On certain questions related to information and symmetries – in physics from certain view of philosophy of science

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Introduction

My presentation aims at answering a part of the questions posted in the invitation to the session. The questions arose in and originated from the FIS discussion on *Physical informatics …* in October 2014. No doubt, they were formulated in provocative manner. The goal was to challenge discussion. I plan to illustrate my personal answers with a few examples quoted from the history of 20th c. physics. My answers to the questions are not intended to be enunciations and to provide final solutions, rather they serve as arguments and indicate that nothing is closed, the discussion is open. Methods

1

> What do we consider physical information? Can one speak about physical information when there is no live percipient to accept, evaluate and use it? Can one speak about physical information (e.g., signal exchange) between inanimate physical objects (cf., e.g., Feynman diagrams)? And if so, what is it for? Is (physical) information a passive phenomenon, or its existence presumes activity?

Interpretation of 'activity' plays important role in the possible answers. *One of the interpretations* says that activity is an antropomorph phenomenon. It is a privilege of the human mind, which is able to perceive and process information, able to teleologically evaluate its possible consequences and (re)act accordingly. *Another interpretation* says that there is inanimate activity, that means, reception of information between physical agents and their reaction to it. I argue for the latter concept.

Let us see the example of the interaction between two (electric) charges. There were two approaches in the classical age of developing these theories (1928-33). When two electric charges interact, there appear *two types of interaction*. One is a Coulomb-type repulsion/attraction (according to their mutual signs) governed by their scalar potential, and the other is a Lorentz-type one governed by their vector potential depending on their relative velocity to each other.

One type of the theories considered first the interaction between the scalar potentials and calculated the effect of the vector potentials as perturbation. It considered two charges approaching to each other from the infinity, when in first approximation they have got information on the amount of the Coulomb charge of the other, but not its velocity and the caused Lorentz force. The latter was considered in the perturbation process.

The other type of the theories considered first the effect of the Lorentz force of the approaching charges, and took into consideration the effect of the Coulomb force in course of the perturbation.

Representatives of both types of theories agreed that the roles of the interacting electric charges must be symmetrical, but Christian Møller. Møller [7], who belonged to the latter type of theoreticians, applied scattering matrices (1931). He showed that there appeared a component among the matrix elements that was asymmetric in respect to the two interacting charges. H. Bethe (that time a doctoral student of E. Fermi, 1932) could not accept this asymmetry and 'corrected' Møller's theory. He 'symmetrised' those matrix elements artificially [1]. That was a rough and unjustified involvement in Møller's equation, but due to the later attained high authority of both Bethe and Fermi, the physics community accepted the apparently convenient symmetrisation of the theory without discussion and has not treated it until the recent years. Thus any possible distinction between (roles and properties of) interacting charges were unrevealed until the past decade.

However, the question can be formulated so: *how do the charges, ready to interact, get information from each other*? All theories agree that interaction between two charges take place by the exchange of a boson. In case of electromagnetic interaction this boson is a photon. Which of them emits the first photon towards the other? Did this emitter receive any information from the direction of the partner charge prior to the photon emission? *What else is this if not an asymmetry between the roles, and possibly between properties of the two interacting charges*? The distinction between the interacting charges was introduced by the isotopic field-charge theory, and the notion of 'isotopic field-charge' made the distinction between the properties of the two charges [2],[3],[4],[5]. The latter led to the proof of the gauge invariance under rotation of a newly introduced property, the isotopic field-charge spin, in an abstract field, and its conservation. This conservation is a result of a symmetry. Nevertheless, this mechanism argues for activity between physical objects without an animated (human) agent.

2

What are the limits between (closed and open) systems, from the aspects of information and of symmetries? Further, if so, how wide can we extend the meaning of activity to be still accepted for generating information? What are the roles of different appearances of symmetries in taking a stand in the mentioned questions? What kinds of symmetry (or their absence) may play a role in making decision in the listed problems?

The 'classical' (20th c.) relativity theories demanded that all physical laws were invariant under the Lorentz transformation. This was established first in the special theory of relativity that was formulated for electromagnetic interactions [6]. Lorentz invariance of physical laws was in fact a symmetry principle (conservation of the form of the laws during reference frame change) [9]. This invariance proved to hold for many other physical laws, so later also the symmetry principle was extended to other physical laws as well.

The Lorentz invariant relativity theory included another consequence: there is no distinct (odd) reference frame in nature. In other words, all reference frames are equivalent. Aren't they? Based on Noether's theorems [8], one can show that conservation laws hold in all reference frames. However,

the quantity of the conserved property (e.g., mass, charge, etc.) may change in the different reference frames. E.g., the amount of mass of matter in a closed system depends on the velocity of the observer relative to that system where the mass is to be measured. One can always find a reference frame from which the amount of the measured mass is minimal. This fact contradicts to the absence of a distinct (odd) reference frame. And there are more. *Is there any invariance that compensates this lost equivalence of all reference frames?*

The observer can be not only a human agent who measures with instruments and reads the records. It can be another inanimate mass that perceives *information* about the mass from the observed system. Its 'activity' is that this information can be obtained by experiencing a force. This force can be gravitational or inertial. According to the general theory of relativity the 'observer mass' is unable to make distinction whether the experienced force is of 'inertial' or 'gravitational' origin. At the same time, the inertial mass changes its value according to its relative velocity to the observer, while the gravitational mass does not. Thus the 'observer mass' in different reference frames will experience different inertial forces originating from the 'observed mass'.

Something similar distinction can be made between the Coulomb charges and the Lorentz-type (current) charges. They are sources of the Coulomb force and the Lorentz force, respectively, and similar to the two types of masses, originate from the scalar potential and from the vector potential of the Hamiltonian of the charged object, respectively.

The two types of masses and the two types of electric charges are called isotopic field-charge pairs, respectively. They are subject of the same gauge invariance. As such, they can exchange their roles (switch into each other) by the exchange of a gauge boson (in addition to the graviton and the photon, respectively), called delta bosons in the theory. As a consequence of the additional invariance and the corresponding additional mediating gauge boson, the respective systems of the two interacting isotopic field-charges (masses or electric charges) are not subjects of the Lorentz invariance alone. They are subjects of a convolution of the Lorentz- and this additional invariance. One can conclude two things.

First, along with the development of physics, there is no more enough to demand invariance under the Lorentz transformation. At extended conditions, one should demand the invariance under a combination of the Lorentz invariance and an additional invariance. In short, we demand invariance under (the applicable) transformations.

Secondly, when two charges (let they be either gravitational, electric, or other field-charges) interact, they make a distinction between each other. The system, composed of the interacting two field-charges, follow the Pauli principle. That means, the two interacting field-charges must be in different quantum states. Since this state in which they differ cannot be characterized by any of the earlier known properties, it must be a characteristic of the newly introduced property. It must be one of the two stable positions of the isotopic field-charge that are rotated into each other by the SU(2) symmetry group in the isotopic field-charge field. These two stable positions are called, by an analogically given name, the *isotopic field-charge spin* (not identical either with the angular momentum spin or the isotopic spin). According to its proven invariance, the isotopic field-charge spin is a conserved property. When two field-charges interact, they must be in the opposite isotopic field-charge spin states. The information that they exchange about each other is about this state: they check whether the partner is in the opposite state. Otherwise they are 'not allowed' to interact (Pauli's exclusion principle). The information exchange takes place by the exchange of a delta boson (called also dion) between them, in addition to the exchange of the traditional mediating bosons (like graviton,

photon, weak charged and neutral bosons, or gluons). That delta boson switches the emitting charge from inertial to potential state, and the absorbing charge from potential to inertial state.

Conclusions

The asymmetry of the interacting charges has been explained. It was subject of information exchange *between the interacting particle partners. In order to meet the Pauli principle, physical objects should exchange information about the (opposite) states of each other before getting into active interaction. The explanation led to the* loss of an invariance property. *However, this* loss has been restored *by introducing a new physical property (*isotopic field-charge spin*), by proving its conservation, and* completing the Lorentz invariance with the respective invariance *attributed to the newly proven conservation.*

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