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A quest for understanding and a persuit for elaboration of the fundamental theories of physics

For Constantin Piron on his sixtieth birthday

Constantin Piron was born in Paris in 1932. He has Belgian nationality but has never been resident in Belgium. His family are freemasons and his mother studied theoretical physics with T. De Donder at the Free University of Brussels. She specialized on Einstein gravitation and electrodynamics and obtained a position in Paris at the Joliot-Curie laboratory to finish her doctoral thesis. In Paris she married and finaly never went to the laboratory. The young Constantin learned from his mother the Einstein gravitation before he came into contact with Newton's theory. He began his primary school at the famous Cours Saint-Louis, rue de Monceau, in 1939, but due to the war had to stop almost immediately. The family left Paris for a small village in Burgundy.

Due to these circumstances Constantin Piron never obtained a school certificate and therefore he could not officially enter the university. Even after having passed the entrance examen for the Ecole Polytechnique at the university of Lausanne, he did not have the right to register as a student until 1964, when he supervised the examinations of the doctoral students of Professor Stueckelberg. Finaly he obtained the right to matriculate for his own thesis, which he obtained in two weeks. In this thesis he proposed his celebrated representation theorem (1), where he proves that a complete, atomic, orthocomplemented, weakly modular, irreducible lattice of propositions, satisfying the covering law, is isomorphic to the collection of closed subspaces of a generalized Hilbert space, and in this way identified a set of axioms for quantum theory.

In 1956 he was assistant to the chair of Descriptive Geometry of the university of Lausanne, where he studied with fascination the newly arrived complete works of Elie Cartan. From 1957 to 1965 he worked in the experimental nuclear research laboratory at Lausanne, and from 1958 to 1964 he assisted Professor Stueckelberg at Lausanne. From 1961 to 1966 he worked with Professor Jauch at Geneva, and became a full Professor in 1971.

When I was a student in the last year of Brussels university, sharing the well known feeling of 'not understanding quantum mechanics' with my fellow students, I came across one of Piron's articles. For the first time I saw an approach to quantum mechanics that was founded on concepts, the experimental propositions of a physical system, that were much closer to physical reality than the concepts of orthodox quantum mechanics. I was so intrigued that I started immediately to study this material, and when a year later I got a grant from the Belgian National Fund, I decided to go to Geneva, to investigate the possibility to make a doctoral thesis. My intuition, reading Piron's work, was correct. Coming in Geneva I was delighted to be able to join in the creative process that was developing there: the elaboration of a fundamental approach to physics [2,3,4].

From the start, Constantin's conception of nature and the profoundness of his reflection made a great impression on all of us in the Geneva group. What amazed me most, and what was very different from the general attitude towards quantum mechanics, was his conviction that quantum mechanics could be understood and that the orthodox theory could be improved. Indeed, his representation theorem brings quantum theory and classical theories into one framework, and gives a natural explanation for the existence of superselection rules. The attitude of not reconciling to orthodox quantum mechanics, neither for the mathematical formalism nor for the interpretation, brought the Geneva group in a stream of renewal, together with other groups sharing this general attitude. The results of the new approach came steadily but always had to struggle hard against the existing paradigms.

An important aspect of the formalism is that philosophically it represents a 'realistic' point of view. The physical system is considered to be a part of reality and whether it is known or not by the physicist does not change anything on its reality. The basis of the approach is the concept of *experimental project* (in short test or question), an experiment that can be performed on the system and where in advance is defined exactly what is a positive result. A property of the system is said to be actual if in the event of the corresponding experiment, the positive result would be certainly obtained. Other properties which are not actual, are said to be potential. The complete set of actual properties is by definition the *state* of the entity. By itself or by influence of the exterior the system changes, in other words its state changes: some actual properties becoming potential while others, potential at the start appear in actuality [2,4].

The formalism proceeds by looking for a mathematical framework capable of describing a system by its complete family of properties, its possible states and the corresponding structures inherent from these notions. It is shown that the collection of properties is a complete lattice [2], and the collection of states has an orthogonality relation [5].

The concept of classical property is introduced in a physical way, and one proves that the collection of classical properties forms a sublattice, called the 'classical' property lattice. A macrostate is defined as the equivalence class of 'macroscopic equivalent' states, and one shows that the classical property lattice is the set of subsets of macrostates [4,5], and the set of macrostates coincides with the set of superselection rules [2,4,6].

When the physical system is one entity making a whole one can impose axioms that make it possible to represent the irreducible components of the property lattice by the closed subspaces of a generalized Hilbert space. The axioms make the property lattice atomic, orthocomplemented, weakly modular and satisfying the covering law, such that the representation theorem can be used [2].

When the system consists of two or more separated entities it is proved that such axioms fail and cannot be maintained without contradictions [5]. More specifically it are the axioms leading to weak modularity and the covering law that are not satisfied for the system consisting of two or more separated entities.

It can be shown that the shortcoming of the formalism of orthodox quantum mechanics, of not being able to describe two separated quantum entities, 'is' the incompleteness pointed out in the Einstein Podolsky Rosen paradox [7], and the missing elements of reality can be identified explicitly [8].The paradox disappears in the general description proposed in [5].

The quantum probability appears as the probability connected to an 'ideal experiment' (an experiment that perturbs the physical system at little as possible) in the case of a Hilbert space realization. For a real experiment one has to add corrections, that can be computed in the approach, having no meaning in the orthodox theory. A theory of probability is developed much more powerful than the one developed from the density matrix or the W- or C^*-algebra approach [2].

Different particle models have been built, and the classical and non-classical particle models appear in the theory as two different solutions of the same problem, without any appeal to some correspondence or quantization principle [2,9], and also the Schrödinger equation can be justified.

As we have mentioned, the equation for a reversible evolution can be proved to be of the Schrödinger type, but the same theory also gives the most general equation for the deterministic irreversible evolution [2,9,10].

A model for the measurement process can be proposed which fulfills the conditions that one can physically expect: no collaps at the end, a deterministic law of evolution, an explanation of the probability as some unknown initial correlation between the system and the apparatus [11].

It is possible to built a model for the decay process, where a final state is not a superposition of decayed and undecayed states, making use of the possibility of the presence of continuous (and also non compact) superselection rules in the theory. The instant of decay is a random variable, but is nevertheless well defined for each individual event [6].

In [11] is proposed a unique equation for spin relaxation and spin echo processes.

There are difficulties in the usual theory for the quantization of the electromagnetic field even in the Gupta-Bleuler formalism. This is due to the existence of a continuous superselection rule, and the problem is solved in [12], and for such fields a localisability concept has been developed [13].

The Mösbauwer effect can be derived in the formalism, with the center of gravity of the crystal treated as a superselection rule. The perturbation due to a global motion of the crystal can also be predicted.

For the usual two-body Schrödinger operator for the Hydrogen atom having a completely continuous spectrum, no rest state exists. This paradox is solved by the two-body model in [14].

It can be shown that the experiments connected to the Einstein Podolsky Rosen paradox violate the Bell inequalities, because the measurement apparatuses break the one entity (e.g. the two photon composite globule entity) into two separated entities (two separated photons), and by such a mechanism of breaking one entity into two separated entities, Bell inequalities can also be violated by means of experiments performed on macroscopic entities [7].

During the years, several connections with other general formalisms have been investigated [15], and several aspects of the formalism have been elaborated [16].

I liked very much my stays in Geneva and loved the visits of Constantin to Brussels, the city of his ancestors, that he still considered also his. I cherish the many non-classical hours that we spent together, tasting Belgian beer in an at random restaurant near the Brussels *Grand Place*, exchanging ideas, meat and vegetables. Constantin is now working at the difficult problem of relativity theory, and how to reconcile this theory with a realistic view on the world. I hope that he continues for a long time to surprise us with his work and his deep and elegant ideas concerning the many still unsolved problems of physics.

Diederik Aerts,
University of Brussels.

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