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# ZENO AND DESCARTES INFLUENCE ON EXPERIMENTAL METHOD IN PHYSICS [1]

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**ABSTRACT.** In this paper, we are comparing Greek and modern methods of research, and finding that after giving identical answers to Ontological and Gnosio-Ontological postulates, the two thoughts are going apart in answering to Existence-Interaction postulate. Greeks gave priority to existence, while modern thought considers interaction to be a priori. This results in two formulations of causality: Greek thought – *Every object has its cause*; Modern thought – *Every change of the state of object has its cause*. Using this analysis, we show that modern thought through Quantum Mechanics is going back to Greek approach. So, it seems that modern method of research closes the cycle. But examining differences of the two thoughts, concerning experimental approach we show also that in Quantum Mechanics two approaches are parallel, leaving the question open.

**Keywords:** Analytics of causality, existence-essence opposition, experimental method.

## INTRODUCTION

The causality principle is the most durable discovery of humankind, as it probably came into minds of our ancestors in the Middle Paleolithic period[2], when the first burial customs were discovered, and it was used in Neolithic period when fairy tales were shaped, and magic was practiced, but definitely, it became very important in the bronze age, when mythology was founded. Most probably this is the reason it was never precisely defined. Of course, there is an intuitive definition of it, thanking to Leibniz, commonly used, which can be formulated as follows: "every cause has its effect, and vice versa", but it includes into itself the problem of defining what is a "cause" and "effect", and so on. We will rephrase above "definition": *Nothing happens without a cause, and no cause remains without a consequence*.

[1] A large part of this manuscript was presented at COLLOQUIUM IN HONOR OF VALERIJ BOČVARSKI, Belgrade 13th – 14th October, 2017 (https://mail.ipb.ac.rs/~centar3/text/COLLOQUIUM-IN-HONOR-OF-V_BOCVARSKI_web.htm)

[2] This early causality emerged as the tool for getting order into perceptive chaos (KANT, 1998), and wasn't recognized as a principle, of course.

Yet there is still a problem of giving precise definition of a cause, because cause in the beginning was treated as something "preceding in time" (sensuous consciousness - magic - phase of thinking), but, later, the need for logical preceding also was recognized (perception or common sense phase of thinking)[3]. Thus, even the oldest human discovery – the causality principle, may be formulated in a variety of ways:

In the *Posterior Analytics*, Aristotle places the following crucial condition on proper knowledge: **we think we have knowledge of a thing only when we have grasped its cause** (*APost*. 71b 9–11. Cf. *APost*. 94a 20). That proper knowledge is knowledge of the cause is repeated in the *Physics*: we think we do not have knowledge of a thing until we have grasped its why, i.e. its cause (*Phys*. 194 b 17–20), (FALCON, 2019).

But, more than two thousand years later, Kant in his Introduction to *Critique of pure reason* (KANT, 1998) claims: *every alteration [change] must have a cause*.

## ANALYTICS OF CAUSALITY

Having all this in mind, but using more Kantian approach, BOČVARSKI et BAUDON (2015) notice in their book on philosophy of physics:

***Ontological postulate (O)*** is something every researcher must accept before starting his research: *the world of different objects, which researcher examines, exists and is given in itself*. Such choice, made intuitively in the beginning, was criticized by young Nietzsche (DJURIĆ, 1984), because it is not necessary, but only useful (notice also Husserl's approach). Yet in modern science axioms and postulates may be considered founded if the thought construction that is built on them is true (so, if our description of the world is to some extent near the truth, this choice is necessary). Nevertheless, there are researchers who choose that the only thing that exists is one's self – but solipsism was rejected both by Greek and Modern thought.

In order that world be intelligible and could be interpreted using human logic we must accept ***Gnosio-Ontological postulate (GO)***: *objects and their relations are not accidental, but in them and between them there are regulated relations or* ***causal*** *connections*. Thus, this choice establishes causality, and is the reason why, as Galileo put it, "nature is written in mathematical language", or intelligible, yet, this choice was made by Greeks also. If the other choice is made, one obtains indeterminism, which is a sideway of human thought.

Until this moment in developing the logic of research, paths of Greek and of modern thought are the same. But if one goes to the next phase which emerges when implementing causality, namely (terminology is modern):

(i) Is an *interaction* (relation) a consequence of different *existences*? I.e. is an individual existence (Dasein[4]) with its qualities *a priori* and interaction *posteriori*? (Existence prior to interaction)

[3] According to Hegel's classification of phases of consciousness (thought) there are these phases of thought: sensuous consciousness (which uses causality as in magic level of thought in history); perception (i.e. common sense); understanding and reason.

[4] Heidegger writes "Being is found in thatness and whatness, reality, the objective presence of things [Vorhandenheit], subsistence, validity, existence [Dasein]" (HEIDEGGER, 1972).

(ii) Or are *existences* (individual objects) appearing through or because of interaction, making thus interaction *a priori*, and an individual existence *posteriori*? (Interaction prior to existence)

Thus, one obtains the point where Greek and modern views are differing, and this becomes ***Existence – Interaction postulate*** (***EI)*** – yes to (i) being Greek choice, and yes to (ii) being modern choice. Of course, these choices are made intuitively. Tales was the first to make this choice for Greeks, but it was founded couple of centuries later in Aristotle's definition of causality (ARISTOTEL, 1970). Also, Galileo, practically, and Descartes, theoretically, made the other choice, which is justified couple of centuries later by Kant (KANT, 1998), and especially Hegel's dialectics (HEGEL, 1986), and with development of mathematics and physics, of course.

This needs an explanation, because the choice is not so obvious. In fact, it seems that only the choice (i) is logical, and thus possible. It is made, intuitively, also by all first (pristine, i.e. those which came directly after the magic phase of thinking) civilizations: Egyptian, Chinese, Indian, …. The choice (i) seems natural because there cannot be interaction without existence, so Greeks and others were right. But later it is shown that this research "ambient" produces Zeno and his paradoxes. On the other hand, one should notice that interaction could be temporarily simultaneous with existence, but logically preceding it. An object A cannot be existent, unless it had its attributes, and attributes can only be noticed in "mutual relation" (hence *interaction*) with another object, B (BOČVARSKI et BAUDON, 2015). This produces Descartes and all his achievements in mathematics, also his laying foundation for many physical discoveries, that is, it enables including movement into physical research, or if world is logically regulated, one needs to learn the *laws of motion*, not the *laws of existence* (BOČVARSKI et BAUDON, 2015).

Indeed, Greek choice in EI postulate leads to conclusion: if attributes of the object like color, taste, …, or velocity (because, from ontological point of view, velocity is something attributed to the object (BOČVARSKI et BAUDON, 2015)) are produced together with the object, and this must be so if existence is a priori, then they cannot change, without changing the object. So, for this thought, if the object has become existent its attributes cannot change. Thus, for Greek thought puppy disappears while dog appears (RISTIĆ, 2008). I.e. object cannot change velocity (it can only be at rest, or move with the constant velocity, but for Greeks the rest is only acceptable). Movement as changing place (Descartes, which is acceptable definition for modern thought, for Greeks the growth of plants and animals was also movement) is not apprehensible for Greek thought. So, for Greeks, movement as changing place can only be an illusion.

Thus, for Parmenides and Zeno movement is illusory, i.e. they explicated the results of Greek choice in EI postulate. Here very serious objection can be made, that Zeno paradoxes do not represent the whole Greek thought. Indeed, many Greek thinkers were refuting Zeno, from Pythagoreans, Plato and Aristotle to Archimedes (HEGEL, 1955). Yet, never with complete success, so the paradoxes came back over and over to Greek thought[5], which had a Herculean task to abandon obviousness in the comprehension of the world. Tales (HEGEL,

[5] How difficult it was for Greek thought to explain movement as changing place can be illustrated by Aristotle's explanation of moving of projectiles: Aristotle in his *Physics*, explained the continued motion of projectiles, which are separated from their projector, by the action of the surrounding medium, which continues to move the projectile in some way. Aristotle concluded that such violent motion in a void was impossible. So, basically for Greeks the movement is an illusion, but for modern thought (Descartes was the first!) being at rest is an illusion.

1955) had to reject obviousness of permanent decay and rebirth of everything, to find "Archimedean point" for human thought, and was followed by all pre-Socratic thought, until, consequently, Parmenides and Zeno said "change (i. e. movement) is an illusion", and Euclid consolidated that view making Geometry, which has only simultaneous relations, the basis for describing the world (Plato in Timaeus even geometrizes numbers, thus adjusting Pythagorean tradition to geometricized mathematics (BOČVARSKI et BAUDON, 2015)). That is, Greek mathematics was geometry, which describes only static relations, and can incorporate into itself Achilles who never overtakes the tortoise. Notice that Indian and Arabian mathematics was algebra, which also cannot describe movement.

Zeno paradoxes were fundamental problem in and after scholastic period either. Scholastics is in many ways' extrapolation of Greek philosophy, and especially regarding the EI postulate, though they gave it another name, i.e. Guillaume de Paris and Saint Thomas introduced notions of existence and essence (BOČVARSKI et BAUDON, 2015)[6]. This doublet seems to originate from theological discussions about the nature of Christ, which produced distinction between the nature (φυσισ) of Christ and his essence (ουσια) (MEYENDORFF, 2010), which went over to Latin as existence and essence[7]. So, our Existence-Interaction (EI) postulate firstly was the Existence-Essence (EE) postulate, because for knowing essence of a thing, you need to know its attributes, which become known through *interaction*. Hegel always gave priority to essence. Later existentialists gave primacy to existence over essence, which is the Greek choice in the EE postulate.

Zeno paradoxes are resolved only introducing calculus, which was developed on one side by Newton, who introduced movement (through *fluxions* (RISTIĆ, 2008)), which were based on moving lines, which are made from moving points) into static construction of geometry, and on the other side by Leibniz, who was using functional dependence[8] and all apparatus that stems out of it. Yet, historically, Zeno paradoxes only were resolved in the beginning of XX century by Bertrand Russell (Standard solution) who leaned on Cantor's and Dedekind's work, which included the calculus apparatus in explaining those paradoxes.

The choice a researcher makes in the EI (EE) postulate has an intermediate consequence: the two formulations of causality principle (mentioned earlier) - Greek thought: **Every object has its cause**; Modern thought: **Every change of the state of object has its cause**. Which leads to different Greek and modern approach to the experimental method.

An illustrative example is obtaining vapor from water (BOČVARSKI et BAUDON, 2015). Aristotle in his *Meteorology* (ARISTOTELES, 2015) offers us following explanation: *If heated, water disappears, and vapor appears*. But for modern thought: *water* (heated, having according pressure - Greeks were not aware of the issue of pressure -, and so on) *goes over to vapor*. I.e., there is no need for *asking what is the cause of something* (Aristotle), but *one should ask what kind of development has the related process* (Galileo, Descartes, Kant - see BOČVARSKI et BAUDON (2015)).

[6] The existence - essence doublet wasn't explicated in Greek thought, but was underlying all of it.

[7] Most intriguing is how "φύσισ" became "existence". Maybe the line of thought was the following: one does not know anything about the ""φύσισ" " of God, except that it exists, so "φύσισ" became the equivalent of existence.

[8] Introduced by Descartes (the term "function" was coined by Leibniz) functional dependence uses the successive change of arguments (which implicates the succession of time), i. e. Analysis has become the tool for describing the world, and movement enters the modern way of apprehension of the world. See, also (RISTIĆ, 2008).

On the other hand, apart from Kantian statement (see above), modern formulation of causality principle can be traced over modern introducing dynamical balance as the goal of research, unlike Greeks who stuck to geometry, which is static and simultaneous, and does not request time – that is, their world was the world of statical balance. But that was so until in the beginning of the XX century Greek views were revived in Quantum Mechanics.

Thus, we shall discuss photo effect and Bohr postulates in detail, as they are incorporated into Quantum Mechanics. Greek thought got stuck on the notion of "quantum" of time, as we can tentatively call Aristotle's try to divide time into very small portions, which inevitably "tended" to nothing ("zero" was discovered later by Indian thought, and wouldn't be very helpful to Aristotle, because for refuting Zeno, he needed something that is zero in the process of dividing time, and, yet, when added is giving a definite relation, i.e. mathematically speaking infinitesimal portion of time, or, "loosely" speaking "quantum" of time). Nevertheless, Modern thought did not get stuck on Planck's "quantum of action", which contended in itself the "infinitesimal behavior", that is, when dividing the process it wasn't zero, but stopped at something undefined, very near to zero, a quantum. Instead, Modern thought, introduced "quantum of light" through Einstein's resolving the problem of photo effect, sweeping under the carpet the problem of "quantum of action". Of course, a concept put aside always gives effects later, i.e. Bohr postulates were needed to keep the "construction" (atom) working.

Bohr postulates are stating:

1. Electrons in an atom exist in *stationary states*.

2. Transmission between stationary states produces/absorbs *em* radiation.

3. The *angular momentum* of a stationary electron is *quantized*.

From the point of view of EI postulate:

**1.** Bohr states that electrons are not interacting when in stationary states, so, they must be existent before interacting or noninteracting.

**2.** Electrons when changing their orbits are behaving like "Greek objects", i.e. *disappearing* and *appearing*, without any relation to the time, and to portion of space in which they should be per Galileo-Newtonian approach, between these two events. This line of thought produces later Heisenberg's uncertainty relations as an explanation.

**3**. "Quantized" is here something ad hoc (deus ex machina), regulating changing of angular momentum, i.e. movement of the objects – electrons, and which has lost the connection to Planck's "infinitesimal" action ["quantum of action"]. So, this is restricted interaction forced upon existing objects.

Thus, even when formally investigates interaction Bohr's approach starts with existence, which is the Greek choice in EI (EE) postulate. So, since Bohr's theory, later Quantum Mechanics, which incorporated Bohr's views into itself, the Greek formulation of causality principle begins to be parallel with modern formulation, conquering this thought. Heisenberg's excluding, over the uncertainty principle, the modern approach of tracing every step of movement of the object – i.e. electron, helps intrusion of Greek formulation of causality into modern research. Usually it is explained as abandonment of continuity of classical physics and replacing it with quantum discreetness. But this discreetness originates from the choice in EI (EE) postulate (BOČVARSKI et BAUDON, 2015) and is not anything new.

Yet, in Heisenberg's *matrix mechanics* and Schrödinger's *wave mechanics*, the Greek principle of causality was accepted through the eigenvalues of operators (founded by Born and Wigner), representing physical quantities. Eigenvalues which represent the orbits that are changed by *appearing* and *disappearing* of electrons. It has been noticed (BOČVARSKI et BAUDON, 2015) that Pythagoras' theorem could be viewed as a *Production operator* which produces right triangles as eigenvalues, in opposition to Descartes view of moving points, who are taking shape of different geometrical forms.

So, the two approaches are parallel in modern science. In a sense that Quantum Mechanics uses Greek principle of causality parallel with Modern causality, which is not contradictory at first sight. Still Einstein offered a thought experiment called EPR paradox showing that there are deeper inconsistencies (RISTIĆ and STANKOVIĆ, 2016).

## EXPERIMENTAL METHOD

Thus, we have two research models, which are inherently uncontradictory and both can be true, so we must go out of them to find a truth criterion. This procedure would have not been acceptable for Greeks, but Modern thought has even produced Gödel's theorem, which, paraphrased, states "that the first principles (axioms) of some theory could only be proven if one goes outside of that theory". There is yet another blasphemy for Greek thought, because that outside criteria is in fact praxis (experience). Greek thought never even considered the criteria of praxis, because, for this thought world is logically apprehensible and no practical experience has any role in understanding it. Namely, the "praxis" is always connected with *interaction*, so if you are interested in *existence* you do not need any *praxis* (experiment).

But, modern solution of the problem is, as F. Bacon put it, "…simple experience; which, if taken as it comes, is called accident, if sought for, experiment…" (https://en.wikipedia.org/wiki/Baconian_method). And it began with Galileo who with elegance switched to practical tests (experiments) in his discovering the law of movement on the inclined plane. He posed questions to nature, but did not ask about the origin (existence) of Gravity which drags his test particles down the plane, and asked only "how the process was developing", making interaction (relation) the center of the research. This approach resulted in Newtonian "explanation" of Gravity.

On the other side, Archimedes made some miracles with lenses, but he never posed questions to nature, which no Greek would have ever done. Because, if you take the existence as a priori, you do not feel the need for posing questions to nature - for you these answers are irrelevant as interaction is posteriori. It was only trial and error, out of which none of the laws of the process in mathematical form came. Here is yet another difference between Greek and modern approach (which is a direct consequence of the choice in EI (EE) postulate): Greeks never used explicit mathematical notation in physics (like v=x/t, for instance), while after Galileo modern physics gradually became "mathematical".

Though generally praised to be one of the most efficient concepts in the development of human thought, experiment is not completely defined (RISTIĆ and STANKOVIĆ, 2016). We suggest here that experiment should be comprehended as the way to introduce experience as criteria of truthfulness of logical constructions, i.e. hypothesis and theorems, theories and so on, which is nothing new for modern thought, but would have not been acceptable for Greeks.

**FINAL REMARKS**

Comparing Greek and modern methods of research we have shown that after choosing the same answer to Ontological and GO postulate, avoiding thus solipsism and indeterminism, those two thoughts went on different paths after picking different answers to Existence – Interaction (EI) postulate. Greek choice was "existence is a priori and interaction posteriori", modern choice was opposite "interaction is a priori". Leading thus to "attributes" changing with objects, so, in fact, the attribute of velocity is never changing (Greek choice, it produces Zeno paradoxes), and attribute of velocity added to the object and changing during some process (modern choice). So, modern thought describes movement, over modern mathematics, which is analysis, opposite to Greek mathematics, which is geometry, and can incorporate into itself Achilles who never overtakes the tortoise. These differences are manifested in two formulations of causality principle.

Yet, the two paths joined again in Quantum Mechanics, in its offspring Quantum Field Theory, and finally in the Standard model, producing Big Bang. Maybe, after all, the existence is a priori? No, we don't advocate such a statement, but obviously, the question is not closed, yet. Especially, as Quantum Mechanics after its origins has been giving primacy to interaction, and as from our analysis follows that the two approaches have different views on experimental method, but Quantum Mechanics is on that matter completely modern. Obviously the two approaches are in some sense parallel in Quantum Mechanics, so one could hardly say, which is a priori, existence or interaction. Maybe, their primacy should be altered during further research.

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