LUCIANO BOI
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Luciano Boi is Professor at the Centre d'Analyse et de Mathématique in École des Hautes Études en Sciences Sociales, Paris.
Made his studies in Philosophy, Mathematics and Physics and delivered, in December 1997, is Habilitation, Géométrie et philosophie de la nature. Sur les interactions des mathématiques avec les sciences naturelles et humaines.

Researches mainly on the interface between mathematics, sciences of nature and of the living; published extensively on subjects of topology in biology, morphology and morphogenesis, on the relationship between geometry and physics, and on geometry, perception and spatial cognition.

Author of several books and studies, his latest title is The quantum vacuum: a scientific and philosophical concept. From electrodynamics to string theory, and the geometry of the microscopic world *(The John Hopkins University Press, Baltimore, 2011).*

From **16h** to **19h**
followed by an hour of open discussion.

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THREE REVOLUTIONS IN GEOMETRY

prof. LUCIANO BOI \\\ EHESS PARIS
days 30/04\02/05\04/05\2012 ///

\\\session > 1

30\04/2012

A FIRST «REVOLUTION» IN MATHEMATICS: THE TRANSITION FROM A SINGLE, PLAN SPACE TO A PLURALITY OF CURVED, MULTIDIMENTIONAL SPACES (RIEMANN, KLEIN, POINCARÉ)

One of the most significant changes in mathematics occurred when geometry passed on from the science of the figures in space to the science of spaces, which can be endowed with several different geometrical structures and objects acting in various ways on these spaces. The introduction of the abstract concept of *n*-dimensional manifolds by Riemann in the middle of nineteenth century and the contemporaneous discovery of non-Euclidean geometries by Gauss, Lobachevski, Bolyai, and Riemann itself, followed by the construction on non-Euclidean models of geometry in the form of the “classical” differential theory notably by Beltrami, Klein, Poincaré and Hilbert, have contributed in a crucial way to the development of new visions in geometry, which effectively influenced almost all areas of mathematics, as well as of theoretical physics all over the twentieth century. Clifford, Einstein, Weyl and E. Cartan showed that these new geometries might be the right description of the physical space; they all proposed far-reaching mathematical and philosophical hypothesis, which apply to the structure of the real world.

\\\session > 2

02\05/2012

A SECOND «REVOLUTION» IN MATHEMATICS: THE NEW INTERACTION BETWEEN GEOMETRY AND PHYSICS, FROM A PRE-DETERMINED SPACE TO A DYNAMIC SPACE-TIME (CLIFFORD, MINKOWSKI, EINSTEIN, WEYL)

Among the most important events of the twentieth century physics, we must surely account the special theory of relativity and the general theory of relativity, both discovered by Einstein in 1905 and 1916 respectively, and quantum mechanics, which was worked out by Bohr, Heisenberg, Schrödinger, and de Broglie. Owing to these theories, the physicist’s conception of space-time underwent two major upheavals. General relativity theory and quantum field theory plays a fundamental role in describing the same natural world although at different scales, so a more complete description of nature must encompass both of them. The formal attempt to quantize general relativity leads to nonsensical infinite formulas. In the sixties non-Abelian gauge theory emerged as an adequate framework for describing all natural forces except gravity; however, at the same time, the inconsistency between general relativity and quantum field theory emerged clearly as the limitation of twentieth-century physics. The problem is a theorist’s problem “par excellence”. Experiment provides little guide, and the inconsistency mentioned early is an important problem which clearly illustrates the intermingling of philosophical, mathematical, and physical thought.

\\\session > 3

04\05/2012

A THIRD «REVOLUTION» IN MATHEMATICS: GEOMETRY AND THE GENERATION OF NATURAL AND PERCEPTIVE FORMS (D’ARCY THOMPSON, THOM, NEO-GESTALT)

There are at least two distinct approaches to theorizing natural phenomena and morphology. By theorization one can mean, first, to recognize the regularities among the spatio-temporal appearances, patterns or structures. One way to look at things is that of physics: among the data we are perceiving or observing, to be able to recognize the underlying regularities, and then express them in terms of laws or of the reproducibility of phenomena. These laws allow to systematize the data and to organize the structure of the data of our experience. Accordingly, we have as definition that theorization can be considered as the reduction of arbitrariness in the description. However, this approach paves the way for the reductionist explanation of natural phenomena by mechanist laws or by atoms. This conception states that the visible morphology of phenomena can be entirely reconstructed by applying precise quantitative laws and general physical principles. Nevertheless, it isn’t the only approach. One may follow another approach in front of any morphology. One could try to explain this morphology by introducing unknown parameters or hidden variables, and in the new space obtained by adjunction of these parameters introduce conceptually simpler objects, whose projection on the space of observables would yield the given data. So, on the one hand, we have the space of observables P which is the support of the experimental morphology, and we get a lot of complicated forms in this space, which we don’t know how to explain? Consequently, we introduce a space of unknown or hidden parameters, say T, which we suppose (or imagine) it plays a role in the engendering of the complicated forms. Then we construct in the product space $P \times T$ simpler objects which, by *projection* in the space $P \times T$, will help to reconstruct and possibly to explain the complex morphology.