LINGUISTICS AND PHYSICS: MUTUAL RELATIONS AND FASCINATION

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Abstract:
The aim of the paper is to present diverse and multidirectional relationships between the two disciplines which are apparently only distantly related to each other - physics and linguistics. Mutual fascination results from the concern to describe the "physical world" the most adequately using the language in which it is sometimes difficult to express new cognitive ideas and inaccessible to the average language user reality that is based not on accepted rules of common sense thinking and speaking. Three moments that were breakthrough in the development of science, which show the connections between discoveries in physics and linguistic developments, will be analysed in the main part. In the conclusion the attempts to get closer the worldview contained in the (SAE) language and the image emerging from contemporary physical experiments will be briefly evaluated.

Key Words: Linguistic, physics, relations

Linguistics and physics: mutual relations and fascination

In its long history linguistics as an academic discipline has been classified as humanistic, natural or science studies. The most general reason for this is, of course, that the language (understood in various ways) is of interest to many fields of science, just because they are expressed in it. On the other hand, linguistics takes from other fields, while remaining in compliance with the "spirit of the times", defining and interpreting the language for the use of a specific "present day". A mutual interest of physicists in the language and linguists in physics, which will be discussed in this paper, results from the concern to describe the "physical world" the most adequately using the language in which it is sometimes difficult to express new cognitive ideas and inaccessible to the average language user reality that is based not on accepted rules of common sense thinking (and speaking), but on the scientific experiment the results of which are often surprising.

Of course, the relationship of linguistics to physics have a long history - its origins can be traced to ancient times, when the observation of the "physical world" became a touchstone of discussion on the nature of the language. Heraclitus of Ephesus, the creator of the theory of eternal changeability (*panta rhei*), subordinate to the constant factor of the change order, called the world reason (*logos*), found the antinomy of external changeability and internal unchanging principles also in the language, pointing to its natural (*physe*i) and not conventional *(thesei*) relationship to reality [Heinz, 1979: 7]. The dispute about the nature of motivation between the language and the outer world, perceived with senses, was reported by Plato in the Cratylus, considered the first linguistic treatise in European linguistics, which can indirectly testify to the fundamental importance of physical issues for linguists and language issues for physicists. However, this paper will not so much track these relationships in the course of history (due to lack of space and competence), but it will present ground-breaking moments in which - at the time which generally can be described as modern time - they were raised with particular intensity. These moments are of course related to epochal discoveries and the most famous names in the world of science: Newton and Leibniz, Einstein and Jakobson, and contemporary Bohm and Halliday – I suggest presenting these great names as pairs of opponents in the discussion on the indissolubility of the two, apparently only distantly related to each other disciplines - physics and linguistics.

– **Isaac Newton and the "mechanistic way of speaking"?**

The first of the milestones is from the days when it still seemed possible to achieve the ideal of the "clear language" in scientific descriptions and classical western cosmology was formed - as Benjamin Lee Whorf said - with *prominent participation of Indo-European languages* [Whorf, 2002: 317]. It is, of course, the discovery of the law of universal gravity, published by Isaac Newton in The Principia in 1687. This work was widely discussed, and the intellectuals of that time also referred to several linguistic issues which they believed contributed to the obfuscation of physical laws. The concept of gravity, which Newton described as the "force of attraction", was found particularly flagrant. Today its metaphorical character is little tangible, and it is treated as a "literal" description of the behaviour of particles / objects in the universe, which can perhaps be seen as an indirect proof of the approval of the theory of gravitation in the common worldview. But then describing gravity as the "force of attraction" was seen as a return to medieval physics of quality and power with its animistic standards of explanation. One of the great opponents of this description was Gottfrid Leibniz, who strongly supported the idea of expressing reality in a logical and accurate way. The idea crystallized in the form of designing a universal language, which he called *characteristica universalis*. It was supposed to enable "proper" communication beyond all divisions of science. He claimed that the wording of the law of gravitation was obscuring and illogical. In a letter of 1711 he described the "force of gravity" as "nothing but a certain inexplicable, incorporeal virtue", as an "occulty quality" producing effects without measures that could be understood. Thus, the scientific value of the theory of gravity was criticized, as the theory said that the two bodies separated by a large space can interact, but it did not explain what "real" forces are the reason of it, assigning the bodies some "inherent powers"[270].

This criticism, however, did not convince Newton. Although in his correspondence he admits that figurative presentations that are appropriate for the language "artificially adapted to the sense of the vulgar" do not have the precision of mathematical concepts, but on the other hand he does not reject the metaphor of attraction, noting that it allows unsophisticated readers to understand the idea of gravity by referring it to their everyday experience (for example a well-known story of the apple falling from a tree that was to make Newton realize the law of universal gravity). The source of the dispute and incorrectness in the interpretation of the law of gravity is, in his opinion, that the words about the attraction and repulsion of bodies have added meaning – they attribute efficacy and even will to bodies. At the level of language expression the problem lies not so much in the use of metaphors as in syntax.

The fact that Newton saw obstacles deeply rooted in the structure of English and Latin, and was not always effective overcoming them, is presented by J.M. Coetzee in his essay *Newton and the Ideal of a Transparent Scientific Language*. He gives examples of how Newton in *the Principia*, *De mundi systemate* and *Optics* struggles with "natural" in Standard Average European (SAE) languages order of subject - predicate - object, which imposes semantic properties of the agent on the subject, i.e. efficacy (and often will), the semantic properties of the patient on the object, transitivity on prediction, and the word order itself stands as an iconic symbol of cause-effect relations. Examples show that the brilliant physicist was aware of these structural and semantic interconnections and tried to avoid them by using passivation and nominalisation - and not just as rhetorical devices, to avoid pointing to gravity as the driving force behind the movement of bodies, but also as a way to describe it more adequately as an indirect cause of this movement.

A list of language structures that were to meet the description or construction of a new reality is broadened by Michael Halliday, who points to: the use of abstract nouns as technical terms, the use of metaphoric verbs as verbalization of logical relations, the expansiveness of nominal groups and complex syntax (especially in the description of experiments) etc. [Halliday, 1990: 153-157]. Newton (or Galileo in Italian) did not invent new grammar forms, but reconstructed the capabilities of the system, providing the foundation of a new scientific language that enabled the codification, survival and development of new scientific knowledge – says Halliday, denying the relativist thesis that Newton's cosmology reflects mechanistic structures of thinking and speaking in the language rather than culturally and linguistically indeterminate projection of the order of the universe. It seems that

[270] The citations come from [Coetzee 1992: 181-194].

physicists tend to argue with the linguistic worldview rather than obeying it, and attacks on the language as a "serious source of errors and illusions" or attempts to reform the language in the spirit of the corresponding achievements of physics are clear evidence of sensitivity to linguistic issues. The next turning point, which made the classic principles of Newtonian mechanics verified, and which made the ideal of the "transparent language" a one-dimensional fantasy, shows how this bond tightens**.**

– **Albert Einstein and structuralism?**

This moment is connected with the discoveries of Albert Einstein, and in particular the theory of relativity, which revolutionized views on the nature of time and space. It is the moment when an eternal dilemma in the relationships between linguistics and physics occurs: which came first - the chicken or the egg, i.e. is Einstein's theory of relativity the result of encountering linguistic relativism, or vice versa? Undoubtedly, the theory had a great influence on the twentieth-century linguistic thought, but there are facts showing that the Humboldtian trend in the science of language could have inspired Einstein's way of thinking. Roman Jakobson writes about it in the article *Einstein and the science of language*, referring to the Swiss linguist - "the precursor of modern linguistics" - Jost Winteler, the author of "Relativitat der Verhältnisse" of 1876, who was friends with young Einstein. It turns out that the physicist knew the problem of the inseparable relationship between the concepts of "relativity" and "invariance", which formed the basis of Winteler's linguistic theory, as well as the term "situational relativity", which appears in his theory as the basic principle of language functioning. Moreover, terms used in the work of Winteler originally competed as working names of the theory of relativity [Jakobson, 1989: 67]. Einstein's words in his speech in 1941 sound like a relativist-linguist *creed*: "The intellectual development of the human and their method of forming concepts depend largely on the language". These cross-references are so obvious that they do not require a comment.

The influence of the theory of relativity on structuralism, which dominated in linguistic science for most of the twentieth century, seems to be more interesting (because less obvious). As one of the most outstanding representatives of structuralism R. Jakobson confesses: "our generation of linguists aspired to grasp language mass as "discontinuous" matter which is composed of elementary quanta and thus reveals the "discrete" structure" [Jakobson, 1989: 73]. In this light the basic principles of structural linguistics can be interpreted as essentially "physical" in the sense that they correspond to the laws of quantum mechanics. Under its influence, a new, fundamental to structuralism cognitive perspective developed. The perspective is based on the awareness that despite appearances to the contrary, the world does not consist of objects existing independently the specific features of which can be seen as distinct and individual, and the nature of which can be similarly classified. The difference between mechanistic thinking, characteristic of Newtonian physics, and this new image comes from the very nature of quantum, which is nothing like the earlier ideas of elementary particles, because it is like a whole of higher level that cannot be assembled from parts as a machine: "It is as if the properties of parts affect the properties of the whole, but also vice versa, as if the properties of the whole affect the properties of parts. The whole is like an objective to which the parts adapt. Thus, when explaining phenomena the whole of them must be taken into consideration, they should be recognized "as a whole" (...), or in other words "organically" and not "mechanically" [Tatarkiewicz, 2001: 278]. The revolutionary contribution of Ferdinand de Saussure, who before taking language studies in Leipzig had studied physics and chemistry in Geneva for a year, to the development of linguistics would involve the recognition of the "overall" (systemic), "insubstantial" and "relational" nature of the language and the change of the perspective in its description. The basic statements of the *Course in General Linguistics*, which all students of linguistics know, seem to correspond well with the achievements of Einstein and particle physicists of his generation (Max Planck, Niels Bohr and others), for example:

2. language as a two-dimensional phenomenon, in the abstract dimension recognised as *langue* and in the material dimension as *parole*, is – similarly to "physical" matter – both "discontinuous" ("discrete") and "continuous" ("linear", "analogue");

3. it should be examined "synchronically", as a self-sufficient complete system in which basic units are linked to a regular network of relations (just like quanta) rather than diachronically, emphasising the evolutionary nature of its parts (words);
4. a linguistic sign consists of a signifier (acoustic image) and a signified content (concept), and the relationship between them is arbitrary, i.e. not determined by extralinguistic reality or any rational reasons, but it is embedded in the structure of *langue*, in which what distinguishes one sign from other signs also determines it; thus the linguistic system is of relational and formal nature (and this form is self-steering and self-regulating), and not substantial.

Further search for analogy at a general level, though possible, would be considered over-interpretation, therefore, the relationship of structuralism to quantum mechanics can be considered taking the theory of the phoneme of the Prague School as an example.

It is believed that prior to the publication of works by Nikolai Trubiecki and especially Jakobson in this area, phonemes were seen as a sort of sound "atoms", something that does not require opposites. Then, defining the phoneme as a bundle of distinctive features revolutionized phonology and had far-reaching implications for the diagnosis of the binary nature of the linguistic system, in which the "discreetness" or "quantaness" of the language are manifested. Jakobson himself admits that the distinctive features of speech sounds should be understood as "Einsteinian concepts expressing rigorously established relationships, intuitively recognizable as binary oppositions" [Jakobson, 1989: 73].

It is worth paying attention to another similarity related to the nature of these linguistic findings. Yuri Apresjan notes that linguists usually seek to ensure that their theoretic considerations on different linguistic phenomena do not deviate significantly from the intuitive concepts of the average language users; meanwhile: "In the experiments of Jakobson and others for the first time linguistics looked into the depth of the object the existence of which the average language user does not suspect, and gained experimental data that refuted the primitive intuition" [Apresjan, 1971: 96]. A similar revolution took place in modern physics: both the theory of relativity and quantum mechanics, although proven experimentally, are far from the common thinking and perception of the world and seem to be paradoxical from this point of view.

Polish philosopher Wladyslaw Tatarkiewicz, summarizing the philosophical consequences of the development of physics at the beginning the twentieth century, notes that in the anthropological dimension its impact is negligible compared to the first revolution of the turn of the sixteenth and seventeenth centuries: "After Copernicus's discovery man lost his central position in the universe. And he seemed to himself smaller, when the universe expanded indefinitely (...). Modern man knows infinitely more about the universe than man in the past, but – an interesting thing – he seems not to connect his view of himself with the knowledge of the universe. He lives in a different than the physical scale (...). This scale is psychological, social, religious, but not physical. Man tends to decide about his insignificance or greatness on the basis of the social and historical sciences, but not natural ones" [Tatarkiewicz, 2001: 280]. It seems that post-structuralist ideas seek to link these scale mutually.

3. Bohm and the grammar of human experience?

When structuralism flourished in linguistics, inspired (to some extent) by the discoveries of physics, at the same time linguistic frustration among physicists grew. The inability to express the principles of quantum mechanics in the "natural language" (as opposed to "artificial" language of mathematics) was discussed by Niels Bohr, the Nobel Prize winner for developing the study of the structure of the atom, and his co-worker Werner Heisenberg, who was awarded the Nobel Prize for his discovery of the uncertainty principle in the motion of the atom. The description of their struggle with the new reality of micro scale and the language that could be used for its interpretation, is an exciting yet sad reading for linguists. Heisenberg writes that the language fails, it is a blunt instrument, that the interpretation of quantum mechanics in the language is like "waving hands", that you have to "arrange" how to speak [Heisenberg, 1979: 142-166]. The reason for frustration is the awareness of "being convicted to the language", without which it is difficult to understand experiments.

The problem and its complexity is presented convincingly by Willard van Orman Quine, a mathematician and analytical philosopher: in the physics of light, with its notoriously mixed metaphors of the wave and particle, the physician's understanding of his own words must depend almost entirely on the context: on the knowledge of when to use a variety of sentences, at the same time talking about photons and observed light phenomena. Such sentences resemble levers, the proximal end of which is anchored in what they say about known objects, and the other end supports mysterious objects. Explanations become strangely bilateral: photons are postulated to help explain phenomena; on the other hand, these phenomena together with their theory explain what the physicist mean when talking about photons [Quinn, 1999: 28-29]. The interpretation of the "quantum world" becomes less and less precise, and more and more metaphorical, which obviously cannot satisfy particle physicists, who regard as perfect the language that strictly follows the structure expressed in mathematical patterns [Heller, 1999: 64].

David Bohm is one of those physicists who expressed their opinions on the language in the second half of the twentieth century [Bohm, 1988: 39-59]. He regarded inadequacy of the grammatical structure of the language (referring to SAE languages) to express the dynamic and fluid nature of reality that emerges from the observation of elementary particles and the laws of quantum mechanics, the basic problem of the interpretation . He stressed that the subject - verb - object language structure along with the worldview it implies is strongly reflected in our speech, even when giving little attention enables to see its obvious inadequacy. He saw inadequacy primarily in the fact that this structure reflects and preserves habitual and thoughtless perception of the world as a collection of separate static and fixed entities (of "permanent nature"), which actually prevents more relevant from the point of view of modern physics imaging of the world as a harmonious, non-fragmented whole.

David Bohm's great success is that he does not stop on the accurate diagnosis of the problems in understanding the "new" worldview, but he also tries to overcome the limitations of the language in its expression, realizing an "experiment" which he called *rheomode*. It is, in fact, a proposal to reform the language into its predicativisation, that is putting the verb in the first place in the syntactic (predicate-argument and thematic-rhematic) hierarchy and in the linear order of the sentence, loosening the relationship between the predicate and the subject, and the "independence" in meaning of the predicate from semantic-grammatical relations expressed in nouns. He performs this operation by giving verbs new, more general meaning and creating derivation series with preservation of clear graphic traces of verb formative operations (rejecting the "atomistic approach to words"), for example *ordinate* (meaning: spontaneous and unrestricted act of organizing) → *re-ordinate*→ *re-ordinant* → *irre-ordinant* → *ordination* → *re-ordination* → *irre-ordination*. This would make it possible to gain awareness and express in the linguistic worldview the primordiality of "movement" and its ubiquity - that some activities imply other activities, thus associative (paradigmatic) relationships between verbs in the horizontal section of the sentence should be emphasised.

This proposal could not be welcomed by linguists with enthusiasm. It is considered to be the "eccentric and impractical" [Goatly, 2000: 302], "simplifying and limited" [Halliday, 1987: 123]; not embedded in linguistics and not taking into account contemporary linguistic knowledge. Although it can be linked to Whorf's criticism of linguistic absolutism, it appears as an expression of postmodern "linguistic turn", which is known mainly in relation to philosophy and social sciences. In these sciences an essential role in understanding the world is assigned to the language, and "words" are not treated as mere vocal labels or communicative accessories applied to the previously existing order of things [Harris, 1988]. Michael Halliday considers the concept of *rheomode* an example of the "meta-language" of clear motivation: to decipher a new picture of reality we need a new language [Halliday, 1987: 123]. For Bohm it is a plane on which it is possible to approximate the two scales of human life mentioned by Wladyslaw Tatarkiewicz: physical and psychosocial scale. In this sense, Bohm's *rheomode* can be important also for linguistics.

The problem of adequacy in expressing "new physical knowledge" of grammatical structures existing in the language and reform attitudes in this area is not unknown to linguists. A broad discussion on this topic was begun by Halliday in his breakthrough paper *New Ways of Meaning: The Challenge to Applied Linguistics*. It drew attention to the fact that modern language policy and language planning includes grammar to a small extent. Institutions that deal with the regulation of

language processes in different countries focus mostly on its standardization and corrective codification, not paying attention to the creation of new grammar patterns. This raises the question - why?, or rather - why not? – says Halliday, emphasising that grammar as a centre of constructing human experience with the symbolic linguistic signs (and not just inner linguistic order) cannot be in contradiction with the material and physical conditions in which it operates. He points out that grammar categories (and relationships) of subject – object and agens – patiens types that fragmentarise the worldview were formed under the influence of modern science (especially physics of Galileo and Newton) and reflect the vision of reality then: the constant and precisely defined, but appear to be dysfunctional in representing its more relative and flowing image that emerges today. Therefore, he poses a problem similar to Bohm in his concept of language dynamisation noting, however, that everyday language is much more "dynamic", "complementary" and "sophisticated" in the imaging of the world order than physicists think.

The discussion initiated by Halliday led to the emergence of different attitudes to the mechanisms of the "grammar of human experience" in the context of the new interpretation of the world, brought by quantum mechanics. Andrew Goatly, for example, argues that Halliday's congruent grammar, that is a situation in which the semantic structure corresponds to the canonical structure of the event is not "natural" [Goatly, 2007: 302]. "Adequate speaking", where things are presented as nouns and secondary units and actions in the verbal group, is not - in his opinion - more natural and consistent with extralinguistic reality than presenting actions with nouns in nominalisations criticized by Halliday. The distinction between what is "literal" (standard conceptualizations) and "metaphorical" (nonstandard conceptualizations) is sanctioned by social conventions, and in the modern language (as a system in use) grammatical metaphors become increasingly present (for example, unusual collocations, unconventional syntactic roles of participants), expressing a new vision of the world. Goatly notes that this could be an argument against the reformist efforts of linguists: "Semiosis is embedded in our interactions with the real world. We can access it only through perception, cognition, and with the help of language, but we develop those models of cognition and thinking that best adapt in our environment" [Goatly, 2007: 332] – he says, pointing out that the contradiction between the grammar of human experience and contemporary image of reality (including the interpretation of the microcosm) will be overcome on condition that man - apart from the psychosocial scale of life - will see (and will "language") the larger, physical scale.

Conclusion

The three moments presented in the paper that were breakthrough in the development of science, which show the connections between discoveries in physics and linguistic developments, seem to reveal the existence of mutual fascination between them resulting from the recognition of their importance in discovering the order of the physical world in the micro- and macro-scale as well as discovering the place of man as a cognitive entity in that order. These relationships are diverse and multidirectional: physicists, more or less consciously intervene in the language, in order to express new knowledge "adequately", which is widely commented by linguists. Linguists use the discoveries of physicists to analyse and interpret language phenomena in accordance with the laws of physics. Also physicists observe the trends in linguistics, and use them to reformulate the abstract language of calculations and experiments to the language that is closer to the average user of the "human experience" language. Attempts to get closer the worldview contained in the (SAE) language and the image emerging from contemporary physical experiments are rarely successful, this, however, should not discourage the two groups from further attempts.

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