus, Parmenides)	**Ontology (Plato, Aristotle)**
Particular	hekaston	hekaston, (mē) on
Universal	eon	idea (ontōs on), eidos

I have assumed the classical Heidegger's distinction between "thinkers" and "philosophers"[1], and I have renamed the two famous categories to "physiology" and "ontology". Even though it could be endorsed that such an approach puts a surely existent difference, it is clear that its worth does consist in pointing out some relevant issues, deriving from the interaction of the mentioned levels. First of all, we can notice that the participle *eon-on* has a different function, since for the Greek naturalists it reminds us of the totality that nature actually is, whilst in the ontological arrangement it becomes the name revealing the individuality of something[2]. Then it seems like there is a more stringent use of the word denoting the particular term in the physiological program rather than in the ontological one – but conversely implying that the theory of the particular in the ontological framework is much more stratified than the correspondent picture given within the physiological background –: on the one hand, in physiology we have the *hekaston*, something to which we should not rigorously refer to by the term "*on*"; on the other hand, if we still find in ontology this precise meaning for the word *hekaston*, we also start to observe a slick development of the word "*on*", which may be now used to denote both the unity of the whole (universality) and the unity of the being of a thing (singularity[3]), viz. the unity of the *hekaston*. Plato has deeply acquired the consequences of this setting, in arguing the classical opposition between the sensitive singular as *mē on* and the *ontōs on* of the idea as the universal element of being[4].

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1 *Heidegger M*. Was ist das-die Philosophie? Pfullingen, 1966. P. 12–15.

2 The "individuality of something" could also be that of the whole nature as one thing: a serious question about the logical character of the being one of the whole and of the being one of the one thing is now set.

3 I assume the term "singularity" to mean the function of the unity of a particular being.

4 It is obviously interesting that the term on appears here in a negative form, since it somehow recalls that the nature of sensitive individuality and the nature of intellectual individuality are not the same: the latter aims indeed at presenting the whole extension of a concept, and, so to say, to cover every possible manifestation of an idea into the real world. This means that if many things take part into a specific idea, the individuality of this idea entails a decisive element of universality as synthesis of the manifold, to put it in Kantian words. It is also quite problematic to analyze the transition from the physiological framework to the ontological one in the terms of the "particular" and of the "universal": these are somehow technical words used by philosophy only in a posterior time. It could appear reasonable to talk about universality since the age of the concept, namely

In the foregoing scheme I have purposely omitted the term: *hen*. I did so in order to make that scheme as simple as it could be, but it is worthwhile to introduce the question. As for the term *on*, we can argue that the physiological use of *hen* is generally oriented towards a holistic perspective, viz. it shows the conformity of the whole nature to its own being. By doing this, it also seems to exceed the semantic field of *on*, for it would also envelope the *hekaston*, namely not only every particular *hekaston*, but also every single *hekaston* in its general function denoting every possible particularity: *hekaston* means *hekasta*, *panta*. The particular is *hekaston* only insofar as it is one and singular among *panta*. This is plainly assumed in the ontological structure of physiology in that very often mentioned law of the mutual apprehension of *hen* and *panta*, as Heraclitus stated once (DK 22 B10). In any case, it is quite clear that *hen* is, to the Naturalists, the general ontological attribute for *physis*. When we find us in the ontological era, on the contrary, we see that there is a holistic meaning for *hen* which is still valid, but, as it is for the term *on*, *hen* especially denotes the functional structure which determines the individuability of something (singularity). Aristotle depicted this mutual equation clearly, in the sense of the ontological structure:

> If, now, being and unity are the same and are one thing in the sense that they are implied in one another as principle and cause are, not in the sense that they are explained by the same definition (though it makes no difference even if we suppose them to be like that-in fact this would even strengthen our case); for 'one man' and 'man' are the same thing, and so are 'existent man' and 'man', and the doubling of the words in 'one man and one existent man' does not express anything different (it is clear that the two things are not separated either in coming to be or in ceasing to be); and similarly 'one existent man' adds nothing to 'existent man', and that it is obvious that the addition in these cases means the same thing, and unity is nothing apart from being; and if, further, the substance of each thing is one in no merely accidental way, and similarly is from its very nature something that is:-all this being so, there must be exactly as many species of being as of unity[5].

Following his own typical methodology, Aristotle takes this connection for granted, and does not discuss any further argumentation about: the equivalence *hen-on* becomes a postulate of *logos* itself. This very basic idea implies: every time we can assume the being of something, we should describe this being according to the individuability function. Whatever I can think about, must be assumed as if it were one: there is nothing which can be thought and perceived without being, at the same time, one-thing. It is also very important to point out that this kind of assumption appears, as the others conceived as fundamental by Aristotle, to originate from the

with the invention of the Platonic idea: it is solely within Plato's philosophy that the setting of the concept of idea is able to create the possibility of arguing the function of universality as opposed to singularity. We have, indeed, universality when we can figure out the working of a synthetic faculty capable of blending together different appearances, but this universality, conceived as idea, becomes the only true individuum, because the individuality of an actual thing does not possess the same chronological permanent character. Aristotle has attempted to correct Plato's aim in respect to this point, but he has also held the basic distinction between individual or particular entities and the abstract and universal ones. Accordingly, it is not by chance that idealism has progressively experienced the urgency of overcoming this substantial representation of the concept within its history, to favour functional interpretations of the intellectual activity (this would have become particularly patent with the modern scientific revolution and the philosophy which was inspired by it).

5 *Aristotle*. Metaphysics. Adelaide, 2015. 1003b22-34; see also: 1053b9-1054a19.

language[6], and, since it is somehow unaware, to represent the condition of possibility of the whole knowledge. This version of the heno-ontological principle is exactly what will be questioned by Quantum mechanics (QM).

2. However, Cassirer does not need QM to experience remarkable changes in the formulation of the ontological problem: his epistemology goes in this direction from the beginning, and, from this point of view, one could also say that QM is to him only an ulterior proof of the systematic assumptions developed earlier[7]. The crucial idea of his theory of knowledge is that the transcendental approach has to lead us to abandon the old representation of reality as substance, in order to achieve the superior ground of a radical ontological asset, similarly to that program in which thought and being are finally brought together. Quoting from the preface of *Substanzbegriff und Funktionsbegriff* (SuF):

> Whenever, in the history of philosophy, the question as to the relation of thought and being, of knowledge and reality, has been raised, it has been dominated from the first by certain logical presuppositions, by certain views about the nature of the concept and judgement. Every change in this fundamental view indirectly produces a complete change in the way in which the general question is stated[8].

This also implies that we do not conceive the task of knowledge as consisting in the reproduction of an already given reality (*Abbildungstheorie*), but rather as the infinite work which intellect has to face in its interpretation of reality. The recognisability of the Kantian imprinting is out of question: external reality exists, but its objectivity is exclusively due to the work of reason. Anyway, against Kant himself, who has interpreted this revolution as a rejection of ontology[9], we have to notice that the transcendental approach is quite apt to sketch the inner dynamics of the *Seinsfrage*, and particularly sheds light on the fact that every assumption about an external object depends on the capacity of thought of analyzing reality. As a consequence, there can be no being, viz. no thing (*sic*), no *on*, without postulating the originally infinite work of the *logos*. Transcendental philosophy makes us aware that there are things only in relation to a logos.

It is quite clear that this basic assumption is modelled on the inner tendency of the scientific methodology too. Science, since Galileo, moves from a radical critique of dogmatism. Indeed, experience must play a prominent role in the drawing of theories: thus the very job of the scientist is based on his ability of matching the different aspects (theoretical and empirical ones) in a whole picture, which in any case does not erase the different character of the sources of knowledge, but depicts them as an interactive and always open whole field.

Science becomes the most evident territory in which the work of reason originally appears to belong to reality. According to that peculiar idea that science starts from the primacy of the concept of function, Cassirer infers that this focusing, translated into the language of ontology, means the end of the era in which the idea of thing was dominant, when knowledge aimed at grasping reality in its particular singularity.

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6 *Wieland W*. La fisica di Aristotele. Studi sulla fondazione della scienza della natura e sui fondamenti linguistici della ricerca dei principi in Aristotele. Bologna, 1993.

7 The coherence of this assumption led Pecere to think it as strictly metaphysical (*Pecere P.* La “dissoluzione” della materia in Cassirer // Quaestio. 2007. No. 7. P. 483–488).

8 *Cassirer E*. Substance and Function and Einstein’s Theory of Relativity. N. Y., 1953. P. IV.

9 *Kant I*. Kritik der reinen Vernunft. Stuttgart, 1966. P. 332.

What we can know is not the ultimate substance which we can define as a unity among the plurality of the different actual things; despite that, the progress of science consists of the gradual elimination of any sensitive element in the representation of the object of knowledge, and of its border-representation as thing.

Cassirer justifies this mutation by arguing that science has to balance the dichotomy between "*ein physikalischer Grundbegriff des Seins*" and "*ein physikalisches Grundgesetz des Geschehens*"[10], a dilemma solved showing that the actual precedence has to be given to the fundamental law of becoming, but conceived to be as the mathematical plurality determined by a general *koinōnia tōn genōn* of Platonic inspiration. It is the very basic role played by the concept of series, which drives forward, in SuF, the first version of the theory of the ultimate invariants of experience, and that allows us to conceive becoming not simply as the furious and undeterminable acting of reality, but as the immediate mediating work of intellect in the interpretation of the manifold[11].

Even from these few words, it is possible to figure out the ontological representation that makes of the *Dingbegriff* a pure illusion, if one pretended to base on it both the first step and the goal of philosophical ontology. Physical being is absolutely not a thing; to Cassirer, this implies that it loses its peculiar unity, because the real particular element is only the actual thing we can really perceive and to which we can assign certain attributes, whereas the reality we encounter in physics happens only as a consequence of the law, and particularly as an effect of measurement. It is not by chance that in the book on relativity Cassirer indicates the very essence of physical being in its measurability: the becoming being of a physical entity coincides with its being measured[12].

But we have got in trouble almost without knowing. I have suggested that science begins with this overcoming of thing and with the acknowledgement that the concept of object results from a general law; this brought Cassirer himself to affirm that the real meaning of objectivity is "*Gesetzlichkeit*"[13]. Nevertheless, if the idea of ascribing to a perceivable being a peculiar unity, making a real thing of it, does persist as the very postulate of sensitive reality, this means we have still to face, even in this very wise version of Kantianism, the dualism between *mundus sensibilis* and *mundus intelligibilis*. In order to solve the dilemma, Cassirer amplifies the weight of his assumptions, developing a wider form of transcendentalism, which shows how the perceivable and sensitive being is a result of the work of *Geist* as well, and that even in this case we must consider the thing (the perceivable thing) not as a fixed and unified entity, but as a result of our basic logical activity[14]. This would mean that if we limit ourselves to science, we will not be allowed to fathom the very heart of ontological hypothesis[15].

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10 *Cassirer E*. Substance and Function and Einstein's Theory of Relativity. P. 157.

11 *Pecere P*. Op. cit. P. 460–462.

12 *Cassirer E*. Substance and Function and Einstein's Theory of Relativity. P. 352–366.

13 *Cassirer E*. Determinismus und Indeterminismus in der modernen Physik. Historische und systematische Studien zum Kausalproblem // *Cassirer E*. Gesammelte Werke. Bd. 19. Hamburg, 2004. P. 159.

14 *Cassirer E*. The Philosophy of Symbolic Forms. Vol. 1: Language. New Haven; L., 1955; *Idem.* Vol. 3: The Phenomenology of Knowledge. New Haven; L., 1957; *Idem.* Il linguaggio e la costruzione del mondo degli oggetti // Il linguaggio dei giornali italiani. Bari, 1976. P. 55–84; *Idem.* Zur Metaphysik der symbolischen Formen. Nachgelassene Manuskripte und Texte. Bd. 1. Hamburg, 1995.

15 I introduce the term "ontological hypothesis" by means of which I would like to recall the mutual relationship between logos and on in the definition of the ontological question.

It is now that QM seems to deserve a more acquainted analysis, for it blends together the question of the *Anschaulichkeit* of physical beings and the very constitution of them as "things". However, it must be repeated that, from the point of view of QM, there is no being without measurement. This circumstance can be interpreted as a peculiar confirmation of the ontological hypothesis – assuming this, at all events, we must be careful to find into mathematical physics the decisive proof of an ontological definition – because measurement in QM does not discover a thing or a specific property of a being which would independently exist from the act of measurement itself, but it teaches us, above all, that every measured object is the result of an interaction[16].

3. The most important achievement of QM in the Copenhagen interpretation can be summarized in stating that we cannot determine an objective reality anymore, as an external being independent from the measurement and experiments, since it is the interaction between the device and the real physical beings, that modifies once and for all the very essence of these entities. There is no physical entity before measurement[17]. Hence, the paradox was born because the object of classical

[16] I have consciously omitted to quote the terms of the interaction, basically for two reasons: 1) the so-called "perturbation argument" as crucial influence of the observer on the physical being, which is typical of the Copenhagen interpretation, has been widely criticised within the history of physics and epistemology (Einstein, Popper and Bell were the most renowned among the critics); 2) I do not endorse a subjective interpretation of the concept of "perturbation", as it seems to me a posterior evolution of the critical analysis of the theory and not the own point of view of Heisenberg and especially of Bohr. In fact, Heisenberg was much more interested in developing the argument of the perturbation in a philosophical theory of potentiality of Aristotelic inspiration, whereas Bohr conceived the whole argument in the sense of the interaction between the macroscopic and classical world of the tools and the quantum realm: no subject is involved, both in Heisenberg and in Bohr, in determining the ontological character of quantum reality (see: *Bohr N.* Atom Physics and Human Knowledge. N. Y.; L., 1963. P. 5). As I will explain, I propend for an ontological interpretation of the perturbation: it is not relevant who or what actually modifies the state of the physical being, but it is only crucial that no being is given without the assumption that it is, since the beginning, the result of a modification originated by the act of measurement and of the interaction between classical and quantum world. This means that the real subject is the interaction itself. This approach seems also appropriate in the light of Bell's theorem and of the non-locality of QM: what could be more "objective" than a modification occurred in a physical being without the direct interaction with the observer? But this is still interaction. Accordingly, from the point of view of the ontological interpretation I will defend, and by means of which I will try to depict the core of the Copenhagen Interpretation, the very question is not that of the subjective character of physical knowledge, but that of the exact boundaries between the two worlds: where does the standard world end and the microphysical reality actually begin? This is the very question, as Ghirardi has clearly pointed out (*Ghirardi G.C.* Un'occhiata alle carte di Dio. Gli interrogativi che la scienza moderna pone all'uomo. Milano, 2003. P. 133–174; 311–335), and as the recent history of QM has evidently showed (see: *Laudisa F., Rovelli C.* Relational Quantum Mechanics. The Stanford Encyclopedia of Philosophy, 2013. Available online. URL: http://plato.stanford.edu/archives/sum2013/entries/qm-relational/.

[17] The critique of the realistic interpretation of QM has particularly stressed the questionability of this statement (*Popper K.R.* Quantum Theory and the Schism in Physics. Totowa, 1982). I repeat that it should be clear that I do not assume a subjective approach for the perturbation argument, so I do not mean that the qualities of a physical being (for instance: having this specific velocity or this specific position) are created by the measurement. They are rather created with the measurement: from this point of view, I am oriented to interpret the question in the terms of the critical empiricism, which sees in the act of measurement the condition of possibility of a physical being or of a quality of it. However, since the act of measurement is theoretically planned, it seems that the determination of the being would follow from and end into the thought. I think that the contestation of this argument, recalling Heisenberg's explanation that in quantum physics we do not take into

mechanics, which would have had to be different from perceivable reality, could be at most represented as something objective in the meaning of substance, and then unconsciously assumed to be as an actual thing – above all because material points and actual things share the possibility of a spatio-temporal description; this false assumption was projected also on microscopic entities, which were thought, at the beginning, as substantial unities actually existent as bodies.

In that peculiar mixture of sensitive and already scientific representations, this meant to imagine the particle of microscopic physics as a body endowed with specific attributes, whose the most relevant would have been the motion into a space according to a specific and not ambiguous trajectory. I will discuss these ontological implications only after having briefly presented their physical premises.

4. The most puzzling question asked by those physicists who were concerned with the ground-breaking foundation of quantum theory, was exactly of this kind: the mathematics of the formulas was sufficient to understand experiments and the different scientific proceedings, but it was clear at the same time that the old intuitive concepts which lay at the basis of the classical representation of reality were completely inane to envisage the new situation.

The first reaction to this state of things was the affirmation of a strict positivism, which underlined how every physical being had to be related to the concrete physical experience in which it acted; this means that we can talk about a physical entity only

account the behaviour of physical beings but our knowledge about it, entails a misunderstanding of the Copenhagen interpretation's idea of objectivity: according to this approach, it should not be supposed to say that our measurements create the physical beings and that they make of our knowledge of physical reality a pure account without any reference to an external reality; rather than this, it is claimed that objective reality is interaction in itself. But if objective reality is interaction, we must aim at depicting this complex net of relationships (into which the observer is embodied) to understand reality as such. In a few words, I am convinced that the Copenhagen interpretation does not uphold that any objective reality exists; it would rather remind us that behind every objectivity lies an objectivation-process, and that objectivity as such is only the final result of this process. For instance: 1) we affirm that a certain particle has a given velocity; 2) stating that the determination of this velocity must satisfy certain empirical conditions, according to the general formalism of the theory, does not mean claiming that the velocity is not an objective characteristic of the particle, if we want to measure its position; 3) even though we are referring to the uncertainty relations, what we can infer from the principles of the theory is not that we would not be able to state that a given particle has at once a certain velocity and a certain position; 4) of course, we cannot precisely determine both the variables at the same time, but the particle do always possess a position and a velocity, and the circumstance that one of these attributes is not precisely determinable does not mean that the particle does not have it; 5) but QM teaches us that every experiment has a specific effect on the objects; 6) as a consequence, the general theory must be oriented towards a statistical approach, which could be capable of appreciating the different influences acting at quantum level; 7) if we find that every measurement of position alters the values of the velocities, we must only conclude that we are not able to infer a velocity in case of a precise determination of position, but not that the particle does not have a given velocity when it occupies a specific spot (*Popper K.R.* Op. cit. P. 62–64); 8) the particle, indeed, had it, but we cannot know it; 9) this limitation in the knowledge of the particle is objective or non-epistemic, and this means it does not depend on the lack of knowledge of the observer; 10) the particle is for sure existent and objective, has given attributes at the same time, but there is a limitation prescribed by the uncertainty relations; 11) in a few words, there is, in my opinion, no subjectivism in affirming that we cannot precisely know a certain quantity, because the matter is here that the "perturbation" is not a subjective intervention into the realm of quantum world, but the same interaction of the macrophysical world (observer+devices) with the quantum object. If this were true, the distance between Heisenberg's potentiality account and Popper's propensity interpretation might be viewed from a different perspective.

if we are able to describe it according to an experiment presenting no contradictory element with the general theory. And this is precisely what Heisenberg claimed in his famous essay *Über den anschauulichen Inhalt der quantentheorethischen Kinematik und Mechanik*, in which he presented the uncertainty relations.

The first section of the memory did consist in the ultimate application of that "observability principle" of which he already made use in a paper of 1925, where he affirmed:

> In this situation it seems sensible to discard all hope and observing hitherto unobservable quantities, such as the position and period of the electron, and to concede that the partial agreement of the quantum rules with experience is more or less fortuitous. Instead it seems more reasonable to try to establish a theoretical quantum mechanics, analogous to classical mechanics, but in which only relations between observable quantities occur[18];

a concept he would have recalled in his famous interview with Thomas Kuhn too[19]. In his 1927s paper, Heisenberg took into account the most relevant physical concepts, and tried to propose a renewed definition according to the experimental results and premises of QM. The most important consequence he derived was the necessity of abandoning the idea of trajectory, since what we experimentally observe, of a subatomic particle, is not a continuous progression into space, but a dispersive localization, which does not enable us to conceive the particle as moving according to a definite run (the determination of the position causes uncontrollable effects on the velocity). Moreover, this would have led to another overwhelming difficulty: it seemed as if the identification of physical beings was subject to some restrictions, for the unification happened only for a precise point and a definite situation, but it vanished when we were not able to measure. In a few words: the idea of trajectory did reassure us about the circumstance that the physical being we study might be the same body in every different point of the space it can be possibly situated in, as it remained the same without being modified by its motion. But this, since the theory of relativity, and even more so, with QM, has become in principle impossible – Einstein himself mentioned this assumption as a false premise of classical physics which should be dropped[20].

It is obvious that such an approach is very helpful to overcome all the metaphysical problems which risk to stop the progress of a thorough scientific mentality. This attempt would have been fruitful in addressing the question of the intuitive contempt of the classical physical concepts, such as those of mass, position, energy etc. QM, indeed, assuming that the task of mathematics only entailed describing what is effectively observed, would completely reject the idea of the intuitiveness of concepts, because their "*Inhalt*" is nothing but a precise datum deriving from experiments. At the same time, concepts do not become physical concepts until they have an actual fulfilment due to the experiments, and they mean nothing before measurements. Beyond question, this would make of science an open structure which allows to adapt every time theory to whatever physical event, without claiming a metaphysical, and so to say eternal, respondency between the concept and a physical attribute.

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[18] *Heisenberg W*. Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen // Sources of Quantum Mechanics. Amsterdam, 1967. P. 262.

[19] *Heisenberg W*. Interview with Werner Heisenberg by Thomas Kuhn. Session VIII. 1963. URL: https://www.aip.org/history-programs/niels-bohr-library/oral-histories/4661-8.

[20] *Einstein A*. Zur Elektrodynamik bewegter Körper // Annalen der Physik. 1905. No. 17. P. 896.

What I am going to argue is that the experimental situation of QM can convince us of the fact that the relation between one and being in the definition of the physical entity is not stringent, for we do not get a precise knowledge of a physical being as a body of daily experience; indeed, as far as the microphysical reality is concerned with, this basic heno-ontological relationship does not build a premise in individuating objects, but only a relative result depending on some experimental procedures. It is only after a given experience that we can individuate a physical being as a certain unity; moreover, this unification cannot be held as a definitive result, since every measurement modifies the whole system to reconfigure a new physical situation. Speaking about an object before measuring and speaking of it after its having been measured always means that we are not referring to the perfectly same object[21]. This seems to imply that physical entities are not beings once and for all, or that they are beings only for a while, and that beside the lack of localizability, the heno-ontological equation would now be experiencing a lack of chronological stability.

5. Hence there are basically two reasons according to which we can justify the fall of the classical heno-ontological principle in QM: 1) measurements shows us that in microphysics we are not allowed to infer propositions about the determination of a physical being as a body, for the act of measurement itself implies a very modification of the object we wanted to observe[22], as regards both its localizability and its chronological determination; 2) the theoretical translation of the situation in a stratified dynamics presupposing the primacy of statistic laws. Let us now genealogically present the situation.

As Lacki[23] and Heelan[24] before him have showed, the first approach of Heisenberg about the problems raised by QM was in the sign of instrumentalism: he solved the question of the *Unanschaulichkeit* of physical concepts by definitely tying them to an empirical content which cannot be ambiguous, namely deriving from the actual measurements[25]. So, the fact that everything is physical has to be revealed by measure, and nothing else coming from the outside can be added to scientific experience, is the very premise of his work.

Starting from this point of view, in his celebrated 1927s paper, Heisenberg introduces the meaning of quantum experience to us. He makes this clear example: if we wanted to measure the position of a subatomic particle, we would have to consider a whole system composed by the quantum object, the device and in

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[21] Once again, I must highlight the fact that such a statement does neither imply that there is no object nor that there is no objective representation of the object, or that we solely have a subjective representation of physical world; it rather affirms that an act of measurement changes the status of the measured object, and that the theory has always to carry this assumption. I will then consider the realist argument against the topic as not relevant, because the meaning of Heisenberg's account is that there is an irreducible ontological difference between the object before and the object after the measurement, and not that the subject creates objectivity.

[22] Surprisingly, this argument becomes even more evident if we think about entangled physical states, considering that, in this case, the effect of the measurement upon the object is non-local.

[23] *Lacki J.* Observability, Anschaulichkeit and Abstraction: A Journey into Werner Heisenberg's Science and Philosophy // Fortschr. Phys. 2002. No. 50. P. 5–7.

[24] *Heelan P.A.* Quantum Mechanics and Objectivity. A Study of the Physical Philosophy of Werner Heisenberg. The Hague, 1965. P. 131–133, 137–155.

[25] To Heelan, in fact, the question of the Anschaulichkeit only depends on the incapacity of physicists to recognize the difference between "observable symbol" and "physical property" (*Heelan P.A.* Op. cit. P. 57–62).

the end an ultimate validation, which can also imply the active presence of the observer in the experiment[26]. What we see, in this case, is strictly depending on the Compton effect, because if we have to establish the position of an electron, a quantum of light of the ray we are using to do it, will strike the particle and will deflect it from its trajectory; moreover, the quantum of light will be refracted by the glasses of the microscope too. This is consequently sufficient for him to declare the impossibility of using the concept of trajectory, as that continuum of points describing the motion of a material point. A quote can be then very helpful, in order to envisage the philosophical ground of such an argument: "The difference between classical and quantum mechanics does rather consist in the fact that in classical mechanics we can always think of the phase as it is determinate according to former experiments. In truth, this is impossible, since every experiment for the phase determination destroys or modifies the atom"[27].

What was declared by Einstein as one of the false assumptions of the old mechanics, is here transformed by QM into an impossible result of physics itself: actual experience shows the incongruence of the thought that a body at rest can be assumed to be as the same as if it were in motion. The continuity of trajectory, which seemed to expect the ontological continuity of a body, is specifically refused, because every physical interaction alters a quantum object till the point we cannot conceive as the same thing the object we encounter before measuring and the object with which we interact after having measured. We can now appreciate the whole Kantianism which lies at the basis of this point of view[28], something which makes of QM a pure theory of appearances: "*Die Physik soll nur den Zusammenhang der Wahrnehmenungen formal beschreiben*"[29].

Nevertheless, an objection can still be advanced. In fact, one could also argue that the junction one-being is contested only as regards the whole dynamics, but as far as the peculiar determination of a single measurement is concerned, we can still face a dependence, considering that we would still be handling a precise thing, f. i. an electron standing in a given place, though we could not know its momentum precisely[30]. We cannot hold the idea of reconstructing a whole trajectory, but this situation might be paradoxically interpreted as a further confirmation of the heno-ontological equation, for it finally breaks up with every metaphysical assumption which would conduce to an overlay of the strictly physical properties. In establishing

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[26] But as we will see, the observer does not influence the physical situation by introducing his conscience into the actual experiment.

[27] *Heisenberg W*. Über den anschauulichen Inhalt der quantentheoretischen Mechanik und Kinematik // Zeitschrift für Physik. 1927. Vol. 43. Iss. 3–4. P. 177.

[28] *Heisenberg W*. Physics and Philosophy. The Revolution in Modern Science. N. -Y., 1958. P. 186.

[29] *Heisenberg W*. Über den anschauulichen Inhalt der quantentheoretischen Mechanik und Kinematik. P. 197; see also: *Heisenberg W*. Physics and Philosophy. The Revolution in Modern Science; *Ibongu G*. Cassirer's Structural Realism. B., 2011. P. 90. It has to be pointed out that, according to Heelan (*Heelan P.A*. Op. cit.), despite of the rejection of the concept of Ding an sich, a psycho-physical parallelism survives, because the weight of mathematical determination is decisive and strictly independent from sensitivity since the 1927s paper (in which Heisenberg often highlighted that every physical experience could be inferred from the grounding equation of Born and Jordan): this could still enable a dualistic and thus metaphysical interpretation of Heisenberg's program.

[30] As I have already explained, the non-epistemic character of the uncertainty is decisive, but it does not mean that a particle does not really have a velocity if we are precisely determining its position – it means only we cannot precisely know it (see footnote 17).

the impossibility of depicting a whole trajectory for an object, QM allows us to finally represent motion as an empirical content depending on measurements, emptying it of every link to rationalist premises. Hence we must leave behind the idea of a pure motion which would be inherent to a thing remaining stable among the different physical experiences. But as I have already pointed out, it might even be this fallen idealization of the concept of motion which could also lead to the triumph of a strict henology, insofar as we could take into account, in this case, the actual conditions of possibility of every physical entity more properly.

Anyway, all the objections should be overcome when considering the theoretical grounding of this magnificent operative system. The foundation we are speaking about goes through two important moments: i) the original primacy of statistic laws upon the deterministic ones and ii) the acceptation of Bohr's complementarity principle as the very basis of the Copenhagen interpretation.

The new role for statistical laws is earned as a consequence of the experimental reasons we have already presented: the basic interference of the measurement process upon the determination of scientific objects compels us to assume a new point of view about the connection between theory and reality. The new setting has to envisage, on the one hand, the problematic link between matrixes and subatomic particles, and on the other hand must clearly individuate the whole transition from the theoretical to the empirical steps of the theory.

In *Physik und Philosophie* Heisenberg proposes a general model of understanding quantum experience as follows: 1) a description of the initial conditions in terms of a probability function, also known as wave function; 2) the "following up" of the wave function as regards time; 3) measurement and actualization of the wave function[31]. The introduction of the wave function allows us to consider the whole question of the link between matrixes and physical entities through a systematic approach. When Heisenberg struggled for his quantum model against Schrödinger's theory, he risked compromising a general comprehension of the pattern of subatomic systems, for the focus on matrixes basically aimed at the description of a single state, or of a plurality of singular states, but it seemed unable to surmise a unified understanding model. This is just why the wave function appeared: it lets us consider a global description of the evolution of physical systems, of which the single measurements are thought to be actualizations. In any case, it is fair enough to understand this connection only as a relative and not deterministic connection at all, because we cannot know a single stage of the system before measuring, and we are not able to sketch an original picture of physical reality which could be able to collect all the stages together in a foreseeing point of view, as it was in classical mechanics[32]. This theoretical scheme translates the experimental fact that measurements annihilates the preliminary atomic configuration, which is at the best describable through the wave function, that, as Born wanted it to be[33], is only a probable indication for finding a particle in a given range of positions. What this means from the ontological point of view is diaphanously stated by Cassirer in this excerpt:

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31 *Heisenberg W*. Physics and Philosophy. The Revolution in Modern Science. P. 46.

32 *Cassirer E*. Determinismus und Indeterminismus in der modernen Physik. Historische und systematische Studien zum Kausalproblem. P. 19–35.

33 *Born M*. Zur Quantenmechanik der Stoßvorgänge // Zeitschrift für Physik. 1926. Bd. XXXVII. P. 863–867; *Ghirardi G.C*. Op. cit. P. 117–118; *Cassirer E*. Determinismus und Indeterminismus in der modernen Physik. Historische und systematische Studien zum Kausalproblem. P. 231.

> Thus we may continue to speak of an electron as a determined "object"; but this has not that individuation which can be characterized through a simple "here" and "now". Waves are not related to a single space-time-point, and they have rather a kind of "omnipresence". Each of them is extended to a "whole space", which has to be determined not as intuitive space, but as "configuration space"[34].

This means:

> What a "thing" is in an absolute way, outside of the actualisable circumstances of the observations in the different sets of experiments, about that we do not get any answer anymore[35].

Here we get the implicit but decisive problem, a corollary of the heno-ontological equivalence, which is worthwhile to make plain.

In the fourth book of *Physics*, Aristotle analyzes the concept of space, and shows how its basic work is to ensure the final stability of the ontological unity of a being. Accordingly, we should consider that every being, to actually exist, has to occupy a specific place in reality (*topos*); then it must fill a space (*chōra*). In truth one has to say that Aristotle used the terms *topos* and *chōra* as if they had the same meaning, but this is now unessential; we must, on the contrary, focus on the awareness that place, and space more in general, is not the same with the things we can encounter into it. He consequently sets as premise of the individuation of a being, of its unification, the condition of being in a place[36], and he basically refuses the hypothesis of the hollowness of the latter by stating that every being has to occupy a place in order to be something. Aristotle clearly sees a dangerous ambiguity at this point: if space differs from the filling things filling it, but if whatever thing occupies a space, space can be confused with the very form of a being, and could consequently become the thing itself. Aristotle upholds his scepticism about this, and he replies that space cannot be assumed as the *peras* of a thing, since it is more accurately the *periechon*, something containing the thing but which is not the thing as it is[37]. He then emphasizes a representation according to which space is declared to be the *peras* not of things, but of the body holding the different things. This argument which seemed to present a *contradictio in adjecto*, shows its fruitfulness in the positive grounding of the premise of the heno-ontological equation, which now lies in the basic possibility of having a place. There is no being without a spatial determination and vice versa, and space, so Aristotle points out, is "the first stationary limit of what is holding"[38]. To complete the basic definition of the physical being, solely the chronological invariance of the body must be added, or, even better, the immunization against the effects of motion.

Given what stated above, it evidently appears how difficult it would be to reach the correct representation of the unity of being, if we have to put aside both a full localization of the being and its invariance in respect of the motion. A double possibility then arises: i) stating that the heno-ontological is not valid at all, or ii) affirming that the relativization we have to uphold is the only reasonable solution in

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34 *Cassirer E*. Determinismus und Indeterminismus in der modernen Physik. P. 217; see also P. 227–228.
35 Ibid. P. 229.
36 *Aristotle*. Physics. Adelaide, 2015. IV, 208b27-29.
37 Ibid. IV, 210b32-211a6.
38 Ibid. IV, 212a20-21.

order to represent physical reality as the physical theory does. I would lean towards the second solution, and I will explain the reasons later in the text, even though I have already suggested some arguments on the topic.

6. I now would like to recall a distinction made by Heelan in his classic work on Heisenberg's thought, *Quantum Mechanics and Objectivity*. In the *Introduction*, he distinguishes among different conceptions of object, which we can sum up as follows:

i) first of all, we have the concept of "*thing*", which is the transcendent being correlated to a substance as a stable subject of properties. Heelan says that such an object could be both a "*phenomenal object*", given in perception, and a "*constructed* object", such as an electron;

ii) secondly, a phenomenal object has to be always conceived in regard to a precise spatial organization, and it is phenomenal because it has to be represented in consciousness, but it is thinkable as a *body* too, since it is external to mind.

Hence it appears very clear that it is impossible to make of a scientific object, and specifically of a subatomic particle, a body in the strict phenomenal sense. In a significant way, the most important lack is then showed as it determines the failure of every ontological closure of the unity of being: the impossibility of collocating entities in a "spatially organised World"[39]. So if we try to apply Heelan's scheme, we may affirm that, to some extent, the electron can be interpretable as a thing, but not strictly as a body anymore: it is a "constructed object". This can be inferred by arguing that for the macroscopic objects the old classical laws were still valid, since the microphysical interactions dominated by Planck's constant are unessential; upon this ambiguity classical physics has built its fortune and its intuitive force, which would seem to authorize scientists to think of their physics as an objective description of an external world independent from any interaction, and more in general as a fixed and substantial reality acting as an unchangeable monolith.

What QM is able to teach us, consist of the fact that the basic ontological assumptions have to be partially changed in facing the concept of reality as it is revealed by the new physics. This new concept does not allow us to conceive a real objective and independent nature anymore, till the point in which Heisenberg claims that in modern science man does only encounter himself[40]; on the contrary, one should assume the inescapable interaction among the world, the device and the quantum object, a whole picture into which the role of the observer is very important, because without intervention nature would remain a pure and sliding nothing. But this is not subjectivism at all, if by this word is meant the idea of the "*esse est percipi*": here, reality still keeps an objective meaning, but this meaning is not independent from the context of its definition anymore (and it does not matter whether this framework were represented by the observer or by the device). Heisenberg tried to solve this hard problem by introducing, in *Physik and Philosophie*, the concept of "*potentia*"[41], which he assumed from Aristotle's philosophy – from this point of view, it is particularly significant that Aristotle represents both the crisis and the

[39] *Heelan P.A*. Op. cit. P. 7.

[40] *Heisenberg W*. Das Naturbild der heutigen Physik // *Heisenberg W*. Gesammelte Werke. Abt. C, Bd. I. München; Zürich, 1984. P. 412.

[41] *Heisenberg W*. Physics and Philosophy. The Revolution in Modern Science. P. 167–186.

turning point of ontology when it deals with QM[42]. To him, this necessity had become unavoidable for his most recent work on the physics of elementary particles, a field in which he aimed for a general framework involving the idea of a primary energy actualizable in a whole range of individuals, according to a mechanism regulated by geometrical laws of symmetry[43]. This scheme, anyway, appears to be also available for the foregoing approach he advanced for QM: therefore, we would have the pure functional probability of the wave function and then the actualizations, viz. the collapses of the function generated by the different measures. Here we obtain neither a strict determination of a physical being, for the measure destroys the first system and with it the object we wanted to know something about (this implies the lack of chronological permanence of the substance), nor a whole localizability of the particle, which is in principle only statistical (because of the uncertainty relations).

Finally, as regards the complementarity principle, it is very easy to demonstrate how the acceptance of the principle by Heisenberg was a sufficient sign of the correlated acknowledgement of the new QM ontology. At a first moment, Heisenberg was pretty reluctant to the idea of incorporating some elements of wave mechanics into the standard version of QM, but Bohr's increasing pressure convinced him to change his mind. The principle was a wise philosophical compromise, which allowed physicists not to take any definitive decision upon the definitive truth of waves or of quantum mechanics: in the definition of physical entities, they were declared to be incompatible and at the same time complementary. Bohr's idea was that of raising up the difficulty to the realm of postulates: the unity of microscopic physical beings questioned by science through the basic dualism between wave and particle, is assumed to be this unity as such. In doing that, it is also clear that a substantial unity of being is contested, but a functional one is still possible.

To summarize, we can say that QM represents a very hard challenge for ontology, because it realizes a particularization of the unity of being, but it simultaneously shows the impossibility of including the extension of that being in the very structure of unity. As Cassirer brilliantly suggested, the being of a physical entity has become "omnipresent" – the very being is indeed energy – and this means that it overcomes its ontological unity; but, since this new situation convinces us to abandon the old idea that physical objects can be figured out as bodies, it in turn authorizes a more acquainted concept of singularity[44]. In this way, we could affirm

[42] Johanna Seibt has given a profound explanation of the relationship between the ontological theory of quantum particles and Aristotle's ontology in general (*Seibt J.* "Quanta", Tropes, or Processes: Ontologies for QFT Beyond the Myth of Substance // *Kuhlmann M., Lyre H., Wayne A*. Ontological Aspects of Quantum Field Theory. New Jersey; L.; Singapore; Hong Kong, 2002. P. 53–98); here I have only taken into account the basic question concerning the heno-ontological equation, which seems to me the fundamental and preliminary part of the whole discussion. However, I hope to write a specific paper on the topic in the near future.

[43] *Heisenberg W*. Platons Vorstellungen von den kleinsten Bausteinen der Materie und die Elementarteilchen der modernen Physik // *Heisenberg W*. Gesammelte Werke. Abt. C. Bd. I. München; Zürich, 1984. P. 394–397; *Cappellettii V*. Dall'ordine alle cose. Saggio su Werner Heisenberg. Milano, 2001. P. 165–167.

[44] In the present paper I have not discussed new interpretations of the theory, but I guess that, if Dorato (*Dorato M.* Events and Ontology of Quantum Mechanics // TOPOI. 2015. Vol. 34. P. 369–378) is right about proposing an ontological model based on the unity of events, my analysis could save its worth also in considering the new forms of QM. According to Dorato, indeed, the concept of event could save both the determination of the physical being in its singularity, and the potential initial frame. Hence the goal of thinking of a non-substantial individuality would be accomplished.

that QM teaches us to settle a pure henology as distinguished from any ontological implication[45]. But it would still remain a problem: what one can actually be? Is it the result of a measurement, or a pure idea which would be the hollow form of being expected to be fulfilled[46]? If for the latter statement one can think about a non-substantial concept, or similarly if we keep saying that physical entities are not bodies, the two possibilities can find a very peculiar accordance. However, here we observe an inversion of Aristotle's physics, for the real being is not actual, but it rather consists of its potential relation to a whole set of possibilities; it is as if the famous statement about the fact that the form of a being is more nature than its matter[47] appeared to be upturned[48]. Heisenberg himself claims that the word "*Gestalt*" has to be put aside in QM[49].

In conclusion, the at least partial disentanglement of *hekaston* and *on* implies the possibility of somehow coming back to the physiological situation and setting the necessity of a coherent theory of the world, in addition to the new version of the heno-ontological equivalence.

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[45] See: *Stamatescu I.O*. Cassirer und die Quantenmechanik // Von der Philosophie zur Wissenschaft. Cassirers Dialog mit der Naturwissenschaft. Hamburg, 1997. P. 22–23.

[46] It might be argued that the conception of the one is not substantial in Aristotle as well (Metaph. 1053b9-1054a19). Anyway, this does not solve the problem, basically for two reasons: i) the localizability principle is never rejected, while QM has showed its unbearability; ii) one and being are still conceived to be in an unbreakable and strict relationship.

[47] *Aristotle*. Physics. IV, 193b6-7.

[48] Nevertheless, I have to emphasize once again with Heisenberg that also the idea of a primacy of the potentiality setting derives from Aristotle: "By matter I mean that which in itself is neither a particular thing nor a quantity nor designated by any of the categories which define being. For there is something of which each of these is predicated, whose being is different from that of each one of the categories; because all other things are predicated of substance, but this is predicated of matter. Thus the ultimate substrate is in itself neither a particular thing nor a quantity nor anything else" (*Aristotle.* Metaphysics. 1029a20-23). How can this paradoxical situation be explained? I guess that a possible solution should endorse a functional explanation, for it has to be considered a double plan of meanings: i) on the one hand, the quote about the form is taken by Physics, and shows Aristotle directly dealing with nature, where his biological approach could lead only to the representation of physical beings as species of a genus; ii) on the other hand, a more general outlook, which for Aristotle involves the kind of production of the artefacts, would emphasize the perspective according to which the primary matter of a single being has to be considered as undetermined, insofar as it must be distinguished from the singularity of every being – if not, there will be only the singularity of matter, while that of the beings might have been lost.

[49] *Heisenberg W*. Über den anschauulichen Inhalt der quantentheoretischen Mechanik und Kinematik. P. 174.

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Пытаясь представить пламя задутой свечи: заметки об онтологической структуре Копенгагенской интерпретации квантовой механики

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В данной статье автор рассматривает вопрос об онтологической структуре квантовой механики и анализирует эволюцию хенолого-онтологического равенства (проблему тождественности единого и бытия) в новой формулировке, предваряемой ортодоксальной интерпретацией данной теории. Таким образом, статья будет сосредоточена в частности на Копенгагенской интерпретации и недостаточности интуиции [*Anschaulichkeit*] в репрезентации внешних физических объектов. В том, что касается последнего вопроса, автор также рассматривает классическую репрезентацию философии Гейзенберга, опираясь на материалы П.А. Хилана. Автор показывает невозможность сохранения старой репрезентации физического тела, которая работала бы также для классической механики, поскольку квантовая механика отрицает абсолютную локализуемость физических сущностей. Действенная детерминация локализуемости и была тем постулатом, который лежит в основе хенолого-онтологического равенства в том виде, в каком его представлял Аристотель: то, что не локализуемо, не является единым. Это также необходимо рассматривать как специфический недостаток в отношении к хронологической устойчивости тождества квантового объекта, который представляется как постоянно изменяемый своими взаимодействиями с инструментами и с другими частицами. В соответствии с этим автор дает свое объяснение своеобразного определения физической сущности в Копенгагенской интерпретации квантовой механики как не-вещественной сущности, как не-тела, рассматривая аргумент, утверждающий, что, таким образом, наличная субстанция в физике может быть только целостной тотальностью. Относительно последнего утверждения автор предлагает определение индивидуальности, которое не чуждо самым последним интерпретациям квантовой механики. Квантовый индивидуум представляет собой не столько тело (по аналогии с телами нашего повседневного опыта), сколько сущность, чье онтологическое содержание является лишь

относительным, зависящим от трансформаций в примитивном контексте: это означает, что его онтологический заряд не может рассматриваться как постоянный. С этой точки зрения, можно утверждать, что квантовая механика намного ближе старой интерпретации природы как сущности в древнегреческой натурфилософии, которая стремилась различать онтологические определения индивидуальных сущностей и единство бытия как целого. Таким образом, через анализ Э. Кассирера, в статье будет показано, как возможно представить новые основания для отношений между единым и бытием, а также как попытаться пролить немного света на базовые предположения онтологии Копенгагенской интерпретации и современной квантовой механики.

Ключевые слова: Аристотель, Э. Кассирер, Копенгагенская интерпретация, хенология, квантовая механика, вопрос о бытии, В. Гейзенберг, онтология