Imagining Scientific Objects as a Bridge Between Metaphysics and Science

Luis Flores, Santiago de Chile, Chile

lfloresh@puc.cl

Scientific imagination is a sophisticated and controlled reverie, but not an illusion. We define "metaphysics" as a type of background thinking about the categories and principles of reality. Husserl said, in the *Logische Untersuchungen,* that "as distinctive mark of reality (*Realität*) is enough for us the temporality (*Zeitlichkeit*)" (Husserl 1968, 123). In this sense, reality includes temporality. On the one hand, metaphysics is a subset of ontology as the general theory of objects, as including not only real or actual objects, but also ideal, fictional or imaginary objects. On the other hand, empirical sciences aim to access to reality. The way to do this is through phenomena. These are real things perceived according to certain parameters imposed by a scientific observer. What does "real" mean for a scientist? In 1957, Wolfgang Pauli wrote: "That which we come upon, which is beyond our power of choice, and with which we have to reckon, is what we designate as real" (Pauli 1994, 128).

In turn, access to these phenomena is through theories, laws and observation data obtained with scientific instruments. Properly speaking, these phenomena are intelligible insofar as we have theories containing rational and order principles. Nevertheless, laws can be conceived not only as mere regularities of observation data, but also as idealizations that contain ideal objects: *e.g.* the ideal gas in the Boyle-Mariotte's law, the ideal conditions concerning free fall in Galileo's law. Scientific theories are general structures that need to be connected to some phenomena. These phenomena are the domain (model in the mathematical sense) in which those theories are true. For example, the planets of the solar system are a domain in which Newton's theory of gravitation is true. If we appeal to this theory to understand all the characteristics of the forces governing the motion of electrons in an atom, we fail. If we consider theories purely as theories, they are networks of logical and mathematical structures. The mathematical concept of *group* applies both to the Galileo's group of classical mechanics and to the Lorentz's group of special theory of relativity. Nevertheless, as Pauli says,"it seems to me probable that the range of application of the mathematical group concept in physics has not yet been exhausted today" (Pauli 1994, 130). Therefore, to appeal to mathematics entails an ontology of ideal objects at work: functions, groups, geometries, complex numbers, matrices; *etc*.

But we need to take a new step: the connection with phenomena needs fictional objects concerning scientific imagination. For example, the enlargement of the hydrostatics and of the hydrodynamics needed a new object in Torricelli's imagination: an air sea. And Leverrier's hypothesis of Uranus' anomalies also required a new object: Neptune. Wolfgang Pauli first imagined the neutrino in beta disintegration. But not all of these objects survive: *e.g.* Vulcan in Leverrier's hypothesis about Mercury's perihelion, ether, phlogiston; *etc*.

The scientific imagination is a special procedure that satisfies this need by means of metaphors, analogies, models and reductions. Firstly, metaphor identifies two heterogeneous objects. For instance, the air and the sea in Torricelli – both are objects of perception, but the air *as* a sea is an object of imagination –; the planetary system as metaphor of the atom ; the computer as metaphor of the brain; and the clock as metaphor of the world; the pump as metaphor of the heart. Nevertheless, metaphor is yet vague imagination. The schema is:

A is similar to B

All A is C

(We know scientifically that A has certain properties C)

Therefore, all B is C.

Secondly, it compares objects and takes into account the explicit relationships of analogy between them. For instance, we have Faraday's comparison between stressing a body, which affects the transmission of light (Brewster's experiment), on the one hand, and electrifying it, which produces the same effect, on the other. We have also Young's analogy between colours and sounds with respect to light as a wave. Or we have the Enrico Fermi's analogy between the collision of slow electrons with the atom and the collision of slow neutrons with the nucleus. The schema is: A is to B, as C is to D.

Thirdly, scientific imagination yields models. We do not speak about the mathematical sense of a model: "In the mathematical sense, *models* are models of structures, and a model of a structure of a given species is any set endowed with structural features satisfying the requirements of that species (Torretti 1990, 306). We speak about a kind of pictorial representation of phenomena. In this sense, a model is an image (pictogram, diagram; *etc*.) that simplifies a phenomenon, defining a scale about it and controlling it by mathematical prediction. For example, the double helix model in the case of deoxyribonucleic acid (DNA), the seismological model concerning strain and subduction of tectonic plates, the pilot wave picture, the Feyman's diagram. A classical example of a model is the moon as a perfect sphere. Being a geometrical model, we can predict its behaviour by an equation. Nevertheless Galileo has changed this representation. He imagined the moon as an irregular sphere in a space crossed by light and endowed with perspective (see G. Holton). Nowadays, after Mandelbrot, we can make a fractal model of the moon.

Fourth, the reduction as an imaginary procedure. Schwann imagined that a biological structure like a cell could be conceived as an atom endowed with physical and chemical properties. Ferdinand de Saussure has reduced language to its synchronie and he has eliminated methodologically its diachrony. As an application of Von Bertalanffy's theory of systems, N. Luhmann reduces a complex phenomenon such as society to a system. The biological process of nutrition can be understood as enzyme changes and, in its turn, these one as energy processes. At the end, there are equations to govern them. The broadest reduction is mathematical reduction: nature should be understood in mathematical terms (Pythagoras, Galileo). The imagination concerning this mathematical reduction has been fruitful. For instance, Euclidean geometry is exact with a margin of error less than the diameter of a hydrogen atom within the range of 1 meter (R. Penrose).

Fictional objects are established according to certain rules. For example, if "water" is replaced by "H_2O", then we should first take into account only the *cognitive* structure in chemistry. That is to say, the deontic, symptomatic or aesthetic aspects of the image concerning "water" are excluded: this is firstly the rule of abstraction. For instance, see the meticulousness of Robert Hooke's drawing about a flea (Barrow 2008). Secondly, H_2O as a new object is a combination of pure entities (H, O). More precisely, as a molecule it is a combination of atoms. In the case of living body, we can conceive it as a combination of cells. In linguistics, a sentence can be understood as a combination of phonemes, or morphemes. Therefore, there is a rule of combination. Thirdly, these new objects are imagined by taking some properties to the limit, that is to say, it is the case of the rule of idealization. For instance, in Newton's laws of motion of a solid body, we assume it to be quite rigid; or in the law of elasticity, it is assumed to be deformed in a perfectly reversible and linear manner.

My point is that these fictional objects constitute the horizon for the phenomena and they are linked with metaphysics concerning the sense of the reality of phenomena. From the phenomenal standpoint, an electron is only a trace on a photograph or a tiny flash on the screen, from the imaginary point of view, it doesn't exist in a real world, but it does exist in a broader sense on a map about fictional objects. These objects survive by a selection process concerning empirical verification and refutation, but also by their connection with metaphysics. Metaphysics can help firstly with the analysis of the concept of reality. For instance, is the reference to a sensation, as Mach claimed, the criterion of reality? "Atoms cannot be perceived by the senses; like all substances they are things of the thought. […] The atomic theory plays a part in physics similar to that of certain auxiliary concepts in mathematics; it is a mathematical *model* for facilitating the mental reproduction of the facts" (Mach 1960, 588-589). Mach's assertions are extra-scientific, because they cannot be demonstrated by science, *e.g.* statistically. And metaphysics can help secondly by discussing the sense in which some principles of scientific research are merely useful or are grounded upon reality.

Let us review some of these principles:

1) Simplicity. Leibniz says about it: "Pour ce qui est de la simplicité des voies de Dieu, elle a lieu proprement à l'égard des moyens, comme, au contraire, la variété, richesse ou abondance y a lieu à l'égard des fins ou effets" (Leibniz 1967, 32). And he adds "car la raison veut qu'on évite la multiplicité dans les hypothèses ou principes, à peu près comme le système le plus simple est toujours préféré en astronomie" (Leibniz 1967,32). 2) Symmetry as a criterion for choosing hypotheses about phenomena . Is reality symmetrical? 3) Harmony. In what sense, do the triads of whole numbers relations govern the atomic world? A. Sommerfeld has written, in the spirit of Kepler, about the quantum theory: "It is the mysterious organon on which Nature plays her music of the spectra and according to the rhythm of which she regulates the structure of the atoms and the nuclei" (Sommerfeld 1923, Preface). 4) Order, that is to say, reality without order makes impossible scientific research. What kind of order is related to reality? However, the order underlying chaos theory is quite different from the order underlying Newtonian theory of gravity. 5) Duality. Could reality be coupled in pairs (wave/corpuscle, position/velocity, and so on)? If we consider the duality substance/accident (see, for example, the Aristotelian or Kantian distinction), it doesn't necessarily hold true. John Bell says: "In the case of the waves of wave mechanics we have no idea what is waving… and we do not ask the question" (Bell 1989, 361). 6) Consistency. Metaphysics should take account of the extent of the principle of non-contradiction concerning reality. Kant did not accept the contradiction in the domain of thinking (denken), nevertheless Husserl accepted it in the domain of the sense: see the concept of countersense (Widersinn) . With respect to N. Bohr, John Bell's interpretation is the following: "By 'complementarity' he meant, it seems to me, the reverse: contradictoriness" (Bell 1989, 363). Today we even have paraconsistent logic for it.

Notwithstanding, one difficulty for metaphysics in regard to its understanding of physics is that the philosopher is related to the ordinary experience and we don't know if the familiar notions of space, time and causality will work: "We have no right to a clear picture of what goes on at the atomic level" (Bell 1989, 362). Moreover, there is another difficulty: the quantum theoretic account of the electron gun could include the scintillation screen, the photographic film, the developing chemicals, and then the eye of the observer and, why not, his brain. And this leads us to a metaphysical problem raised by Descartes: is our mind included in this account?, is our mind quite different from our brain? (the distinction between *res cogitans* and *res extensa*)

My point is that scientific imagination builds a map of possible worlds with the objects implied by hypotheses. The problem is how to choose among these objects. The solution concerns not only the experiments or the theories, but also the connection of the new objects with metaphysical reflection about certain rational principles for understanding reality, that is to say, simplicity, symmetry, harmony, order, duality, consistency.

Acknowledgments

This paper was written as Professor of the Faculty of Philosophy of the Pontificia Universidad Católica de Chile. I am grateful to Prof. Carlos Friedli (Faculty of Physics) for his discussions and suggestions.

Literature

Barrow, John 2008 *Cosmic Imagery. Key images in the history of science*, U.K.: The Bodley Head.

Bell, John 1989 "Six Possible Worlds of Quantum Mechanics", in Sture Allén (edited by), *Possible Worlds in Humanities, Arts and Sciences*, Berlin-New York: Walter de Gruyter, 359-373.

Husserl, Edmund 1968 *Logische Untersuchungen*, Zweiter Band, I. Teil (fünfte Auflage), Tübingen: Max Niemeyer Verlag.

Leibniz, G. W. 1967 *Discours de Métaphysique* (5ème édition), Paris: Librairie Philosophique J. Vrin.

Mach, Ernst 1960 *The Science of Mechanics: A Critical and Historical Account of Its Development* (Sixth Edition), La Salle, Illinois: The Open Court Publishing Company.

Pauli, Wolfang 1994 Writings on Physics and Philosophy, edited by Charles P. Enz and Karl von Meyenn, Berlin: Springer Verlag.

Sommerfeld, Arnold 1923 *Atomic Structure and Spectral Lines*, London and New York: Dutton.

Torretti, Roberto 1990 *Creative Understanding. Philosophical Reflections on Physics*, Chicago and London: The University of Chicago Press.