Theories of Physics and Impossibilities

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Abstract

The role of impossibilities in theories of Physics is mentioned and a recent result is recalled in which Quantum Mechanics is characterized by three information-theoretic impossibilities. The inconvenience of the asymmetries established by such impossibilities is pointed out.

1. Preliminary Remarks

Theories of Physics were seen by Einstein as falling into two main categories, [1].
Some are constructive as :

"they attempt to build up a picture of the more complex phenomena out of the materials of a relatively simple formal scheme from which they start out. Thus the Kinetic Theory of Gases seeks to reduce mechanical, thermal and diffusional processes to movements of molecules ...".

Other theories can be seen as principle theories, since :

"these employ the analytic, not synthetic method. The elements which form their basis and starting point are not hypothetically constructed but empirically discovered ones, general characteristics of natural processes, principles that give rise to mathematically formulated criteria
which the separate processes or the theoretical representations of them have to satisfy. Thus the science of Thermodynamics seeks the analytical means to deduce necessary conditions, which separate events have to satisfy, from the universally experienced fact that perpetuum motion is impossible."

And in Einstein’s view the Theory of Relativity, for instance, belongs to the second above category.

These second category theories of Physics recall Euclidean Geometry which had impressed Einstein himself during his school years. Indeed, one starts from certain empirically evident principles, and then based on them, constructs the whole theory by using logical deductions.

Another most intriguing remark of Einstein relates to the foundational role of impossibilities in certain theories of Physics, [2]:

"The totality of physical phenomena is of such a character that it gives no basis for the introduction of the concept of 'absolute motion', or shorter but less precise: There is no absolute motion. It might seem that our insight would gain little from such a negative statement. In reality, however, it is a strong restriction for the conceivable laws of nature. In this sense there exists an analogy between the Theory of Relativity and Thermodynamics. The latter, too, is based on a negative statement: 'There exists no perpetuum mobile.'"

In fact, Special Relativity is based solely on two impossibilities:

- there is no absolute motion,
- no physical entity can move faster than light in vacuum.

The remarkable fact is that in Physics, within the second category theories, one can start with principles expressed by very simple impossibilities, like for instance those mentioned above.
2. Three Impossibilities as the Foundation of Quantum Mechanics

Recently in [3], see also [4, 5], it was shown that Quantum Mechanics can be characterized by the following three information-theoretic impossibilities:

• the impossibility of superluminal information transfer between two physical systems by performing measurements on one of them,

• the impossibility of perfectly broadcasting the information contained in an unknown physical state, which impossibility for pure states amounts to ”no cloning”,

• the impossibility of communicating information so as to implement a ”bit commitment” protocol with unconditional security.

3. Comments

One may, of course, think that in the case of second category theories of Physics, namely, those called ”principle theories” by Einstein, it is rather trivial to formulate the respective principles as impossibilities. Indeed, any principle, say, ”P”, and not only in Physics, can be stated equivalently by its double negation ”non-non-P”. And then this equivalent form is nothing else but stating as principle the impossibility of ”non-P”.

From the above examples, however, it is clear that the respective impossibilities are not of that trivial form. Indeed, as they are given, none of them is a double negation, but only a simple, one time negation. And as such, they describe definite binary choices concerning fundamental properties of the whole of their corresponding realms of physical situations, choices in which, a priori and on purely logical grounds, both alternatives may appear to be possible. Furthermore, and quite importantly, they describe binary choices in which one of the alternatives may appear to be particularly convenient, yet it is precisely that alternative which ends up being denied in principle.
In other words, these impossibility principles are establishing *asymmetries* in their respective realms, and do so in ways which appear to be inconvenient.

For instance, a priori, it may not be clear whether there is, or on the contrary, there is no perpetuum mobile. And needless to say, it would be so much more convenient for us if there were any at all. Yet the principle adopted denies the existence of even one single perpetuum mobile. A similar situation happens with the limitation given by the velocity of light in vacuum, or for that matter, with the above three impossibilities which characterize Quantum Mechanics.

**References**

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