What is the Main Reason that Physics and Theology Do Not Really Match? What Can Be Done to Amend that Situation?

Rudolf Larenz, Helsinki/Riga, 24.01.2020

(pro manuscripto)

Let me **anticipate**, right from the outset, the **answers** to the two questions in the title.

The first main point is that Physics and Christian Theology are moving in *opposite* **epistemological climates**, when they are speaking about the same common object. Here *both* terms are important: *opposite* – which is nothing special – and *epistemological climate* – which is very special. Epistemological questions are considered difficult and normally bypassed.

The second main point is that a possible amendment of that situation consists in trying to get a **control of the cognitive losses of Physics**.

Content:

I. Four lengthy preliminary reminders

1. The common object of Physics and Christian Theology: material things. A dialogue of two different domains of knowledge must refer to what is common to both, i.e. to a common object. **This can be determined most easily by exclusion: the common object demands from physics the restriction of not speaking of and not even making implicit reference to mathematics** (because Theology has no Mathematics at all)**, and from theology the restriction of not speaking of God and not even making implicit reference to God**. It is important to be very strict from the very outset. There are many discussions where theologians speak about creation, even though this does not belong to the common object. And in all discussions, physicists rely implicitly or explicitly on Mathematics when speaking about material things.

After this amputation on both sides one might **wonder whether there remains anything common**. We then can remember that Physics grew out of the old philosophy of nature, which in turn grew out of ordinary experience and langugage. And Christian revelation and theology rely on ordinary experience and language. This means that the common object of both Physics and Theology is precisely this: ordinary experience and language. Sometimes, this is called 'Common Sense' or, with a more philosophical touch, 'Natural Realism'.

'Natural Realism' refers to the way of thinking that can be found everywhere throughout **antiquity until the high Middle Ages**. Thereafter it is confined to the philosophical traditions which have maintained that way of thinking such as Aristotelians, Thomists, also a certain group of Phenomenologists, to mention the main currents. On the other hand, Rationalists and Empiricists, Kantians and most Analytic philosophers would group themselves more or less apart from Natural Realism.

At a first glance, all that might look as an **undeclared methodical naturalism**. However, that would be a sort of claim *a priori*, i.e. a claim *before* the effort to understand material things in the light of ordinary experience has come to an end. The claim cannot be made before an end has been unequivocally reached. However, one must take into account that modern natural science has found herself, after having answered one question, before ten new questions. And as the scientific exploration of things has started from what we know by ordinary experience, it seems likely that such ordinary experience contains more than some simple "brute facts". It is not excluded that it is due to that experience that the inquiry will never come to an end, however great the increase of knowledge may be.

Therefore, the following considerations are ***not* inscribed in a methodical naturalism**. Rather, the question of the reference to a Creator is *open*. It might be added that some philosophers speak of a 'natural theology' whose result is precisely the being created of material things and the existence of their Creator. But in the limits of the following considerations, we are not dealing with natural theology. Returning to our topic, we interpret the *quantiative proliferation of information*, scientific and other, as an authentic *growth of insight*. That in turn suggests to make the *intelligibility* of material things a central concept in our considerations. Altogether: material things are the common object, and their intelligibility is the common aspect to be investigated, not laws of nature, not their being created.

2. The historical development: The requirement of leaving Mathematics out of the relationship between Physics and Theology, seems to pose a considerable handicap to Physics, because Mathematics has an important role in Physics. Some analytic philosophers speak, in this context, even about the 'indispensability argument'. It is true that Physics grew out of philosophy of nature developed in antiquity, and that philosophy of nature dealt with individual material things. But then came the scientific revolution of the 16th and 17 th centuries, the greatest singular issue of which was precisely the **mathematization of physics**. Since then, the mathematization of Physics has grown, and nowadays Mathematics seems to have a dominant role. Yet, Physics continues dealing with individual material things and, thus, can hardly be identified with Mathematics.

Limiting oneself to ordinary experience as the common object seems to be tantamount of **going back to the times before the Scientific Revolution**. But that is not so clear when we take into account that

3. it is not known *why* Mathematics is successful in Physics. In fact, the lack of understanding the Mathematization of Physics has bothered many scientists and constitutes **a major and unsolved philosophical problem** until our days.. Let the following quotations speak for themselves:

First, Albert **Einstein**: The world of experience and the world of concepts are united in the same person, but experiences do not influence the shaping of concepts and vice versa.

Therefore it is possible that “all concepts, even those which are closest to experience, are from the point of logic freely chosen conventions, just as is the case with the concept of causality.”[1] And even more explicitly: “The theoretical attitude here advocated is distinct from that of Kant only by the fact that we do not conceive of the “categories” as unalterable …, but as … free conventions. They appear to be *a priori* only insofar as thinking without the positing of categories and of concepts in general would be as impossible as is breathing in a vacuum.”[2] Nevertheless, the hermetic separation of the two worlds coexists with their (ununderstandable) correlation: “The very fact that the totality of our sense experiences is such that by means of thinking (…) it can be put in order, this fact is one which leaves us in awe, but which we never shall understand. … The fact that it is comprehensible is a miracle.”[3]

The Einsteinian formula ‘incomprehensibility of the comprehensibility’ goes hand in hand with his view that the scientist’s epistemological attitude is divided into strongly opposed parts: “The scientist … must appear to the systematic epistemologist as a type of unscrupulous opportunist: he appears as a *realist* insofar as he seeks to describe a world independent of the acts of perception; as *idealist* insofar as he looks upon the concepts and theories as the free inventions of the human spirit (not logically derivable from what is empirically given); as *positivist* insofar as he considers his concepts and theories justified *only* to the extent to which they furnish a logical representation of relations among sensory experiences. He may even appear as *Platonist* or *Pythagorean* insofar as he considers the viewpoint of logical simplicity as an indispensable and effective tool of his research.” [4]

Second, Eugene P. **Wigner**: "The miracle of the appropriateness of the language of mathematics for the formulation of the laws of physics is a wonderful gift which we neither understand nor deserve.”[5]

Third, Richard P. **Feynman**: "I think, it is safe to say, that no one understands quantum mechanics. Do not keep saying to yourself, if you possibly can avoid it, "But how can it be like that?" because you will go "down the drain" into a blind alley from which nobody has yet escaped. Nobody can know how it can be like that".[6]

Fourth, Roger **Penrose**: "I should begin by expressing my general attitude to present day quantum theory, by which I mean standard, non-relativistic quantum mechanics. The theory has, indeed, two powerful bodies of fact in its favour, and only one thing against it. First, in its favour are all the marvellous agreements that the theory has had with every experimental result to date. Second, and to me almost as important, it is a theory of

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[1] Einstein, A. Autobiographical Notes, in Schilpp, P. A. (ed.) *Albert Einstein - Philosopher and Scientist*. La Salle (Illinois, USA): Open Court, 1949 (first edition), p. 13.

[2] Einstein, A. Remarks concerning the essays …., in Schilpp, P. A. (ed.) *Albert Einstein - Philosopher and Scientist*. La Salle (Illinois, USA): Open Court, 1949 (first edition), p. 674.

[3] Einstein, A. Physics and Reality. Philadelphia, Pennsylvania, U.S.: *Journal of The Franklin Institute*, 1936, 221,3, p. 351.

[4] Einstein, A. Remarks concerning the essays …., in Schilpp, P. A. (ed.) *Albert Einstein - Philosopher and Scientist*. La Salle (Illinois, USA): Open Court, 1949 (first edition), p. 684.

[5] Wigner, E. P. The Unreasonable Effectiveness of Mathematics in the Natural Sciences. *Communications in Pure and Applied Mathematics*, New York: John Wiley & Sons, Inc., 1960, vol. 13, No.1, last paragraph. Also accessible on-line, for instance, at www.dartmouth.edu/~matc/MathDrama/reading/Wigner.html. Wigner is a major figure in the development of quantum theory during the 30’s, 40’s and 50’s of the 20th century.

[6] Feynman, R.P., *The Character of Physical Law*, Cambridge, MA: MIT Press, 1967, p. 129. Feynman is a major figure in the development of quantum theory during the 40’s, 50’s and 60’s of the 20th century.

astonishing and profound mathematical beauty. The one thing that can be said against it is that it makes absolutely no sense!"[7]

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These quotations represent the general view. They all reflect that, since several centuries, physics is built upon *two* different bodies of knowledge, namely experience and mathematics. While it is *unknown* why and how mathematics is connected to material things, there is a huge body of experience of the true *success* of mathematical physics in the whole range between elementary particles and cosmological objects. This allows the statement that these two bodies of knowledge are *somehow interlocked*. In other words, physics has been transformed from a purely theoretical science aimed at the knowledge of truth, into a practical science not unsimilar to engineering.

This situation may give a hint to where to focus our attention. In order to corroborate this, consider the following fictitious conversation about the importance of modern physics for mankind, between a physicist and an interested non-physicist. At a given moment, the physicist stresses the capacity of physics for predicting future events or looking into the past in virtue of mathematical laws of nature. Then the non-physicist asks him:

- What are you speaking about? About mathematical theories or about *this* material world? *What* is the connection between mathematical theories and the material world? And, still more important: *Where* is the connection between mathematical theories and the material world? What can be seen from outside is only that physicists *apply* certain mathematical theories to material things. That means that there is made a connection between both mathematics and the *experienced* material world, in the physicist. But it remains unclear, whether there is a connection between mathematics and the material world *itself*. As you know, Einstein insisted many times that physical concepts are pure invention, because they have no relationship whatsoever with sense experience (He admired Kant, who said practically the same.). Therefore, he stated equally often, that it is a “miracle” that our theories are so successful.
- Let me answer to your initial question: *of course, I am speaking about this material world*.
- But on what grounds can you do that? If you join the stance of Kant, with Einstein and others, you cannot maintain that you are speaking about this world while using mathematical terms. On the other hand, if you think that physical concepts have to do with material things that we perceive, you have changed sides and passed, so to speak, from Kant to Aristotle.
- To be honest, I cannot tell on what grounds I have said ‘about this material world’, because I’m not sure. I feel myself inclined to a mixture of both extremes, to something like Hawking’s stance who said: "There is no picture- or theory-independent concept of reality. Instead we adopt a view that we call *model*-dependent realism: the idea that a physical theory or world picture is a *model* (generally of a mathematical nature) and a set of rules that connect the elements of the *model* to observations …” and “Your reality depends on the *model* you employ”. (*Italics* are mine)
- But that is not satisfactory. Natural scientists are inclined to admit a world, which has its properties independently of whether they are investigated or known. Of course, here is a problem as to what is meant by ‘properties’. Leaving that question aside, one feels uncomfortable with the idea that there are only different models, which correspond to different realities. Isn’t there a way to jump out this prison called ‘model’ or ‘models’?
- Perhaps; who knows? But allow me one question: are you aiming at eliminating the models altogether and thus renounce of predictions and technology?! You cannot possibly throw out the window something that has proven to be *successful*!

[7] Penrose, R. Gravity and State Vector Reduction, in: R.Penrose and C.J.Isham (eds.), *Quantum Concepts in Space and Time*; Oxford: Clarendon Press, 1986, p. 129. Penrose is a major figure in the development of mathematical tools in quantum and relativity theory during the 70’s and 80’s of the 20th century.

- No, I don't want to throw anything out. But I would like to know *why the models are successful. The natural claim is that the models root, in one way or other, in the material things they describe. But to claim that is one thing and to prove that claim, is another.*
- Ok, but is it your goal to prove that claim, if you are not going to dismiss the models?
- Yes, exactly. I feel it necessary to go beyond making statements that an experiment has confirmed a hypothesis to a certain degree of precision, or has failed to confirm such hypothesis. In other words, my goal is to investigate in depth the relationship between model and the reality the model pretends to picture. Don't you think that physics would become better if we knew the answer to that question? Wouldn't it be a good combination to keep, on the one hand, physics as it has developed until today and, on the other hand, *know what physicists are really doing when using models*?
- It seems to be a difficult question. But why care about it at all, as long as Physics continues being so successful? Wouldn't we loose the competitivity of our civilization, if we – a number of people with an adequate academic preparation for that purpose - invest an uncertain amount of time in order to try to reshape Physics, without having a clear idea of what would be the outcome?

  Additionally, wouldn't that mean to radically change the basic mindset? Wouldn't it be in opposition to contemporary mainstream positions in epistemology and philosophy of mathematics and philosophy of physics? And which method should be followed in such investigation? What would be its starting point? No, no, there are too many risks.
- This answer seems to move on a predominantly practical level. Therefore, I cannot but challenge your speaking about the success of mathematical theories in Physics. What, in rigor, *is* success? To the date, the success never has been absolute, with *total precision*, but only with relative precision. And it is only in a certain domain, say low energies, high energies, and so on. Doubtlessly, this is already very much. But we are faced here with a serious option: do we want to proceed, in tackling this problem, in the *spirit of engineers* or in the *spirit of philosophers?*

  Engineers aim at efficient technology and push the precision ahead as far as they need it, and neglect the question why on earth does relative precision exist at all. On the other hand, philosophers do not neglect but rather focus, for instance, on the question of what precision is and why on earth it is only relative. For engineering, a working model is sufficient. But for philosophy, any simplification or abstraction from things because they are considered as irrelevant, can be fatal. In other words: it seems that one cannot avoid making a basic option: either engineer or philosopher.

4. A basic decision has to be made: either more engineering or more philosophizing; Highly influential in shaping a science is the contrast between practical goals and theoretical insight. Experience shows that one does not need Quantum Theory in order to construct a bridge, or General Relativity for jedging a 100m –race. There is a difference between success and understanding, between neglecting "dirt effects" and trying to understand why there are such realities called "dirt effects" by engineers. Into the same context should be grouped abstractions and simplifications. In order to achieve a practical goal, respecting deadlines, costs and safety, abstractions and simplifications are fully justified. But this ordinarily goes at the expenses of understanding the natural processes one is dealing with.

One argument to discard "dirt effects" consists in claiming that "experience has shown that this and that phenomenon is just a "dirt effect"". That is not quite true, because in most cases, if not in all, no experience is available of situations where this and that phenomenon is absent. For instance, gravitation is considered very small in comparison with the electroweak "force", let alone in comparison with the strong subatomic force. But gravitation cannot be eliminated, so that the "gravitationfree" experience does not exist. The case of mechanical friction that makes movements diminish xxxxxxxx

An equivalent wording to 'more engineering or more philosophizing' is given by the concepts of *success* and *truth*. Success is limited and gradual, whereas truth is

bivalent, i.e. not gradual. That is to say that **success and truth never are identical**. Nevertheless, **success is true**. It is this double-sided relationship between success and truth, that makes that Physics needs some non-practical understanding of ist practical side – so to speak, a philosophy of experiment, in particular measurement -, while the truth of success makes it reasonable to expect that such an understanding exists – success and truth are not categories completely alien to each other.

But if one is not satisfied with that situation that success and truth co-exist, i.e. without understanding the foundation of their coexisting, one feels the need of a philosophical answer to the question what an experiment and, more specifically, a measurement *is.*

The solution of this problem consists, in general lines, in a *certain foundation* of mathematical structures on the material things they are thought to refer to. The other direction would be an *interpretation* of physico-mathematical theories by their material instances. As is well known, everybody speaks about interpretations of theories. They start always from such physico-mathematical theories and pretend to arrive at this real world. Conversely, a foundation departs from this real world and arrives either at physico-mathematical theories or at a certain frame of them, which controls the losses. Both approaches have to cope with the difference between the individual and the abstract. **But meanwhile a theory does not contain individual elements, the question remains to be examined whether individual material things contain abstract or non-individual elements.**

II. Reductionisms and models in Physics and their epistemological climate

IIa. Reductionisms

Mainly during the Scientific Revolution, experiments have come to occupy their systematic place in Physics they have continued keeping until our days. In order to not lose ourselves in historical considerations, we give here just a list of the measures taken by physicists in order to make individual material things and their changes and abstract mathematical theories fitting to each other. Let us put emphasis, above all, on the contrast between the *unsubstitutably individual* and *abstract-non individual*, that has to be "bridged" by the physicist. It is clear that this cannot be achieved by material devices, but has to be done by the experimenter's mind. This is to say that the experimenter is an indispensable part of a physico-mathematical theory, which is an insight that is quite often overlooked.

In order to pinpoint the difficulties linked to the contrast individual-non individual, the Schrödinger cat-paradox is a good instance. …

After this warning, we present the promised list of measures taken by the experimenter:

(i) *The experimenter chooses* two material things. By doing so, he *gives* them a preferential position with respect to the rest of the world. At the same time, he *assigns* them the functions 'object' and 'experimental apparatus' in an experiment to be carried out by him. In doing so, he chooses between two alternatives by *determining* which of the two sides should be considered the object and which the apparatus. The two possible attributions of 'object/apparatus' to the two sides exclude each other, *in the same experimental process. Neither the categories 'object' and 'apparatus' nor the subsequent choice of one of the two alternatives have a foundation in nature. They have their exclusive roots in the interests of the experimenter-investigator*;

(ii) *The experimenter puts spatial limits* to experiments, even though their real connection with the rest of the world continues unaltered. But that real connection gets lost in the theory;

(iii) *The experimenter stops* his intervention by his own initiative. Only this makes possible a result, though at the expenses of separating it from the "ongoing flow of nature";

(iv) *The experimenter* mentally isolates part of the experiment from the whole, i.e. the *result*, by abstracting from the process the termination of which brings about that result. Exceptions are instantaneous processes (particle decays and -reactions), because there the process is identical with its result;

(v) *The experimenter* almost entirely *abstracts from* the apparatus after having used it by attributing the result to the object *only* instead of equally to both sides. This has no foundation in nature, but exclusively in the experimenter-investigator's interests;

(vi) *The experimenter weakens* the relevance of the observations concomitant to the experiment and often replaces experiences by results of experiments (e.g., the colours seen by wave lengths measured). Through the concomitant observations, it is known that the reductionisms (i) – (v) are precisely this: *reductionisms*.

None of the experimenter's six interventions corresponds to anything in nature. The results of investigation obtained under such conditions do not refer to the true nature, but rather to its reductionist picture. The reductionist picture is successful, but not true. Rather they contain a lack of truth. At first sight, the six interventions seem to *add* something to the true picture of nature. But in reality, all these interventions take away reality and thus cause *losses* in the knowledge of the full material reality.

IIb. Models

After having established a bridge to mathematical structures by means of the above reductionisms, the work of the theoretical physicist consists in making out of such mathematical structures a physico-mathematical theory. The main guideline for this task is the *correspondence* between theory and experiment. Secondary guidelines deal with the extension of what is called 'validity' of the theory, conceptual economy, mathematical beauty and similar issues.

The mind of model-making is beautifully expressed in a text by Heinrich Hertz, who could even be called the father of the concept 'model':

> "The most direct, and in a sense the most important, problem which our conscious knowledge of nature should enable us to solve is the anticipation of future events, so that we may arrange our present affairs in accordance with such anticipation. … In endeavouring thus to draw inferences as to the future from the past, we always adopt the following process. We form for ourselves images [*innere Scheinbilder*] or symbols of external objects; and *the form which we give them is such that*
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> - now comes the first key passage -
>
> *the necessary consequents of the images in thought are always the images of the necessary consequents in nature of the things pictured*." [8] (italics are mine)

Here we have clearly expressed the motivation for making models: to *predict* events or processes. And to predict not just in order to *know*, but in order to be able to *act now* in prevision of what is going to happen *later*. It is this what makes possible machines,

[8] Hertz, Heinrich. *The Principles of Mechanics Presented in a New Form.* London. McMillan, *1899,* p.1.

because if future events can be controlled by making suitable arrangements in the present moment, you can let the process doing its work "alone", because you already know the result. After having introduced the notion of model, he goes on mentioning some of there properties, among others the following:

> "… The images which we here speak of are our conceptions of things. With the things themselves they are in conformity in *one* important respect, namely, in satisfying the above-mentioned, requirement. For our purpose it is not necessary that they should be in conformity with the things in any other respect whatever. As a matter of fact, we do not know, nor have we any means of knowing, whether our conceptions of things are in conformity with them in any other than this *one* fundamental respect. …
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> - And here comes the second key passage -
>
> The images which we may form of things are *not determined without ambiguity* by the requirement that the consequents of the images must be the images of the consequents." (Italics are mine)[9]

Altogether, physical models are considered to be not uniquely determined by the material reality they are supposed to picture. Therefore, they also reflect the genius of the model maker and not only the reality of the material things involved. The model of a process is *successful* in the sense that it predicts the development of that process.

Even though Hertz does not mention it, the experimental practice shows *without exception* that prediction is possible only up to a *relative* precision. This relative precision can be good, high or even excellent. 'Relatively precise' can mean 'exact with a margin of 2% deviation', or of 0,2% deviation, or of 0,02% deviation – but of a deviation anyway. Relative precision can vary over a range and, thus, is not identical with truth. *A model's success might be true, but that does not mean that the model is true. The reason is that it does not make sense to say that a model is 'more or less true' or 'true within certain margins'.*

The bifurcation between truth and success (allowing for little deviations) makes that understanding a model is not the same as understanding the corresponding natural things. It is not possible to substitute success for truth or vice versa. Instead of one criterion for judging a discourse in Physics, one has now two criteria ***which never coincide****. Because of that gap, the epistemological climate of Physics becomes "foggy" or even dark. It can only be brightened up when one achieves an understanding of the link between natural things and the pertinent model that goes beyond the category of success.*

To the "darkening of the epistemological climate" of physics exists another contribution stemming from abstractions, idealizations and simplifications. They are very often carried out in order to make the models manageable in a practical way. It is the stated intention to leave the "main effect" untouched, the latter being judged according to the rules of art, from the perspective of existing models. Of course, this does not change the reality experienced, but only the model from the physicist's side. In other words, the reality is *independent* of the model. Nevertheless, the abstractions, idealizations and simplifications make that the full reality must be described with fewer elements. The incompleteness emerging here may then be bridged by hypotheses. Precisely this is the additional darkening of the epistemological climate.

In addition to the needs of Physics comes the historical philosophical climate. The idea of making models is not only supported by the desire of being able to arrange our

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[9] Hertz, Heinrich. *The Principles of Mechanics Presented in a New Form.* London. McMillan, *1899*, p. 2.

present affairs in accordance with a model that predicts the consequences of present actions. The philosophical tradition shaped by **Immanuel Kant (1724-1804)**, in particular its epistemological aspects, is very likely to have supported the making of models, because it claims that knowledge of natural things stems, by and large, from man himself. In order to substantiate that, we need only recall some key quotations from Kant's *Critique of pure reason*: "Although all our knowledge begins *with* experience, that doesn't mean that it all comes *from* experience."[10] For "[t]he order and regularity in appearances, which we call Nature, are put there by ourselves. We could never find them in appearances if it weren't that we, or the nature of our mind, had first put them there."[11]

And a little bit later, another reference to the *copernican turn*: "Even though it might seem counterintuitive, the understanding isn't a mere power of formulating rules through comparison of appearances; it is itself the lawgiver of Nature. It's only through the understanding that Nature exists at all! …. Nature is the synthetic unity of the manifold of appearances according to rules. And appearances can't exist outside us—they exist only in our sensibility. Thus, Nature … is possible only in the unity of self-awareness."[12]

In fact, it is known from Hertz's diaries that he was an avid reader of Kant's writings. The same is true with respect to Einstein. Therefore, it is likely that their views in Physics were influenced by Kant's thinking. It is not surprising, then, that the epistemological climate in Physics in general has become increasingly Kantian. This leads to a sort of exchange of roles: *it is not any more the real world only that determines the properties of the model, but it is the model that increasingly determines what the real material world should be like. The genius of the model maker becomes more and more important.*

This change is reflected in the concept of 'theory-ladenness of experience' which, in our context, can be characterized by saying that the experiences or observations are affected by the theories held by the observer or experimenter. This idea – although not the word - is contained in the following text, written by **Karl Popper (1902-1994)** in 1935:

> "Even the careful and sober testing of our ideas by experience is in its turn inspired by ideas: experiment is planned action in which every step is guided by theory. We do not stumble upon our experiences, nor do we let them flow over us like a stream. Rather, we have to be active: we have to 'make' our experiences. It is we who always formulate the questions to be put to nature; it is we who try again and again to put these questions so as to elicit a clear-cut 'yes' or 'no' (for nature does not give an answer unless pressed for it). And in the end, it is again we who give the answer, it is we ourselves who, after severe scrutiny, decide upon the answer to the question we put to nature"[13].

A contemporary voice confirms that the idea of theory-ladenness of experiences continues being influential. The following passages stem from **Stephen Hawking (1942-2018)** and represent, by and large, the mindset of the overwhelming majority of physicists. The two first paragraphs show, how models might carry the model maker from the observed "real reality" away to a theory-shaped reality, i.e. to theory-laden observations. The last sentence shows that it is only a small step from the theory-ladenness of observations to the theory-createdness of observations:

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[10] I. K a n t . *Critique of pure Reason* (2. edition, 1787), www.earlymoderntexts.com/assets/pdfs/kant1781part1.pdf, margin number 1.

[11] I. K a n t . *Critique of pure Reason* (first edition, 1781), www.earlymoderntexts.com/assets/pdfs/kant1781part1.pdf, marginal number A125.

[12] I. K a n t . *Critique of pure Reason* (first edition, 1781), www.earlymoderntexts.com/assets/pdfs/kant1781part1.pdf, marginal number A127.

[13] Popper, Karl R. The Logic of Scientific Discovery, p. 280. Hutchinson & Co. [1]1959, Routledge (Routledge Classics), London [3]2002.

"There is no picture- or theory-independent concept of reality. Instead we adopt a view that we call model-dependent realism: the idea that a physical theory or world picture is a model (generally of a mathematical nature) and a set of rules that connect the elements of the model to observations ..." [14]

"According to the idea of model-dependent realism … our brains interpret the input from our sensory organs by making a model of the outside world. We form mental concepts of our home, trees, other people, the electricity that flows from wall sockets, atoms, molecules, and other universes. These mental concepts are the only reality we can know. There is no model-independent test of reality. It follows that a well-constructed model creates a reality of its own." [15]

"Your reality depends on the model you employ" [16]

Now, if models were only meant to construct machines or bring about other products of *engineering*, the ranking of success before mere knowledge would be perfectly legitimate. It is really astonishing how successful this method work, even after all the severe interventions of the physicist, which we have pinpointed so far with the concepts of *reductionism* and *model*. Accordingly, if the models are claimed to tell *how things really* are, then it is obvious that the question is not about engineering, but about *man's relationship to reality at all*. And this is a *philosophical* stance. Therefore, it is necessary to sharply distinguish between the point of view of engineering, on the one hand, and of philosophy, on the other.

As a matter of fact, the dominating mindset among physicists and in society in general is inclining to *conflate* or mix the engineering stance with the philosophical one and say: Because a model is *successful*, it must *be true*. This opinion is not limited to professional physicists, but spreads through school education and the many programmes for the popularization of science to all members of society. *However, such a mindset has little to do with Common Sense.*

The way of doing Physics is almost fully determined by the *reductionisms* and by the fact that Physics deals more with *models* of reality than with reality itself. Both together yield the following characterization of the epistemological climate:

(i) Physics is not aiming at *truth*, but at *success*. Nevertheless, *the success is a true one*.

(ii) In order to achieve that success, Physics does not focus on *real* material things, but fabricates *abstract models* of those material things. Such models are not uniquely determined and, thus, more or less *hypothetical*. Additionally, these models abstract from the major part of reality in order to investigate the remains. Furthermore, they use to make major simplifications. These abstractions and simplifications are *losses* for the pretended knowledge of material realities, i.e. they make impossible to achieve a full knowledge of what material things are and why and how they behave as they do. In other words, they are *reductionisms*.

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[14] Hawking, Stephen; Mlodinow, Leonid, *The Grand Design – A New Explanation of the Universe*, New York, Bantam Books, 2010. p. 42.

[15] Hawking, Stephen; Mlodinow, Leonid, *The Grand Design – A New Explanation of the Universe*, New York, Bantam Books, 2010. p. 172.

[16] Hawking, Stephen; Mlodinow, Leonid, *The Grand Design – A New Explanation of the Universe*, New York, Bantam Books, 2010. p. 175.

(iii) The hypothetical character of those models as well as their lack of correspondence to the material reality *prepares the way for an ever increasing skepticism*. despite of the sharp rationality of Mathematics, the use of which in Physics is ever increasing.

III. The epistemological climate in Christian revelation

Embedded in ordinary language. Christian revelation and, thus, Christian Theology focuses on God and on man and the world insofar they are related to God. This is a conclusion based on the biblical text. The Bible contains notions such as *Creator*, *God*, *create*, *image* (Gen 1:26.27) together with the greatest commandment of *loving God above all things* (Dt 6:5; Mt 22:38-40), *Soul*, *Angel*, *Bread of life*, *living Bread*, *Holy Spirit*, *Father*, and many others. They are not isolated pieces like a foreign body in a living organism, but semantically and inseparably interwoven with the surrounding text made of every-day's language. Even much more: on every page, the mystery of God shines through in an unspeakable way. Furthermore, there is an analogical meaning of material things for the Kingdom of Heaven (for instance the pearl, the treasure, etc., cf. Mt 13) as well as, for instance, the sacramental meaning of water in Baptism. The Bible in general and Jesus in particular use common language which carries also implicitly the view this language refers to *things*. Altogether, there exists a most intimate co-presence of ordinary language and reality and biblical-theological language and reality. One might say that the use of human means of communication is a sort of "natural" way God has chosen to *reveal* himself.

Another important point must be stressed: the God of Christian revelation is the God of truth and, thus, of intrinsic intelligibility. The Old Testament precedes God's self-revelation through His Son (Hebr 1:2), and the New Testament follows this self-revelation, which was already prepared in the Old Testament (cf. Lk 24:27; Jo 5:39). Furthermore, the Son indicates as reason for that He calls the apostles 'friends' that He *has made them know all* that He has heard from His Father (cf. Jo 15:15; Mt 11:25). And the Son promises the assistance of the Holy Spirit, the Spirit of truth, who *will bring to their remembrance all that He has said to them* (cf. Jo 14:17; 15:26.27; Jo 16:13). **The triune God is the God of truth, communication and transparence.**

On the other hand, ordinary language carries the insight that **natural things possess an intrinsic intelligibility**. This insight is an essential characteristic of a philosophical stance that also has led to its name 'Natural Realism'. Therefore, Natural Realism extends to any other sort of (purely human) knowledge and cannot be left behind in order to step over, for instance, to an artificial language and a purely immanent representation of what the subject conceives as real. Taking into account that God uses ordinary human language in order to convey His revelation, it follows that *Christian Theology and Natural Realism are intimately related with each other. Both cannot be separated from each other*.

Notice that the **intelligibility first belongs to the objects** of the domain of knowledge in question. However, as the term 'intelligibility' refers also to the mind that "hosts" the knowledge in question, the notion of intelligibility refers inseparably to both object and subject of knowledge. Here, the object has a logical priority: the mind can have an insight into the object, because the object is intelligible. All these are insights of Natural Realism.

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Before going on, three pertinent statements of the Magisterium of the Catholic Church might be quoted for supporting the view of the relationship between Christian revelation

and Natural Realism just proposed. The first statement stems from the Encyclical *Fides et ratio* (FR, 1998) by Pope John Paul II. In the final part of this document, the Pope encourages scientists, to do their science within a "*sapiential horizon"* (FR 106,2). While it is not made explicit in that passage, what precisely this sapiential horizon is, it is clear that natural sciences are situated *within such a horizon*, which excludes the alternative that *natural sciences* themselves *constitute* such a sapiential horizon.

Now, the text of *Fides et ratio* as a whole presents a positive view of the human capacity of insight, which means above all other things a metaphysical knowledge, and a metaphysics of being. It is worthwile noting that *Fides et ratio* uses the term 'metaphysics of being' and its equivalents 23 times[17]. This is why scholars have qualified this Encyclical as the first document of the Magisterium that does not only recommend that philosophers and theologians draw their leading ideas from a realist philosophy (and theology) in general and that of Thomas Aquinas in particular but, specifically, by a realist *metaphysics*[18]. Therefore, it can be concluded that Natural Realism is the main piece of the sapiential horizon mentioned in FR 106,2. In other words, it is Natural Realism that should be the philosophical frame for the natural sciences. As we have seen, at present it is not.

The second magisterial statement consists of three passages taken from the address of Pope John Paul II on 23.4.1993, shortly after the publication, by the Pontifical Biblical Commission, of the document *The Interpretation of the Bible in the Church*. One of the main ideas of the address is the "harmony between Catholic exegesis and the Mystery of Incarnation" (section 2). Among the passages relevant for the relationship between Theology and Natural Realism are, above all, the following three. In these passages, the expression 'human language' should be understood as parallel to 'Natural Realism':

> "The God of the Bible is not an absolute Being who, crushing everything he touches, would suppress all differences and all nuances. On the contrary, he is God the Creator, who created the astonishing variety of beings "each according to its kind", as the Genesis account says repeatedly (Gen 1). Far from destroying differences, God respects them and makes use of them (cf. 1 Cor 12:18.24.28). Although he expresses himself in human language he does not give each expression a uniform value, but uses its possible nuances with extreme flexibility and likewise respects its limitations. … None of the human aspects of language can be neglected." (no. 8)

and. on the other hand:

> "The Sacred Books cannot be likened to ordinary writings, but, since they have been dictated by the Holy Spirit himself and have extremely serious contents, mysterious and difficult in many respects, we always need, in order to understand and explain them, the coming of the same Holy Spirit, that is, his light and grace, which must certainly be sought in humble prayer and preserved by a life of holiness". (no. 9)[19]

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[17] Knasas, John F.X., *"Fides et Ratio" and the Twentieth Century Thomistic Revival*. in: New Blackfriars, Vol. 81, No. 955 (September 2000), pp. 400-408. see also: John Knasas on Thomist Metaphysics: Past, Present and Future, https://www.innerexplorations.com/philtext/john.htm.

[18] *Fides et ratio* contains more specifications so that one can say that *The Church Does Have a Philosophy of Her Own*, as a scholar (Alan Vincelette) puts it as a title of an article with the subtitle "Ruminations on Fides et Ratio and the First Principles of Catholic Philosophy". Bogoslovni Vestnik (Theological Quarterly) 73 (2013) 1, 17-46 (Faculty of Theology of the University of Ljubljana, Slovenia). The author mentions twelve first principles, in particular 1. *Foundational Empirism* (Experience is the foundation of philosophical knowledge), 3. *Epistemological Realism* (Correspondence Theory of the Truth) and 7. *Natural Theology* (Metaphysics is Prior to Science).

[19] Address of His Holiness John Paul II on the Interpretation of the Bible in the Church, on April 23rd 1993, con occasion of the publication (15.4.1993), by the Pontifical Biblical Commission, of the Document *The Interpretation of the Bible in the Church.*

These statements acquire their full weight by the parallelism between that the Son of God has become man, on the one hand, and that God's revelation is expressed in human language, on the other. This is how John Paul II puts it in the same address (no. 6):

> "The strict relationship uniting the inspired biblical texts with the mystery of the incarnation was expressed by the Encyclical *Divino afflante Spiritu* in the following terms: "Just as the substantial Word of God became like man in every respect except sin, so too the words of God, expressed in human languages, became like human language in every respect except error" (EB, 559). Repeated almost literally by the Conciliar Constitution *Dei Verbum* (13), this statement sheds light on a parallelism rich in meaning."

The third statement is more specifically Catholic, for it concerns the assertion that a natural theology is possible. The formulation of the First Vatican Council's Dogmatic Constitution *Dei Filius* is short: "The … Church holds and teaches that God, the beginning and end of all things, can be known with certitude by the natural light of human reason from created things, "for the invisible things of him, from the creation of the world, are clearly seen, being understood by the things that are made" (Rom 1:20)."[20]. This sober assertion can be circumscribed in a somewhat narrative manner by saying that Christian Revelation gives to understand that it is *possible* that a healthy person, who has got normally developed cognitive capacities, but lacks even the faintest idea about Christianity, is able to come, by his or her own intellectual resources, to the following insight: it is adequate to shape a proper *concept* for expressing the innermost state of the things of this world. If that person would encounter later the real Christianity, it would become clear to him or her that that *new concept* is equivalent to 'creation' or 'create', and that the inference to the existence of a Creator is true. It must be specified that the Church does *not* say that the possibility *has* or *will* become reality. It is rather a statement about the harmony between our world's being created and its intrinsic intelligibility, on the one hand, and the human mind's cognitive capacities, on the other.

Most probably, theologians like Karl Barth would denie the possibility of such a natural theology. We need not go into details here, because we are *not* concerned with natural theology. But the Catholic position somehow supports what has been said so far about the *should be*-relationship between Christian Theology, Natural Realism and Physics. Such a corroboration goes like this: the possibility of a natural theology allows the conclusion that the laws of nature are not necessarily a product of the model maker's genius, but might well stem from just those material things the behaviour of which they describe. This does not exclude a *contribution* of the model maker's genius, but it is not the essential part.

It is as if Christian revelation said: "it is almost "forbidden" to use the Bible as a source of scientific information. While the Christian revelation has very little to offer with respect to the particularities of the laws of nature, it has very much to offer with respect to the intelligibility of the things of this world and the human mind's cognitive capacities. It is as if Christian revelation gave to understand: "*scientists, trust your eyes and your mind! Through them you are in contact with reality!*" It encourages somehow to not ultimately rely on reductionisms, but to trust that the full material reality will disclose itself to the human mind. This corroborates a mindset that tries to assimilate that reality, rather than to intervene by introducing reductionisms. Others than Christians do not know that, and they more easily assimilate less critically the intellectual climate which they are born into.

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[20] cf. 1st Vatican Council, Dogmatic Constitution *Dei Filius*, Chapter 2 (De Revelatione). Cf. DH 3004.

IV. Intermediate conclusion: opposition of the epistemological climates

Taking both sections II and III together, one can say that: **First,** present day Physics essentially relies on models for prediction, at the cost of making severe reductionisms. Models and reductionisms are bound together by the requirement of successful prediction. However, the reductionisms heavily reduce the intelligibility of the material processes investigated. Low intelligibility in terms of a reductionist terminology leads physicists, on the long run, to a deep skepticism, which is not eliminated by the sharp and clear rationality of Mathematics. Rather, the latter covers up the former. **Second,** Christian theology supports ordinary experience and language - i.e. the raw material of philosophical natural realism - by asserting material things their intelligibility and to the human mind a capacity of insight. **The "intellectual climates" of physics, on the one hand, and of Natural Realism and Catholic Theology, on the other, do not match.** This situation is not satisfactory, and it is therefore convenient to react.

Stress on intelligibility as the main point of opposition. Here we have reached a somehow satisfactory answer to the first initial question, namely *What is the main reason for that Physics and Theology do not really match?* Unfortunately, public discussion completely ignores the important link between the *object of knowledge (such as planets, atoms, water, protons etc.)*, on the one hand, and its *intelligibility* (*something between completely transparent/intelligible and completely ununderstandable*), on the other. Instead, public discussion very often focusses on *particular* questions such as the age of the Universe, the beginning and development of the Universe, the age and development of the Earth and the historicity of the Flood. Another frequent topic in this context is Fine tuning. *But the central rôle of the intelligibility of material things suggests that the public discussion of the relationship between Physics and Theology should be re-orientated such that the philosophical concept of intelligibility occupies its due place.* Therefore, the second question of how to amend the situation shall be dealt with in the light of intelligibility.

V. Thoughts about how to avoid the opposition: the idea of *control*

At this point we might conveniently remember what has been said about the common object of both Physics and Theology resp. Christian revelation: both are confined, in order to establish a dialogue, to ordinary experience and language. We have already argued that that is not an undeclared methodical naturalism, i.e. a stance which excludes methodically the idea of God and, in particular, a Creator. It must be added, that this stance does not exclude either the idea of mathematical laws of nature. **Rather it leaves both questions – God and mathematical laws of nature – *open*.** It cannot be excluded that, by continuing to reflect upon what one already knows by ordinary experience, one would find reasonings that lead into the neighbourhood of the concept of a Creator-God, on the one hand, and on the other, into the neighbourhood of abstract laws of nature. The first way is linked to what is commonly called 'natural theology', the second has not yet received a proper name. **In this talk, I will follow that second way.**

At first sight, one might feel nostalgy for the sharp rationality of Mathematics, which is essential in formulating the laws of nature and which exhibit so much coherence and universality. With the same strength, but in opposite direction, one might feel repelled by what one expects from natural realism: unexact and flighty statements about our material world. In fact, such statements would be absolutely

unable to achieve a technology our civilization is so proud of. It seems that *windmills* and *horse-carriages* are the top one can expect from our ordinary understanding.

But no other way seems to show up. This **is an additional motive to ernestly explore what Natural Realism really can yield, irrespective of what it is commonly believed to yield.** Moreover, as Mathematics does not belong to the common object of Physics and Theology, there is no reason any more to maintain the reductionisms. In fact, dismissing the reductionisms is a necessary step towards an authentic dialogue. Because a theologian may state that otherwise there is no common object of dialogue, given that theologians do not perform any reductionisms. **This means nothing less than that, in order to be suited for an authentic dialogue with Theology, Physics needs, at least, to be enriched with a sort of frame where the reductionisms are absent from the very outset.**

In order to determine more properly **which sort of frame** is reasonable, it should be taken into account, that the success of Physics is a true success, not a fictitious one. Therefore, it would be **unreasonable to simply dismiss Physics** as a whole. Conversely, it is not unreasonable that Physics continues in the same way as it has done to the date. The other extreme position would be that the attempt to **derive somehow the known successful laws of nature from ordinary experience**, within the mindset of Natural Realism. But that **is not only unreasonable, but impossible**, because the laws of nature have incorporated the reductionisms, and Natural Realism does not consent to perform these reductionisms.

Yet, the difference between success and truth should be filled with something. This leads to the attempt of looking as carefully as possible at the treasure of ordinary experience. One reason to do so is the seemingly unlimited growth of knowledge, which according to the mindset of Natural Realism is ultimately rooted in the material things, object of our ordinary experience. Knowledge and its growth is not rooted, or only rooted in a secondary way, in the physicist's genius. So we are left with the expectation that it might be possible to derive something from ordinary experience. This something would be independent from reductionisms and could, in the best of cases, be a sort of **control of what has been achieved *under* the reductionisms. The word 'control' is appropriate, because current physical models are obtained by reductionisms, and yet pretend to describe the full material reality, while a control is obtained from the full reality and gives a picture of the full reality.**

These considerations stress again that it is important to ask what are the expectations of really coming, from Natural Realism, into the neighbourhood of mathematical laws of nature. To my mind, there is no *a priori* reason that provides certainty about that, let alone gives an idea of how far one would come on this way of thinking. There is no choice but trying to do and, most probably, to endure some thurst periods. Let me just note in passing by that Christianity backs powerfully up an attitude in virtue of which somebody tries to deal with that topic over and again, with a sort of moral certainty that he will eventually get something out of it. Let me outline, supported by this idea, some general features of ordinary experience or, in other words, of Natural Realism.

First distinctions. Historical representatives of Natural Realism are Aristotle, Thomas Aquinas, and their disciples through the centuries. One should leave aside, however, those who call themselves either transcendental or analytical Aristotelians and Thomists. The reason is, to my mind that, on the one hand, transcendental philosophers like Kant have made a "critical turn" *away* from natural Realism. On the other hand, analytical

philosophers have made what they call a “linguistic turn” which, by and large, passes by sense experience without ruling it out by seeing thought and language in a tight parallel: ”The basic tenet of analytical philosophy, common to such disparate philosophers as Schlick, early and late Wittgenstein, Carnap, Ryle, Ayer, Austin, Quine and Davidson, may be expressed as being that the philosophy of thought is to be equated with the philosophy of language; more exactly: (i) an account of language does not presuppose an account of thought, (ii) an account of language yields an account of thought, and (iii) there is no other adequate means by which an account of thought may be given.”[21]

Natural Realism cannot be fully systematized. It is important to note that Natural Realism is more comprehensive than any particular consistently formulated building of metaphysical thought, like what we encounter in Aristotle’s thought of the *metaphysical categories* of substance and accidents, and the principles of *act* and *potency* that are “operative”, for instance, in the hylomorphic structure of material things. Or what we encounter in the thought of Thomas Aquinas, who formulated a sort of synthesis of the Aristotelian metaphysical view with the notion of *participation* inspired by Plato.

Natural Realism can never be completely left. There are many philosophers, who follow, to one degree or another, the spirit of Natural Realism. Perhaps the most important reason for this is that a person normally is brought up in the mindset of Natural Realism without his parents need to make any decision to do so. That is to say that Natural Realism is not just one philosophical position besides others that can be chosen from a philosophical no mans land. It has a *priority*, not only in a temporal sense, but also in the sense of being present in any philosophical position. Even if somebody turns away from this connatural intellectual stance, *her or she must decide to do so* and, despite of that, can *never completely* leave Natural Realism. The philosopher Nicolai Hartmann (1882-1950) is an example, insofar he adhered during the first part of his philosophical career the Neo-Kantian school of Marburg, but then left it in order to embrace – at least temporarily - a position which he himself called ‘Natural Realism’[22]. However, a closer analysis suggests that Hartmann’s position is close to, though not identical with Aristotle would presumably call Natural Realism.

Natural Realism = immediate contact with reality. The most characteristic feature of Natural Realism is that a person living within the spirit of Natural Realism is convinced, without a need of decision, that he or she perceives and understands something *real*, i.e. *independent* of him or her. In doing so, he or she becomes aware of the own perceiving and thinking. Therefore, a natural realist is also convinced, explicitly or implicitly, that he or she does *not* primarily perceive own perceptions of the senses and does *not* primarily think own thoughts. He does not need to *fabricate representations* of what he thinks might stand behind his perceptions and thoughts – the “outer world” -. A natural realist is in *intimate contact* with what he comes to call *reality*, based precisely on that contact.

Natural Realism does not exclude anything. Finally, **Natural Realism cannot be defined by placing it into a more comprehensive category of human knowledge. The reason simply is, that Natural Realism itself does not exclude any sector of human knowledge.** Accordingly, Natural Realism can be *described* somehow by saying that it does *not put any preliminary condition* to philosophical inquiry and is careful to *not leave out anything* that comes before the mind’s eyes. Therefore, given that the word

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[21] Dummett, Michael, The Interpretation of Frege’s Philosophy, Harvard University Press, Cambridge Mass., 1981, p. 39

[22] Hartmann, Nicolai, *Grundzüge einer Metaphysik der Erkenntnis*. 1965 (first appeared 1921), chapter 13: ’Natürlicher Realismus’, p. 133-134 (first and second paragraph) and p. 134-135 (third paragraph).

‘reductionism’ gets its content by what ordinary experience tells us and what has been listed in section II, ***Natural Realism tries first of all to avoid all sort of reductionisms from the very outset in order to do justice to the whole reality*.** Obviously, it remains to be seen whether that yields a sort of control of the losses through reductionisms. But **irrespective of the eventual findings, an argument based on natural realism would help the epistemological climates of Physics and Christian Theology to approach each other.**

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At this point the fundamental considerations have their end. The first question of this talk “What is the Main Reason that Physics and Theology Do Not Really Match?“ has got a serious attempt of an answer. The cause of their mismatch is the difference of epistemological climates or, in other words, the view that material things are (almost) not intelligible versus the view that material things are quite inteligible. **We now turn to the second question “What can be done to amend that situation?“** That is tantamount to ask, how the distant epistemological climates can be made to approach each other. It goes almost without saying that the change has to take place on the side of Physics. It is quite clear that elaborating a control cannot limit itself to minor re-arrangements, so to speak, to *tactical* manoeuvres. It must reach the very foundations. In other words, they must be, so to speak, a *strategical* manoeuvre. Any specification of such a manoeuvre should take into account the two following basic facts:

> **(i)** Physics depends on the severe reductionisms, while Theology has *no* voluntarily made reductionisms such as Physics.
>
> **(ii)** Theology can grow, but only in a way that posterior stages are fully consistent with all previous ones. The reason is that a theologians understanding of God’s revelation can *grow*, but God is *always identical* with Himself. In contrast, Physics has already undergone several major changes “of paradigm” [the last two: determinism/indeterminism (quantum theory), and the relativity of observer and observed (theories of relativity)]. Therefore, there is no problem at all if *Physics would change once more*.

In other words, Physics is envisaged to undergo another change of paradigm, namely the change from doing Physics after the reductionisms without any control or estimate of the losses due to the reductionisms to doing Physics after the reductionisms, ***but together with the light of a control or estimate of the losses due to the reductionisms****. This control would have to be obtained in the mindset in Natural Realism.*

The immediate challenge is to find a starting point for the derivation of a control. It is likely that much time must be spent with attempts to start from various points, either universal aspects or particular experiments like the famous double slit –experiment or the Schrödinger’s cat experiment. It is impossible to give a something like a survey. **This is why we should limit ourselves to a sample of what is covered by a control. First, we shall treat briefly, in the following sections, two *general* topics dear to Physics, namely space and dynamics. Then we come to the finding of Physics which is, to my mind, the most important one in the last hundred years, namely the existence of elementary particles at all.** This is foreign to Classical Physics. It might well be that here is a change of paradigm. Yet, to date it has gone unnoticed.

VI. Space and dynamics

VI.a Space

Einstein proposed a classification of notions of space as follows: Space is either conceived as

a) *positional quality* of every single material thing,

or as

b) a *container* of all material things together.

In the first case, there is no space without things, and in the second case, there are no things without container, and the container-space exists also without things[23]. Obviously, Newton's concept of absolute space belongs to Einstein's category of container space, while Aristotle's concept of place is closer to, but not identical with, the idea of a positional quality.

As a container-space has never been observed, we stick to the 'space as positional quality of every single material thing', even though this alternative has never been seriously taken into account. The reasons are easy to find: First of all, one must determine, what a single material thing is. Are elementary particles such single material things, or macroscopic solid bodies, i.e. huge agglomerations of elementary particles? Second, a space made up of the positional qualities of material things seems to become more and more complicated together with the increasing number of material things. In practice, it looks like an impossibility to deal with billions of billions of billions of positional qualities of elementary particles, and the conceptual elegance of such an idea seems to be null. Third, it is unclear how material things would relate to their container – what is it to be in a container? In this respect, the alternative 'positional quality' is much clearer.

Positional qualities of material things are *mutual or reciprocal*. That is to say, material things adopt their positions exclusively with respect to other material things and vice versa. Together with the observed "flexibility" of all these relational arrangements – on the astronomic level as well as on the level of elementary particles, everything is uninterruptedly moving – one is led to the conclusion that they are *dynamic*. That the dynamic positioning of material things is really uninterrupted is confirmed by the following observation: when looking at whatever place of the universe, we observe that solid bodies have uninterruptedly clear positions, which vary in a clear way. This means that material things interact continuously with each other performing their mutual positioning. It can be shown that this argument extends to microscopic things as well, picturing the *whole universe as a thoroughly dynamic entity*. That immediately leads to the question, how it can be understood that material things act one upon the other, without that they cease to be what they are – *different* material things.

VI.b Dynamics

It belongs to the most elementary experiences that material things act one upon the other. Historically, is has been taken for evident until the beginning of modern time, that things *really* act one upon another. The experience *that* it does happen, is too overwhelming, even though there is no experience, *how* it happens. This is why the philosophical

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[23] Jammer, M. *Concepts of Space*. Cambridge, Mass.: Harvard University Press, 1993 (3rd edition), p. XV; first edition 1953).

treatment has been satisfied with stating that the effect – that what happens to the receiver of an action – belongs to the receiver *as well as to* the source of the action. Only the way of belonging is different: the receiver is the "carrier", the other thing is the source. Nothing material is observed to pass from the source to the receiver.

This might be difficult to accept and it has been, perhaps, the reason that matter was conceived as absolutely inactiv, and that the interactions between material things *either* take place through *intermediate material things* – the exchange particles in modern particle physics – *or* that interaction is *not real*, but an impression caused by a prestabilized harmony, as Leibniz has it. These alternatives make it difficult to give an account of the fact, that ordinary experience as well as Physics uses to *characterize things by their very interactions*. This corroborates the view that action is rooted in material things themselves. It makes it more difficult to accept the view of intermediators between them or the view of a prestabilized harmony.

Altogether, the compound **[**space as positional qualities **&** intrinsic dynamics of the pieces of matter**]** offer a perspective quite different from the container space. The latter does not exhibit such a natural connection between both elements as the former does. A particular consequence is that the positional-quality-plus-intrinsic-dynamics view yields an understanding of the famous double slit –experiment, albeit to date a purely qualitative one. That is to say, the particles "feel" always the two slits, irrespective of which slit they are passing through.

VII. Invariable combinations of invariable properties: the re-emergence of "substance thinking" instead of "function thinking"

The shift from a container space for all material things together to positional qualities of single material things, together with the view that positions are relativ and based on interaction of single material things and that *action* as well as *receiving action* ("passion") is rooted in (different) material things and not a mental structure, focuses the attention on the material things. This is how Natural Realism should work.

Without going into details of putting order in the huge body of experiences, one is led to the view that elementary particles themselves exhibit themselves to the surrounding experimental settings as individual „pieces of matter" with an **invariable bundle of invariable properties** (such as electrical charge, spin, helicity, rest mass, etc. invariably bound together). Precisely this *invariability* calls attention, and so elementary particle are characterized in this way, i.e. they are grouped into different species.

One might object that the experimental data that lead the experimenter(s) to recognize an invariable combination of invariable properties are so many and so fragmented that the recognition of such an invariable combination of invariable properties appears to be completely arbitrary. To that objection one could reply that, on the one hand, the events in the microworld truly are extremely unrestfull, and they can perceived only with a high degree of indirectness. The degree of indirectness is even much higher than in the case an observer sees his car indirectly through light as medium. There are also doubts about whether quarks or gluons are really material realities and not only physical names given to mathematical objects. But, against this objection stands the firm conviction of all experimental physicists, who have embraced the view of the reality of elementary particles *notwithstanding* their doubts concerning the physical reality of particular species such as quarks.

From a natural realist point of view, this is the typical way of how such combinations manifest themselves experimentally. They cannot be measured as such, and this might be at the background that they are not sufficiently recognized as *something superior* than the single properties belonging to them. Remaining in the framework of Natural Realism, the discovery of individuals of species in the microscopic domain reminds very much of the Aristotelian analysis of macroscopic bodies as a hylomorphic compound. This is quite surprising, because Aristotel had no idea whatsoever of atoms and elementary particles; neither of higher mathematics.

That is to say, Aristotle viewed such things as a **[**thing as individual**]** and complementarily, at the same time, as a **[**thing as species**]**. Of course, it would be against realist spirit to simply copy something from an author. Nevertheless, these ideas – in this particular case, Aristotle's ideas – might inspire the analysis of the modern experimental findings. If these ideas prove to be realistic, the face of Physics might change considerably from a property-oriented view of nature to a thing or substance-oriented view of nature. Properties would appear as "owned" by substances. More precisely, Physics would continue performing experiments and formulating mathematical theories, but both experimental and theoretical activity would be inspired and shaped by the unifying substances. In other words, the "function thinking" would be enriched and somehow shaped by a "substance thinking".

VIII. First features of the control of the losses through reductionisms and final remark

This outline presents the general ideas, but not any specific consequences. This is why one could object that it sounds all very nice, but that nothing will change without an elaborated philosophical solution of the internal problem of Physics. Although we cannot present the solution in all detail – a control of the losses of knowledge -, we are able to indicate (though with some repetitions) in the following the essential ideas and first results.

1. *Everybody knows* that Mathematics is essential for Physics. It is commonly supposed that experiments (including the human experimenter) are, so to speak, the *bridge* between individual material things and abstract mathematical theories. Furthermore, *everybody knows*, how successful physics has been over the three or four last centuries, and that there is no reason to think that this development would stop one day. Science and technology will continue shaping our civilization.

2. The notion of *success* is typical for knowledge that refers to *practical actions*. Purely theoretical knowledge would be labeled according to the category of *truth*. Now, physico-mathematical theories are a *common* result of internal principles of Mathematics and practical procedures, i.e. experiments. And, according to all experience, a theory meets the results of the pertaining experiments only to a *degree of more or less precision* and *only within a smaller or greater range*. As truth does not admit degrees, *success is not identical with truth*. That is to say that, while *the success of a theory is a true success, the theory itself is not true in the sense that it faithfully reflects material realities*. Theories have, thus, an internal truth, but instead of giving a true account of those material realities they are referring to, they give only a successful one.

3. One might suspect that the difference between the "outer" success of a theory and its "inner" truth is caused by certain *knowledge gaps* or *impediments of knowledge*

acquisition, which also are something “external”. In fact, there is a knowledge gap insofar as *nobody knows*, *why* experiments can successfully be considered as a *bridge* between *individual* material things and *abstract* mathematical theories. However, it is clear that the experimenter is indispensable. As to impediments of knowledge acquisition, they are likely to be brought about by specific and far-reaching *reductionisms* performed by the experimenter, which are essentially the same throughout Physics.

4. In the last centuries, the strategy in Physics to compensate for both knowledge gaps and impediments of knowledge acquisition by establishing mathematically formulated hypotheses or *models* of reality, together with making abstractions and simplifications. Obviously, these are measures on the side of the theory. This has become the backbone of the methodology of Physics. From an epistemological perspective, this method has been increasingly invaded by a strong skepticism which, in turn, has been notably corroborated by Kant’s epistemological views. That situation is, however, disguised by the clear-cut rationality of Mathematics, as can be seen by the fact that *mathematical* concepts often have got, in Physics, *physical* names. Despite of all that, the success of Physics remains impressive.

5. The better way to diminish the dependence of physical knowledge from hypotheses seems to consist in finding out *why* physico-mathematical theories can be successfully applied to material things. Such an inquiry can depart *either* from the successful physico-mathematical theories already known, *or* from the experiential knowledge of material things without relying on theories at all. The first alternative is commonly known as ’*scientific* realism’, and the literature about that approach increases every day. However, very little progress has been made so far.

6. The second approach starts from what everybody knows by mere observation of natural material things. This ansatz is rightly called ’*natural* realism’. It does not make any reductionisms and, therefore, would not yield a derivation of existing theories. Instead, precisely because of not being affected by any knowledge gaps or impediments of knowledge acquisition, it might yield a sort of *indirect control* of the knowledge gaps and the impediments of knowledge acquisition in present day physics. Such a control should not be understood as something *outside* Physics, but rather as a future *integral part* of it. However, this approach has not yet got any attention.

7. Only recently has been done an important step forward in the natural realism -approach. It rests on observation and the following three carefully pondered affirmations:

- All (unorganic) material things consist ultimately of elementary particles. These particles have a hylomorphic structure in the Aristotelian sense, i.e. they are individuals of species;

- Elementary particles, and only these, are sources of dynamics, i.e. of activity and passivity. The dynamics of composed (unorganic) material things is determined by the dynamics of their elementary constituents. The dynamics of elementary particles, in turn, is determined by a sort of parallelism between their hylomorphic constitution and their activity/passivity. Every single elementary particle interacts with every other elementary particle and, therefore, *every material thing interacts with everything else* (the physical term is ‘non-locality’.);

- Elementary particles relate to each other by their mutual position, and this positioning is based on their dynamics. That is to say that space is not a unique container of all things, but the collective result of the mutual positioning of all elementary particles.

From this situation have been obtained so far the following (not yet published) conclusions:

- All elementary particles together constitute, by their mutual position, a *global dynamical order*. (**xxx**) All possible laws of nature are "embedded" into this global order.

- The positional quality of every elementary particle can be identified with what in Physics is called '*particle spin*'. Every elementary particle has its spin, and this positional quality is, in a logical sense, the particle's *first property*. All particles constitute together the "space" by means of their spin. All other properties, like what in Physics is called '(inert or gravitational) mass' or 'electrical charge', are logically posterior.

- The Newtonian axiom *actio = reactio* leaves it open whether any two material things interact mutually *and equally perturb each other*, or interact mutually *without perturbing each other at all*. [A material thing is *perturbed* by other material thing(s) **iff** its activity upon others also *depends* on whether it receives actions from other(s).] *The hylomorphic constitution of elementary particles excludes any mutual perturbation.*

8. These statements tell that material things *themselves* generate dynamically their mutual order. The experimenter does not stand outside that order, but he is part of it. The result so far provides a good reason to think that further insights are likely to follow and that this approach offers many topics for fruitful investigation. Such investigations can be carried out most suitably by philosophers, whose thinking is realist in the Aristotelian sense, and who have previously got a good education in Physics. But also scholars of other disciplines, who relate somehow to the history of science and general culture (school and university education, didactics of Physics, television, literature and, last not least, theologians), should take careful notice of that advance.

One final remark about the particularities of this approach. Obviously, it finds itself far away from mainstream thinking. If somebody would be interested in searching here a topic for his or her long-term academic project, he would certainly find more than enough open questions to deal with. But the problem as a whole is not at all easy and would require, together with its distance to the mainstream, that such an academic has a certain intellectual independence from the mainstream, and also a certain economic independence.

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