Quantum causality

Zeno and Descartes influence on the experimental method in physics

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1. 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, 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, 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.

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- With a cause it is more difficult, because cause in the beginning was treated as something “preceding in time” (sensory experience - magic - phase of thinking), but, later, the need for logical preceding also was recognized (common sense phase of thinking). The terminology is related to much later thinkers (Kant, Hegel). 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). [1]
- But, more than two thousand years later, Kant in his *Critique of pure reason* [8] claims: *every alteration [change] must have a cause*.

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- 2. Analytics of causality

Having all this in mind, but using more Kantian approach, Bočvarski and Baudon notice in their book on philosophy of physics [3]:

- *Ontological postulate* (O) every researcher must accept before starting his research**: *the world of different objects, which researcher examines, exists and is given in itself***. 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.

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- 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) with its qualities *a priori* and interaction *posteriori*? (Existence before interaction)
- (ii) Or are *existences* (individual objects) appearing through or because of interaction, making thus interaction *a priori*, and an individual existence *posteriori*? (Interaction before existence)
- This becomes *Interaction – Existence postulate* (IE) – yes to (i) being Greek choice, and yes to (ii) being modern choice. Of course, these choices are made intuitively.

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- Tales was the first to make this choice for Greeks, but it was founded couple of centuries later in Aristotle's definition of causality [1]. Also, Galileo, practically, and Descartes, theoretically, made the other choice justified couple of centuries later by Kant [8],
- 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. 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, noticing 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 [3]) 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* [3].
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- *Indeed, Greek choice in IE 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 [3]) 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 [11].*
- 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, movement as changing place can only be illusion.
- Thus, for Parmenides and Zeno movement is illusory, i.e. they explicated the results of their choice in IE postulate. And Greeks produced mathematics (geometry!) which can incorporate into itself Achilles who never overtakes the tortoise.

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- The choice in IE postulate has direct consequences in defining causality [3]:
- Greek formulation of the causality principle could be expressed as
- *Every object has its cause*
- (here "object" is used as a modern equivalent of Aristotelian "thing"), [3]. As Aristotle saw it this is so not only for efficient (effective) cause, but also for other three Aristotelian causes (material, formal, and final), though Modern European thought uses only effective cause, but in a new formulation:
- *Every change of the state of object has its cause.*
- An illustrative example is obtaining vapor from water [3]. Aristotle in his *Meteorology* [2] 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 a cause of something* (Aristotle), but *one should ask what kind of development has the related process* (Galileo, Descartes, Kant see [3]).

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- Zeno paradoxes were fundamental problem in and after scholastic period either. Scholastics is in many ways extrapolation of Greek philosophy, and especially regarding the IE postulate, though they gave it another name, i.e. Guillaume de Paris and Saint Thomas introduced notions of essence and existence [3]. Later existentialists gave primacy to existence over essence, which is the Greek choice in the IE postulate.
- The Zeno paradoxes are resolved only introducing calculus, which was developed on one side by Newton who introduced movement (through *fluxions* [11], 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 and all apparatus that stems out of it.

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- 3.Quantum causality
- Now, 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). 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.

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- 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 point of view of IE 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 period, and to portion of space in which they should be per Galileo-Newtonian approach, between these two events. This line of thought later produces the Heisenberg 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. So, this is restricted interaction forced upon existing objects.

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- Consequently, 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.
- Thus, two approaches are parallel in modern science.
- **4. Experimental method**
- So, we have two research models, which are inherently uncontradictory and both can be true, and 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". Praxis (experiment) is introduced. Galileo.
- We suggest here that experiment is 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.

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- ***References***

- [1] Aristoteles, *Organon*, (1970) BIGZ, Beograd, (Serbian translation);
- (http://plato.stanford.edu/entries/aristotle-causality/
- [2] Aristoteles, *Meteorology,* (2015) *University* of Adelaide, eBook.
- [3] Bočvarski, Valerij et Baudon, Jacques, (2015), *Morphologie de la physique,* Edilivre, Paris, [4] Djurić, Mihajlo (1984), Niče i metafizika (Nietzsche and Metaphysics), Prosveta, Beograd, (in Serbian); Heidegger, M (1998) *Nietzsche*, Oxford University Press, Oxford
- [5] Einstein, A, Jahrb. d. Radioakt. u. Elektronik, **4**, 411-462 (1907) (in German), see Russian translation in Compilation "Al'bert Einstein i rel'ativnost'" Mir Publishers Moscow (1979)
- [6] Einstein, A, *Relativity, the Special and General Theory*, Crown Publishers Inc., New York, 1961.

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- [7] Heidegger, M, *Basic writings*, Harper & Row Publishers, New York, Hagerstown, San Francisco, London, 1972.
- [8] Kant, I, (1998), *Critique of pure reason*, Oxford University Press, Oxford.
- [9] Newton, Isaac, *Mathematical Principles of Natural Philosophy*, Philosophical Library, New York, 1964.
- [10] Ristić, V.M. and. Stanković, N.D (2016), **JPRMPC,** Vol. 1**,** 1, 10-14
- [11] Ristić, Vladimir M, *Noether's Theorem*, 2008, Faculty of Science monographs, Kragujevac; http://www.pmf.kg.ac.rs/ristic/pdf/Noether%27s%20theorem.pdf
- [12] Wesley C. Salmon, *Space, Time, and Motion*, University of Minnesota Press, 1980.
- [13] Stanković, N.D, and Ristić, V.M. (2016). Kragujevac J. Sci. 38 (63-69)
- [14] https://en.wikipedia.org/wiki/Baconian_method

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- Thus, modern mathematics has included into itself movement using functional dependence and developing geometrical entities from the sequence of (moving) points (both methods join together in *Analysis*). Those methods were introduced by Descartes, who, also, defining the concept of momentum, whose background was inertia, has practically changed Parmenides' and Zeno's statement "movement is illusion" to the approach "being at rest is illusion" [3]. Of course, the first scientist who pointed out explicitly to phenomenon of inertia was Galileo in his ingenious thought experiment on the inclined plane (the first thought experiment ever [13]).