

## Symmetry and its consequences: from Pierre Curie to transdisciplinarity

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**ABSTRACT.** A transdisciplinary seminar entitled Synergy and Coherence in Biological Systems was created in April 1983 at the Jussieu-St Bernard Campus in Paris. As a postdoctoral curriculum, this seminar remains an unprecedented event at a European University. Its goal was to offer an exchange of ideas and research results on hierarchical aspects (or vertical, such as position, choice, rank and classification) of synergy (an action which cannot be reduced to the simple sum of constituents) and of coherence (a definite space-time relationship, a concept derived from laser technology, by identity or analogy), from the exact sciences to life sciences. Its goal was two-fold, to introduce a novel educational mode and to encourage scientific innovation through new conceptual tools. In particular, on March 14, 1988 a lecture was presented as part of the fifth annual curriculum of this seminar, entitled: "Identities, symmetries and isomorphisms" with an homage to Pierre Curie, a transdisciplinary forerunner. In 1998, contract HPCFCT 99-00011 (European Commission, Research DG, Human Potential Program, High-Level Scientific Conferences) enabled the creation of a transdisciplinary cybersymposium: "Pierre and Marie Curie, the first century of their impact on human knowledge". As such, this initiative allows for a broader investigation of the work of Pierre Curie regarding symmetry and its consequences. These are indeed relevant in areas from life sciences to information sciences, for example with the concept of the phoron or informational fields.

The Louis de Broglie Foundation was present in the transdisciplinary seminar Synergy and Coherence in Biological Systems several times: on October 28, 1983 with Georges Lochak (Coherence considered as the becoming of a system, and not to be taken for granted) on December 13, 1984 with Olivier Costa de Beauregard (The Einstein-Podolsky-Rosen

paradox. Causality identified with conditional probability and the amplitude of transition in relativistic mechanics) on February 28, 1985 with Rene Thom (Toward a theory of intelligibility: pregnancy and salliancy).

On March 14, 1988 my lecture of the fifth yearly curriculum of this seminar represented an homage to Pierre Curie, a forerunner of transdisciplinarity "Identities, symmetries and isomorphisms." The Greek origin of the concept of symmetry implies a certain measure, a certain proportion. It is a correspondance of proportion, of form, of measure with respect to a reference (for example an axis), between the elements of a set or between two or more sets, and by extension all sort of arrangement according to a certain equilibrium. It is also the invariance of a property or a relationship during a transformation. Symmetry establishes a relationship between objects, phenomena and theories which do not have external links (Herman Weyl, *Symmetry*, Princeton University Press, 1952). Isomorphism (as an extension of the concept used in cristallography and mathematics) is an identity of form, structure or function compared with a different situation. A correspondance (or perfect analogy) one to one between elements of different systems such that the relationship between the elements is preserved. It is a constancy of a pattern maintained among diversity. In general systems theory, it is a transformation which conserves information, or the possibility of relating or representing correctly an element in another structure or situation. It may also be a formal identity between two conceptual systems (D.R. Hofstadter, Godel, Escher, Bach, Basic Books, 1979). These two concepts were illustrated with references from recent scientific publications, as well as proceedings and lectures of this seminar over five available annual curricula.

In his seminal paper of 1894, Pierre Curie declares that asymmetry is what creates a phenomenon, and goes to discuss different cases of symmetry breaking. The status of Pierre Curie as a transdisciplinary firerunner motivated me to create in 1998 (Contract HPCFCT 99-00011, European Commission, Research DG, Human Potential Program, High Level Scientific Conferences) a transdisciplinary cybersymposium "Pierre and Marie Curie: the first century of their impact on human knowledge". A forum was thus created to discuss the work of Pierre Curie regarding symmetry and its consequences, relevent to areas from the exact sciences, information sciences, to life sciences.

In the proceedings available online you are invited to consult two papers in particular: "Pierre Curie and symmetry" by Georges Lochak and

"Pierre Curie, the forerunner of magnetic monopoles", closely related to the topics discussed this week at Peyresq.

Stubborn experimental data, such as those presented during the conference we are engaged in this week at Peyresq, may require childish and even silly questions. In our case, hierarchical aspects of symmetry in attempts at classification and unification, lead to research on hidden and nested symmetries. The understanding and the significance of physical symmetries present a challenge to both physics and philosophy. Epistemological aspects of symmetry lead to invariance principles: in 1952 Herman Weyl noted that objectivity means invariance with respect to a group of automorphisms of space-time. All known physical laws are related to conservation principles (of electrical charge, baryonic number, mass-energy and angular momentum). Will research results discussed this week lead to new conservation principles? Will they be related to asymmetry, similitude, information, chirality? Are we considering asymmetry of physical law, or of concepts in a transdisciplinary perspective?

As far as information-centered asymmetry is concerned, an important direction is suggested by Anton Zeilinger from the University of Vienna (quantum teleportation and EPR) who has formulated a physical theory where the paradoxes of quantum physics disappear when binary information is introduced.

In a recent paper Georges Lochak states that the aim of science is to find a representation of the world which is beautiful and also adapted to reality. Rene Thom used to say that the essence of science is to decrease the arbitrary nature of the description of reality. My personal contribution to this quest was proposed as early as 1983 by a two-fold (physical and information) concept of the phoron, (from the Greek: phorein, to carry) or information-carrying field.

The following non-exhaustive list gives some parameters for the phoron: nature, source, production, emitter, intensity, orientation, anisotropy, topology, range of action, interaction with material targets, interaction with other fields/phorons, informational content, temporal characteristics. Let us consider the case of phoron emission (from an emitter to a receptor), through a medium of propagation. The following (non-limitative) parameters may be considered: speed of propagation, density and anisotropy of the medium, power and spatial disposition of the emitter, obstacles to emission (filtering, competition, quality of the receptor). It is noteworthy that informational aspects of photon emission are not superposable nor reducible to physical aspects: field lines

from a field map are not all information channels. Is an interaction with a receptor, the recording, amplification, reflexion, dispersion, diffraction and absorption are physical aspects. But coding, memorisation, modulation and storage are of an informational nature. The conservation laws of physics (particularly energy conservation) have not found their equivalent in information theory. However, one may ask if, by analogy with Curie's law in physics, the existence of inequality-asymmetry is not necessary for information to arise. The availability of information may increase its use. On the other hand, the conservation laws of time are subtle and paradoxical, and complementarity of available resources of energy, information and time are evidently different on the microscopic and macroscopic levels. This represents new directions for research.

Rather than ask ourselves why are these matters only now gaining a slightly broader audience, as manifested by this conference at Peyresq, let me recount the following story. When the celebrated pianist, Ignace Paderewski, was touring the Western part of the United States with concerts at the end of the nineteenth century, he was often confronted with instruments of poor quality. On one such occasion, he had to play a piano which would function only if another person constantly removed the hammers from the strings wfter each key was touched. Therefore, during the entire performance, a man with rolled-up sleeves was busy at the top of the piano, operating with the speed of lightning, as fast as Pederewski was moving his hands on the keyboard. After the concert, who do you think was encored and applauded by the audience? Yes, you are right... The time of the pianist had not yet come.

## References

- [1] [www.ccr.jussieu.fr/scbs](http://www.ccr.jussieu.fr/scbs)
- [2] [www.ccr.jussieu.fr/curie.100](http://www.ccr.jussieu.fr/curie.100)

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