THE FIFTH SOLVAY CONGRESS REALLY OVER OR STILL OPEN BETWEEN PHYSICS AND PHILOSOPHY

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ABSTRACT

The relations between : reality in itself and phenomenal reality, mathematical world and world of experience, exactness and approximation in physics and mathematics, these are issues, among others, that invest both physics and philosophy. There is a vast area of intersection between physics and philosophy. The article is located precisely at this intersection. The headlines of the main topics addressed are : realism and phenomenalism in epistemology and physics, relation world of experience - mathematical world, eulogy of inexactness and therefore of approximation and probability. Furthermore, two quite original working hypotheses : a draft of a 'theory of uniqueness, irreducibility and unrepeatability of the event' and the criticism of substantialization, which attributes reality in itself to the objects of the cognitive process, with the consequent proposal for a 'change of perspective', which eases fundamental physics from epistemological assumptions and prejudices.
Physics, even theoretical physics, is an experimental science. Physics does not exaust human thought, but its sphere and its effectiveness are exactly this.

The article contains, in a very synthetic way, some working hypotheses, which on the one hand concern the field of physics and on the other the epistemological research. The contents lie in the intersection between physics and epistemology.

1) Physics and epistemology are, historically and still, closely intertwined. Einstein[1], Bohr[2] and Heisenberg[3], prominent examples, presuppose epistemological and philosophical frameworks, which are incorporated into their physical theories. In Einstein the realist assumption, in Bohr and Heisenberg the phenomenalist point of view.
2) Phenomenalism, like realism and idealism, does not constitute a univocal epistemological position , but rather a family of different positions. Think of Democritus (" We know nothing real"),[4] English empiricism, in particular Hume[5], Kant[6] himself, empiricist positivism, Mach[7] and empiriocriticism, logical neopositivism, Wittgenstein[8], Popper[9], as well as numerous exponents of the Arab and of Indian and Chinese thought, in different periods of time. The main common trait is that reality cannot be known as it is in itself, but only as it appears. Among the variants of phenomenalism, the epistemological version affirms the existence of reality in itself, an 'external' reality independent of observation, that exists independently of the cognitive process, not directly accessible, while the ontological version resolves reality into phenomena, i.e. there would be no reality beyond what appears. It should be emphasised that phenomenalism is something else compared to sensualism. The ontological variant contains an unprovable metaphysical assumption.
It can be objected that even the affirmation of a reality in itself implies a metaphysical assumption. In short, reality in itself is a metaphysical concept just like the denial of the same. However, it can be argued that, since knowledge appears almost universally to consist of an interaction between the observing system and the observed system, it is reasonable to suppose that it is not the only knowing subject that produces the world entirely. This reasoning obviously does not constitute a demonstration, but rather a plausible argument.
3) The phenomenalistic method in the epistemological version is widely considered, I think this position can be considered correct, perhaps the most plausible theory of knowledge. It would be superfluous to enumerate here the many thinkers who can be placed in this trend, naturally with more or less marked differences. The position according to which scientific progress is *ad infinitum* (e.g. Popper), rather than *ad finitum*, mostly fits into this framework. Even the thinking of the main authors and standard-bearers of quantum theory is placed within this context, unlike the epistemological positions prevalent in classical physics. Furthermore, the study of Hume and Mach significantly influenced Einstein, in particular on the elaboration of Special Relativity. One of the cornerstones of quantum theory consists in considering physics as referring to the data of experience, to phenomena, as they are observed by the observing systems and in stating that in general observation modifies what is observed.
A rigorous epistemology, it seems correct to me to declare the my philosophical point of view, can only be phenomenalist, (not sensualist and obviously this does not amount to mere sensory data), clearly in the epistemological version. The fundamental information we have about reality itself is the impossibility of accessing it directly. We can do nothing more than conjectures about it, which must be verified, as far as possible, in the

phenomenal world. This is a boundary, beyond which the human mind may not even be able to push. This is not known to us.

4) For classical physics, or at least for most of its expressions, natural events are completely determined, both in terms of properties and the cause-effect principle and, furthermore, in principle they are exactly knowable. For it one can know, in principle, exactly and completely the state of a system at any instant and for it there is nothing indeterminate. In classical physics, that is, the existence of a specific structure of the real world is postulated . Very deep and detailed the analysis conducted by A. Kojéve[10]. For classical physics, knowledge provides an adequate image of reality in itself and, therefore, the constitution of the phenomenal world is seen as an approximate structure of the exact form of reality in itself.
   The world of experience in this framework is the realized mathematical world or in other words the realization of the mathematical world[11].
5) The phenomenal world is given by the interaction between the observing system and the observed system, in which we are immersed. The comparison between the **'mathematical world',** in the literature 'the mathematical universe ' (see among others M. Tegmark[12]), and the **'world of experience'**, i.e. phenomenal world, must be placed in this context . Mathematics, unlike physics, which is an experimental science, is independent from the study of physical systems, whether it is reality in itself or phenomena, it freely generates structures and models, with only the internal constraints of coherence and completeness. The possibilities are limited only by its own rules. In a word, it is a system of **logical nature.** Reality is not relevant to logic, unless reality is able to refute it. The proposition A=A can be invalidated or that A $\neq$ NOT A? Being within the rules of a logical system, it seems not, but the verification becomes very complex and uncertain if we refer to physical systems. The equality or inequality of two systems (objects , events), which in logic and mathematics can also result in an affirmation or denial or even in a tautology, in physics can constitute an assumption or a definition or a convention, which cannot be achieved through empirical evidence or through a logical procedure (demonstration).
   The guiding idea of the mathematical world seems to be the exactitude of axioms, definitions, rules and procedures. Axioms, definitions, rules and procedures must be exact. Mathematics is built with invariance and the identical[13]. The problem of measurements is different. Physical experiences, in fact, cannot be rigorously exact, they are instead approximate and the differences can be below those detectable by observation devices. 'Indistinguishability' is not equivalent to 'identity'.
   In its development, mathematics has had to face, since the discovery of the side/diagonal incommensurability of the square and gradually the paradoxes of infinity , irrational and complex numbers and subsequently, above all, with the outbreak of the crisis of the foundations, the non-rational and the not-exact.
   In the universe of exactitude, i.e. also in the sphere of pure thought, non-exactness, non-rational and irrational emerge , but the idea of the limit still remains exactitude, which can sometimes be achieved sometimes not.
   The world of exactitude is made up of a set of *assumptions*, *definitions*, *procedures* and also of actual *ideal entities* . All of this constitutes, in fact, the mathematical world . Mathematics is the science par excellence of the regularity of events, therefore of models, structures, schemes, that is, of

processes of generalization and abstraction. The meaning is to find what is identical in different events and, also, give them the same name and the same number.
There is a boundless literature on the relationship between nature and mathematics and also on their correspondence. Platonism and various neo-Platonisms affirm that ideas (numbers, structures, models...) are not only real, but constitute the true essence of the world of experience. This paragraph could be titled *Against Platonism* . Even the ' *Everything is number* ' of the Pythagorics fit into this framework and perhaps *Pythagoreanism* was the main progenitor of *Platonism* . It can immediately be noted that the proposition 'everything is number' requires three non-obvious definitions, in the absence of which it would have no meaning, i.e. what is meant by 'everything', by 'being' and by 'number'. Philolaus aphorism, '*Without numbers you can't think or know* ', on the contrary, is completely different and still unexceptionable. The various forms of Platonism can be interpreted as the result of a deep-rooted and boundless anthropocentrism. We will have to unlearn anthropocentrism, even if it is very difficult for us to abandon the belief that we constitute the center and end of the universe. The arrogance of our observation point has no reason to exist, even though it is the only one we have. Let us observe, first of all, that mathematics is a human creation, a historical product of biological brains. Nature doesn't care about us and our claimed centrality. It will be good to get used to the idea of our marginality in the cosmos.

6) Underlying question , the truly formidable challenge, is to understand the great **power of mathematics** in the description and prediction of phenomena. A particularly simple example is that of *dimensions* . Starting from a non-dimensional point we arrive at the representation of the physical object. In fact, the straight line derives from the ideal moving point , the surface from the ideal moving straight line, the volume from the ideal moving surface, and the irregular physical object from the regular volume or solid. The line is not made of an infinity of non-dimensional points, nor the surface of an infinity of one-dimensional lines or the volume of an infinity of two-dimensional surfaces and yet our idealized mathematical objects work, with extremely effective results , proven by experience. A straight line is not a geometric line, a flat physical surface is not a two-dimensional plane, but they are respectively approximated, the same happens for a physical body and for a three-dimensional volume. To be more precise, classical physics doesn't really think like this. It measures, or rather claims to be able to measure, the physical system completely and exactly, in principle and in any case with an approach to exactitude that can progress indefinitely. The edifice of classical physics was assumed to be fully satisfactory until the emergence around 1900 of the well-known profound critical issues, which paved the way for Planck's[14] introduction of *discontinuous physical action* , that is, of the quantum, and to the double revolution in both physics and epistemology : relativity, special and general, and quantum mechanics. This scientific revolution leads to the abandonment of some fundamental principles of classical physics, including causal determinism, the correspondence between reality in itself and phenomena and the exactitude, in principle, of knowledge. Mathematics itself goes through an earthquake in the same period with the 'crisis of foundations', which highlights the difficulty of founding mathematics on complete and incontrovertible foundations and of defining a certain foundation for it. In

1900 we have, limiting ourselves to the iconic moments, D. Hilbert's[15] speech at the International Congress of Mathematicians in Paris (« Wir müssen wissen . Wir werden wissen ») and in 1931 the publication of the famous article by K. Gödel[16] , entitled *Über formal unentscheidbare Satze der "Principia mathematica " and verwandter System* . Another revolution, therefore, another fall of the gods, this time in the field of logic and mathematics. In a nutshell, mathematics cannot prove everything even in mathematics itself. The non-rational, the unpredictable and the random do not only constantly emerge in sequences of events and phenomenal data, but arise within the models themselves, in the mathematical world of pure thought. Simple geometric figures such as the square or the circumference generate the irrational number, the non-exact and the infinite.

7) Let's go back to the **'world of experience'**. The method of abstraction and generalization is not exclusive to mathematics, instead it characterizes the entire process of knowledge. A disorganized data set or a flow of events without regularity does not convey information. The researchers of *perception*, this concerns not only sight, but the entire sensorial knowledge, therefore the whole of the interpretation of sensory information, shows that it too, in a certain analogous sense, with mechanisms of abstraction from differences and generalization, processes the flow of phenomena, transforming meaningless events into information **.** Perception is not aimed at exactitude, because it would not be useful, but it works very well with approximation, which is what it needs.

The *concept* , i.e. the process of conceptualization, does not act in an essentially different way from perception, as regards the fundamental operating mechanisms. Rather, we see a difference in degree and complexity. All this must naturally be framed also in the **evolutionary scale** , from the beginning to us. If there is knowledge that cannot be ignored, in its central content, it is the theory of evolution, at its various levels. As B. Lotto[17] writes beautifully : «… when we look at the world, we actually look through millions of years of history». We usually imagine physical reality as something exact and perfectly defined, but the 'world of experience' doesn't really seem to be a world of exactness. Inexactness, generally considered a deficiency, on the contrary seems to constitute a resource. Survival requires not the ability to precisely identify that specific predator, but the ability to identify a possible predator beyond the differences between individuals and species and the same need arises for the search for food and partners. Exactness does not appear useful. Brains lost in detail would have been easy food for predators. Approximation, i.e. inexactness, produces an evolutionary advantage, because it is easier, faster, more effective. Inexactness is also richer and more creative, because it projects us into variety and change, sends us outside the ideal world of exactness and places us in the world of experience. On the contrary, a world based on the rule ' either you get it right or you're wrong' would not allow survival. The guiding principle here is of a different kind: it is evolutionary success that shapes knowledge or the search for fitness. *Inexactness and approximation are all you need* . Furthermore, even in certain operations of ordinary life what is needed is not exactly exactness , rather a certain degree of approximate *precision* . Even the archery requires this more than exactness.

In short, we can affirm that in the process of knowledge, except in mathematics and logic, exactness does not have a primary role. This paragraph constitutes a true eulogy of inexactness. Contrary to mathematics, experience is constructed with variation and difference. The tool that actually guides our actions is made up of approximation and probability. The world of experience appears primarily as the world of inexactness and approximation. On the role of approximation in mathematics and in physics, see for example M. Cacciari[18] and A. Quarteroni[19]. The cognitive process, in general, is not made up of a copy or a reflection, but rather of approximations of reality. The variety of events cannot be reduced to exactness and number. *The world of experience cannot be enclosed in exactness* . We will see that even the concept of a number restricted to exactness would constitute a very poor idea of the number itself. One may ask whether the same sign of equality, = , which constitutes one of the essential stones with which the mathematical world is built, can really make sense in reference to the world of experience. As for the question of whether it exists in reality itself, we can't say this.

8) The history of philosophical and scientific thought is certainly extremely complex. The *theoretical constructions,* with which we try to make sense of the experience of reality, are necessarily based on the information constituted by the phenomenal world of perceptions and concepts. It is not necessary to retrace, since it is one of the most studied topics in various disciplines, the path from cosmogonic myths to the great religious and philosophical systems and to the scientific method, with the progressively growing entry into play of mathematics with the multiplicity of its branches. Mathematics, first with geometry and arithmetic, then gradually with its entire arsenal, creates the world of exactness. *But there is a however* . Not only are absolutely exact experiences not achievable, but *not even the mathematical world can be entirely enclosed in exactness* . Number theory shows this clearly. One of the most informative reads on this aspect is André Weil's [20]*Number Theory*.
   The question fullest of meaning is that of the irrational number and, consequently, of infinitesimal quantities.
   Really perfidious topic[21].

9) In general, we use to put together, with an operation of superposition, reality in itself, the phenomenal world and the mathematical world. This is of no benefit to either epistemology or theoretical physics. Considerable confusion emerges. Everything has been said and continues to be said on the subject :
   - 'The true world is the mathematical one and the phenomenal world is pure illusory appearance';
   - 'Phenomena are the only reality';
   - 'There is a mysterious correspondence between the two worlds'. And so on.
   Let's try to propose some provisional but tidy points:
   a) what we know about reality itself is that it cannot not exist;
   b) on the phenomenal and mathematical worlds, it turns out that they are of a different nature, as the mathematical one is a product of pure thought, while the phenomenal world is what we experience in the observer-observed interaction;
   c) they partly function similarly (abstraction and generalization mechanisms) and partly not (one produces a world that is basically exact, the other proceeds by approximation and inexactness) and certainly cannot be reducible to each other ;

d) mathematics constitutes the first and indispensable tool for processing, organizing and interpreting experience;
e) a superposition usually occurs in scientific thought, by virtue of which the functioning of the world of experience is explained with the application of the mathematical world and, at the extreme, with the transposition sic et simpliciter of the mathematical world into phenomenal experience;
f) the identification between the mathematical and phenomenal world, which has characterized classical physics to a considerable extent, has produced a great advance and opened the way to a powerful innovation, not yet completed, with the new great questions with which we are faced currently in progress.

10) The **first innovative** and also partly original idea of this work is inserted here: an epistemological theory of the ***uniqueness, irreducibility and unrepeatability of the event*** , understood as the elementary unity of experience. A theory, obviously, to be tested.
In terms of physical description an event is a point in spacetime and we know from general relativity that one point in spacetime cannot be perfectly identical to another[22]. We are referring here to the process of knowledge, not to the processes of nature, about which we can only know what emerges from the phenomena. The idea is that the entire cognitive process, from perception to theory, can be explained with an *epistemological theory of the event* , with the following fundamental properties:
    - *An event is a phenomenon or a set of phenomena, which manifests itself in a specific reference system, in a specific place, at a specific moment;*
    - *Each event is single and irreducible, that is, it cannot be perfectly identical to any other;*
    - *It cannot even be perfectly identical to itself at a different instant or in a different place;*
    - *No event can be known perfectly and completely, starting from the initial conditions.*

      These points, however, can be derived by combining the principles of SR, GR and QM together[23].

    The most normal and repeatable thing is that each event is unique and unrepeatable . I'll try to clarify it in a few lines.
The event, a point in spacetime, is a set of interconnected data that reaches us at a given instant and which is processed by our brain. This processing capacity, briefly summarizing, is the product of a long evolutionary process, which embraces not only the history of homo sapiens, but that of primates, even before vertebrates, to include the entire history of living things.
To survive we had to learn to grasp regularities, patterns, structures, invariants, in the bombardment of events. Capturing in the variety, in the differences and in the changes, what is similar and what lasts.
The invariant in change. The products of abstraction and modeling have always been tools for survival and interaction with reality. Events, single and connected, constitute the components and basis of cognitive processes, of elementary cognitive units and also of more complex ones.
And as mentioned above, we have always been inclined to mistake them for reality in itself. There seems to be an inevitable tendency to substantialize the objects of the cognitive process. I would say a pragmatic strategy. We could make a list of the ideas in our mind that are or have been believed to be real

entities, but the same mechanism manifests itself from perception to abstract theory.

But no event and no combination or elaboration of events can be (or coincide with) reality in itself.

The great scholar of Greek thought and philologist C. Diano develops an extremely stimulating reflection on the concept of event, in a thematical context very different from ours, however with points of affinity, for example, when he states : «… We cannot speak of an event except in relation to a specific subject and from the scope of this specific subject… As *id quod cuique èvenit* the event alwais is *hic et nunc*. There is no event except in the foreseen place where I am and at the moment in which I perceive it »[24].

11) Let’s now see the relationship between the mathematical world and the world of experience. The mathematical world, in reference to both theory and the technological universe, functions in the description and prediction of phenomena to the point that, many times and in many different ways, it has been thought and is thought to reflect reality in itself. The mathematical scheme certainly represents the most powerful tool for finding invariants, for building schemes and models, maps, but no scheme can be said to be equal to (or reflect) reality in itself. We don't know what or how this is.

Classical physics assumed that it was possible, through the progressive increase in the precision of measurements, to indefinitely approach the ideal of full correspondence between knowledge and reality in itself.

Relativity and quantum theory profoundly change the scenario in physics. From that moment on, physical theory continues to pursue effectiveness, but cannot achieve perfect correspondence with the physical systems that constitute its object. What we are calling exactness or exactitude consists precisely in almost correspondence perfect between the real object and our representation of it .

For SR , which has achieved extraordinarily important results, I limit myself to recalling: a) uniform rectilinear motion and inertial reference system have the same value in curved spacetime as 'geometric entities' with respect to experiential objects; b) questioning the concepts of 'same time', 'same place', 'same thing' (refer to the article ' *On the velocities addition relativistic equation* '). The analysis conducted, assuming the principles of SR and GR and applying them jointly, demonstrates that these three concepts are the result of *approximation procedures* and not of logical-mathematical identities and that they are not rigorously founded either on the level of observation or on the level logical. As for QM , the uncertainty principle reveals that exact observations are impossible in principle, starting from exact and detailed knowledge of the initial conditions of a system. It is fruitful to reread Heisenberg's[25] basic article of 1927 and the next Bohr's[26] essay on the quantum postulate. Physical experiences are essentially inexact. The limits to the knowledge of the single state, for which it is not possible to have complete knowledge about a single system, nor to make exact physical predictions about it, and the indeterminacy of the properties of the systems, as it is not possible to state that a system has defined properties before being observed, complete the Copenhagen interpretation. Therefore, with the emergence of QM, capital problems in the principles of physics are manifested to a completely new extent.

12) In particular, the irreducibility of the world of experience to the mathematical world comes to light . Science itself presents, using the expression of L. Geymonat, a theoretical non-neutrality, in the sense that it would be neutral if it provided absolute truths[27]. Many examples can be given, but two seem particularly significant. The first, taken from relativity, is represented by the mathematical equation of time with spatial dimensions. The procedures and problems connected to this equation are dealt with in the article '*Space and Time…'* to which I refer[28]. The construction of spacetime (Einstein-Minkowski[29]) has a powerful descriptive capacity, as well as being splendid, but it is a spacetime that does not describe our world, in which time has properties for the observer's experience that are absolutely not comparable to spatial coordinates. The universality of the irreversibility of time is perhaps the most uniquely strong fact of the experience of mankind.

The second example, taken from quantum theory, is the wave-particle duality, i.e. the need for simultaneous use of the corpuscular and wave models. Some suggest 'corpuscular waves or wave particles'. Bohr addresses the question with extreme clarity repeatedly in his work.

Bohr's position can be faithfully summarised in this way : neither particles nor waves are attributes of nature. They are nothing more than ideas in our minds, which we impose on the natural world…we acquire knowledge of the natural world only through intermediaries[30]. Particles and waves are very different objects, in the first case reality is discontinuous and composed of elementary units, in the second case it is continuous and not granular. But are we talking about reality or our representations (schemes, models, maps)? If we are talking about reality in itself we are referring, meanwhile, to something not directly accessible and, furthermore, there would be a clear alternative between the two possibilities, that is, one of the two. If, however, we are talking about our representations, things are decidedly different. Bohr, in this regard, introduced the concept of *complementarity* .

There is something in the phenomenal world that appears not to be reducible to models, schemes and maps, that is, to the mathematical world, even if in mathematics there is the counterpart of irrational numbers and infinitesimal quantities. In a word, there is a ***residue*** in the world of experience , that is, an ineliminable component of irregularity, unpredictability, randomness, which cannot be reduced to a pattern, not modelable and non-mappable. In the *residue* it is also legitimate to place the unexplored world of distances and, more generally, of infinitesimal quantities. Let's think, for example, about the gravitational field: if we take two points distant from each other by a magnitude less than a distance ε as small as desired, the value of the field will be *almost* identical, but *not exactly* identical. The time at the two points will also pass at an *almost* equal pace, but *not exactly* the same. The *almost* constitutes the indicator of that unavoidable component that we are calling the residue. *There is an unexplainable residue.* Despite the effectiveness and success. In twentieth century and contemporary physics it emerges, more and more clearly, that neutralizing, canceling or ignoring the *residue* proves more difficult than one might think. The residue cannot be described in any way, but its mere existence is already in itself problematic. The mathematical technique of 'renormalization', which is used to resolve the problem of non-eliminable infinities, itself constitutes an example to be examined further in depth, as R. Feynman[31] himself, who was one of its main architects, was very clear about.

Particularly interesting, on these themes, are the contributions of N.V. Bugaev and P. A. Florenskij, taken up and commented by S. Tagliagambe[32] in a beautiful essay on M. Cacciari.

13) Thus we have arrived at the current deadlock, made evident by the incompatibility between relativity and quantum theory and by the vanity of the efforts of the best minds , for just under a century now, to produce a unitary synthesis. On this aspect, I refer you to the work '*On the Infinitesimal Quantities . Physical-Epistemological Minor Essay*' [33].
The crisis arises from the same extraordinary success of the two theories, but the fact is that we do not currently have a single shared framework capable of bringing together our physical knowledge.
The stalemate, of course, concerns fundamental physics, while other fields, starting from many sectors of experimental physics, but also electronics, materials science, astrophysics etc., have gone through and are still going through phases of formidable productivity. From the debate between Einstein and Bohr, symbolized by the legendary V Solvay Congress, to today it is increasingly evident, with the progressive mathematization of physics, that our most effective constructions in the description of phenomena, i.e. experimental data, can no longer be modeled as particles or waves of matter or energy and that the representations of them are not physical models, but mathematical structures. The waves and particles of quantum theory do not correspond to any entity in the physical world. Particles, waves, fields and so on are mathematical structures, that is, mental constructs, not unlike groups, matrices or rings. Obviously it must always be remembered that mathematical structures in some cases are effective in describing and predicting phenomena, in other cases not or not to the extent prescribed by scientific methodology. The logarithmic spiral does not arise from the observation of nature, but is then useful from snails to galaxies. With success.

14) Let us now ask ourselves if there is something and, if so, what is preventing or slowing down the path of fundamental physics. First of all, it must be underlined, recalling Bohr again, that incompleteness is not a defect of quantum theory, as Einstein tenaciously tried to demonstrate, but appears inherent in the very functioning of knowledge (Bohr actually said: in the functioning of nature) . QM itself has demonstrated that it is impossible to obtain exact and complete knowledge of a physical system. It can now be clearly discerned that the theory of knowledge, after Relativity and QM, with its development in QFT, must necessarily be coupled with a *theory of the limits of knowledge.* At this point**,** the **second innovative idea** and also a certain originality of this work is inserted **.**
In fact, the need for a ***Change of perspective*** or of Paradigm shift becomes plausible and verifiable in theoretical physics. There is something that almost all scientists, and in particular physicists, epistemologists and philosophers of science, know and repeat, but which is then mostly put aside. Precisely here lies one of the brakes or the main reasons for the stalemate of theoretical physics. We continue to talk, for example, about the mathematical structures of the theory as if they constituted the physical reality or the mathematics of nature. And we frequently continue to think in terms of the ultimate irreducible realities of the universe.
Of course the double slit experiment becomes in this ontological return of epistemology an inexplicable mystery!

The same reasoning can be advanced, as well as for the *corpuscular-wave pair,* also for the *quantizable-non-quantizable* and *discontinuous- continuous pairs* . I am arguing that an impediment of a philosophical or epistemological nature acts negatively in theoretical physics. This impediment can be overcome, or rather it must be overcome.
There is also, in parallel, the temptation of modeling without experimental verification, but this is a different aspect, which is also very worrying. « If we think a priori, everything can be capable of producing anything »[34]. When in physics we use *our language*, inevitably formed on the basis of intuitive knowledge of the world of experience and ontological presumptions about reality in itself and therefore essentially *improper*, we should never lose sight of the fact that this is unfounded and slippery, even more so when referring to atomic and subatomic physics.
Language always incorporates a way of seeing things. A statement by Heisenberg is very clarifying :
«Light and matter are a single physical phenomenon. Their apparent double nature is due to the essential inadequacy of our language»[35]. To get out of the impasse we must, therefore, try to see things in a different way. Physics doesn't care and shouldn't care, because you can't know if the phenomenon coincides with the underlying reality or if the object is as it appears, but rather if the object or the system can be described in a logical-mathematical scheme capable of allowing experimentally verifiable predictions about their behavior. On reality itself or, which is the same thing, on the ultimate constitution of reality, everyone can hypothesize what they like, but this is certainly not physics. What matters is answering the questions posed by observations and experiments. Our language is essentially inadequate and full of pitfalls. This determines the need for a conceptual leap. As C. Rovelli effectively writes[36] : «The difficulty is not learning, it is unlearning». Again Rovelli proposes a reading for which space and time «...are approximations of a quantum dynamics which in itself knows neither space nor time. Only events and relations». The real question is to identify the most effective conceptual schemes for understanding the phenomena. After all, we essentially have mathematical structures , the test of which is the ability to describe and predict in relation to experiments and interaction with the environment and with events in general. In mathematical physics there are neither waves nor particles, but rather functions with different mathematical properties. There is a purely symbolic relationship between the phenomenal system and mathematical structures. Atoms, quarks, electrons , neutrinos are also mental constructs and ultimately, given the advanced mathematization of physics, they are *calculation tools*. Some will object: but we see the atom, and in some ways even the electron, under the microscope! We usually see and touch glass marbles, but this does not mean we can say that we know them as they are. The sensory properties of marbles are very different from the scientific description and this presumably applies not only to the macroscopic scale but also to the microscopic scale.
If we are lucky, a theoretical intuition or well-designed and clever experiments may also pave the way for a greater correspondence with real entities of the phenomenal world. In the meantime, we should stick to a rigorous theory of knowledge and the limits of knowledge itself, freeing research from inconsistent epistemologies and ontological preconceptions.
Theoretical physics would proceed more easily .

This is the reason for the Change of perspective or, if you prefer, the Change of mentality , which we are proposing here.

We could also refer to Wittgenstein's lesson: «What we cannot speak about we must remain silent»[37].

But we are saying something more. Conjectures of an ontological nature about reality in itself, which we know is not directly accessible, or physical theories that take on that value, are in fact conditioning theoretical physical research and acting as an impediment.

The conceptualization of the world translates into substantialise, that is, into the attribution to our conceptual representations of the character of reality in themselves. Preconceptions and presumptions of this kind must be removed from physics and left to metaphysical speculation.

Just to give some other examples, in addition to the double slit:

a) the thesis that the wave function contains complete information on a system does not appear to be effectively demonstrated, unless one simply wants to state that it $\boldsymbol{\psi}$ contains all the information that physics has on a state, which is moreover predisposed in a specific experimental setup and this would then constitute nothing more than a tautology;

b) not even the definitive nature of the demonstration of the impossibility of hidden variables, attributed to Bell's theorem, represents with certainty a closed game [38].

What do Bell's[39] inequalities and proven experimental confirmations actually demonstrate? Do they exclude any theory with hidden variables tout court or do they establish the incompatibility between theories with *local hidden variables* and quantum physics, which correctly describes the experimental data?

A large number of experiments have established in a way that is difficult to dispute the inadmissibility of local realistic hidden variables. All types of local loopholes were progressively excluded . A new inequality advanced by A. J. Leggett[40] has also been tested experimentally, particularly since 2003, which would include realistic non-local variants. Subsequently A. Zeilinger and others[41] tested these inequalities, concluding that every form of realism, local and non-local, must be abandoned. The discussion, however, is completely open, as emerges from the position of A. Aspect[42] and various scholars of the De Broglie[43]- Bohm[44] trend.

Another stimulating highlight : entanglement, as has now been experimentally established, undermines the traditional thesis according to which nature would necessarily have local behavior. In short, it shows that nature does not have the constraint of locality and that the emerging question of possible *non-local correlations* must be investigated .

Thus, with entanglement a previously unexplored research frontier has opened up , on what a horrified Einstein called «disturbing actions at a distance»[45].

The possibility of *non - local hidden variables* is an extremely intricate knot, also because it clearly involves the concepts of space and time. At present, there are no certainties on the topic, but only a great discussion.

c) Finally, it can be noted that, by adopting the *Change of Perspective* proposed, the description of one or more systems of events and experimental processes would not require the use of space and time as elements of reality in themselves, but would allow one to limit oneself to the phenomenal description of systems in relation to variations in space-time coordinates, i.e. variations in distances and intervals, without the need for any substantialization and ontological conjectures of various kinds. Said in other words, spatial and temporal coordinates could also be ways of ordering events by a class of observers. There would be an appreciable difference compared to the current picture characterized by the proliferation of unprovable and untestable, yet active and influential conjectures, including for example that according to which space, or even spacetime, are physical entities. Spatial distances and temporal intervals are data from the world of experience, but we are not at all, at least in the state of knowledge, legitimated to treat them as reality in themselves and to attribute certain properties to them (see also Cacciari on this point[46]) .

15) Human thought and creativity certainly cannot be imprisoned, they go wherever they want. No one will ever be able to stop us from questioning reality itself and from building hypotheses, conjectures and narratives about it. Physics obviously does not exaust human thought, which is expressed through the arts, poetry, narratives, religions, philosophy, the various sciences and so on. However, physics is an experimental science and theoretical physics must also have and maintain this character. The emergence of non-Galilean and anti-Galilean positions, even among some physicists, is worrying.
The *change of perspective* proposed above certainly does not mean renouncing theory, but only to free fundamental physics from epistemological assumptions and prejudices , that slow down and cage its development.

In conclusion, on many of the issues mentioned here, we can also, somewhat provocatively, ask a question: are we sure that the V Solvay Congress (1927), the central moment of the discussion between Einstein and Bohr, is really over? For what reason? Because Einstein's point of view, realism, and Bohr's point of view, phenomenalism, the first based on relativity and the continuum, the second on quantization and the discontinuous, both still present completely open problems.
In the meantime, it would probably be effective to overcome the epistemological impediments in fundamental physics.

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